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# Preface

Sports medicine and sports science are relatively new and rapidly developing fields of knowledge. During the past 2 decades, a significant body of scientific knowledge has been published in these areas. However, there is a demand for practical references which address sports medicine and science in the context of different sports. This demand is higher in some sports including combat sports, which are highly physically and mentally demanding, and cause challenging issues such as risk of blood-borne infections, weight reduction, head injuries, stress management, and safety for women and children. This book has been developed to meet the needs of the practitioners who work with combat sports athletes in order to improve their health and performance.

Combat sports include four Olympic sports (boxing, wrestling, judo, and taekwondo) and other popular sports such as karate, kick boxing, and Wushu. These sports are popular in most countries of the world, both at competitive and recreational levels. Combat sports are practiced by people of different ages for a variety of reasons such as to gain fitness and health benefits and to learn self-defense.

This book has two parts. The first part deals with topics which are common in many combat sports. This is presented in four main sections: (a) nutrition and psychology; (b) ethical and social issues and doping; (c) specific injuries such as head injury, and infections; and (d) combat sports in specific groups including women, children, and professional athletes. In the second part, aspects of sports science and injuries in selected popular combat sports are discussed.

There are literally hundreds of styles of combat sports practiced worldwide today, with many nations having indigenous forms. They include both ancient styles such as wrestling and twentieth-century styles such as taekwondo, and every year new styles of combat sports are developed. It is not possible to directly discuss all the combat sports styles in one book. However, we try to cover the most popular ones as well as topics on sports medicine and sciences which are related to these. This information is likely to be applicable to other combat sports of similar style.

Evidence-based medicine is "the integration of best research evidence with clinical expertise and patient values."[1] A book in a practical field of sports science and medicine should be based on this framework. However, availability of high-quality scientific resources is a limitation in some combat sports and some areas of sports science and medicine. Very limited data are available in areas such as pre-participation physical evaluation. An international team of authors has written this book based on the best available research evidence, their experience, and the concerns and expectations of the target athletes as a group.

We are sure you will enjoy it!

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Nicola Maffulli
Randall R. Wroble
W. Angus Wallace

## Reference

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# Contents

# Chapter 1
# Nutrition in Combat Sports

**Louise M. Burke and Gregory R. Cox**

## Learning Objectives

- To understand the influence of "weight making" for competition on the everyday eating practices of combat athletes
- To appreciate long-term solutions for achieving ideal levels of body fat and lean body mass for health and performance
- To appreciate strategies for achieving goals for fuel, protein, vitamin, and minerals in the everyday diet
- To appreciate the range of nutritional issues underpinning preparation for competition in combat sports, and recovery after sessions of training and competition
- To understand the role of supplements and sports foods in the overall nutrition plan for a combat athlete

## 1.1 Introduction

The need to make weight in many combat sports dominates the nutritional interests of its athletes and coaches. However, well-chosen eating patterns offer a number of advantages to assist the combat athlete enhance his or her training and competition performance. Supporting the fuel and nutrient needs of training will allow the athlete to train hard, recover quickly between sessions, maintain health, and reduce the risk of injury. Although it is often difficult to achieve, maintaining adequate hydration during intensive training periods and throughout competition is also an important goal for these athletes. Challenges to good nutrition practices not only include the need to manipulate food and fluid intake to meet weight goals, but also to find access to suitable supplies in the competition environment or when traveling away from home.

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The science of sports nutrition has become so sophisticated that specific eating strategies can be developed to suit each combat sport, and even each type of competition or workout undertaken by the combat athlete. Although the specific nutritional goals and needs of each athlete are unique, some themes are common across and within combat sports. This chapter provides an overview of common nutritional issues experienced by combat athletes. We will cover the background to these issues, strategies for the prevention or management of common nutrition-related problems, and guidelines for optimal nutrition practice by combat athletes. Finally, we will discuss the role of the sports nutritionist/dietitian in providing expertise to combat athletes, and the way that sports foods and supplements can be used to help the athletes meet their training and competition nutrition goals.

## 1.2 The Overlay of "Weight Making" on Nutritional Practices of the Combat Athlete

Most athletes who compete in combat sports will be required to meet a weight target to qualify for their event. The rationale and guidelines surrounding weight divisions in combat sports are discussed in detail in Chapter 2, along with an elegant overview of the practices, pitfalls, and guidelines involved in "weight making" by combat athletes. Much of the focus of weight making is on the day(s) leading up to a weigh-in and the recovery period between weigh-in and competition. After all, this is when the most extreme nutritional practices may be undertaken to manipulate body weight, and when there is an opportunity to reduce or reverse some of the nutritional consequences incurred. However, a successful approach to weight making requires effort over the entire year including the preseason, season, postseason, and off-season. Therefore, before discussing the global picture of the nutritional needs of combat athletes, it is important to consider how the weight concerns and weight-making experiences of combat athletes may have an impact on their everyday nutritional practices. Table 1.1 summarizes some of the common ways in which making weight influences the nutritional beliefs and practices of combat athletes outside the direct sphere of competition. It also offers ways in which these overt and hidden issues can be overcome to improve the combat athlete's opportunities to meet the nutrition goals that will be discussed in the remainder of this chapter.

## 1.3 Successful Strategies for Long-Term Loss of Weight and Body Fat

The basic principle of a combat sport is to compare the skill, power, and strength of two athletes who are matched for body weight. Therefore, combat athletes strive to maximize their muscle mass and reduce their body fat content to maximize their "power to weight" ratio within any given weight category. The "weight-making" strategies covered in Chapter 2 are typically designed to manipulate body weight in the short term,

**Table 1.1** Ways in which weight-making techniques confined to competition weight divisions affect overall/long-term nutrition beliefs and practices

| Issue | Problems | Solutions |
|---|---|---|
| Where a substantial weight loss is required in the lengthy lead up to a competition, the combat athlete may undertake severe energy restriction for a prolonged period (e.g., a boxer may undertake an extreme weight loss program during a 12-week preparation to fight in a weight division well below his or her current or natural weight) | Chronic and extreme energy restrictions may be associated with disruptions to hormonal, metabolic, and bone function due to energy drain<br>Restricted energy intake limits the potential for intake of protein, carbohydrate, and micronutrients, making it difficult for the combat athlete to meet overall nutrition goals | The combat athlete should only commit to competing in a weight division that is close enough to their current weight such that good nutritional practices can be followed during their lengthy preparation.<br>The combat athlete should avoid gaining excessive amounts of body fat/weight after a competition or competition season, so that substantial weight loss is required before the next competition phase |
| A lengthy competition season with repeated requirements for weight making may lead to prolonged periods of inadequate nutrition: severe restriction followed by post-competition binges on "taboo" foods such as fast food and alcohol. This may occur repeatedly within a season, or from one season/competition to the next | Prolonged periods of energy drain (as above) Increased risk of inadequate intakes of protein, carbohydrate, and micronutrients consurption as restricted energy intake is interspersed with intakes of high-energy but low-nutrient density food choices Exacerbation of problem in achieving an ideal weight/physique due to large fluctuations in weight | The combat athlete should choose an appropriate weight division that reduces the need for repeated extreme weight-making practices and extreme weight fluctuations The combat athlete should seek expert help to devise a safe and long-term weight management plan, based on nutrient-dense food choices |
| The combat athlete becomes fixated on eating practices that temporarily reduce body weight – including fad diets and eating only "light foods" (e.g., a 50 g chocolate bar rather than a thick salad sandwich) | The athlete has a distorted view of everyday nutrition goals and poor nutrition knowledge, which may spill into everyday eating as well as weight-making practices | The combat athlete should seek expert advice from a sports nutritionist/dietitian to improve their nutrition knowledge and eating practices |
| The combat athlete equates weight change, which occurs over a session of exercise due to dehydration as true weight loss. Therefore, the combat athlete restricts fluid intake during training sessions deliberately or unconsciously because they like to see a "weight loss" | The combat athlete may risk poor training performance and recovery due to dehydration | The combat athlete should be encouraged to train with good hydration practices so that they can train hard and recover optimally. Periodic monitoring of daily hydration status should be undertaken to determine if athletes are keeping pace with daily fluid losses |
| The combat athlete develops disordered eating practices or eating disorders as an outcome of their weight-making practices | Disordered eating and eating disorders are associated with poor nutrition status, health problems and poor emotional well-being | The combat athlete should seek early intervention if they develop food-related stress and disordered eating practices |

with techniques that primarily involve dehydration, and brief but severe energy restriction. This chapter will limit itself to comments on longer-term strategies that achieve substantial changes in body mass and composition. Ideally, the combat athlete should identify a safe and healthy weight/body composition target for competition and then achieve this over the long term with an eating plan that supplies appropriate intakes of energy and nutrients to meet other nutritional goals for good health and training support. In real life, these principles are complicated by the practical and cultural issues within a sport. For example, many combat athletes qualify for major events such as world championships and Olympic competitions by winning national or regional championship events. Adolescent athletes can experience major problems when these events are separated by many months unless consideration is given to their potential growth and its impact on their ability to achieve the previously qualified weight category. Furthermore, in some situations, athletes are encouraged to change weight divisions in response to an opportunity or perception that a lighter or heavier weight division is less competitive. In many cases, the identification and achievement of a desired body weight/composition for each combat athlete requires constant review.

Long-term reduction in body fat levels is a common nutritional goal for combat athletes. This goal should be achieved by an eating program that achieves a safe reduction in energy intake (e.g., reducing from current energy requirements by 500–1,000 kcal or 2–4 MJ/day) while providing adequate intakes of protein, carbohydrate, and other nutrients. Strategies that underpin such an eating program are summarized in Table 1.2 and are reviewed in more detail by O'Connor and co-authors (2006) [1]. Changes in height, body weight, and body composition should be

**Table 1.2** Eating for safe, long-term loss of body weight/fat

- "Caution with portion" – combat sport athletes attempting to reduce body weight and/or body fat long term will need to modify the total volume of food and energy-containing fluids consumed to achieve and maintain a lower body weight or reduced body fat level
- Low-fat cooking methods and alternatives in recipes should be incorporated wherever possible. This may require practical cooking sessions with athletes and their parents to demonstrate and highlight low-fat methods and alternatives
- Low-fat and reduced-fat foods and fluids should be included when suitable options are available. Menus based on reduced-fat milks or low-fat milks, reduced-fat cheese and yoghurts, lean red meats, skin removed from chicken, and use of lower-fat snack foods will assist athletes to reduce their total energy intake. Athletes should be educated that "low-fat" does not equal "no energy", so portion control still remains a priority with these foods and fluids
- Low-energy snack items such as fruit or vegetable sticks should be incorporated on lower-activity days to replace compact food and fluid options that are regularly consumed to support training and recovery on high-activity days
- Total daily "energy" or "kilojoule" intake should reflect daily energy requirements. Strategies should be provided to athletes that eat in response to emotional stress or boredom to avoid overeating
- Combat sport athletes required to travel regularly for domestic and international purposes should avoid being distracted from their nutritional plans by new food cuisines. Travel commonly involves considerable downtime and increased access to compact, less-nutritious fast foods, and convenience foods and fluids. Athletes should remain focused and avoid overeating on travel days as a result of boredom

(continued)

**Table 1.2** (continued)

| |
|---|
| • Energy-containing drinks, particularly nutrient-free beverages such as sports drinks, soft drinks, cordials and juices are a compact source of energy and should be avoided in lieu of whole foods and nutrient-rich fluids |
| • Higher-fiber cereal options and lower glycemic index carbohydrate foods may assist athletes to reduce total energy intake, by sustaining a feeling of fullness after meals and snacks |
| • Specific education should address post-competition nutrition habits for combat sport athletes. Strategies to assist athletes from binge eating on "taboo" foods and alcohol post-competition should be incorporated into nutrition education for combat sport athletes |
| • A food diary may help to identify the combat athlete's *actual* intake rather than perceived intake, and note the occasions or situations in which the athlete is unable to adhere to their agreed food and fluid intake plan |

assessed regularly by an accredited anthropometrist to help the combat athletes identify their ideal levels for various periods of a season, and to monitor the success of any program aimed at achieving change. Some individuals are naturally muscled and have low levels of body fat, or can achieve these without paying a substantial penalty or having to undertake severe, long-term food restriction. Furthermore, some combat athletes can vary their body fat levels for a competition so that very low levels are achieved only for a specific and short time. In general, however, combat athletes should not undertake extreme strategies to lose substantial amounts of weight or minimize body fat levels unless they can be sure that there are no side effects or disadvantages to this practice.

Although it is difficult to obtain reliable figures on the prevalence of eating disorders or disordered eating behaviors and body image issues among combat athletes, there is a higher risk of problems in sports in which success is associated with specific weight targets or low body fat levels [2]. Even where clinical eating disorders do not exist, many combat athletes may be "restrained eaters," restricting their energy intake over repeated or lengthy periods, and experiencing considerable stress related to their food intake [3, 4]. There is evidence that a low level of "energy availability," defined as total energy intake minus the energy cost of the athlete's exercise program, has serious consequences on the athlete's hormonal, immunological, and health status [5]. The "female athlete triad" – the coexistence of poor energy availability, menstrual dysfunction, and impaired bone health – is covered in the following section on female athletes. There is a stepwise relationship between optimal body function and energy availability, and the threshold for maintenance of normal menstrual function in females is an energy availability of above 30 kcal (125 kJ) per kg fat-free mass (FFM) (e.g., see Table 1.3) [6]. It is also likely that male athletes also suffer consequences of low energy availability that are not as yet well described, but may include reduction in hormones and function related to growth and metabolic rate [7, 8]. Expert advice from sports medicine professionals, including dietitians, psychologists, and physicians, is important in the early detection and management of problems related to body composition manipulation and nutrition. Beals provides more information on the treatment of disordered eating in athletes [9].

**Table 1.3** Example of low and adequate energy availability in combat athletes

Example of low energy availability
- 57 kg female judo player with 15% body fat = 48 kg FFM
- Daily energy intake = 1,800 kcal (7,560 kJ)
- Cost of daily exercise (1 h/day) = 500 kcal (2,100 kJ)
- Energy availability = 1,800 – 500 = 1,300 kcal (5,460 kJ)
- Energy availability = 1,300/48 or 27 kcal/kg FFM (113 kJ/kg FFM)

Example of adequate energy availability
- 70 kg male boxer with 10% body fat = 63 kg FFM
- Daily energy intake = 3,000 kcal (12,600 kJ)
- Cost of daily exercise (1 h/day) = 700 kcal (2,100 kJ)
- Energy availability = 3,000 – 700 = 2,300 kcal (9,660 kJ)
- Energy availability = 2,300/64 or 36 kcal/kg FFM (113 kJ/kg FFM)

## 1.4 Gaining Lean Muscle Mass

Since success in combat sports is linked with power, many athletes undertake periods in which they pursue specific muscle hypertrophy through a program of progressive muscle overload. This may occur during the off-season or preseason to correct the effects of weight loss over the season, or as a result of the athlete's decision to move up into a higher weight division. An important nutritional requirement for this program is adequate energy, to support the manufacture of new muscle tissue, as well as to provide fuel for the training program that supplied the stimulus for this muscle growth. Many combat athletes do not achieve a consistent positive energy balance to optimize muscle gains during a strength-training phase. Specialized nutrition advice incorporating energy-dense foods and fluids will assist athletes achieve the required energy intake to facilitate muscle gains. Despite the interest in gaining muscle size and strength, there is little rigorous scientific study on the amount of energy required, the optimal ratio of macronutrients supplying this energy, and the requirements for micronutrients to enhance this process.

Many strength-training athletes consume very large amounts of protein, in excess of 2–3 g/kg body mass/day (2–3 times the recommended intakes for protein in most countries), in the belief that this will enhance the gains from resistance training programs. However, the value of very high protein intakes in optimizing muscle gains remains unsupported scientifically [10]. Instead, the strategic *timing* of protein intake in relation to training may be an important dietary factor in enhancing gains in muscle size and strength. For example, consuming protein immediately after or even before a resistance training session substantially increases net protein balance compared with the control condition [11, 12]. Currently, there is inadequate information to provide specific details on the amount and type of protein required to achieve the optimal response in net protein balance. However, consuming a relatively modest amount of protein (a source providing ~3–6 g of essential amino acids or ~20 g of a high biological value protein) either before or after a resistance workout causes a substantial increase in net protein synthesis [12, 13]. There may also be some benefits to net protein balance by including carbohydrate with these protein "recovery" snacks [14]. These ideas are incorporated into the guidelines in Table 1.4.

## 1.5 Competition Preparation

To achieve optimal competition performance, the combat athletes and their coach should identify nutritional factors that are likely to cause fatigue during their event, and undertake strategies before, during, and after the event that minimize or delay the onset of this fatigue. For many combat athletes, activities undertaken to make weight prior to competition become the primary nutritional challenge. Additional issues to consider include the length and intensity of the event, the environment, and factors that influence opportunities to eat and drink before, during, or in recovery

**Table 1.4** Eating to support a gain in muscle mass

To increase muscle mass, the combat athlete should achieve a high-energy intake, and eat strategically in relation to training to maximize the response to each session. The following practices can help to achieve these goals

- A pattern of small frequent meals each day can be valuable in achieving an increase in energy intake and promoting recovery/adaptation to resistance training and other key training sessions.
- Incorporating a snack providing carbohydrate and protein will enhance recovery after key training sessions as well as contribute to total daily energy intake. Such a snack should also be consumed prior to resistance training sessions. Examples of foods combining these nutrients are provided in Table 1.5.
- Carbohydrate should be consumed during prolonged exercise to provide additional fuel and to contribute to total daily energy intake.
- The combat athlete is often faced with a chaotic and overcommitted lifestyle. Good skills in time management should see the athlete using quieter periods to undertake food shopping and meal preparation activities so that food is available during hectic periods.
- During periods of travel, the combat athlete should take a supply of portable and nonperishable snacks that can be easily prepared and eaten – for example, breakfast cereal and powdered milk, cereal bars, sports bars, liquid meal supplements, dried fruit/nuts and creamed rice.
- Specialized products such as sports drinks, sports gels and sports bars provide a practical form of carbohydrate during exercise, while sports bars and liquid meal supplements provide an accessible form of carbohydrate and protein for postexercise recovery.
- Energy-containing drinks such as liquid meal supplements, flavored milk, fruit smoothies, sports drinks, soft drinks and juices provide a low-bulk way to consume energy and other important nutrients while simultaneously meeting fluid needs.
- Although fiber intake is important in a healthy diet, excessive intake of high-fiber foods may limit total energy intake or lead to gastrointestinal discomfort. It may be necessary to moderate intake of wholegrain or fiber-enriched versions of foods.
- A food diary may help to identify the combat athlete's *actual* intake rather than perceived intake, and note the occasions or situations in which the athlete is unable to adhere to their plan of frequent meals and snacks.

afterwards. Depending on the combination of factors, competition performance may be limited by dehydration, depletion of glycogen stores, low blood glucose concentrations, gastrointestinal distress, and hyponatremia (low blood sodium levels caused by excessive intake of fluid).

General sports nutrition guidelines encourage athletes to consume appropriate amounts of carbohydrate and fluid in the days leading up to competition and in the pre-event meal to ensure that they are well hydrated and fuelled up for their event. Table 1.5 provides examples of types of carbohydrate-rich foods that could be consumed as snacks or meals 1–4 h prior to the event. Such guidelines are of little

**Table 1.5** Carbohydrate-rich choices suitable for special issues in sport (Taken from Burke 2007)

| | |
|---|---|
| Recovery snacks – to be eaten postexercise, or pre-exercise in the case of resistance training to promote refueling and protein responses | Portable carbohydrate-rich foods suitable for the traveling athlete |
| (Each serve provides 50 g carbohydrate and at least 10 g protein) | Breakfast cereal (and skim milk powder)<br>Cereal bars, granola bars |
| Carbohydrate-rich choices for pre-event meals | Carbohydrate-rich foods suitable for intake during exercise (50 g carbohydrate portions) |
| Breakfast cereal + low-fat milk + fresh/canned fruit | 600–800 ml sports drink |
| Muffins or crumpets + jam/honey | 2 × packets/sachets sports gel |
| Pancakes + syrup | 1–1.5 sports bars |
| Toast + baked beans (note this is a high-fiber choice) | 2 Cereal bars or muesli/granola bars |
| Creamed rice (made with low-fat milk) | |
| Rolls or sandwiches | |
| Fruit salad + low-fat fruit yogurt | |
| Spaghetti with tomato or low-fat sauce | |
| Baked potatoes with low-fat filling | |
| Fruit smoothie (low-fat milk + fruit + yogurt/ice cream) | |
| Liquid meal supplement | |
| 250–350 ml of liquid meal supplement or milk shake/fruit smoothie | Dried fruit, trail mixes |
| 500 ml flavored low-fat milk<br>Sports bar + 200 ml sports drink | Rice crackers, dry biscuits plus spreads – jam, honey, etc. |
| 60 g (1.5–2 cups) breakfast cereal with 1/2 cup milk | Quick-cook noodles and rice |
| 2 Slices bread with cheese/meat/chicken filling, and one large piece of fruit or 300 ml sports drink | Baked beans |
| 1 Cup of fruit salad with 200 g carton fruit-flavored yogurt or custard | Sports bars |
| 200 g carton fruit-flavored yogurt or 300 ml flavored milk and 30–35 g cereal bar | Liquid meal supplements – powder and ready-to-drink tetra packs |
| 2 Crumpets or English muffins with thick spread of peanut butter | |
| 250 g tin of baked beans on two slices of toast | Sports drink |
| 250 g (large) baked potato with cottage cheese or grated cheese filling | |
| 150 g thick crust pizza | |

practical value for combat sports, since the driving nutritional goal for most combat athletes in the pre-competition period will be to achieve their desired weight target. In addition to rehydrating and refueling from the last exercise sessions, the weight-making athlete will need to recover from the strategies used to manipulate their body weight (see Chapter 2). Therefore, combat athletes should find their individual way to balance weight goals with fuel and hydration needs.

Competition nutrition strategies will generally be divided into preparation leading up to the weigh-in (often involving dehydration and food restriction), strategies undertaken between the weigh-in and the bout (aggressive rehydration and refueling to recover from weight-making practices), and opportunities for nutrition during a bout and between multiple bouts (rehydration and refueling to meet ongoing competition needs as well as the deficits remaining from weight-making strategies). Suitable strategies will vary between combat sport athletes, due to the rules that govern the weigh-in and re-weigh-in procedures and the individual preferences and tolerances of each individual. The amount and timing of a pre-event meal or snack for combat sport athletes is largely dictated by the timing of the weigh-in prior to the start of competition and the requirements placed on the athlete to weigh-in for subsequent bouts if successful in the initial competition bout. Practical issues include the availability of suitable foods or drinks at an event and gastrointestinal tolerance to eating or drinking before, during, or immediately after competition. Unfortunately, many combat sport athletes have limited opportunity and reduced tolerance to drink and consume fuel during a competition bout. Sports nutrition professionals need to consider long- and short-term weight targets when advising athletes about pre- and during-competition nutrition strategies, particularly in situations where athletes are required to compete over several days.

## 1.6 Recovery Between Training Sessions or Repeated Competition Bouts

Recovery is a major challenge for the athlete who undertakes two or even three workouts each day during certain phases of the training cycle, with 4–24 h between workouts. An additional challenge faced by many combat sport athletes is competing several times with short recovery within a single competition schedule. Recovery eating after the weigh-in may play a critical role in competition performance if the combat athlete has had to restrict intake of fluid and food to make weight. Recovery involves a complex range of processes of restoration and adaptation to the physiological stress of exercise, including:

- Restoration of muscle and liver glycogen stores
- Replacement of fluid and electrolytes lost in sweat
- Synthesis of new protein following the catabolic state and damage induced by the exercise
- Responses of the immune system

According to sports nutrition guidelines, an athlete's carbohydrate intake should meet the fuel requirements of training and competition and the restoration of muscle glycogen content between training sessions [15]. In endurance training sports, at least, chronic depletion of muscle glycogen stores due to the failure to consume adequate carbohydrate causes a perception of fatigue and an impaired ability to train [16]. These studies have not been undertaken in combat sports. However, several studies of the post-weigh-in diet have demonstrated the importance of restoring carbohydrate status for competition performance in other sports involving weight making [17, 18]. The guidelines for carbohydrate intake are no longer given as a "one size fits all" or as a percentage of total energy intake (e.g., 60% of total energy intake). Rather, amounts of carbohydrate are scaled to the athlete's body size and to their training program – for example, 5–7 g/kg BM/day for an athlete with moderate daily fuel requirements and 7–10 g/kg BM/day for an athlete wanting to maximize daily glycogen storage [15]. These guidelines are, of course, to be treated as a starting point, and the combat athlete should experiment with their own intake of carbohydrate to determine what is needed for optimal training and competition performance.

In the case of a combat athlete who must restrict their energy intake to achieve a (sensible) target of weight loss or maintenance, there may be a need to "periodize" carbohydrate intake goals. For example, on days or periods of lighter training it may be possible for the athlete to consume less than their theoretical carbohydrate needs to prioritize their goal of energy restriction. However, on days when high-intensity training is undertaken, strategic intake of carbohydrate before, during, and after workouts should be undertaken to support training performance and to reduce the immunosuppression that accompanies prolonged training [19]. Finally, during competition, where optimal performance is desired but definite weigh-in targets must be met, the combat athlete may need to move between restriction prior to a weigh-in, and aggressive refueling between the weigh-in and the competition bout. The expertise of a sports dietitian is valuable in assisting the combat athlete to develop a plan for carbohydrate intake in light of competing nutrition challenges.

Although the major dietary factor involved in postexercise refueling is the amount of carbohydrate consumed [15], the type and timing of carbohydrate intake may have some effect on the rate of glycogen restoration. This information may be useful in maximizing post-training refueling in an energy-restricted (and carbohydrate-restricted) diet, or in the recovery period after a weigh-in. Carbohydrate-containing foods and drinks with a moderate and high glycemic index (GI) appear to promote greater glycogen storage than meals based on low GI carbohydrate foods [20]. The form of the carbohydrate – fluids or solids – does not appear to affect glycogen synthesis, but carbohydrate-containing drinks may provide a practical way to refuel without causing gastrointestinal discomfort. This may be useful for combat athletes who have poor appetites immediately after high-intensity training sessions, or to allow refueling in the short time period between a weigh-in and competition.

Early research indicated that glycogen synthesis was enhanced by adding protein to the carbohydrate eaten after exercise, due to an enhanced stimulation of the insulin response [21]. However, these findings have been refuted in other studies, especially when the energy content of protein or amino acids included in recovery feedings was matched (for review, see [15]). Nevertheless, the combination of protein and carbohydrate in recovery meals or snacks may allow the combat athlete to meet other nutritional goals, including the enhancement of net protein balance after exercise. This may be important for the optimization of the goals of a hypertrophy-based training program (see above), but may also be useful for recovery from a strenuous session of training or competition leading to muscle damage and soreness [22]. Examples of food combinations that provide a combination of protein and carbohydrate for a postexercise recovery snack are shown in Table 1.4

Athletes have been advised to enhance recovery by consuming carbohydrate as soon as possible after the completion of a workout or competition bout. The highest rates of muscle glycogen storage occur during the first hour after exercise, and the immediate intake of carbohydrate takes advantage of this effect [23]. Conversely, the failure to consume carbohydrate during postexercise recovery leads to very low rates of glycogen restoration until feeding occurs. Although early refueling may be important when there are only 4–8 h between exercise sessions [23], it may have less impact over a longer recovery period [24]. Therefore, when the interval between workouts or competition bouts is short or total energy intake is restricted, the combat athlete should maximize the effective recovery time by beginning carbohydrate intake as soon as possible. To achieve this, the athlete will need to have suitable snacks and drinks on hand at the training or competition venue. Alternatively, the daily timetable might be structured to allow combat athletes to eat a meal straight after an exercise session. In situations of a long recovery period, combat athletes can choose their preferred meal schedule as long as total carbohydrate intake goals are achieved. In either scenario, when total energy intake is restricted, the athlete should choose carbohydrate-rich foods that provide a valuable source of other nutrients.

During training periods, most combat athletes can expect to be at least mildly dehydrated at the end of workout, and should aim to restore fluid losses before the next workout or competition bout. Anecdotally, many combat athletes do not hydrate well during and after training sessions – this may be a legacy of their reliance on dehydration to manipulate body weight for competition. It is possible that these athletes have never developed good drinking behaviors during training sessions, or that they are subconsciously happy to see “weight loss” occurring over the session, even when they do not need to make weight. In some combat sports there are practical limits on fluids consumption during competition bouts and sparing sessions because of the discomfort of having fluid in the gut during high-intensity exercise or gut contact. In competition, however, the major challenges of dehydration are likely to be seen as a result of weight-making activities prior to competition.

It is unlikely that a combat athlete will find it easy to rehydrate where moderate to high levels of hypohydration have been incurred (e.g., a fluid deficit equivalent to 2–5% body mass or greater) and the interval for rehydration is less than 6–8 h. Voluntary intake is enhanced when fluids are flavored and kept at a cool temperature [25], and when sodium is consumed to preserve thirst [26]. Therefore, in situations where rapid rehydration of fluid deficits >2% BM is required, for example, after making weight, combat athletes are advised to follow a plan of fluid intake rather than relying on thirst.

A planned volume of intake is an important part of a hydration plan. Since sweating and obligatory urine losses may continue, the athlete must replace more than their postexercise or post-weigh-in fluid deficit before finally achieving fluid balance. Typically, a volume of fluid equivalent to ~125–150% of the fluid deficit must be consumed over the 4–6 h of recovery/rehydration to compensate for these ongoing losses [27]. This may not be possible or practical when the time between weigh-in and competition is less than 2 h. In addition, fluid replacement alone will not guarantee that rehydration goals are achieved. Unless there is simultaneous replacement of the electrolytes lost in sweat, particularly sodium, consumption of large amounts of fluid will simply result in large urine losses. The consumption of sodium in rehydration fluids or meals consumed during the rehydration period has been shown to reduce urine losses and enhance net fluid balance at the end of 6 h of recovery [27]. In contrast, with little or no sodium replacement, subjects may still be substantially dehydrated at the end of a recovery period, despite drinking more than the volume of their fluid deficit. On a practical note, the acute replacement of large amounts of fluid in the absence of sodium may provide false information to the combat athlete, since they will observe the production of "copious amounts of clear urine" despite being in fluid deficit. Recovery may also be interrupted if such urine production occurs during the night, leading to interrupted sleep.

The optimal sodium level in a rehydration drink appears to be ~50–80 mmol/l [28], as is provided in oral rehydration solutions manufactured for the treatment of diarrhea. This is considerably higher than the concentrations found in most commercial carbohydrate–electrolyte drinks or "sports drinks" (typically 10–25 mmol/l), although some specialized sports drinks with higher sodium levels are now available (25–40 mmol/l). Alternatively, sodium may be ingested during postexercise recovery via everyday foods containing sodium (e.g., bread, breakfast cereal, cheese) or by adding salt to meals. Including sodium-containing foods is often more appealing, substantially cheaper, and allows athletes to simultaneously meet other nutrition goals related to recovery.

Since caffeine and alcohol increase urine production, consumption of alcoholic and caffeine-containing drinks during postexercise recovery may result in greater fluid losses compared to other fluids [29, 30]. Athletes are often advised that caffeine-containing beverages such as tea, coffee, and cola/"energy" drinks are not suitable rehydration fluids, and should be avoided in situations where there is a risk of developing dehydration, such as during and after exercise or during air travel. However, according to a recent review of caffeine and hydration status, there is little evidence that caffeine intake impairs fluid status [31]. Instead, it appears that the effect of caffeine on diuresis is overstated, and may be minimal in people who are habitual caffeine users. Importantly, the voluntary intake of fluids that are well liked and cemented into normal eating behaviors may more than compensate for small increases in fluid loss. Of course, the intake of large amounts of alcoholic beverages after exercise will interfere with recovery, particularly by distracting the athlete from undertaking their recommended dietary practices and by promoting high-risk behavior [32].

## 1.7 Meeting Needs for All Nutrients

All athletes want to be able to train hard and compete without the interruptions of illness and injury. Maintaining optimal health and performance requires the intake of a large number of nutrients and food chemicals. In general, when athletes consume an adequate energy intake and a wide variety of nutrient-dense foods, they are likely to meet their requirements for all these compounds. However, not all combat athletes consume adequate energy or a varied diet. Challenges include energy restriction for weight loss in general, fad weight loss diets, fussy eating, poor nutrition knowledge and awareness, and limited access to a variety of foods while traveling. The expertise of a sports dietitian/nutritionist may be valuable in assessing inadequate intakes of nutrients and educating the athlete to improve the quality and quantity of their food intake. At times, a vitamin–mineral supplement may be needed when it is not possible to achieve these changes – for example, during prolonged travel or a lengthy period of restricted energy intake to achieve weight loss and body composition goals.

The most common micronutrient deficiency among athletes, just as it is in the general population, is iron deficiency. Regular strenuous exercise causes the alteration of various measures of iron status, due to changes in plasma volume or the acute phase response to stress. Therefore, conventional hematological standards are often inappropriate for diagnosing the true prevalence of problematic iron deficiency in athletic groups. Inadequate iron status can reduce exercise performance via suboptimal levels of hemoglobin, and perhaps also via changes in the muscle including reduced myoglobin and iron-related enzymes (for review, see [33]). However, it is often difficult to detect the stage of iron deficiency at which impairments to exercise performance are observed. Despite initial conflict in the literature, it now appears that iron depletion in the absence of anemia – i.e. reduced serum ferritin concentrations – may impair exercise performance [33]. In addition, athletes with reduced iron stores complain of feeling fatigued and failing to recover between a series of competition or training sessions. Combat sport athletes who restrict energy intake over long periods to meet weight goals should be considered at high risk for an inadequate intake of iron. It makes sense to monitor these athletes for iron depletion and to intervene as soon as iron status appears to decline substantially or to symptomatic levels.

The evaluation and management of iron status in athletes should be undertaken by a sports physician. It is tempting for fatigued athletes to self-diagnose iron deficiency and to self-medicate with iron supplements which are available over-the-counter. However, there are dangers in self-prescription or long-term supplementation in the absence of medical follow-up. Iron supplementation is not a replacement for medical and dietary assessments and therapies, since it typically fails to correct the underlying problems, which have caused iron drain – factors causing iron requirements and losses to exceed iron intake. Chronic supplementation with high doses of iron carries a risk of iron overload, especially in males for whom the genetic traits for hemochromatosis are more prevalent.

Although iron supplementation may play a role in the prevention and treatment of iron deficiency, the management plan should be based on long-term interventions to reverse iron drain – reducing excessive iron losses and increasing dietary iron. Dietary interventions should not only increase total iron intake, but also its bioavailability. The heme form of iron found in meat, fish, and poultry is better absorbed than the organic or nonheme iron found in plant foods such as fortified and wholegrain cereal foods, legumes, and green leafy vegetables (for review, see [33]). However, iron bioavailability can be manipulated by matching iron-rich foods with dietary factors promoting iron absorption (e.g., vitamin C and other food acids, "meat factor" found in animal flesh) and reducing the interaction with inhibitory factors for iron absorption (e.g., phytates in fiber-rich cereals, tannins in tea). Changes to iron intake should be achieved with eating patterns compatible with the other nutrition goals of combat athletes. Such education is often a specialized task, requiring the expertise of a sports dietitian.

## 1.8 Supplements and Sports Foods

Elite athletes are constantly searching for products or interventions which might improve performance by even a small margin. Even recreational athletes fall under the spell of the multitude of supplements that promise to enhance speed, increase endurance, improve recovery, reduce body fat levels, increase muscle mass, or whatever it takes to make them a better athlete. Although supplements and sports foods carry many claims that they can enhance an athlete's performance, in reality only a small proportion of the available products are supported by credible scientific support (for review, see [34]). These include sports foods such as sports drinks, sports gels, liquid meal supplements, and sports bars, which may be used by the combat athlete as a practical alternative to everyday foods to help them meet their unique nutritional goals for training or competition. Other supplements that enjoy considerable scientific support for a potential role in enhancing performance include caffeine, creatine, and bicarbonate/citrate as a buffering agent. Few studies have been undertaken on the specific use of these and other proposed ergogenic aids in combat athletes. It is beyond the scope of this chapter to comprehensively review the literature on these and other supplements. However, information including validated protocols of use, a review of studies investigating performance enhancement, and concerns associated with their use can be found in the review of Burke et al. (2006) [34], and among the resources underpinning the AIS Sports Supplement Program found at www.ausport.gov.au/ais/nutrition.

In terms of specific use by combat athletes, there is some evidence that creatine supplementation is of benefit to wrestlers [35], particularly in the recovery from acute weight loss [36]. This fits well with the theory that creatine supplementation can aid the performance of repeated high-intensity sprints or exercise bouts with short recovery intervals. Bicarbonate supplementation may be of benefit to the performance of events that are reliant on anaerobic glycolysis, with the simplified explanation that increased blood alkalinity can buffer the excessive buildup of $H^+$ ions in the muscle. A recent study has provided evidence of benefits of this strategy to the performance of a protocol simulating judo activities [37]. Further sports-specific research is required to study the benefits of supplements on training and competition goals in combat sports.

It is important that combat athletes are aware that the appropriate use of a supplement as much as the supplement itself may lead to a beneficial outcome. Therefore, education about specific situations and strategies for the use of supplements and sports foods is just as important as the formulation of the supplement. Any decision to use supplements or sports foods should consider the evidence for real or even placebo-driven benefits versus the risk of side effects or a positive doping outcome. Supplement use, even when it provides a true performance advantage, is an expense that athletes must acknowledge and prioritize appropriately within their total budget.

A number of ingredients that may be found in supplements are prohibited by the codes of the World Anti-Doping Agency (WADA), the National Collegiate Athletic Association (NCAA), and other sporting bodies. These include pro-hormones (steroid-related compounds such as androstenedione, DHEA, 19-norandrostenedione) and stimulants such as ephedrine or related substances. In some countries, including the USA, these substances are available in supplements and over-the-counter "medical" preparations. Drug education programs highlight the need for athletes to read the labels of supplements and sports foods carefully to ensure that they do not contain such banned substances.

However, inadvertent intake of banned substances from supplement products can still occur even when athletes take such precautions. This is because some supplements contain banned products, not identified on the label, as a result of cross-contamination or poor labeling processes. The pro-hormone substances seem to provide the greatest risk of inadvertent consumption via supplement use, with a positive test for the steroid nandrolone being one of the possible outcomes. Disturbing evidence of these problems was uncovered by a study carried out by a laboratory accredited by the International Olympic Committee [38]. This study analyzed 634 supplements from 215 suppliers in 13 countries, with products being sourced from retail outlets, the Internet, and telephone sales. None of these supplements declared pro-hormones as ingredients, and came both from manufacturers who produced other supplements containing pro-hormones as well as companies who did not sell these products. Ninety-four of the supplements (15% of the sample) were found to contain hormones or pro-hormones that were not stated on the product label. A further 10% of samples provided technical difficulties in analysis such that the absence of hormones could not be guaranteed.

This is a major area of concern for amateur and professional athletes who compete in competitions that apply anti-doping codes, since many of these codes place liability with the athlete for ingestion of banned substances, regardless of the circumstances and the source of ingestion. As such, full penalties can be expected for a positive doping test arising from the ingestion of a banned substance that is a contaminant or undeclared ingredient of a supplement [39]. Combat athletes should make enquiries at the anti-doping agencies within their countries for advice on the specific risks identified with supplement use, and any initiatives to reduce this risk.

## 1.9 Special Issues for Females

Since exercise provides a major stimulus for the formation of bone and good bone health, it seems counterintuitive that many female athletes are reported to suffer from compromised bone health – ranging from frank osteopenia to a failure to achieve optimal levels of peak bone density. Poor bone health can reduce an athlete's potential by increasing the risk of injury, including stress fractures. Long-term problems include an increased risk of osteoporosis. Initially, an awareness of poor bone health was raised via the coining of the "female athlete triad" syndrome [40]. This cluster involved disordered eating, amenorrhea, and osteopenia, and the focus was directed on the prevalence of menstrual disturbances in females with the recognition that disruptions to reproductive hormones have a negative effect on bone formation and remodeling. Much debate centered on the cause of the menstrual dysfunction with theories focusing on low body fat levels or high training volumes. We now know that the common thread to impairment of menstrual status and other hormonal systems is low energy availability [5].

The female athlete triad has now been updated [41] to target energy availability, menstrual health, and bone density. The new message is that each of these issues involves a continuum between optimal health and frank disorder and that the athlete should be alert to any change in her status of any issue. There is little information on the prevalence and severity of low energy availability and related problems among female athletes in combat sports. Such information would be useful to assist in programs to prevent or manage such problems at an early stage. Athletes need to be educated that negative outcomes occur at a much earlier stage than previously considered. Recent research has shown that low energy availability directly impairs bone formation and resorption [42]. Some studies have found evidence of reduced bone status in weight-making athletes [43], although another has found that the biomechanical characteristics (weight-bearing contact) of at least some combat sports may counteract the effects of reduced energy availability [44].

The detection, prevention, and management of the female athlete triad, or individual elements within it, require expertise and, ideally, the teamwork of sports physicians, dietitians, psychologists, coaches, and fitness advisors [45]. Dietary intervention is important to correct factors that underpin menstrual dysfunction as well as those that contribute to suboptimal bone density. Prevention or early intervention is clearly the preferred option, since it is not always certain that damage to bone strength can be overturned, particularly when it is long-term. Dietary goals include adequate energy intake and adequate intake of calcium, with daily requirements increased to 1,200–1,500 mg/day in athletes with impaired menstrual function. Where adequate calcium intake cannot be met through dietary means, usually through use of low-fat dairy foods or calcium-enriched soy alternatives, a calcium supplement may be considered [46].

## 1.10 Traveling to a Special Training Camp or Competition

Participation in elite competition in combat sports will expose the athlete to frequent travel, either to specialized training camps or to domestic and/or international competition. Athletes must be able to achieve their peak performance at important competitions such as Olympic Games and world championships in an environment that is often both far away and different to their home-base. Frequent travel can pose a number of challenges, including the break in routine and training while in transit, the sudden change in climate and environment, and the loss of availability of important foods in a new food culture.

The combat athlete can tackle the challenges of travel by preparing well ahead of time and by ensuring travel plans and arrangements have been made to accommodate the added stresses associated of making weight soon after arrival, as is the case when traveling for competition. Issues that should be considered when traveling include the travel itself, the general food supply at the destination site, the quality and safety of food and fluids, and access to staple foods and sports foods regularly used at home. A supply of staple foods and regularly used sports foods and fluids should be taken by athletes or organized by team officials to assist athletes in meeting daily nutritional requirements, particularly in situations where food quality is likely to be inappropriate. Examples of portable food supplies are also included in Table 1.5. Combat athletes traveling as a team maybe fortunate to have the assistance of a sports dietitian to investigate local food culture and food availability at the destination point.

## 1.11 Summary

The combat sport athlete is faced with a unique set of nutritional challenges which routinely requires expert advice from a sports dietitian or sports nutritional professional with an in-depth understanding of the nutritional requirements of the sport. Although combat sport athletes are required to make weight to compete, nutrition intervention should incorporate strategies to support daily training performance, recovery between training and competition bouts, and maintenance of health. The implications for athletes competing in a weight category sport influence dietary habits beyond those exclusively surrounding competition. Specific attention should address daily nutrient requirements for iron and calcium; and consider issues contributing to the development of eating disorders and restrained eating among this group.

Despite not having to "make weight" during regular training, combat sport athletes' preoccupation with qualifying weight for competition may interfere with daily fluid intake habits. Specific attention should be placed on the importance of maintaining daily hydration status by developing a fluid intake plan to match daily fluid losses during periods of intense training. Creatine supplementation and bicarbonate loading may enhance recovery and performance in combat sport athletes. However, a sports dietitian should be consulted to ensure efficacy of use and issues relating to supplement contamination and safety should be considered. Hectic training and competition schedules involving domestic and international travel add an extra level of complexity for combat sport athletes and pose a unique set of nutritional challenges.

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# Chapter 2
# Making Weight in Combat Sports

**Craig A. Horswill**

## Learning Objectives

- To describe the rationale for weight loss in athletes in combat sports
- To identify undesirable (unregulated) methods of reducing weight by weigh-class athletes
- To recommend appropriate methods (regulated) for making weight
- To describe the adverse effects of making weight on performance, acute physiology, and chronic nutritional status

## 2.1 Introduction

Unlike most other sports, combat sports match competitors based on size. The purpose of matching, which relies on body mass, is to create equity between opponents and reduce injury risk because of discrepancies in physical strength and mass. Utilizing weight classes also allows a broad range of specific-sized individuals to participate (Tables 22.1 and 2.2). This is seldom the case with team sports and non-combat individual sports in which athletes of greater mass are drawn to the sport. By pairing opponents by mass, skills, strategy, relative strength, and conditioning are emphasized as factors that produce success in these combat sports.

A difference in body mass would provide an advantage in one-on-one combat. Anyone who watches a wrestling team train has observed the outstanding light weight struggle to keep up with an average-caliber middle weight training partner. Combat sports use scoring systems that favor power – a competitive wrestling bout can end with a fall or technical fall; likewise a bout in boxing ends when a knockout or technical knockout occurs. The "work" required to win an event can be accomplished in less than the regulation time established for the event. Therefore, many participants

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**Table 2.1** Current international weight classes for males in kilograms

| Boxing | Judo | Wrestling |
|---|---|---|
| 46 | | |
| 48 | | |
| 50 | | |
| 52 | | |
| 54 | | 55 |
| 57 | | |
| 60 | 60 | 60 |
| 63 | | |
| 66 | 66 | 66 |
| 70 | | |
| 75 | 73 | 74 |
| 80 | 81 | 84 |
| 86 | | |
| 86+ | 90 | 96 |
| | 100 | |
| | +100 | 120 |

To make the weight class and be eligible to compete, an athlete must weigh exactly the weight or less at the time of the official weigh-in

**Table 2.2** Current international weight classes for females in kilograms

| Boxing | Judo | Wrestling |
|---|---|---|
| | 48 | 48 |
| | 52 | 51 |
| | 57 | 55 |
| | | 59 |
| | 63 | 63 |
| | | 67 |
| | 70 | 72 |
| | 78 | |
| | +78 | |

To make the weight class and be eligible to compete, an athlete must weigh exactly the weight or less at the time of the official weigh-in

chose to reduce their body mass to a weight class lower than their normal weight to thereby incur advantages in leverage, power, and strength over the opponent and presumably increase their chances of success.

This chapter addresses the protocol for the weigh-in that qualifies competitors for equal mass, the prevalence of weight loss, the methods used by the athletes to reduce weight, and the outcome of making weight on the physiology, health, and performance of the weight-class athlete. It also focuses on amateur levels of combat sports and excludes professional levels (e.g., boxing, Sumo).

## 2.2 Protocol for Weigh-In

For all combat sports that have weight classes, competitors are weighed by an official at a specified time prior to competition. This "weigh-in" is conducted to ensure that the competitors truly are at the weight class. Besides being checked for weight, competitors may also be evaluated for contagious skin infections, finger nail length, and other requirements (length of hair and beard stubble). The protocol for weigh-in will vary between sports and different levels within a sport.

### *2.2.1 Wrestling*

*Youth division*. At the youth level, weigh-ins occur approximately 2 h prior to competition. In most cases, the majority of youth wrestling does not use official weight classes. Instead, they are bracketed in groups of four or eight to make a weight class. For official tournaments (state, regional, and national competitions), preset weight classes are used and weigh-ins occur the day prior to the competition. This is also true for adolescent wrestlers who compete in open styles – Olympic styles. A tournament that lasts more than 1 day may require only one weigh-in to be held.

*US Interscholastic and intercollegiate competition.* At the interscholastic and intercollegiate levels, weigh-ins are held close to the time that competition begins. In part this is done to help discourage rapid weight loss by allowing relatively little time to rehydrate and recover. Interscholastic competition provides a minimum of 30 min and a maximum of 60 min between weigh-in and the first match. Tournaments may allow 2–3 h. Intercollegiate competition provides 2 h between weigh-in and competition regardless of whether it is a dual meet or a tournament. For multiple-day tournaments, wrestlers are required to weigh-in everyday of the tournament and receive a 1-lb (0.45 kg) weight allowance on each successive day.

*International open or senior division*. Similar to the preset tournaments for youth wrestling, weigh-ins for international competitions or wrestlers vying for national teams occur the day prior to the competition. A tournament that lasts more than 1 day may require only one weigh-in to be held.

### *2.2.2 Boxing*

*International seniors*. According to the 2006 US Boxing Rules (Rule book, http://www.usaboxing.org/), boxers must weigh-in everyday of a tournament. For US Boxing Nationals the weigh-in is held between the hours of 7 and 9 a.m. The duration between the close of weigh-in and beginning of competition is determined on a per tournament basis. Boxers have two attempts to make weight and must be within 2 lb (~1.0 kg) of the weight class at the first attempt.

### *2.2.3 Martial Arts: Judo*

Weigh-ins for senior-level judo are held in the morning on the day of competition. For youth competition, weigh-ins are held the day prior to competition. Usually, there is a 2-h period before competition starts; hence, judoists would have at least 2 h to recover prior to combat. Unlike boxers, judoists are allowed only one chance to weigh-in. In a tournament situation a division is completed within the day, so there is only one weigh-in for the tournament.

## 2.3 Prevalence of Weight Loss in Combat Sports

Relatively little data exist on the prevalence of weight reduction in athletes in combat sports. The information is limited primarily to the wrestling community, and even in that group, the studies are not definitive. While a generalization, it is likely that at some point during an athletic career, every participant in a weight-class sport practices a degree of self-restraint, if not outright deprivation to assure making the weight class. The exception might be the unlimited class (heavyweight); however, in the last 20 years or so even the heaviest weight class has had an upper limit. Personal correspondence with US Judo indicates that 70–80% of participants reduce weight for their weight class regardless of gender. There is no information on the prevalence of weight loss in women wrestlers.

### *2.3.1 Intercollegiate*

Prior to implementing programs that regulate weight loss in wrestlers (explained in Section 2.4.1), Steen and Brownell [1] reported in 1990 that approximately 87% of US collegiate wrestlers ($n$ = 63) lost at least 2.7 kg on a weekly basis. These wrestlers lost weight 15 times on average during the 4.5-month season. The average amount of weight reduction estimated from their distribution was around 5 kg. Slightly more than a decade later and after the National Collegiate Athletic Association (NCAA) imposed a regulation program, Oppliger, Steen, and Scott [2] reported that in 741 college wrestlers the average weekly weight loss was 2.9 kg. The lesser amount more recently suggests that regulation of weight-class selection has had influence on the extent of weight loss among the athletes. Interestingly, Oppliger et al. report that the frequency of weight reduction is about half that reported by Steen and Brownell. This is more likely to be a change in scheduling of competition (fewer weigh-ins, more events with multiple matches in a day) than an effect of minimal weight program considering the average weekly weight loss remains at a fairly significant mass, i.e., 2.9 kg.

### *2.3.2 Interscholastic*

In adolescents who competed in US interscholastic wrestling during the late 1980s, 70% of adolescent wrestlers ($n$ = 368) lost up to 2.3 kg, an average of nine times during their 3.5-month season [1]. Following the implementation of regulating weight-class selection in the high school program for one state, survey data suggested regulation-improved practices such as reducing the most weight lost on a weekly basis, the frequency of weight loss, and longest time of fasting [3]. While the changes were statistically significant, the mean values were only slightly different for the variables tested.

In those opportunities where weight-class selection is not regulated, adolescents appear to lose greater amounts of weight. On average, adolescents competing at the US junior freestyle and Greco-Roman national championships regained 3.4 kg during the time between the weigh-in and competition (~20 h). The amount of weight regained is indicative of recent weight loss through fasting and dehydration. Because of the challenge that complete rehydration in a limited time presents [4], 3.4 kg is likely an underestimate of the weight that was initially lost [5].

## 2.4 Methods of Weight-Class Selection and Weight Reduction

### *2.4.1 Regulated and Recommended*

Relatively recently in the USA, the sport-governing bodies of wrestling at the intercollegiate and interscholastic levels have implemented programs to regulate the process used for selecting a weight class and reducing body weight [6, 7]. These programs generally work in the following way: in the preseason or early season, athletes are tested for hydration level using urine specific gravity (USG). If the urine specific gravity is 1.020 or less (collegiate and some scholastic programs), or less than 1.025 (other scholastic programs), the athlete is deemed euhydrated and proceeds to a body fat test. Using body fatness as the index, minimal weight is calculated at which the college male wrestler has 5% fat, the scholastic male wrestler has 7% fat, or the female wrestler has 12% fat. These levels of body fat are accepted as the leanest composition that sustains good health and performance [8–10]. The weight class at or just above the minimal weight is assigned as the lowest weight at which the athlete may compete. If the wrestler fails the hydration test, he or she must return on another date, retake, and pass the hydration standard before being evaluated for body fatness and a minimal weight class. When estimated to be in a compromised hydration state, the wrestler is temporarily disqualified from competing.

After the wrestler has been evaluated for minimal weight, the difference between the present body weight and the minimal weight establishes how much weight may be lost safely by the athlete. The governing bodies recommended that no more than 1.5% of body weight or about 0.45–1 kg of weight can be lost per week to eventually achieve the minimal weight class. Using this guideline, the program projects at what point during the season the athlete can compete at the lowest weight class. Athletes may compete at higher weight classes as they reduce their mass to the target weight class.

To accomplish the weight reduction in the regulated system, the sport-governing bodies provide education materials on nutrition, diet, and exercise conditioning. The general approach encourages reducing caloric intake and increasing energy expenditure through aerobic exercise to create a daily energy deficit of 500–1,000 kcal. The goal is to reduce body fat, to maintain lean body mass, and not to dehydrate. Recommendations for calorie intake and food groups to obtain adequate intake of macronutrients and micronutrients are also offered by the sport-governing bodies or other agencies identified by them. For example, the National Wrestling Coaches Association offers for minimal cost a diet program at its web site (http://www.nwcaonline.com/).

This is presumably the optimal approach for safe, relatively healthy weight reduction. Yet it is idealistic to conclude that because these programs exist, all athletes abide by them. Athletes still use dehydration and other methods, which are described in Section 2.4.2. For example, anyone who has observed an interscholastic wrestling season beyond the completion of the State Finals and into the postseason competition of the international styles is well aware of competitors who jump four or more weight classes (e.g., 11 kg) in a period of only 4 weeks. This is well beyond expected growth rates for adolescents and suggests that a degree of dehydration and food deprivation is being used during the interscholastic season.

The extent of regulation in boxing, per US rules, is that boxers who attain the privilege of representing the USA on an international team must weight no more the 5 lb in excess of their competitive weight class.

### *2.4.2 Unregulated*

Youth wrestling, Olympic wrestling styles for adolescents [11], and open levels of wrestling (including FILA-sponsored events such as World Cup, World Games, and Olympics) and other sports such as boxing and judo do not currently regulate weight classes the way interscholastic and intercollegiate wrestling in the USA does. A recent case report indicates that even at the age of 5 years, young wrestlers may practice making weight [12].

For a number of reasons, weight-class athletes seldom use strategies that focus on slow, long-term weight reduction as outlined in Section 2.4.1. One reason is that most athletes in combat sports are already relatively lean and lack substantial body fat stores for weight reduction. Consider, also, that an energy deficit of 9,000 kcal is required to oxidize 1 kg of fat and thereby reduce body weight by 1 kg. This will take approximately 1 week to accomplish using a proper diet and physical training program; a relatively slow process that requires sustained discipline. In contrast, an athlete need exercise only for an hour to generate 580 kcal of heat that requires at least 1 l of sweat (~1 kg of weight) be evaporated to maintain body temperature [13]. Disregarding other outcomes and effects of the fluid loss, the athlete is likely to opt for the latter approach, i.e., use some form of dehydration.

The approaches used to dehydrate include active (exercise-induced sweating) and passive water loss (sitting in a sauna) [1, 2, 11]. Fasting and food restriction are practiced to avoid adding mass to the intestinal tract particularly within the last 24 h before the official weigh-in [2]. This can also have the effect of helping deplete body glycogen stores and further reduce body weight when water is released as the remaining stored glycogen is oxidized during exercise. Less common methods include catharsis through diuretics or laxatives [1, 2, 11, 14]. In a rare report, athletes were described to have blood withdrawn to induce hypovolemic hypohydration to help make weight. The blood is reinfused after the weigh-in [15].

A case study from our lab shows the efforts of two adolescent wrestlers of similar initial weight and body composition. Data are presented in Table 2.3 and Fig. 2.1. These athletes relied on physical training and food restriction to reduce body weight. One wrestler reduced his weight by approximately 6.7% of body weight during the course of 5 days. The other wrestler reduced his weight by only 2.5%. The fluid turnover rate as measured using deuterium oxide is remarkably low in the weight-reducing athlete during dramatic weight loss. There is a simultaneous increase in urine specific gravity reflecting progressive dehydration. In both wrestlers, body fat stores, estimated using skinfold thickness, changed minimally (from 7% to 6.9% in the weight loss wrestler and from 9.2% to 8.3% in the weight maintenance wrestler); hence, primarily fluid loss and possibly some loss of lean body mass allow the athlete to achieve the weight class. Even the wrestler maintaining weight relied on dehydration to make weight based on the rapid loss in between day 4 and 5, based on the increased USG and minimal loss of body fat.

**Table 2.3** Case study of making weight in adolescent male wrestlers

| | Weight-losing wrestler (WL) | Weight-maintaining wrestler (WM) |
|---|---|---|
| Age (years) | 16.5 | 17.5 |
| Initial mass (kg) | 54.4 | 55.5 |
| % fat[a] | 7 | 9.2 |
| Initial TBW (L)[b] | 36.8 | 37.0 |
| Weight class (kg) | 50.9 | 54.1 |
| % mass reduction | 6–7 | 2.5 |
| Fluid turnover (L/day)[c] | 0.9 | 2.25 |

[a]Calculated using an equation [85] for skinfold thickness that has been validated for adolescent wrestlers [86]
[b]Measured using deuterium oxide dilution [87]
[c]Calculated using the two-point method described by Wolfe [87]

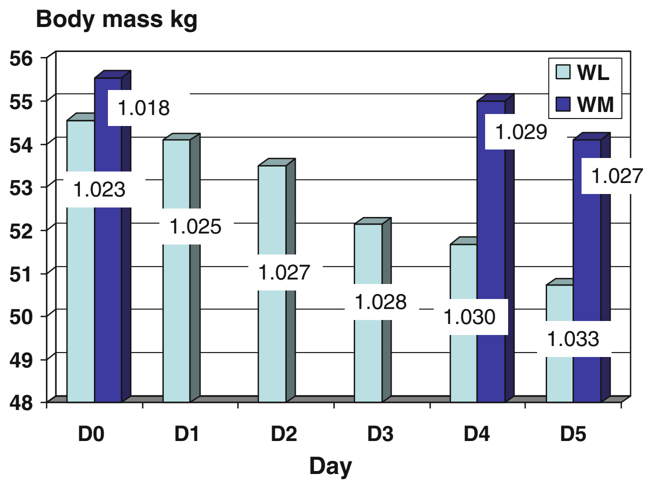


**Fig. 2.1** Body mass (bars) and urine specific gravity (USG) (overlaid numbers) during "weight-losing" (WL) and "weight-maintaining" (WM) in two adolescent wrestlers

## 2.5 Effects of Weight Reduction on the Athlete

### *2.5.1 Physiology*

Weight-class athletes experience a reduction in hydration status, i.e., hypohydration, and energy stores, primarily glycogen, when food and fluid are restricted to achieve rapid weight reduction. Exercise added to diet restrictions further accelerates the reductions in endogenous substrate through oxidation and total body water through sweating.

Houston et al. [16] have shown that with 8% reduction in body weight during a 4-day period, muscle ATP and creatine phosphate concentrations were not affected while muscle glycogen content of the vastus lateralis decreased by 46%. A 3-h recovery of feeding and hydration increased these levels by only 14%. Tarnopolsky et al. [17] confirmed this in the upper body muscles showing muscle glycogen concentration of the bicep brachii decreased by 54% at the end of a 3-day period during which the wrestlers reduced weight by slightly more than 5%.

Dehydration initially impacts the plasma osmolality and volume based on research [18–20]. Given a period of time for equilibration between the end of exercise and sweating and the measurement of plasma volume (PV), the PV attempts to restore itself suggesting that blood indices of hydration status may be inaccurate when athletes are allowed a period of time to reach homeostasis after dehydration [18, 21, 22] and urine may be a more accurate index of hydration status [21]. The hypertonicity of the blood of a dehydrated individual may offer a protective mechanism to draw fluid into this vascular space to enhance restoration for cardiovascular function, particularly when there is a delay or avoidance in drinking. However, upon resuming physical activity in a dehydrated state such as training to further reduce body weight, the compromised state of the athlete impairs cardiovascular function [23–28] and thermoregulation [24, 29, 30].

### 2.5.2 Performance

The debate continues over whether weight reduction to a lower-than-normal body weight affords a performance advantage to the combat athlete. This review will examine what research shows in the lab and in the few field studies that exist. Only those studies that focus on combat athletes will be reviewed. It has been noted that non-athletes and non-combat athletes used in research to examine the effects of "making weight" on physical performance may not be relevant to that which occurs in athletes who have subjected themselves to weight reduction and are accustomed to performing in a nutritionally deprived state. Because of the limited amount of research on weight loss in all combat sports, this section will not categorize the research according to sport.

*Physical performance in lab-based research.* Previous reviews have addressed the topic in detail; the readers are referred to them for more details [31–34]. With a few exceptions, most of the research on the effect of rapid weight loss on physical performance in weight-class athletes shows that short-duration high-intensity performance is less likely to be affected adversely [31, 35, 36]. If the effort is extended and repeated, i.e., requires an element of endurance, performance deteriorates [32]. For submaximal efforts of longer duration, performance is clearly impacted in a negative way [32]. Because most combat sports are relatively short in duration and a period of time, while short, allows for partial recovery after the weigh-in, most combat athletes will take advantage of the system and reduce body mass to make a lighter-than-normal weight class. Considering, though, that training sessions require longer efforts frequently in warm combat rooms to facilitate sweating-induced weight loss, the athletes may not be able to optimize physical conditioning, develop new techniques and strategies that require cognition, and minimize the risk of heat illness. Prior studies on wrestlers, boxers, and judoists showed deterioration of mood (although the change may be gender-specific) [22, 37, 38], ratings of perceived exertion for a given effort [36], and cognitive function [39] concomitant with weight reduction.

There are suggestions in the literature that exercise-induced weight reduction may be less detrimental than diuretic-induced weight loss for impact on physiology [40, 41], that diet composition during weight reduction may influence subsequent physical performance such that hypocaloric but high-carbohydrate diets may be beneficial [22, 42, 43], and that rehydration by oral means may be preferable to intravenous administration of an equal volume of fluids for recovery of physiological functions, physical performance, and perceived exertion of the subsequent effort [30, 44, 45].

*Performance in sport-specific tasks.* Because combat sports have a large technical component associated with the competitive performance, lab-based tests that measure power, total work, or endurance are arguably lacking. A few studies have attempted to simulate combat performance specific to boxing to examine the effect of weight loss. One study reported that rapid weight reduction (3% of body weight over 5 days) did not affect the force of punching against a boxing ergometer [46]. Another study indicated that "burst units," which integrated the force generated with the number of punches thrown against a boxing ergometer, found no effect of approximately 4% weight reduction [47]. Both boxing tasks were designed to simulate 9-min bouts (3, 3-min periods with a 1-min rest between periods) used in international competition. This is truly an area that needs more research.

*Success in competition*. Few studies have examined the relationship between success in the sport and weight reduction. At the collegiate level, Horswill et al. [48] did not find any benefit of weight manipulation or advantage of being heavier than an opponent during the first round of competition at the US collegiate level. Success was evaluated in several ways including seed coming into the tournament, team points scored, tournament placement, and likelihood of winning in the first round of the tournament. In contrast, Wroble and Moxley [49] reported that in interscholastic wrestlers matched for weight classes, weight regain (reflective of magnitude of acute weight loss) was greater in those who won in the first round (1.5 kg or 2.4%) versus those who lost in this round of competition (1.2 kg or 1.9%). Similarly, Alderman et al. [11] reported that among adolescents competing in international styles, place winners in the national tournament average significantly greater weight regain just before competition (3.8 kg) than did the wrestlers who failed to place (3.0 kg). Alderman et al. also reported that the older age divisions (17–18 years) regained more weight (mean 3.6 kg) than did the younger division (15–16 years) (mean 2.9 kg). This may be due to older adolescent wrestlers being more intent on and closer in their careers to making college teams, receiving the offer of a college athletic scholarship, and closing out their scholastic career as a national place winner. With the notion that weight loss enhances chance of success, the older wrestlers may be more willing to engage in the practice. The lack of clear and definitive data showing that weight loss hurts chances of success may be due to the fact that success in sport is dependent on other variables such as tactics, strategy, and the right mental approach. An athlete who must make weight may be able to adjust his technique and strategy to overcome weaknesses caused by weight reduction and still achieve success.

At this point there are no studies available on the relationship between weight manipulation and success at the senior level (Olympics, world championships) in other combat sports.

### 2.5.3 Health and Safety

Concerns about acute health and safety effects of rapid weight loss to make weight include heat illness, stress on the kidney [50], and case reports of pancreatitis after refeeding [51] and pulmonary embolism [52]. Heat illness may be most concerning in light of three deaths among US collegiate wrestlers in 1997. All three were attributable to hyperthermia and dehydration while the athletes were attempting to make weight for competition [53]. As explained previously, dehydration may have less of an impact on an athlete during competition because the competition is a relatively short-duration event. The problems arise during training when the athlete is attempting to further reduce body weight while already in a state of hypohydration and impaired cardiovascular and thermoregulatory functions.

In recent years, attention has focused on the effects of making weight on immune system responses. Several papers have investigated this in judoists and revealed decreased neutrophil phagocytic activity [54], serum immunoglobulins, and serum complement [55]. In wrestlers who achieved an average weight loss of 7% of initial body weight during 1 month of training, CD3/T-cell receptor-mediated T-cell function was diminished [56]; however, function still remained within normal ranges. Whether these changes result in increased rates of infection has yet to be determined, but the change versus no change in the control group suggests food restriction and arduous training to make weight compromise the immune system response. One paper suggests illness rates are not higher among weigh-class athletes compared to non-weight-class athletes training during similar seasons of the year [57].

Protein nutritional status has been shown to be compromised in adolescent wrestlers while making weight over the course of a season. Horswill et al. [58] showed that plasma transport proteins, transthyretin (prealbumin), and retinol-binding protein decreased in wrestlers who repeatedly made weight during a 3-month season. Roemmich et al. [59] confirmed a decrease in transthyretin and found that controls did not exhibit the same change. Roemmich also observed decreases in a testosterone and IGF-1 while growth hormone increased, suggesting the development of growth hormone resistance [60]. Despite these hormonal changes, Roemmich et al. reported that all values remained within normal ranges, and growth rate was not impaired [60].

A number of studies have reported a decrease in fat-free mass during weight reduction in combat athletes [59, 61–66]. The change, though, may be due primarily to a reduction in total body water and less due to decrease in dry cell mass. However, an earlier study showed that weight-class athletes did experience a negative nitrogen balance somewhat dependent on the composition of the diet ingested during weight loss [42]. Fat mass is also reduced [59, 61–66], but seldom to the extent that fat-free mass is predicted to be lost possibly due to the fact that these athletes are very lean initially and the fluids of the fat-free body are the only other source of weight to be lost. A few recent studies have investigated the impact of making weight on markers of bone turnover. Prouteau et al. [66] reported an increase in C-terminal telopeptide of type I collagen, a marker of bone resorption, while osteocalcin, a marker of bone formation, was unchanged with 4% reduction in body weight during a 7-day period in judoists. With weight regain these markers quickly reverse themselves in favor of a positive metabolic bone status [66]. Prior work indicates that athletes in combat sports have higher bone mineral densities than that of athletes in other weigh-bearing sports [67, 68] questioning whether the adverse effects of making weight on metabolic bone markers are of physiological significance.

Presently, only one study, and that a cross-sectional study, exists on growth rates of combat athletes. Housh et al. [69] reported that the slope for the relationship between height and age was not different for adolescent wrestlers and national growth data (NHANES) on non-wrestlers. A longitudinal study on a group of wrestlers and non-wrestling controls has yet to be conducted.

## 2.6 Strategies for Weight Reduction

Early in this chapter, strategies were presented for weight reduction that emphasized fat mass reduction and minimized loss of lean tissue. Table 2.4 summarizes the recommended approach for an entire season. The goal is to minimize the extent

**Table 2.4** Recommended approach to weight control and preparation for optimal performance at a lean weight

| Phase of season | Objective | Approach | Specifics |
|---|---|---|---|
| Preseason | Determine optimal weight class | • Assess body composition for lowest health weight<br>• Strategic analysis for ideal weight class<br>• Initiate program to change body weight<br>• Refine technique for chosen weight class<br>• Basic conditioning to reduce fat | • Aerobic conditioning<br>• Resistance training for strength development and maintain muscle mass<br>• Reduce intake of dietary fat and energy to reduce body fat |
| In season | Maintain weight close to weight class and train specifically for sport | • Increase energy intake and nutrients to maintain new weight and training<br>• Sport-specific training to optimize conditioning<br>• Refine technique, correcting errors in competition | • Primarily directed by the coach<br>• Athletes should maintain resistance training to prevent strength loss<br>• Ingest adequate amounts of carbohydrate, protein, and micronutrients |
| Postseason | Minimize fat gain when season ends | • Initiate resistance training<br>• Maintenance aerobic conditioning via combat sport or other sport<br>• Evaluate goals versus outcomes of the past season | • Avoid excessive dietary fat<br>• Compete in postseason competition<br>• Set goals for increasing strength<br>• Evaluate technical strengths and weaknesses<br>• Aerobic conditioning 2–3×/week |
| Off-season | Stay lean and gain muscle | • Maintain intensive resistance training<br>• Develop new techniques | • Attend camps, try new workout partners, and clubs<br>• Resistance training 4–5×/week |

and duration that a combat athlete dehydrates. Three other aspects of weight reduction will be discussed briefly here.

### 2.6.1 Strategies During Weight Reduction

*Diet composition*. Horswill et al. [22], Walberg et al. [42], and McMurray et al. [43] have demonstrated maintenance of high-power performance similar to that required in combat sports when their subjects reduced body weight while on hypocaloric but high-carbohydrate content diets. The expectation is that the high-carbohydrate diet helps better maintain muscle glycogen and thereby enhances performance compared to a diet low in carbohydrate but of similar calories. Horswill et al. [22] and McMurray et al. [43] kept protein intake constant for the two diet treatments. Walberg et al. [42] examined a high-protein diet and found that while performance was not maintained, nitrogen balance was. There was a trend for nitrogen balance to rebound over time for subjects on the high-carbohydrate diet.

*Supplements.* Arginine [70], branched-chain amino acids (BCAA) [71], chromium [72], and creatine [73–75] are the few supplements that have been tested for effects during weight reduction in weight-class athletes. The expectation is that such supplements would enhance fat loss, maintain lean body mass and/or maintain performance, and prevent the deterioration typically seen with fasting and dehydration. The effects of BCAA suggested that the supplement could help reduce body fat, particularly visceral fat. However, there is not an apparent mechanism for this effect, and the findings have yet to be replicated by other scientists [71]. Creatine supplementation during a 4-day period of acute weight reduction appeared to promote better nitrogen balance than the placebo [75]. There was also a strong tendency for enhanced sprinting capacity with creatine intake. Others have shown that the creatine effects are less beneficial to weight-class athletes. Performance was not as well maintained and weight reduction was not as large for athletes receiving creatine versus the placebo group [73]. Creatine is thought to act as an energy buffer for repeated sprint efforts, consistent with higher creatine and creatine phosphate in the muscle of the supplemented subjects [75]. By way of fluid shifts, creatine may promote an uptake of water into the muscle cells and expand the muscle volume [76]. At the cell level, this effect may stimulate protein synthesis [77, 78], which might help preserve the fat-free mass. Arginine and chromium did not have the effects of maintaining fat-free mass, reducing body fat or enhancing performance as hypothesized during periods of weight loss in weight-class athletes [70, 72]. It is also worth mentioning ephedra and other supplements that are known as "fat burning" and that increase metabolic rate. Ephedra use has been banned by the Food and Drug Administration (FDA) and has been linked to a number of deaths. Anecdotally, deaths of wrestlers and football players who suffered heat stroke have been linked to ephedra use, but this has not been substantiated in published investigations. Because of the increase in resting blood pressure and heart rate, athletes who make weight are strongly discouraged from using these compounds.

*Strategies of rapid verses slower weight loss.* Fogelholm et al. [79] showed that rapid weight reduction compared to a more sustained reduction promoted better status for some of the vitamins. Possibly because athletes do refeed during periods when they are not practicing rapid weight loss, they are able to acquire all the dietary nutrient needs. In contrast, a sustained reduction in energy and nutrient intake may increase the likelihood of deficiencies in the diet that accumulate for a significant effect on body status.

Smaller, more frequent meals may help nitrogen balance as indicated by 3-methylhistidine (3MH) excretion. Iwao et al. [80] reported that during a 2-week study of weight loss, boxers who consumed six small meals a day compared to a group who consumed only two large meals (either treatment providing 1,200 kcal/day) had less loss of lean body mass and had less of an increase in 3MH excretion. The latter effect would suggest less myofibril degradation. Bernardot's lab [81] has seen a similar effect in gymnasts and runners: greater meal frequency and fewer energy deficits within the day are associated with greater leanness.

### *2.6.2 Recovery After the Weigh-In*

Several studies have examined the effects of rehydration and specific nutritional strategies for their effects of recovery of performance after the weigh-in. Ribisl and Herbert showed that simply rehydrating, presumably with water, brought physical work capacity as estimated from heart rate back to normal levels [27]. Allen et al. [26] showed that restoring cardiac output was the mechanism for this effect. The benefits of beverage formulation, particularly of varying electrolyte content, have yet to be tested for benefits in recovery of weight-class athletes. The presence and amount of sodium in the beverage and the total volume of beverage consumed are expected to directly enhance the rehydration process [4, 82, 83].

Walberg-Rankin et al. demonstrated that a high-carbohydrate feeding between the weigh-in and performance helped to restore capacity for arm work [84]. In contrast, isocaloric feedings of low-carbohydrate content resulted significantly less arm work, similar to the amount measured at the time of the weigh-in before the athletes recovered.

### *2.6.3 Off-Season Recovery of Lean Body Mass*

To this point, no one has investigated training or dietary approaches to increasing fat-free mass and minimizing fat gain after competition has ended for the season. Typically, weight gain is very rapid and of substantial magnitude for wrestlers, as an example [59, 65]. Much of the gain is likely to be water. Because the volume of training drops off precipitously and energy intake may increase 2–5-fold, there is a strong possibility that weight-class athletes would accumulate body fat. Roemmich et al. [59] have reported this and also shown that dietary fat nearly doubles compared to the intake during training.

In summary:

- Athletes who need to make weight should consume a high-carbohydrate diet (60% total energy) with adequate protein (1.0–1.5 g/kg body weight).
- In general, dietary supplements are not recommended for weight loss.
- Between the weigh-in and before competition, weight-class athletes are encouraged to rehydrate. Sodium and adequate volume will help stimulate complete rehydration.
- Carbohydrate ingested in the meal after the weigh-in will help enhance performance.
- After the season, weight-class athletes should be diligent to minimize increasing body fatness when diet restrictions are removed and the amount of training may abruptly decrease.

## 2.7 Conclusions

Weight reduction continues to be a prevalent practice in combat sports, and likely will remain so as long as weight classes exist. The nature of the scoring system to determine success in a competition, the ease of applying dehydration and food deprivation for quick weight loss, the opportunity to recover partially prior to competition, and the relatively minor risks, at least in the eyes of the athletes and coaches, all encourage athletes in boxing, wrestling, and martial arts to reduce body weight for competition. With an absence of data to show weight reduction adversely impacts success in competition and the sport-cultural belief that weight loss is required for success, the practices of making weight will perpetuate.

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# Chapter 3
# Sport Psychology in Combat Sports

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## Learning Objectives

- To understand basic psychological principles concerning stress, coping, emotion, and emotion regulation, and their impact and influence on combat sports such as judo
- To understand the *zone of optimal stress* related to performance
- To understand the close relationship between stress and emotion with motivation and behavior
- To provide practical insights into how coaches and athletes can improve the management of stress and emotions related to competition

Psychological issues play a major role in optimizing health and improving performance of athletes in combat sports. Psychological principles are important to understand and maintain motivation for grueling training regimens over long periods of time, dealing with pre-competition preparation and stress during competition, and redefining goals and objectives after competition. Coaches and athletes at all levels realize the importance of all of these issues.

In this chapter, we discuss the psychological issues related to motivation and competition stress in the one combat sport that we know best, judo. We all bring our experiences in competitive judo to bear on the issues we introduce in this chapter,[1] and blend them with the psychological research literature providing a

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pragmatic approach to the topics discussed. We do not focus on the many psychological benefits of the practice of the combat arts. Indeed, a number of studies have documented the positive effects of the practice of sports in general, and combat arts in particular, on the development of character, life satisfaction, and well-being [1, 2]. These studies provide empirical evidence that participation in sports and many combat arts such as judo are important life-long activities with positive psychological benefits, regardless of whether this participation is competition-oriented. Instead, we provide this chapter from the perspective of former coaches and athletes in high-level competition, who also have a background in psychology. Thus, many of the guidelines we provide and examples we use come not from time-tested research, but from our experience and the application of basic psychological principles to the areas of our experience in which we believe they are most important.

We begin by introducing the concepts of stress and coping. Then, we highlight issues related to pre-competition stress, competition stress, and post-competition stress. In each of these areas, we analyze the concept of stress using a model of emotion, because stress is a catch-all phrase that refers to specific emotions that tax our energy systems. We also discuss issues concerning the maintenance of athletes' motivation between competitions.

## 3.1 Stress and Coping

### *3.1.1 Eliminating Versus Managing Stress*

Managing stress before, during, and even after competition is a most important battle that all athletes face. While this is true for all sports, it is especially true in combat sports, because the "usual" stress of athletic performance is compounded by the fact that one is in actual combat with others who can produce pain and injury. In judo, for example, getting thrown or pinned to lose a match is one thing; but even a lapse of focus for 1 s can lead to being strangled unconscious or being arm-locked, and dislocate or fracture an elbow. These aspects of combat sports increase the amount of stress during competition, and thus make psychological issues more actual.

Managing stress does not mean *eliminating* stress. Classic research in psychology has demonstrated that some degree of stress is necessary for optimal performance in both cognitive and motor tasks. For many people, the relationship between stress and performance can be depicted as an inverted U. Too little stress is often associated with minimal performance, but, as people get more stressed, their performance increases. Likewise, for most individuals there is a point that defines "too much stress." If stress increases beyond that point, therefore, performance declines. This is known as the Yerkes-Dodson law.

Thus, eliminating stress altogether does not lead to better performances. For coaches and athletes it is probably more important to find the *zone of optimal stress* *which is associated with peak performance*. Each athlete has one. Yet what makes this difficult is the fact that each athlete's zone is different than the other's. And the methods of how to get them there, keep them there, or bring them back to that level if the athletes go past that point, are probably very individualized. Thus, individual athletes have their own profiles of what their inverted-Us look like. The job of many coaches and athletes, therefore, is to work together to find out what those individual graphs look like, and to explore methods of intervening when the athlete is too high or low on the graph.

### *3.1.2 What Is Stress?*

As coaches and athletes move to work with athlete stress, it is important to have an operational definition of exactly what stress is. In fact, stress is really a catch-all phrase that refers to *the strains on our physiological and psychological well-beings that occur because of the taxing of emotions that arise because of our appraisals of events, situations, or occurrences that are threatening to our sense of well-being*. When emotions turn on, they engage our physiology, skeletal muscles, and cognitions, all of which can be taxing on our bodies, especially if they occur repeatedly over long periods. Stress is the tax that emotions extract from our bodies and minds.

If stress is the tax that emotions extract from us, then it is important for practitioners (i.e., coaches and athletes) to identify exactly what kinds of emotions athletes experience during competition. For example, anger can be stressful, but so can sadness, fear, or disgust. Each of these different emotional reactions refers to a specific way in which athletes react to a given situation. Anger, for instance, is elicited when goals are obstructed. Disgust occurs when an individual comes into contact with something repulsive. Fear occurs when there is an imminent threat to one's safety or well-being. Each of these emotional reactions can lead to "stress." Thus, in dealing with stress, it becomes important to identify the specific emotional triggers that are occurring to cause the stress, and to deal with the triggers on their own basis. In the case of combat sports, it is likely that these emotions are occurring repeatedly and intensely, and are probably often blending with each other.

### *3.1.3 Coping with Stress*

Individuals all have their own unique ways of dealing with stress, which in psychology is known as *coping*. Coping helps to produce changes in our emotional reactions [3]. It refers to both cognitive and behavioral ways we devise to deal with the demands of the stresses and strains on our bodies and minds [4]. Coping is necessary for us because we cannot remain in an excited, emotional state forever. Emotions tell us something about our relationship with the environment, others, or ourselves, and they motivate us to do something. Coping is the response we have to this emotional need.

**Table 3.1** Eight ways of coping [5]

| | |
|---|---|
| Confrontive coping | Aggressively trying to alter the situation, with some degree of hostility and risk taking |
| Distancing | Gaining physical or psychological distance from the event or situation that produced the stress |
| Self-controlling | Exerting cognitive control over your emotional reactions when stressed |
| Seeking social support | Seeking information, emotional, or tangible support to help deal with the situation |
| Accepting responsibility | Acknowledging your contributions to the situation that brought about stress and trying to make things right |
| Escape-avoidance | Wishful thinking and acting to escape or avoid the problem |
| Planful problem solving | Deliberately analyzing the problem and situation in order to alter it |
| Positive reappraisal | Creating positive meaning from a negative event by focusing on personal growth |

There are many different coping strategies, and many different ways to think about them. One of the pioneers in psychological research on stress and coping, Richard Lazarus, identified eight major coping styles that individuals adopt (Table 3.1). When one is stressed, for instance, one might directly confront the situation that brought about the emotional reaction (Confrontive Coping); or one might just escape from the situation and avoid those kinds of situations altogether in the future (Escape/Avoidance Coping); or one might ask friends for help to deal with the situation (Seeking Social Support Coping).

Some types of coping focus on doing something concretely about the situation or event that brought about the emotion and stress: these are known as problem-focused coping strategies [4]. Some types of coping focus on doing something to reinterpret the situation or the response: these are called emotion-focused coping strategies [4], and involve mainly changing one's thinking rather than acting to change the situation.

Athletes (and coaches) deal with their stresses before, during, and after competition in unique, individual ways which typically engage one or more of the coping strategies outlined above. Coping during actual competition, however, is extremely difficult, because coping needs to be done in second-by-second precision with limited resources in a highly emotionally charged environment.

## 3.2 Pre-competition Stress

Given that athletes have an optimal level of stress at which they will perform their best, one important issue concerns how to prepare them appropriately to be at that level prior to competition, and not have too little or too much stress. Obviously, this presupposes that coaches and athletes know what that optimal level is in the first place. One of the first things to do, therefore, is to determine exactly what that optimal level is.

How can that be done? One method is based on the link between anxiety and heart rate; the more anxious (stressed) a person is, the faster the heart will beat. Measuring heart rate, therefore, is a quick, unobtrusive way to gain a glimpse of the athlete's level of anxiety at any one time. The next question is, then, when would one measure it? There are many possible times when this measurement can be taken, but perhaps the period most directly applicable to pre-competition is the pre-workout stage, after warm-ups, but before randori (sparring in judo, which is the closest form of practice to competition; literally, "catching chaos"). If athletes are warmed up, report that they are "feeling good," and are about to engage in strenuous sparring, which mirrors competition, that may be an optimal time at which to measure heart rate to gauge that athlete's optimal level of stress. If that value is known, then it can be compared against the value when heart rates are measured immediately before competition. If it is too high prior to competition, the athlete may need to be de-stressed. If it is too low, the athlete may need to be 'pumped up.'

One method used by many coaches and teams to bring their athletes to optimal levels of pre-competition stress is to utilize a standard pre-competition warm-up procedure. If this procedure is standardized, athletes are able to allow their minds to flow into the rhythm of the procedures, and not ruminate about the competition, which would add to unnecessary stress. A proper warm-up procedure would also ensure that athletes are prepared physically for combat.

Although too much and too little pre-competition stress are both problems for athletes, in our experience the more common problem is too high stress. Too much stress prior to competition may lead to less-than-optimal performances during actual competition, possibly because one's emotions are too strong and/or one's body just cannot adapt to changing combat situations in an optimal fashion. Thus, coaches and athletes need to be aware of this potential problem, and, if recognized, engage to reduce (but not eliminate) the stress.

One very successful technique to regulate one's emotional reactions involves deep breathing. Breathing, in fact, is a part of many healing arts. It fosters the development of self-awareness, which is an aspect of emotion regulation that is important if one is to be able to monitor and manage one's emotional reactions. However, breathing needs to be practiced. Breathing can be introduced as a way of fostering centering and self-awareness for athletes in many ways, such as the beginning and end of practice. It can also be introduced in the middle of practice, especially during tough rounds. Once well practiced, individuals can often derive the benefits of deep breathing even by just starting the procedure. This can be useful for athletes in the few seconds prior to matches, or even in the breaks during matches, and coaches can keep their athletes focused by having them breathe. Breathing is also an integral part of proper stretching routines, and can be utilized effectively when stretching.

Clearly, each athlete is different, and deals with stress in his or her own way. Some prefer to stay in a corner by themselves thinking; others prefer to listen to music and walk. Some prefer to be in groups and chat away; others prefer to lose themselves in a vigorous warm-up routine. Athletes should not be pigeonholed into a standard routine for everyone because there is no routine that is the best for everyone, especially in individually based combat sports. However, coaches and athletes can bring some clarity to this process by understanding optimal stress levels, and helping to find ways in which their athletes can achieve that optimal stress level prior to competition.

## 3.3 Competition Stress

### *3.3.1 Dealing with High-Intensity Stress in High-Stakes Environments*

Judo competition, like all combat sports, is difficult because athletes constantly need to make motor decisions to adapt their tactics and techniques to their opponents and the flow of the matches in a highly stressful environment. While this is true for all sports, the difficulty inherent in this process is compounded by the fact that judo is a combat art, and athletes are not just competing, but are fighting as well. Moreover, within matches, athletes may be scored against, putting additional pressure on them to come back to win. In judo, and we suspect in many combat sports, defending a lead is usually easier than coming from behind, and athletes in this situation thus have additional stress to deal with during the match. For these reasons – competition, combat, and the flow of the match – judo competition is highly stressful, and thus the athlete's ability to deal with this high level of stress becomes a major factor in determining competitive outcomes.

Despite the great importance of this psychological ability in determining competitive outcomes, we strongly believe that the priority in *supplemental* training for high-level judo competition is first in strength and conditioning. (The priority in primary judo training is the development of judo skills and technique.) The reason for this is that judo competition at the highest levels – Olympics, world championships, union championships, international tournaments, and many national championships – include the strongest and best-conditioned athletes in the world. Judo competition requires enormous aerobic and anaerobic conditioning, and judo athletes at the highest levels train to achieve these. They also develop extraordinary strength, both through normal judo training and supplemental weight and plyometric training. Athletes who are the best physically conditioned and who have tournament experience are often in a better position to do well in high-level competition than athletes without such conditioning. For the latter, it makes little difference how well athletes are prepared mentally, and how much ability they have to regulate their stress during competition.

Achieving strength and conditioning necessary for high-level competition brings with it, in fact, many psychological benefits. Athletes who are stronger and who can go more rounds at high intensity will develop more self-confidence in competition. Judo, unlike many other combat sports, involves gripping the other opponent, and, when doing so, often athletes gauge the strength of their opponent. Athletes at their peak of strength and conditioning will know, at the time of the grip, that they are stronger than their opponents, and that can lead to a boost in confidence during a match. Athletes who are stronger can also break the grips of their opponents. Thus, these psychological benefits are positive side effects of an emphasis on strength and conditioning in supplemental training.

If athletes can match the strength, conditioning, experience, and talent of their opponents, then psychological factors during matches are crucially important. Of course, athletes must be motivated to win, and, if they are not motivated to win in the first place, then no amount of strength, conditioning, experience, or talent will help them. Assuming they are motivated at all costs to win (or, equally important, not to lose), then one important psychological variable that must be considered concerns the degree to which athletes can manage the high-intensity stress that is inevitable in competition, and especially during matches.

The ability to regulate or cope with stress is known as emotion regulation. It refers to the degree to which an individual can monitor, manage, and modify one's emotional reactions to achieve constructive outcomes. Emotion regulation is a key skill in adjusting and adapting constructively to many changing life circumstances [6–14]. Athletes with high degrees of emotion regulation will be able to manage the high-intensity stress associated with high-level competition in order to adapt and adjust well during matches. They will be able to keep their emotions in check, even when they are behind or put under pressure, so that they can think clearly, rationally, and rapidly about the adjustments in their performance necessary to win. Athletes with low degrees of emotion regulation, however, are slaves to their emotions, overcome by their feelings, and unable to think clearly. They might freeze or panic, or do things they would not normally do. Differing ability to regulate emotion is one reason why players who are strong in practice may lose to those with less talent in actual competition.

### 3.3.2 Training Emotion Regulation in a High-Stress Environment

One of the difficulties of sport psychology in the combat sport arena is the fact that one needs to make psychological principles applicable to this very specific area of competition. In practice, it is one thing to mentally train athletes when they are out of competition in a non-stress environment. It is, however, a completely different thing to train athletes mentally in a high-stress, emotionally wrung environment, which is precisely the environment of high-level competition. Skills in a stress-free environment are often not applicable in a high-stress environment, which is why we believe many mental imagery tasks, a commonly used sport psychology task with athletes, may not be as successful in judo. These tasks are often conducted in a stress-free environment, and, although some athletes may be able to image success in competition in that environment, it is very difficult to get them to perform to the best of their abilities in a high-stakes, high-stress environment if their emotions are in control of their behavior, and not vice versa.

Thus, we strongly believe that the best psychological training programs that can have a positive impact on actual competition are those implemented in a high-stress, high-intensity environment. To do so, coaches will need to simulate the intensity of competitive combat and then to implement psychological training as part of the simulation. For example, one technique may involve having athletes engaged in a high-intensity run on an inclined treadmill to exhaustion, and then immediately having them do a cognitive task that requires intense concentration. Such training would simulate the physical demands made by competition (which can lead to heart rates of 200 bpm), but requires the athlete to maintain their composure to engage in the cognitive task. In the past, we know of such programs that have used math problems, untying knots, or spinning around blindfolded to grab objects resting on a table or pedestal, all during the resting periods of intense interval training. All of these require high degrees of concentration when athletes' hearts are racing at competition speed.

Another possibility may involve intervening during actual practices. Again, it is necessary to bring athletes to the limits of their physical abilities, which maximizes the stress of the environment, and then to allow them to gain control of their emotions to adapt effectively within that stressful environment. In judo, this may be achieved by having athletes engaged in the most taxing rounds of randori in which they are losing to their partners because they have lost control of their emotions, stopping the action, and guiding them to think through what they need to do in order to regain control of the situation or adapt successfully to their opponents.

To be sure, these tactics are very successful when athletes are not taxed during practice, because emotions have not yet overcome them. But if supplemental psychological training does not occur in an environment that simulates the intensity of actual competitive combat, athletes will not become used to regulating their emotions in a high-stress environment.

There are many ways to train emotion regulation in a high-stress environment. The methods are limited only to the creativity of the coaches. For now, we offer the general guidelines that the most effective mental training for competition involves the simulation of the high-intensity stress of competition, and then finding ways in which athletes can gain a better control of their emotions and thoughts in that high-stress environment.

## 3.4 Post-competition Stress: Interpreting Winning and Losing

Once a competition is concluded, athletes are flooded with a range of emotions, whether they win or lose [15]. The emotions of athletes who win may range from ecstasy, achievement, pride, and joy to tears for all the hard work and sacrifices they and all those around them have made throughout years of grueling training. Athletes who lose may experience sadness, despair, dejection, anger, shame, contempt, disgust, and even fear. Clearly, athletic competition, especially in combat sports, can be associated with strong, raw emotions for all involved.

When athletes are gripped by emotion after competition – regardless of its type – there is little that others can do except to share the emotion with the athlete.

Emotions have their own life course, and, when elicited, they need to run their course [16]. Attempts to prematurely block or change the course of an emotion will be futile. Coaches, friends, and family members, despite their good intentions, often do not realize that this is the case, and attempt to intervene when athletes have just completed the competition, when emotions are too raw to allow that to occur.

Thus, there is an appropriate time to intervene, and every individual athlete is different on exactly when that time is. Coaches and athletes can work by noting that time. A history of experience together is often the best way to deem so, but, if that time window is known, then even new coaches working with athletes who have that valuable information can adapt appropriately to the needs of the athletes.

Once athletes and coaches are in the proper frame of mind (i.e., when raw emotions are receding into their refractory phase), then one of the most important jobs of coaches, not only as sport coaches, but also as life teachers, is the way in which winning or losing is interpreted to the athlete. In psychology, the interpretation of the causes of events is known as attributions, and the study of attributions is a major part of social psychology. Most individuals, regardless of culture or gender, have a *self-serving bias* when they make attributions about successes and failures [17]. In practice, people have a tendency to attribute their own successes to stable, internal factors ("I am intelligent," "I am a hard worker"), and their own failures to unstable, external causes (referee mistake, "my opponent was lucky"). Also, people have a tendency to attribute other people's successes to unstable, external factors ("they were lucky," "they had a good draw"), and other people's failures to stable, internal factors ("they do not work hard enough," "their technique is terrible"). All of these are ways in which we protect our own sense of self, regardless of our sociocultural background. However, self-serving attributional styles are not conducive to long-term success in performance, or growth as an individual. Instead, a model of self-efficacy and self-agency [18] strongly suggests that objective attributions of both successes and failures to controllable internal factors (e.g., effort, thinking styles, planful actions, etc.) can lead to the most positive outcomes in the long run. This attributional style will help athletes and coaches identify the strengths and weaknesses of a given individual are, one's limitations and shortcomings, and focus efforts on overcoming those, regardless of what external factors may exist to influence performance outcomes. Put succinctly, focusing on others (e.g., opponents, referees, the draw, etc.) does little in the long run to influence positive character development or work habits necessary to achieve positive competition outcomes. Focusing on what one can do to improve future outcomes will most likely lead to improved future outcomes.

## 3.5 Maintaining Athlete Motivation

Once competition is over, one of the primary psychological issues that athletes and coaches face concerns how to maintain motivation (of both athletes AND coaches!) for intense, long-duration training regimens. One of the major reasons for this is that emotions are a major source of motivation of behavior [19, 20], and athletes and coaches need to deal with many different, fluid emotions in between competitions as well. This is often not a problem for athletes who have consistent winning records: success breeds success, and winning produces many positive emotions that lead to sustained, high-level motivation. But the number of athletes who lose matches enough to be emotionally affected by them far outweighs the number who can consistently win and maintain their own training motivation. Sadness and fear can especially inhibit motivation; anger can be constructive if it is directed toward the obstacle to previous successful performance. If directed toward oneself, coaches, or training, then anger may severely hinder motivation. Thus, for most coaches, the more common problem to deal with is how to maintain athlete motivation after less-than-optimal performance outcomes.

There are several guidelines we feel are important to acknowledge in considering how to maintain, or in many cases rebuild, athlete motivation for training and success. We believe that athletes should be as involved as reasonably possible in setting their own goals and developing their own training plans. Younger athletes may have difficulty in doing so, and may need guidance from coaches in this respect. Older athletes may have the skills to do so, but may need the knowledge of sport science that many top-level coaches around the world use in developing their training plans. Regardless, we feel that athletes' motivations will be easier to sustain if they feel that they have *ownership* over their goals and training. The feelings of ownership are one of the first steps toward accepting individual responsibility for training and performance outcomes, a necessary part of self-agency.

Also, athletes need to take responsibility for their training. Part of any training plan will be the establishment of developmental milestones along the way. These milestones may be competitive outcomes in preliminary tournaments, success in the gym or track in supplemental training, or success in developing new skills in the *dojo* (school or club; literally, place to learn the way). Regardless of the specific nature of the milestone, athletes should be involved in deciding what the milestones should be within the training plan, and should take the ultimate responsibility of achieving them. Coaches should provide the framework and the guidance, and sometimes the extra push, to achieve these. Yet, in the end it is the athlete who competes. Thus, it is the athlete who needs to take individual responsibility for his or her training as well. Making the milestones public in the dojo, and reminding athletes that they need to achieve those milestones, is one way of fostering individual responsibility for training.

Finally, coaches should take an interest in their athletes not only as sport competitors, but also as individual people. Athletes (and many students) are not interested in how much coaches (or teachers) know: they want to know that coaches are interested in them. That means learning about athlete's interests, hobbies, ways of thinking, values, philosophies of life, etc. Doing so requires spending time together regularly, and talking and exchanging ideas in a nonjudgmental, inquisitive fashion. One major goal of the development of these relationships is to explore the basis of athletes' emotions, especially in relation to competition outcomes. Joy, sadness, fear, dejection, apprehension, and anger are all part and parcel of the emotional pendulum that athletes are often on, and one important step in maintaining athlete motivation is for coaches to understand exactly what emotions athletes are feeling, and why. Listening, in combination with guiding questions, is a key. Unfortunately, many coaches, of national teams, universities, or private dojos, are just too busy in their lives to make the time to get to know their athletes on this personal level, and conversations about emotions are avoided. Even when conversations about emotions take place, coaches and athletes are often too quick to try to do something about them, instead of learning as much as possible about them in the first place. Part of the reason for this is that coaches and athletes tend to be doers, and talking about emotions seems counterproductive. It also makes many people feel uncomfortable themselves. But an important part of being interested in athletes as individuals is learning about their emotions as well as their ways of thinking. Because emotions are such a central part of motivation, we feel that understanding athlete's emotions is a key to maintaining motivation. And athletes' feelings that coaches are interested in them as people are a large part of their achievement of self-efficacy and self-agency with regard to their training and competition.

## 3.6 Conclusion

This chapter did not focus on the many psychological benefits of the practice of the combat arts. Instead, we wrote this chapter not from the perspective of professional sport psychologists, but as former coaches and athletes in high-level competition, who also have a background in psychology. Thus, many of the guidelines we provided and examples we used come not from time-tested research, but from our experience, and from the application of basic psychological principles to the areas of our experience in which we believe they are most important. We feel that a lack of focus on athlete's emotions, especially in the heat of battle in high-stress, high-intensity combat sports, often renders discussions of sport psychological principles and practices irrelevant to many practitioners. We hope that we have bridged that gap by understanding exactly that high-intensity, high-stress situation from an emotional and psychological standpoint.

Hopefully, future research can test many of these ideas to determine their scientific worthiness. Undoubtedly, the results of those studies may change some of the guiding principles we offered, and/or offer modifications to the specific ways in which those principles can be put into practice. Regardless, we welcome such scientific efforts, and an expanded discourse about these issues among coaches and athletes involved in training for high-level competition. These activities can only help to introduce another element of humanity into this tough, and sometimes brutal, world.

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# Chapter 4
# Doping in Combat Sports

**Farzin Halabchi**

## Learning Objectives

- To define doping and identify all kinds of anti-doping violations
- To describe the epidemiology of drug misuse in combat sports
- To list the effects of frequently misused drugs on the health and performance of combat-sport athletes
- To discuss the roles and responsibilities of athletes during doping control process

## 4.1 Historical Perspectives

In the broadest sense of the term, use of foreign substances to enhance the sporting performance seems to be as old as competitive sports itself [1]. The first recorded instances of substance use were noted in the third century BC at the ancient Olympic Games [2, 3]. In this period, some athletes are known to have used special diets and stimulating potions such as hallucinogenic mushrooms and sesame seeds to enhance performance [4–7]. The ancient Egyptians used a drink made from the hooves of asses, to improve their performance [8]. The use of drugs during the Roman period has also been recorded among chariot racers and gladiators [9].

The first witnessed doping-related death was in 1886 when a cyclist, Linton, died from an overdose of trimethyl [9]. The use of stimulants such as amphetamine, cocaine, and ephedrine to improve performance and reduce fatigue was reported in the early 1900s [10].

In 1928, the International Amateur Athletic Federation (IAAF) became the first International Sport Federation (IF) to ban the use of doping (use of stimulating

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substances). Many other IFs followed suit, but restrictions remained ineffective as no tests were performed [5].

Testosterone was first synthesized in 1935, and in the 1940s, athletes began taking anabolic steroids to increase their muscle mass [11].

Throughout the 1950s and 1960s, amphetamines and anabolic steroids were used extensively in sports [12].

The death of Danish cyclist Knud Jensen during competition at the Olympic Games in Rome 1960 (due to amphetamine abuse) increased the pressure for sports authorities to introduce drug tests [5]. In 1967, the televised death of cyclist Tommy Simpson in the Tour de France triggered the International Olympic Committee (IOC) to set up the first list of prohibited substances [9, 13].

Drug tests were first introduced at the Olympic Winter Games in Grenoble and at the Olympic Games in Mexico in 1968. In 1988, Canadian Olympic sprinter Ben Johnson was stripped of his gold medal after testing revealed the use of an oral anabolic steroid [14].

In 1998, a large number of prohibited medical substances were found by police in a raid during the Tour de France. The scandal highlighted the need for an independent international agency, which would set unified standards for anti-doping work and coordinate the efforts of sports organizations and public authorities. The IOC took the initiative and convened the World Conference on Doping in Sport in Lausanne in February 1999. Following the proposal of the Conference, the World Anti-Doping Agency (WADA) was established [5, 15].

One of the most important achievements of WADA has been the drafting, acceptance, and implementation of a uniform set of the World Anti-Doping Code. The International Olympic Committee (IOC), the International Paralympic Committee (IPC), all Olympic sports, national Olympic and Paralympic committees, national anti-doping organizations, and international agencies unanimously agreed to adopt the Code as the basis for the fight against doping in sport.

International federations of boxing, judo, taekwondo, karate, sumo, and wushu are the combat sports organizations which have accepted the Code. However, some other combat sports organizations have their own anti-doping rules and prohibited lists.

## 4.2 Definition of Doping

There are some interesting suggestions as to the etymology of the word ‘doping.’ One is that it is originated from ‘dop,’ a term that refers to a primitive alcoholic drink used as a stimulant in tribal ceremonies in South Africa during the eighteenth century [16–18].

Another suggestion is that the word is probably derived from the Dutch word ‘doop’ (a thick dipping sauce) that entered American slang to describe how robbers stupefied victims by mixing tobacco with the seeds of a special plant [19], causing sedation, confusion, and hallucinations [20].

Gradually, the term adopted a wider usage and in reference to sport, it became known as ‘doping.’ Dop first appeared in an English dictionary in 1889, where it was described as a narcotic potion designed to influence a racehorse’s performance [17, 18, 21].

Contemporary use has extended the understanding, and hence the definition, of doping to include the unfair improvement of performance. As the practice of doping has developed, the word itself has come to refer not only to the misuse of drugs, but also to the use of other methods of improving performance or of attempting to manipulate the test [17].

Although at first glance, the definition of doping seems axiomatic, but in fact, there has been no consensus agreement regarding the comprehensive and everywhere accepted definition between coaches, athletes, and sports authorities. So, doping has been defined through a variety of viewpoints.

As one of the first organizational definitions, the International Olympic Committee (IOC) defined “doping” in 1967 as the “use of substances or techniques in any form or quantity alien or unnatural to the body with the exclusive aim of obtaining an artificial or unfair increase of performance in competition” [22].

Nowadays, the World Anti-Doping Agency (WADA) has presented a more inclusive and acceptable definition, which regards doping as the occurrence of one or more of the anti-doping rule violations, including:

- The presence of a prohibited substance or its metabolites or markers in an athlete’s bodily specimen
- Use or attempted use of a prohibited substance or a prohibited method
- Refusing, or failing without compelling justification, to submit to sample collection after notification as authorized in applicable anti-doping rules or otherwise evading sample collection
- Violation of applicable requirements regarding athlete availability for out-of-competition testing including failure to provide required whereabouts information and missed tests, which are declared based on reasonable rules
- Tampering, or attempting to tamper, with any part of doping control
- Possession of prohibited substances and methods
- Trafficking in any prohibited substance or prohibited method
- Administration or attempted administration of a prohibited substance or prohibited method to any athlete, or assisting, encouraging, aiding, abetting, covering up, or any other type of complicity involving an anti-doping rule violation or any attempted violation [23]

## 4.3 Epidemiology of Drug Misuse in Combat Sports

Convincing data on the prevalence of drug misuse in elite sports (including combat sports) are difficult to achieve because the athletes involved in the practice will normally deny or conceal their illegal and socially unacceptable activities. However, the existing evidence indicates that the use of performance-enhancing drugs in elite-level sport is now widespread [24].

Evidence may be as diverse as statistics on positive doping tests, results of surveys of athletes on their self-reporting or perceptions of drug use through to anecdotal reports, and speculation by the media. These sources of evidence are widely inconsistent, leading to speculation of levels of prevalence with a wide range.

Nowadays, statistics on doping control are available from the World Anti-Doping Agency (WADA). These are based on results from the IOC-accredited laboratories ($n$ = 33 in 2005). Overall, the percentage of positive test results from IOC-accredited laboratories has remained consistently low, despite a steady increase in the number of tests conducted annually. These figures, which themselves may not be a true reflection of the truth, merely tell us how many athletes have tested positive, not how many are using drugs and avoiding detection.

Figure 4.1 shows the relative frequency of positive doping tests in combat sports (including boxing, karate, taekwondo, wrestling, and wushu) during the last 3 years and compares the results with overall percentage and also with figures from three other sport disciplines (athletics, cycling, and weight lifting). As it is obvious in this chart, the frequency of positive tests in combat sports is not as high as cycling and weight lifting, and is approximately similar to the average figures obtained from all sports. According to the 2005 annual reports of WADA, it has been shown that boxing, taekwondo, and wrestling had the highest percentages of positive tests in combat sports (3.41% [83 in 2,433], 1.97% [26 in 1,318] and 1.65% [53 in 3,218], respectively) [25].

History of drug testing in Olympics (1968–2004) reveals that out of overall 84 positive in-competition tests during these competitions, eight cases (9.5%) have

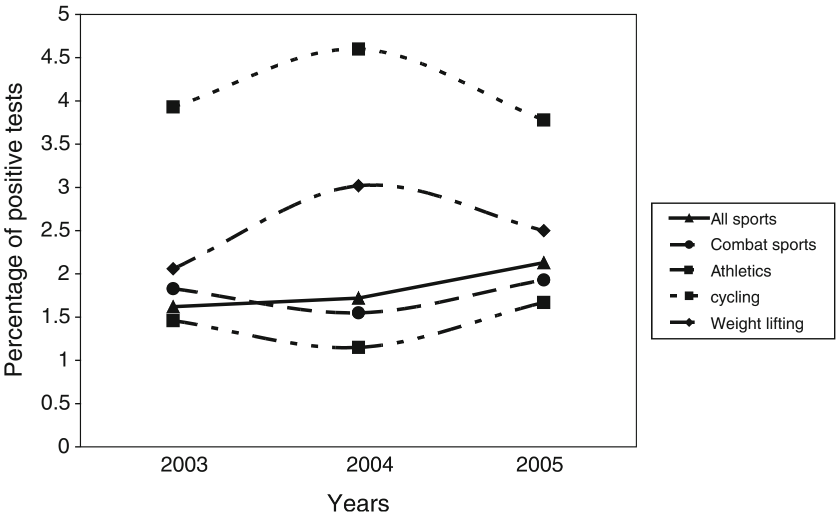


**Fig. 4.1** The comparison of the relative frequency of positive doping tests between combat sports (including boxing, karate, taekwondo, wrestling, and wushu) and some other sports disciplines

been recorded in combat sports (five cases in wrestling, two in judo, and one in boxing) [5].

However, few people would consider these as being an indication of the true prevalence of drug misuse in sport because of the following reasons:

1. Very few tests are conducted relative to the number of athletes competing in sport.
2. A large proportion of the drugs do not need to be used at the time of competing and out-of-competition testing is not widespread.
3. Athletes are becoming more professional at planning their drug use in periods when they are least likely to be tested.

The statistics from the WADA laboratories merely provide an international overview of the problem. More detailed analysis is required, particularly with regard to what is happening country by country, sport by sport, and drug by drug, but now we are left in the position of mere speculation.

There have been many survey-based studies published on the prevalence of drug misuse. Unfortunately, very few are based on surveys conducted with athletes and even fewer with elite athletes, especially in combat sports. Surveys are broadly divided into those that ask about self-use of drugs and those that seek information on perceived use by others. Results from the former study tend to reflect underreporting, while those on perceived use tend to produce exaggerated claims [16].

### *4.3.1 The World Anti-Doping Agency (WADA) List*

The classification and scope of the drugs included in the prohibited list altered over the years as trends in the use of doping substances and methods changed and the methods for drug testing improved. Nowadays, WADA publishes annual review of the list and a 3-month notification is given before the revised list is implemented (Table 4.1).

**Table 4.1** WADA list of prohibited substances and methods (2007)

| |
|---|
| • Substances and methods prohibited at all times (in- and out-of-competition) |
| Prohibited substances |
| S1. Anabolic agents |
| 1. Anabolic androgenic steroids (AAS) |
| 2. Other anabolic agents |
| S2. Hormones and related substances |
| 1. Erythropoietin (EPO) |
| 2. Growth hormone (hGH), insulin-like growth factors (e.g., IGF-1), Mechano growth factors (MGFs) |
| 3. Gonadotrophins (LH, hCG), prohibited in males only |
| 4. Insulin |
| 5. Corticotrophins |

(continued)

**Table 4.1** (continued)

| |
|---|
| S3. Beta-2 agonists |
| S4. Agents with anti-estrogenic activity |
| S5. Diuretics and other masking agents |
| Prohibited methods |
| M1. Enhancement of oxygen transfer |
| 1. Blood doping |
| 2. Artificially enhancing the uptake, transport, or delivery of oxygen |
| M2. Chemical and physical manipulation |
| M3. Gene doping |
| • Substances prohibited only in-competition |
| S6. Stimulants |
| S7. Narcotics |
| S8. Cannabinoids |
| S9. Glucocorticosteroids |
| • Substances prohibited in particular sports |
| P1. Alcohol[a] |
| P2. Beta-blockers[b] |

[a]In combat sports, alcohol and beta-blockers are prohibited in karate and wrestling, respectively.

The list applies to all sports (including combat sports) and identifies those substances and methods that are prohibited within or out of competition.

Examples of drugs within each category are provided in this list, but because new drugs frequently appear on the underground market, the WADA has applied the term "and other substances with a similar chemical structure or similar biological effect(s)" to its lists of examples, where appropriate [26].

## 4.4 Drugs Commonly Misused in Combat Sports

According to the classification of sports disciplines based on the contact level, all combat sports are classified in collision/contact class. These sports necessitate the high levels of strength, agility, alertness, and some degree of vigor and aggression. Furthermore, in almost all of these disciplines, the athletes should compete in separate weight categories, which may dictate rapid weight loss or gain. So, it is logical that these athletes prefer to abuse drugs, which are supposed to exert beneficial effects on the above-mentioned parameters. In these regards, it seems that there is a trend in combat sports toward the use of anabolic androgenic steroids (AAS), stimulants, diuretics, growth hormones, and other peptide hormones. However, the athletes of the combat sports may use other prohibited substances and methods, although with less frequency. In this part, we will discuss regarding the prohibited substances, commonly misused in combat sports, including androgenic anabolic steroids, stimulants, growth hormone, and diuretics.

## 4.5 Androgenic Anabolic Steroids

In spite of numerous reports of health risks associated with their use, anabolic androgenic steroids (AAS) remain a widely abused drug [27, 28]. These drugs have been the most commonly detected substances in urine samples of athletes [29].

### *4.5.1 Basic Science*

Testosterone is the primary male hormone. It serves distinct functions at different stages of life. It regulates many physiologic processes in the adult male including muscle protein metabolism, sexual and cognitive functions, erythropoiesis, plasma lipids, and bone metabolism [30].

Anabolic androgenic steroids (AAS) are chemically modified analogs of testosterone manufactured to maximize anabolic and minimize androgenic effects [27, 31]. Chemical modifications of testosterone have been useful pharmacologically to alter the relative anabolic–androgenic potency, slow the rate of inactivation, change the pattern of metabolism, or decrease the aromatization to estradiol [32, 33]. Carboxylation of the 17-β-hydroxyl group makes the molecule more soluble in lipid vehicles used for injection and, hence, slows the release of the injected steroid into the circulation [31]. Most orally active AAS preparations are 17-α-alkylated derivatives of testosterone that are relatively resistant to hepatic degradation [34]. Contrary to popular belief, oral administration of an AAS is more dangerous than injection [26]. All of the AAS drugs possess both anabolic and androgenic activity; none are absolutely selective [31].

Testosterone, the active ingredient of AAS, has several possible metabolic actions. First, it binds to the androgen receptor (AR) in target tissues to exert its mostly anabolic effects [31]. Second, it is converted in some target tissues (including skin and liver) into dihydrotestosterone by the 5-α-reductase enzyme, which acts in the cell nucleus of target organs, such as male accessory glands, skin, and prostate [31, 35]. Dihydrotestosterone is responsible of the androgenic effect. This steroid is more potent than testosterone because of increased affinity to the androgen receptor [36]. Finally, it can be aromatized to estradiol to exert estrogenic activities [31].

Anabolic effects of AAS will concern organs as muscles, bones, the heart, and kidneys. These organs possess little 5-α-reductase activity and thus AAS induce protein synthesis, muscle fiber development, erythropoiesis, and stimulation and inhibition of bone growth. In addition, anabolic steroids displace glucocorticoids from glucocorticoid receptors and inhibit muscle protein catabolism, leading overall to an anabolic or muscle-building effect [36]. The anabolic effect of AAS is mediated primarily by androgen receptors (ARs) in skeletal muscle. The AR regulates the transcription of target genes that may control the accumulation of DNA required for muscle growth. It was previously thought that ARs are saturated at physiologic levels of testosterone and that providing supplemental exogenous testosterone offered no further advantage. However, recent studies show that ARs can be up-regulated by exposure to AAS [37] and that AR number is increased by resistance training [38]. This suggests a possible mechanism by which supraphysiologic doses of AAS combined with exercise might complement each other [32].

It has also been suggested that AASs exert several complementary anabolic actions, including a psychoactive effect on the brain, and stimulation of the growth hormone (GH) and insulin-like growth factor-1 (IGF-1) [32].

### *4.5.2 Misuse in Sports*

In general, the efficacy of AS is commonly misunderstood and overstated in the athletes. Many beliefs are anecdotal at best, and not supported by the medical literature [39].

Results of clinical trials evaluating anabolic steroids are difficult to evaluate because of methodological and dosing differences. Some studies have shown minimal effects on body composition and strength, whereas others have shown that supraphysiologic doses can lead to an increase in fat-free mass and muscle size and strength in humans [27].

In conclusion, there is only limited evidence to support the efficacy of these drugs in athletic performance [39]. Researchers also found that the positive effects reverted slowly toward normal when the drug misuse was stopped [27].

### *4.5.3 Side Effects*

Studying the side effects and health risks of anabolic steroid use in athletes is difficult. Because the drugs are illegal, there is a paucity of well-controlled studies available for review. Nevertheless, a number of studies have investigated the health consequences associated with these drugs and have provided strong evidence of their risks (Table 4.2) [27].

## 4.6 Stimulants

Central nervous system (CNS) stimulants were originally used by athletes to improve performance on the day of competition. They are supposed to have a performance-enhancing effect in explosive power activities (such as combat sports) and endurance events, since the capacity to exercise strenuously is increased and sensitivity to pain is reduced. However, limited scientific evidence is available to prove that stimulants do improve performance [26]. There was evidence that these drugs might be linked with sudden collapse or death. The class of stimulants includes psychomotor stimulants, sympathomimetics, and miscellaneous CNS stimulants (e.g., amphetamines, ephedrines, and cocaine, respectively). In this part, we will discuss regarding amphetamine, as a prototype of stimulants.

**Table 4.2** Adverse effects of androgenic anabolic steroids [1, 32, 33, 35, 39]

| | |
|---|---|
| **Cardiovascular** | **Psychological** |
| Elevated blood pressure (small and transient) | Mood swings |
| Fluid retention | Increased irritability |
| Increased risk of thrombosis | Possible aggression and hostility |
| Increased total cholesterol | Increased libido |
| Increased low-density lipoprotein (LDL) | Depression |
| Decreased high-density lipoprotein (especially HDL2-cholesterol) | Euphoria |
| Erythrocytosis | (Hypo)mania |
| Myocardial hypertrophy | Psychotic episodes |
| Arrhythmia | Antisocial behavior |
| QT dispersion | Muscle dysmorphia (an expression of a form of body dysmorphic disorder) |
| Risk of myocardial infarction | Suicide |
| Risk of sudden death | Paranoia |
| Increased hematocrit | Dependence and/or addiction |
| **Hepatic** | **Musculoskeletal** |
| Elevated liver enzymes (CK, LDH, ALT, AST, GGT) | Premature closure of epiphysis (children) |
| Jaundice | Increased risk of tendon or muscle injury |
| Cholestasis | Bilateral hip osteonecrosis |
| Peliosis hepatic | Rhabdomyolysis |
| Hepatoadenoma | |
| Hepatocellular carcinoma | |
| **Male reproductive system** | **Dermatologic** |
| Abnormal sperm count and morphology (oligo- or azoospermia) | Acne (vulgaris, fulminans) |
| Testicular atrophy | Oily hair and skin |
| Decreased testosterone production | Sebaceous cysts |
| Gynecomastia | Hirsutism |
| Impotence | Androgenetic alopecia |
| Priapism | Edema |
| Prostatic hypertrophy | Coarsening of skin |
| Prostatic carcinoma | Linear keloid formation |
| Infertility (usually transient) | Exacerbations of psoriasis |
| Feminization | Striae |
| **Female reproductive system** | **Endocrine** |
| Menstrual abnormalities and amenorrhea | Decreased glucose tolerance (insulin resistance) |
| Uterine atrophy | Impairment of thyroid function |
| Breast atrophy | Precocious puberty |
| Clitoral enlargement | |
| Hirsutism | **Miscellaneous** |
| Deepening of the voice | Decreased immunoglobulins |
| Virilization | Injection-related problems (bruising, fibrosis, neurovascular injuries, HIV, hepatitis B and C from shared needles, abscesses) |
| Male pattern baldness | Increased risk of malignant tumors (such as Wilms tumor) |
| Decreased LH and FSH | Sleep apnea |

### 4.6.1 Amphetamine

Amphetamine acts mainly by enhancing the brain activity of noradrenaline and dopamine, intensifying psychological sensations of alertness, concentration, and self-confidence. It may lead to an increase in physical energy, mental aptitude, talkativeness, restlessness, excitement, and good humor.

### 4.6.2 Misuse in Sports

Amphetamines enhanced anaerobic performance while having little or no effect on aerobic performance. It may enhance sports performance from a supplemental mental stimulant effect as well as the effects on physical power. It may also improve reaction time when fatigued, increase muscular strength and endurance, increase acceleration, raise lactic acid levels at maximal exercise, increase aerobic endurance capacity, and stimulate metabolism by inducing a loss of body fat.

### 4.6.3 Side Effects

The major side effects include confusion, delirium, sweating, palpitations, dilation of the pupil, and rapid breathing, as well as hypertension, tachycardia, tremors, and muscle and join pain. Long-term administration of amphetamine is associated with myocardial pathology and growth retardation in adolescents. High chronic doses may lead to a variety of persistent personality changes, paranoid delusions, and tactile hallucinations called “amphetamine psychosis.” Use has been associated with tolerance, dependence, and addiction [27, 40].

Side effects of amphetamine are particularly important to athletes. Indeed, amphetamine use may carry significant health risks as evidenced by several sudden deaths in sport. The behavioral side effects are also important in sport. The euphoriant effects of amphetamine have led in misjudgments and major technical fouls [26, 40].

## 4.7 Growth Hormone

Human growth hormone is an endogenous peptide secreted by the anterior pituitary gland to maintain normal growth from birth to adulthood [41].

It is known to have metabolic functions that are generally anabolic, increasing amino acid uptake and protein synthesis, as well as supporting other growth-promoting bodily functions [42].

### 4.7.1 Basic Science

Somatotrope cells secrete human growth hormone (hGH) in a pulsatile fashion [41]. It has a short (about 20 min) half-life [26]. hGH exerts its effects through target cells by binding to specific membrane receptors found in abundance throughout the body. It has both direct and indirect effects on the tissues; the indirect effects are mediated by insulin-like growth factor-1 (IGF-1), which is generated in the liver in response to GH [41]. IGF-1 is responsible for most of the anabolic actions of hGH [26].

### 4.7.2 Misuse in Sports

Human growth hormone (hGH) has been considered as an ergogenic drug since the late 1980s [41]. It is used for its anabolic properties to increase size, strength, or ultimate height, depending upon the age of the user [26].

The effectiveness of hGH in the improvement of sport performance is still under debate among users. Although there are anecdotal reports on the so-called dramatic increases in muscle mass and strength after large doses of hGH, their effectiveness under controlled conditions is generally less significant. There are few controlled studies on the effectiveness of GH on the performance of top-level athletes. The results of most of these studies are generally less impressive than the claims of those who misuse the substance [41]. In most studies, supplementation with hGH did lead to increases in lean body mass, but with further investigation, these increases were noted to be nonmuscular. In a further review, the authors reported that although hGH may lead to an increase in size of a muscle, it is not associated with an increase in strength or performance [42, 43].

There is only one randomized double-blind, placebo-controlled study on the effect of hGH on muscle strength in trained adult athletes. The results of this study showed no difference in strength measures between the hGH-treated and placebo group at the end of the 6-week study period. Lean body mass and body weight were not affected by hGH treatment [44].So, there is no evidence that growth hormone supplementation will lead to an increase in performance [42].

Until the 2004 Olympic Games in Athens, hGH doping was considered undetectable. During these games, for the first time, the direct method was used for its detection [41].

### 4.7.3 Side Effects

Acromegaly is often cited as one of the major risks associated with excessive use of hGH. The major symptoms are swelling of the hands and feet, coarsened facial appearance, dentition problems, arthralgias, fluid retention, and excessive sweating. Side effects also include increased risk for diabetes mellitus and hypertension, water retention, myopathies, osteoporosis, decreased HDL, menstrual irregularities, impotence, and carpal tunnel syndrome [41, 42]. Some of these side effects are reversible after withdrawal of the drug [41].

## 4.8 Diuretics

Diuretics eliminate fluid from the body and are used medically to remove excess fluid in diverse conditions. Athletes might misuse diuretics for three main reasons: to reduce weight in order to meet weight-class limits; to modify the excretion rate of urine, thereby altering urinary concentrations of prohibited drugs; and to overcome fluid retention as a consequence of anabolic steroid use [17, 42]. It has been noted that the manipulation of urine by diuretic use is not considered effective, since detection techniques are too sensitive.

### *4.8.1 Side Effects*

Misuse of diuretics may lead to dehydration, faintness, muscle cramps, headaches, and nausea, and may damage the kidneys and heart [42].

## 4.9 Doping Control

### *4.9.1 The Rationale for Doping Control*

The reasons for drugs being misused by athletes are several and various; however, the justification for controlling the use of drugs was simply explained as "the use of doping agents in sport is both unhealthy and contrary to the ethics of sport."

However, athletes usually display an improper approach to drug taking and either choose to overlook side effects or stack other substances in an attempt to offset side effects.

### *4.9.2 Therapeutic Use Exemption*

The WADA Code permits athletes and their physicians to apply for a therapeutic use exemption (TUE). Through TUE they request consent to use, only for therapeutic purposes, substances, or methods contained on the Prohibited List. A number of criteria must be met before TUE is approved.

1. The athlete would experience a significant impairment to health if the substance or method were to be withheld.

2. The use would produce no additional enhancement to performance other than a return to a state of normal health.
3. There is no reasonable therapeutic alternative.

Clearly, the TUE Committee should face a considerable challenge in applying these criteria.

### 4.9.3 Drug-Testing Process

Discussion regarding the details of doping control process is not in the scope of this chapter. Nevertheless, the general procedures of drug testing in competition is summarized in Fig. 4.2.

### 4.9.4 Roles and Responsibility of Athletes

In the process of doping control, athletes have some roles and responsibilities, including:

- To be knowledgeable of and comply with all applicable anti-doping policies and rules adopted pursuant to the code
- To be available for sample collection
- To take responsibility, in the context of anti-doping, for what they ingest and use
- To inform medical personnel of their obligation not to use prohibited substances and methods and to take responsibility to make sure that any medical treatment received does not violate anti-doping policies and rules adopted pursuant to the code [23]

### 4.9.5 Testing In and Out of Competition

Originally, testing was scheduled within competition only. Athletes participating in an event recognized that they were likely to be selected for testing. To counter this, they began to reschedule their drug use to the training period and to calculate clearance times in the body. The extension of testing to the out-of-competition period was intended to address this trend.

Establishment of the WADA represents a major step forward in the achievement of a worldwide program of out-of-competition testing [26].

### 4.9.6 Sanctions

According to WADA Code, in the case of anti-doping rule violation, athletes may be subject to two forms of sanction: disqualification and ineligibility.

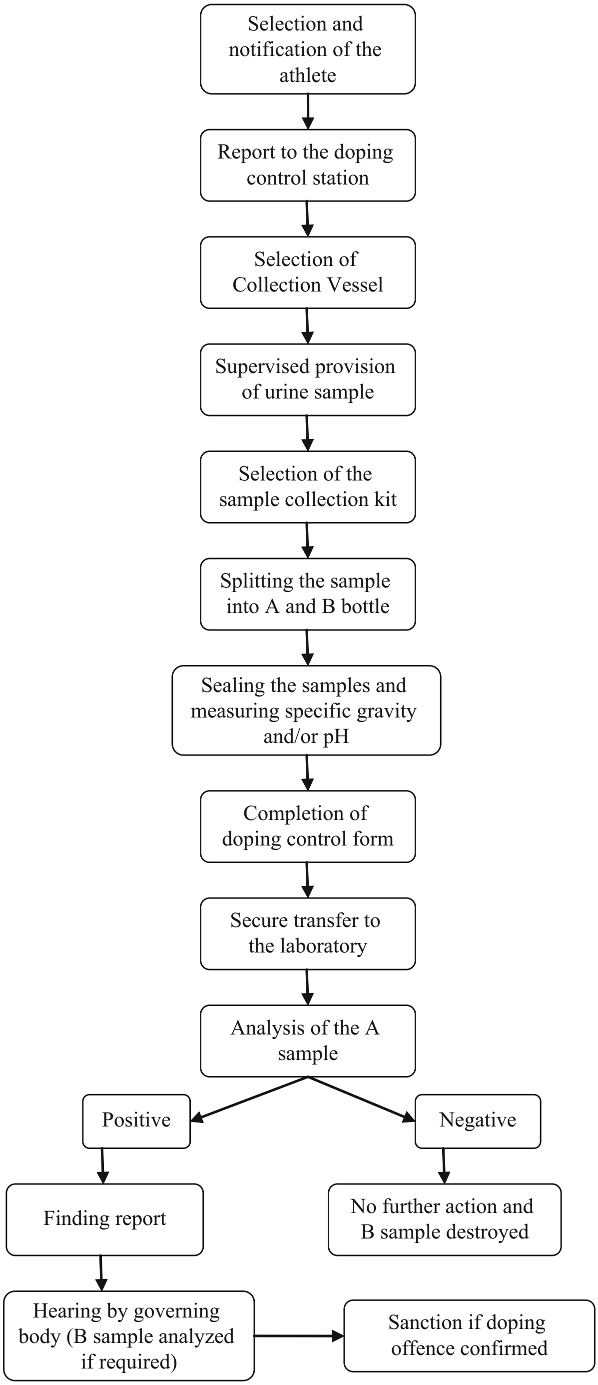


**Fig. 4.2** Flow chart for doping procedures

### 4.9.7 Disqualification

If an anti-doping rule violation occurs during or in connection with a sports event, the ruling body may disqualify the athlete of all individual results obtained at that event with all consequences, including forfeiture of all medals, points, and prizes.

### 4.9.8 Ineligibility

Table 4.3 shows the duration of ineligibility applied to anti-doping rule violations [23].

### 4.9.9 Nutritional Supplements and Potential Risk of Doping

Many athletes use supplements in an attempt to enhance performance without contravening WADA rules. Unlike drugs, nutritional supplements are not required to have scientific and clinical evidence that they are safe and effective before marketing [45].

There may be no legal requirement for manufacturers to list the content of nutritional supplements, and so they frequently make unsubstantiated claims that their products have ergogenic properties, making it difficult for an athlete to conclude whether taking such a product would contravene the doping regulations. There are many preparations that may contain banned drugs [26].

**Table 4.3** The duration of ineligibility in different anti-doping rule violations

| Rule violation | First violation | Second violation | Third violation |
|---|---|---|---|
| Presence of prohibited substance or its metabolites or markers in athlete's specimen | 2 Years | Lifetime | |
| Use of specified substances | Warning and reprimand and no period of ineligibility from future events up to 1 year | 2 Years | Lifetime |
| Use or attempted use of a prohibited substance or method | 2 Years | Lifetime | |
| Refusing or failing to submit to sample collection | 2 Years | Lifetime | |
| Whereabouts violation or missed test | 3 Months up to 2 years | According to the rules of ADO | According to the rules of ADO |
| Tampering with doping control | 2 Years | Lifetime | |
| Possession of prohibited substances and methods | 2 Years | Lifetime | |
| Trafficking in any prohibited substance or method | 4 Years up to lifetime | Lifetime | |
| Administration of prohibited substance or method | 4 Years up to lifetime | Lifetime | |

There are still approximately one in five supplements on sale that are contaminated – whether accidental or deliberate – with products that are not declared on the label [46].

Clearly, athletes take a considerable gamble when using nutritional supplements, because WADA adopts the rule of zero tolerance or strict liability, whereby athletes must take responsibility for what is present in their body, from whatever source [26].

It has been shown that the controls made on the purity of dietary supplements are not sufficient. Authorities and sports federations should be aware of this problem and should dictate new regulations for production, sale, and use of supplements. This is also crucial to inform athletes of the possible contamination of dietary supplements and to prevent the misuse of such products [46].

Athletes and coaches should always know that the use of supplements is completely at their own risk, even if the supplements are claimed to be approved or verified [47].

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# Chapter 5
# Ethical and Social Issues in Combat Sports: Should Combat Sports be Banned?

**Janel Gauthier**

## Learning Objectives

- To explain the concerns of those who are critical of combat sports
- To describe the good and bad points of combat sports
- To recognize myths and realities in the arguments used to oppose or favor combat sports
- To identify the pros and cons of banning versus regulating combat sports

## 5.1 Introduction

Combat sports have a long history. Forms of wrestling and boxing were among the sporting contests featured in the Olympic Games of ancient Greece, and similar sports existed in China over 2,000 years ago. [1–3] Throughout this long history, there has never been any shortage of individuals who wish to test their skills in such sports or of those who are eager to watch such events. [1,4,5]

In modern times, however, there has been growing concern to develop formats of combat sports which minimize the risks to participants, but still allow them to demonstrate their skills and, thereby, provide a thrilling spectacle. In the West, for example, bare-knuckle prizefighting has evolved into modern boxing. Similar reforms have been introduced into Asian combat sports such as Muay Thai, while sporting forms have been developed from ancient martial arts such as fencing, kung fu, and jujitsu. [4–7]

Obviously, the movement toward safer formats for combat sports was not universally supported. Indeed, in the latter half of the twentieth century, new trends emerged. First, practitioners of some relatively safe combat sports (such as traditional karate or taekwon-do) began to develop "full-contact" competition format of

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their art in an effort to test their skills under pressure. [8,9] This led to the development of new combat sports such as kickboxing and full-contact karate, as well as to new sets of rules for combating and competing. Second, following the emergence of full-contact versions of traditional martial arts, other forms of "full-contact" competition were developed which, for example, allow practitioners of striking arts such as karate, boxing, and kung fu to compete on equal terms with practitioners of grappling arts such as judo and wrestling, and vice versa. [10] Generally known as "mixed martial arts," these combat sports take different names (e.g., No Holds Barred – NHB, Vale Tudo – Portuguese for "anything goes," Limited Rules), and are promoted under the auspices of various commercial organizations (e.g., Ultimate Fighting Championship in the USA, Total Fight Forum in the UK). These modern mixed competition formats have attracted considerable negative attention in the mass media, [11] received a mixed reception in the world of martial arts, [10,12,13] and have sometimes been banned altogether by local authorities because they are seen merely as an excuse for violent behavior and a way to effectively legitimate what amounts to little more than street fighting. [14]

Today, combat sports continue to flourish as they have always had. However, they have become a source of intense and heated debates. Combat sports have forceful opponents and proponents. Opponents see them not only as having no value, but also as activities to be banned. Proponents of combat sports view them as healthy forms of competition. This raises the questions of who is right and who is wrong. To answer, one needs to examine what good and what bad, if any, can be found in combat sports. Before engaging in the issue, however, a definition of combat sports must first be made.

## 5.2 Definition of Combat Sports

Combat sports may be defined as sports wherein two individual combatants fight each other using fighting techniques according to a set of prearranged rules. Thus, combat sports differ from other sports as the objective of any contest is for one of the participants to subdue his or her opponent.

There are many forms of combat sports, for example, boxing, sport wrestling, fencing, and mixed martial arts. Different techniques (or variations of techniques) are used in different combat sports to subdue the opponent. These techniques include striking (e.g., boxing, karate, kenpo, Muay Thai, taekwon-do), grappling (e.g., sumo, wrestling), kicking (e.g., kickboxing, Muay Thai, taekwon-do), throwing (e.g., aikido, judo), and weapon use (e.g., fencing, kendo, kobudo).

More importantly, there is considerable variation in the degree of physical contact and level of protective equipment permitted or required in combat sports. No better can we see these variations than in the competition rules. For example, there are some sports in which the use of techniques expected to inflict injury is allowed because the goal of the competition is to cause the opponent to submit by physical and potentially harmful means. This includes professional boxing, full-contact karate, kickboxing, etc. There are other sports in which the use of such techniques is either restricted or prohibited because the goal of the contest has nothing to do with knocking-down or knocking-out the opponent. This would include sumo, judo, wrestling, limited contact taekwon-do, etc.

Sometimes, variations in rules for competitions can also be observed within the same form of combat sports. For example, the World Taekwondo Federation allows full physical contact, and competitors are required to wear protective gear on their head, hands, chest, groin, feet, mouth, and teeth. In contrast, the International Taekwon-Do Federation restricts the amount of force that may be used to hit the opponent, and competitors are not required to wear protective equipment on their head and chest. Likewise, in professional boxing, competitors are not required to wear any headgear. In Olympic boxing, however, such equipment is compulsory.

In a way, given the huge differences in competition rules, it would be fair to say that there are “soft” and “hard” forms of combat sports. It is critical to be cognizant of those differences in any discussion of the “good” and the “bad” of combat sports. Perhaps competitors are more at risk of serious injuries in some combat sports than in others. Perhaps some forms of combat sports are more likely to influence aggressiveness in society. Perhaps some forms of combat sports have greater social value than others. Perhaps some forms of combat sports are more ethically or morally acceptable than others.

Now, I will examine the concerns of those who are critical of combat sports and discuss what good, if any, can be found in relatively safe fighting contests.

## 5.3 The Dark Side of Combat Sports: Myths and Realities

Those who call to ban the practice of martial arts and other combat sports may be divided into three groups:

- First, there are those who believe that any sporting activity that allows (let alone encourages) violent or aggressive behavior is morally wrong and should be discouraged. [15]
- Second, there are those who argue that, if combat sports with relatively few rules are formally sanctioned, their official acceptance will lead to more street or social violence. Those people believe that the rules of combat sports somehow define the limits of the behaviors that will be tolerated in society. [16]
- Third, there are those whose principal objection is to fighting contests that permit techniques (such as blows to the head) which may cause life-threatening injuries or ultimately cause long-term disabilities. [17,18]

Let us examine these three questions separately.

### *5.3.1 The Morality of Combat Sports*

The nature of the violence in combat sports and the rationale that may lie behind it may be difficult to understand for someone who has never been initiated to those sports. To the spectator of a sparring match, all that can be observed is the physical violence. The judgment of the event, whether positive or negative, is then based only upon that. It is difficult for such a person to understand that value is given to what can be learned from the opponent (be it in victory or defeat), and that the opponent is valued and respected, not just physically, but also for their character. [2]

Rightly so, one may wonder whether or not it is morally acceptable to allow (let alone encourage) two opponents to enter a cage or a ring with a clear intent to seriously injure or maim one another in order to win the contest. In Total Fighting, for example, the rules permit any assault except eye-gouging, biting, striking to the groin or throat, or bending back the fingers. Not surprisingly, it has been dubbed the human equivalent of cockfighting. Interestingly, while all states in the USA have legislation banning the practice of cockfighting, mixed martial arts is a legal, regulated sport in at least 20 states (Arizona, Arkansas, California, Colorado, Florida, Georgia, Idaho, Iowa, Louisiana, Massachusetts, Mississippi, Nevada, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Texas, Utah, and Washington), and is unregulated in many others. [14] Some states such as Illinois and Missouri have outlawed mixed martial arts. However, their number is small and may be on the decline. For example, in California, the state governed by Arnold Schwarzenegger, the state athletics commission has recently lifted a ban on mixed martial arts fights. [14] "Mixed martial arts is one of the fastest-growing sports in the country," said Tim Lueckenhoff, national president of the Association of Boxing Commissions (cited in Popiolkowski [19]). "State and tribal commissions are racing to make sure they can regulate it, because it's another revenue source for them."

In my view, combat sport such as Total Fighting is not only barbaric, but also outright immoral. It does not matter if they are mutually consenting adults or if paramedics and medical doctors are always at the ringside. Nothing should ever override the most basic and universal moral principle that involves respecting and caring for others as human beings. I truly understand that there are individuals who may wish to test their skills under more realistic conditions (something more analogous to real self-defence or battle situations), but this does not make it morally acceptable in a civilized world. There are many other ways to be physically challenged, to test one's own physical abilities or to demonstrate one's physical superiority to others. For example, in addition to the traditional martial arts, those include extreme sports (e.g., mountaineering, white-water rafting, sky diving) and embarking on difficult missions (e.g., rescue and peace missions) for the well-being of others.

There are combat sports that do encourage skills and strategies when fighting, while minimizing the risks of physical injuries through limited physical contact or permitting protective equipment, and enforcing strict safety rules. In addition, there are combat sports, such as traditional martial arts, that also emphasize moral character development. Those are morally acceptable. They should not be rounded-up with the other combat sports. For example, taekwon-do competitions sanctioned by the International Taekwon-Do Federation would fall into the category of combat sports that are morally acceptable. So would sumo, judo, jujitsu, and many other traditional martial arts.

### *5.3.2 The Influence of Combat Sports on Social Order*

The question of the relationship between practicing or watching combat sports and the incidence of social or street violence is a difficult one to resolve. However, there is some research that may shed some light on this issue.

*The practicing of sports combats*. It is true that some of the fighters who participate in the bloody and violent unlicenced boxing events, which continue to take place today have records for violent crime, and that spectators at such events may sometimes be hostile to fighters who lack spirit or defeat their favorite fighters. [20] This, however, is arguably more a reflection of the underworld at the extreme margins of society of which unlicenced fighting is a feature, than an inevitable consequence of permitting any kind of limited rules fighting competition. In fact, it may be argued that a sport, which is explicitly a simulation of actual combat and which has clearly defined boundaries is less of a threat to social order than violence that breaks taboos and violates codes of conduct in an uncontrolled manner and without the explicit consent of all involved. [21]

There are no experimentally controlled studies showing that those who practice combat sports may become more violent or aggressive as a result of practicing combat sports. Actually, the available evidence suggests exactly the opposite. For example, Cox[22] reviewed the literature on the martial arts, giving an overview of the personality traits of martial artists. He concluded that the common image of the martial artist portrayed in the movies does not fit the actual profile. Martial artists do not start their studies as more aggressive than the average person, and become less so as they continue their study. They may also become less anxious, more self-confident, and have higher self-esteem as a result of their studies.

Whether or not all combat sports have the potential to produce results such as those observed in martial arts is open to speculation because there are fundamental differences in the teaching of martial arts in comparison with other combat sports. For example, students of traditional martial arts are taught moral values in addition to fighting techniques. Central to these principles is the concept of nonviolence, and the respect for oneself and others. A properly trained martial arts practitioner will do everything possible to avoid a physical confrontation, not only because he knows that such a confrontation is unnecessary, but also because he knows that he has a better than average chance of successfully defending himself and that a physical confrontation is philosophically degrading, as it indicates that all other means of avoidance have failed. Because moral character development is an indivisible part of the study of martial art, martial art practitioners are expected to use their technical skills only for the purpose of doing good deeds. Some martial arts training schools will expel students that misuse their techniques.

It should be noted here that the mechanism whereby traditional martial arts decrease aggressiveness has not been empirically examined. Perhaps the emphasis on teaching moral values and ethics in combat sports does play a role in reducing or eliminating asocial tendencies. Perhaps there are other dimensions of combat sports that are also contributing to those benefits as well. Examples of other dimensions worth investigating would include the challenge to test one's skills against another, the experience of heightened physical and emotional awareness, the reciprocal sharing of acquired skills with an opponent, the challenge to conquer fear, and the experience of transgressing a social taboo (in this case the taboo on aggression and violence). In my view, this question is definitively worth studying, as it may have implications for the understanding and the control of violence and asocial tendencies in society.

*The viewing of combat sports*. The effects of watching combat sports have not been extensively studied. Thus, it is quite difficult to draw clear conclusions. However, the effects of exposure to aggression and violence in the media on spectators have been the focus of many studies, which have been critically reviewed. [23]

Analysis of the scientific literature reveals that a positive correlation between aggressive behavior and the viewing of violence in the media is a consistent finding in the psychological research, a finding that is virtually beyond challenge at the present time. [24] In general, the more persons watch media violence, the more aggressively they behave. However, this finding may be indicative of several different relationships: watching violence may increase the likelihood of subsequent aggressive behavior (an impact effect); aggressive behavior may draw persons to media (an attraction effect); or they may be a vicious cycle of impact and attraction such that media violence causes aggressive behavior and aggressive persons prefer to watch more violence.

While past studies have shown that heavy media-violence viewing may contribute to aggressive behavior in the short term, the most recent research shows that effects can be seen even several years later. For example, in one of those studies, [24] it was found that the more children view violent television programs – particularly ones in which "good" characters perpetrate violence – the more likely they are to behave violently and aggressively as young adults. Those who were found to be particularly prone to violent and aggressive behavior as adults had, as children, viewed large amounts of violent programs, identified with aggressive same-sex television (TV) characters and perceived violent programs as realistic. Of the men who were "heavy viewers" of TV violence as children, 42% reported that they had pushed, grabbed, or shoved their spouses at least once in the last year compared with 22% of men who did not watch violence as children. Nearly 70% of heavy violence viewers reported shoving another person.

To sum up, the literature on the effect of exposure to media violence on aggressive behavior suggests that exposure to television violence does have an effect on violent behavior for some viewers, and that the effect may be long-lasting, particularly if the exposure was massive and happened relatively early in life. For the vast majority of the population, however, exposure to aggression and violence as a passive spectator is generally considered to be of relatively minor significance as a determinant of whether or not they ever exhibit aggressive or violent behavior themselves. [25,26] If this was not a fact, there would be a great deal more aggressive and violent behavior in society because there are large amounts of violent programs broadcasted on television and many viewers of all ages who watch them.

### *5.3.3 The Real Danger of Combat Sports*

Much of the negative coverage of mixed martial arts contests such as No Holds Barred and Limited Rules in the press and on television and radio has referred to fatalities and serious disabling injuries suffered by fighters in poorly supervised events in countries in the former USSR and on semi-underground circuits in the USA [10,18]. While no one wishes to trivialize such incidents, those involved in promoting No Holds Barred and Limited Rules fighting and the like on respectable circuits have repeatedly emphasized that under the rules, which they have devised and uphold, such incidents would be unlikely to occur in events promoted by them.

This is not to say, of course, that there are no risk involved in training for and participating in mixed martial arts competitions such as No Holds Barred and Limited Rules. Actually, nothing would be further from the truth. Recently, a study was conducted in the USA to identify the most salient medical issues associated with No Holds Barred sport fighting. In that study, [27] publicly available video footage of 1,284 men competing in 642 consecutive televised matches from November 1993 to November 2003 was reviewed to determine the reasons for which matches were stopped. Matches were sanctioned by either a USA- or Japan-based mixed martial arts organization. Of the 642 matches, 182 (28.3 ± 3.4%) were stopped because of head impact, 106 (16.5 ± 2.9%) because of musculoskeletal stress, 91 (14.1 ± 2.7%) because of neck choke, 83 (12.9 ± 2.6%) because of miscellaneous trauma, 173 (27.0 ± 3.4%) because of expiration of match time, and seven (1.0 ± 0.8%) because of disqualification, where the values in parentheses are percentages ± 95% confidence interval. Blunt force to the head resulted in the highest proportion of match stoppages. This finding makes it critical to conduct further research to delineate the morbidity associated with participation in No Holds Barred and Limited Rules competition.

The risk of injury exists in other martial arts as well. For example, an investigation based on the statistical data of the sports insurance Gerling-Konzern during a 15-year period in Rhineland Palatinate (1981–1995) revealed that 136 accident protocols were related to martial arts. [28] Listed in hierarchical order, the results were as follows: judo ($n = 47$), karate ($n = 44$), taekwon-do ($n = 9$), jujitsu ($n = 5$), fencing ($n = 1$), and aikido ($n = 1$). However, it is difficult to interpret those results because the number of incidents or accidents may or may not be in relation with the number of practitioners in each form of martial arts. Nevertheless, they do show that the risk of injury is real, and they do raise a question as to whether or not the risk of injury is the same in all martial arts.

Of course, the risk of injury is not limited to martial arts. For example, professional boxing is well known for placing emphasis on deliberately attacking the opponent's head, and the links between punches to the head, permanent brain damage and fatal injuries are established. [29] Furthermore, although it is rarely acknowledged, many professional wrestlers suffer from chronic joint pains, while others have been killed or permanently injured as a result of taking part in professional wrestling matches, which are perhaps one of the most carefully stage-managed forms of sporting entertainment. [30]

It should be noted that the risk of injury is not limited to combat sports. Many sports involve the risk of injury. For example, the movie star Christopher Reeve became paralyzed as the results of a show-jumping accident while many footballers have their careers prematurely ended by leg injuries, [31] and professional cyclists sustain serious injuries and sometimes die in road races such as the Tour de France. [32]

Thus, it would appear that one cannot deny that the risk of injury in combat sports is real. However, the risk of injury may be unevenly distributed across combat sports. Some forms of combat sports seem to involve greater risk for serious disabling injury than others. This would include, for example, mixed martial arts and professional boxing. Furthermore, some forms of combat sports may not involve greater risk of injury than non-combat sports. This would involve mainly traditional martial arts such as taekwon-do, jujitsu, and aikido.

In summary, there are some forms of combat sports that are morally acceptable, and others that are morally unacceptable. Those that are morally acceptable do not constitute a threat to social order, and they do not involve higher risk of fatalities and serious disabling injuries than other socially accepted sports such as American football, rugby, or hockey. Those that are morally unacceptable may not constitute a significant threat to social order, but they do involve higher risk of fatalities and serious disabling injuries than non-combat sports.

## 5.4 The Value of Combat Sports: Myths and Realities

Notwithstanding the violent nature of combat sports such as No Holds Barred and Limited Rules mixed martial arts, "good" can be found in combat sports just like in any other sport. They may not be all the same for all combat sports, and they many not be all equally distributed across combat sports. However, all of them seem to have positive values.

Now, I will examine what good can be found in combat sport training and relatively safe fighting contests. These values are not rank-ordered and, therefore, the order in which they are introduced in no way reflects their importance.

### *5.4.1 Physical Fitness*

Any form of physical activity has the potential to improve physical health and well-being. Combat sport training can be physically demanding and, therefore, can contribute to physical fitness if it is regular, balanced (i.e., respectful of the body's own limits), and strictly regulated with regard to safety so as to limit injuries or strains due to accidents. For example, some studies in martial arts have demonstrated that *katas* – or patterns or forms-based training – can improve aerobic fitness. [33] The practice of combat sports may also help to develop muscular strength, energy, stamina, endurance, flexibility, agility, balance, peripheral vision, and perceptual-motor coordination.

### *5.4.2 Physical Competence*

Physical competence refers to the understanding of one's body and level of control over its actions. To succeed in any sport, there must be a great level of physical competence. Within the arena of combat sports, I would suggest that physical competence has an even greater value at times because of the "imminence of defeat." In tennis, for example, the very first point made does not have the power to finish a match, while the first strike made in a full-contact competition could end it. This means that fighters have to hone their skills to an extremely high level if they do not want to be struck down and defeated two seconds into a match.

### *5.4.3 Self-defence*

In many combat sports, training involves learning powerful techniques of attack and defence. Through regular training, athletes can master those techniques. When they do, they become more able to defend themselves, should they ever be in a situation threatening their physical integrity and, thus, requiring the use of their combat skills.

### *5.4.4 Medium for Self-expression*

Whitaker (cited in Bergmann, [34] p. 38) suggests that "sport provides us with a chance to be different, to express our individuality by placing the personal stamp on our own style of activities … our style of play." A combat sport that would exemplify this would be mixed martial arts, in which competitors fight with their own unique style (e.g., whereas one fighter may be a grappler or a thrower, the other could be a striker or a kicker). Bruce Lee, who is regarded as one of the greatest martial artists of our time, said that "to me, ultimately, martial art means honestly expressing yourself". [35] Translated into competition, a fighter is a person who is communicating with his opponent and the spectators through his way of fighting. Muhammad Ali is an example of expressiveness through sport. Although he was verbally dramatic outside the ring, he was like a silent actor within it, telling a story through his movements.

### 5.4.5 Enjoyable Aesthetics

The physical expression of competitors points to an aesthetic of sport which the spectators have an opportunity to enjoy. In a good fight, just as in a good soccer match, spectators can see the intensity and the passion with which the competitors compete. It is like a dramatic production with only two lead roles and a script that is written as the players make their moves and struggle against each other's opposing forces. No better can we see this drama unfold than in a sport where the struggle is strikingly clear, as each individual endeavours to submit the other in combat – to win in the name of honor and victory.

Another enjoyable aspect of combat sports involves the aesthetic of the techniques used to subdue the opponent and the level of technical competence displayed by each competitor. Great combat skills will be highly admired by those who study or have studied the same form of combat sport as the competitors, and will leave a long-lasting impression on those who have little or no experience with combat sports.

### 5.4.6 Concern for Excellence

The athlete's concern for excellence is another good in combat sport. Athletes involved in combat sport are constantly called to do their utmost when facing the likelihood of injury. There are mixed martial arts fighters who will not give in, but would rather be choked unconscious or fight with a broken arm than submit. In a documentary about Rickson Gracie, a renowned No Holds-Barred fighter, his wife is asked if she is ever scared for her husband. She replies that she knows he is a great fighter, but also knows that he would rather die than give in. Gracie says that this willingness and acceptance of death is necessary for him to do what he does. [36] Although that is not the norm and should not be expected of athletes, in a sport where you can be hurt even on a good day, all athletes are called to achieving personal excellence. For the athletes involved in combat sport, be it full or limited contact, excellence is the result of bringing themselves to a level where they have drawn from themselves all that they possibly can to grasp victory.

### 5.4.7 Human Bonding

It is hard to believe that opponents could experience any human bonding in the ring as they land blow after blow on each other, but the fact of the matter is that bonding can be observed in combat sports. For example, in martial arts competition, it is common to see every fighter embracing their opponent – sometimes with a smile on their face – after the fight is over. Contrary to popular belief, winning is not the sole objective of fighting contests. Value is given to what can be learned from the opponent, be it in victory or defeat. This kind of experience creates strong bonds between opponents. World champion kickboxer Benny Urquidez once said after losing a match, "Of course, I'd like to win all the time … but even when I lose, I win … I learn." [37] At international taekwon-do championships, I regularly observe competitors who exchange their sport outfit (e.g., doboks, sweat shirt) with their opponents after the finals to acknowledge what the other has done, and to bring home a memento of the intense emotional experience they shared together. According to Hyland (cited in Bergmann [34]), this form of human bonding is strongly linked with "striving together" in that the former is a result of the latter.

### *5.4.8 Mental Health and Psychological Well-Being*

Several claims have been made about the positive influence of combat sports on mental health and psychological well-being. Those can be found in all kinds of books, magazines, and ads promoting combat sports and martial arts training. For example, it has been suggested that the practice of combat sports can help to reduce stress, calm and clear the mind, relieve the tensions associated with long hours of work or study, improve sleep, reduce proneness to depression, overcome fear and anxiety, enhance self-esteem and build self-confidence, become more focused in life and more positive in thought and action, improve attention and concentration, and increase academic and work performance. These claims are based mostly on anecdotal evidence. It follows that no definitive statements can be made about the influence of combat sports on mental health and psychological well-being. However, there is an abundance of research literature on the positive influence of exercise on the mind. For example, there are over 100 scientific studies dealing with exercise and depression or exercise and anxiety. Since combat sports training involves much physical exercise, it would be quite appropriate to consider this literature in a discussion of the psychological benefits of combat sports.

When there are several studies on a topic, it is sometimes difficult to interpret the literature because not all of them yield statistically significant results. However, thanks to the appearance of quantitative reviews of the literature, it has become possible to identify some patterns on exercise and mental health. In fact, results derived from large-scale meta-analytic reviews have demonstrated that, for many variables, there is now ample evidence that a definite relationship exists between exercise and improved mental health. [38] This is particularly evident in the case of a reduction of anxiety and depression. For many of the other variables related to mental health, the meta-analyses have shown promising evidence. For example, exercise seems to be beneficial in increasing positive mood, enhancing self-esteem, producing more restful sleep, and helping people recover more quickly from psychosocial stressors. [38] Thus, as long as one considers it appropriate to generalize these findings to combat sports, it may be suggested from a scientific perspective that the practice of combat sports truly has the potential to yield important psychological benefits. Obviously, more research is needed to determine whether this overall relationship is “causal,” and to identify the variables that moderate the overall relationship.

### *5.4.9 Moral Character Building*

Through combat sports training, students come to recognize the reward of hard work and discipline, which often lead to improved academic or work performance in addition to better sport performance. Furthermore, students of traditional martial arts are taught core moral values in addition to fighting techniques. The study of moral culture helps them to develop a stronger sense of ethics and a deeper understanding of moral principles. Central to these principles is the concept of nonviolence, respect for self and others, integrity, honesty, loyalty, courage, perseverance, and patience. Because moral character development is an indivisible part of the study of martial arts, martial arts practitioners are more likely than others to use their technical combat skills only for the purpose of doing good deeds. Likewise, youngsters who have been taught to respect their bodies and minds are less likely to fall prey to using life-endangering substances or engaging in activities that can damage their health.

Moral principles and ethical commitments are needed in situations where ethical duties are clear but the potential cost of doing the right thing is so high that it takes strength of character to overcome the pressures and resist the temptations to do otherwise. Athletes and coaches are continually faced with opportunities to cheat or engage in improper and unsportsmanlike conduct, and there are often great pressures for them to do so to gain a competitive edge. The professionalization and the commercialization of combat sports, particularly mixed martial arts, add to those pressures, and make it more tempting to adopt a winning-at-all costs attitude to fulfill particular obligations.

Like any other sport, competition within the world of combat sport has a tendency of losing its integrity when it comes in contact with the wrong element. Although combat sport should be a place where fighters can learn from one another and strive to excel and express themselves honestly, it can also be a place for brawlers. Some combat sports are more at risk of compromising values than others. In the arena of true No Holds Barred, for example, the lack of rules provides a natural breeding ground for brawlers, whose sole drive is to please themselves by causing others physical pain. However, the whole of combat sports should not be judged by the few who corrupt it.

## 5.5 Conclusions

As stated in the opening of this chapter, combat sports have opponents and proponents, which raises a question as to “Who is right?” or “Who is wrong?” My analysis of the good and the bad of combat sports leads me to the following conclusions:

1. There are some forms of combat sports that are morally acceptable, and others that are morally unacceptable.
2. Those that are morally acceptable do not constitute a threat to social order, and they do not involve higher risk of fatalities and serious disabling injuries than other socially accepted sports such as American football, rugby, or hockey.
3. Those that are morally unacceptable may not constitute a significant threat to social order, but they do involve higher risk of fatalities and serious disabling injuries than non-combat sports.
4. Combat sports training has the potential to yield benefits for the mind and the body.
5. Some of those benefits may be compromised when combat sport comes in contact with the wrong element.
6. Some forms of combat sports may be more at risk than others of losing their integrity.

Thus, proponents and opponents of combative sports are both partly correct and, therefore, both partly incorrect. There are different forms of combat sports, each one with its own rules regarding the degree of physical contact and the level of protective requirement, not to mention its own values and culture. It is important to take those differences into consideration when discussing the pros and cons of combat sports. Combat sports do not consitute a monolithic entity.

## 5.6 A Moral Dilemma: To Ban or Not To Ban

In my analysis, I have seriously questioned the morality of combat sport competitions that allow two opponents to enter a cage or a ring with a clear intent to seriously injure or maim one another in order to win the contest. I have also shown that these forms of combat sports involve higher risk of fatalities and serious disabling injuries than other sports. In my view, both from an ethical and a safety perspective, a question arises as to whether or not some forms of combat sports should be legally banned.

In a society that emphasizes competitiveness, physical strength, and fitness, there will inevitably be young men and women who seek to test themselves in ways that allow them to measure themselves against such ideals. If they are systematically denied such opportunities in legitimate arenas, they may become involved in activities, which are harmful to themselves or others. For this reason, perhaps combat sports should be regarded as part of the solution to the problems of male violence in society, rather than as a phenomenon, which contributes further to those problems. [39]

A civilized society that cares for the well-being of its citizens should not tolerate the practice of any sport involving full physical contact combined with the use of physically harmful techniques and disregard for the safety of its athletes. However, it is not clear that a ban would produce a better state of affairs as a ban may well force the sport underground where the medical controls would be nonexistent, the consequences being much higher health risks to fighters than if the sport had not been legally banned. Apparently, I am not the only one to be concerned about the moral consequences of a ban. In an essay on the legal ban of boxing, Jones [40] expressed similar concerns.

Instead of calling for a ban of specific forms of combat sport, I think it would be better to call for a ban of combat sport practices deemed to be unsafe and ethically unacceptable. For example, the links between punches to the head, permanent brain damage, and fatal injuries are well established. Probably, direct punches or kicks to the head should be forbidden in all combat sports, even when competitors are required to wear protective equipment to prevent fatalities or serious injuries. If all combat sports are regulated so as to ensure the protection and the safety of those who compete, then there will be no need to advocate for any combat sport to be banned.

While reform may appear more desirable than an outright ban, it is not entirely without risk, as reform may well force some combat sport to go underground. However, this risk may be relatively low, low enough to make reform or regulation ethically more acceptable than a ban of any specific form of combat sport. There is so much revenue and profit involved in combat sports that some forms of combat sports are willing to follow much stricter rules to avoid a ban. For example, in mixed martial arts competitions, fighters are now forbidden to headbutt, stomp, or knee an opponent on the ground, strike the throat, spine, or back of the head. In addition, they must fight within a predetermined weight class, and are allowed only one fight per night. All those changes are major, and are implemented with sanctioning.

To conclude, combat sports do raise ethical and safety issues. These issues may be better addressed through regulation or reform than through a legal ban of any form of combat sport deemed to be unacceptable for ethical or safety reasons. In my opinion, this approach is fair in that each combat sport is given the opportunity to review its rules for competition, and is given a chance to operate legally. It also minimizes the risk of forcing a sport underground. A ban should be considered only as a last and ultimate resort when everything else has failed.

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# Chapter 6
# Acute and Chronic Brain Injury in Combat Sports

**Paul McCrory, Tsharni Zazryn, and Peter Cameron**

## Learning Objectives

- To understand the incidence and nature of acute and chronic neurological injury (CNI) in boxing and other combat sports
- To understand the mechanism of neurological injury in combat sports
- To understand the risk factors for these injuries and the strength of published evidence regarding prevention of acute and chronic brain injury

## 6.1 Introduction

Boxing is the physical skill of fighting with the fists and, as a sport, dates from antiquity. It was a component of the Ancient Olympic Games from 644 BC, and was then banned from Roman times until the seventeenth century. The other combat sports, including martial arts, have a similarly long history and a large following worldwide, and are increasing in participation, especially among children and adolescents.

Recently, there has been widespread debate in both the medical and lay press about the neurological risks of boxing and other combat sports, with many calls to ban these sports. This chapter seeks to establish an evidence base for informed decision making regarding the neurological injuries that occur in boxing and other combat sports.

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## 6.2 Injury Rates from Boxing-Specific Studies

To date, only eight studies of boxing have provided estimates of the rates of injury within this sport (see Table 6.1).[1–8]

Despite different methodologies, for professional boxers an overall injury rate of approximately 21–42 injuries per 100 boxers exists, and around one quarter of all fights lead to an injury being sustained. For amateur and military boxing, the injury incidence rate appears to be lower, at approximately 14 injuries per 100 boxers, with another study reporting that almost every amateur will have at least one injury per year.

The majority of boxing injuries were to the head and neck regions (27.1–93.4% of total injuries). With the head and neck being the most commonly injured body regions, it is not surprising that intracranial injury (generally concussion) was the most commonly reported injury type within these studies (8.4–69.7% of total injuries). Reported injury rates and types from training and sparring times, however, are less commonly reported, and should be a priority in future research.[8]

## 6.3 Injury Rates from Martial Arts-Specific Studies

What we know about injury rates among martial arts participants arises primarily from studies of tournament or competition injuries. Some reports from tournaments and competitions were at recreational level; however, most were at national level. The overall injury rates vary depending upon the discipline, with judo reporting 39–104 injuries per 1,000 athlete exposures (13–24 injuries per 100 athletes); karate reporting 50–133 injuries per 1,000 athlete exposures (34–38 injuries per 100 athletes); and taekwondo reporting 34–108 injuries per 1,000 athlete exposures (6–20 injuries per 100 athletes). In almost all studies, the rate of injuries to female participants was higher than that for males.[9–12] The risk of injury in pediatric martial arts has also recently been reviewed, and will not be discussed further here.[12]

In combat sports, concussion accounts for approximately 25% of all injuries at competition level, and male participants sustained approximately three times as many concussions as female participants.[9–12]

## 6.4 Mechanisms of Neurological Injury

The damage that occurs to the head as a result of a blow in boxing is directly proportional to the magnitude and direction of the impact.[13] That is, the force of the impact is dependent upon the velocity of the fist or foot, the mass of the colliding bodies involved, and the mechanical properties of the colliding bodies.[13]

In boxing, head injuries occur due to fist-head contact. In martial arts, contact to the head can be made by a number of striking surfaces (fist, palm, fingers, elbow, knee, foot, etc).

**Table 6.1** Injury rate comparisons in the published boxing literature (Adapted from 83)

| Study | Study design/ data collection methods | Study population | Study period | Exposure | Number of injuries | Injury rates | Comments/limitations |
|---|---|---|---|---|---|---|---|
| Amateur | | | | | | | |
| Welch et al (1986)2 | Prospective monitoring of acute injuries | 2,100 cadets at the US Military Academy, West Point, USA | 2 Years (1983–1985) | 25,305 boxing hours | 294 | 14.0 per 100 boxers or 11.6 per 1,000 h | Only included moderate injuries. Injury rate increased by a factor of 5 during competition |
| Estwanik et al (1989)4 | Prospective monitoring of acute injuries | Active amateur boxers competing in the 1981 and 1982 USA national championships | 2 Tournaments – both lasting 5 days (1981–1982) | 547 Bouts (1,094 personal exposures) | 85 | 77.7 per 1,000 participations | Does not include injuries incurred in bouts that were stopped because of KO or blows to the head |
| Porter & O'Brien (1996)5 | Case series review & cross-sectional study | Active amateur boxers from clubs in Dublin, Ireland | 1. 5 months (1992–1993)<br>2. 4 months (dates not given) | 4,170 man-minutes of active boxing in 281 partial or complete bouts | 1. 64<br>2. 29 | 0.92 per man-hour of competition | |
| Zazryn et al (2006) | Prospective monitoring of acute injuries | 33 Active professionals in Victoria, Australia | 1 Year | 7,772 Boxing hours | 8 | 0.5 per 1,000 h training 1,221.4 per 1,000 h competition | Small numbers of boxers and injuries within study period |
| | | | (2004–2005) | | | 25.0 per 100 fights | |

**Table 6.1** (continued)

| Study | Study design/ data collection methods | Study population | Study period | Exposure | Number of injuries | Injury rates | Comments/limitations |
|---|---|---|---|---|---|---|---|
| Professional | | | | | | | |
| McCown (1959)1 | Medical record review | 11,173 Professional boxers licensed in New York State, USA | 7 Years | Not reported | 2,351 | 21.0 per 100 boxers | No deaths recorded, no boxers revealed punch-drunk syndrome signs |
| Jordan & Campbell (1988)[3] | Medical record review | 906 Professional boxers licenced in New York, USA | 2 Years (1982–1984) | 3,110 Rounds fought | 376 | 41.5 per 100 boxers<br>1.2 per 10 rounds fought | Only acute injuries<br>1 Death recorded in study period |
| Zazryn et al (2003)[6] | Medical record review | Active professional boxers in Victoria, Australia | 16 Years (1985–2001) | 427 Boxing fight participations | 107 | 250.6 per 1,000 fight participations | Data on the number of boxers over the study period was unavailable |
| Bledsoe et al (2005) | Medical record review | Active professional boxers in Nevada, USA | 1.5 Years (2001–2003) | 524 Bouts (5,254 rounds) | 195 | 186.1 per 1,000 fights<br>0.4 per 10 rounds | Limited data on injury types provided |
| Zazryn et al (2006) | Prospective monitoring of acute injuries | 14 active professionals in Victoria, Australia | 1 Year (2004–2005) | 2,949 Boxing hours | 13 | 1.7 per 1,000 h training 1,081.1 per 1,000 h competition 33.3 per 100 fights | Small numbers of boxers and injuries in the study period |

In taekwondo, video analysis studies demonstrate that roundhouse kicks to the head were the most frequent cause of acute concussive injury in tournaments.[9,10]

### 6.4.1 Effect of Glove Weight on Boxing-Related Neurological Injury

The weight of the gloves in boxing can range from 6 to 16 oz (or approximately 171–456 kg). In professional competition, boxers are required to use 8 oz gloves (228 g). These 228 g gloves consist of 114 g of leather and 114 g padding, and similar ratios of leather to padding occur for the different sizes of gloves.

The only scientific method of assessing the effect of glove weight on the impact forces of a blow is through formal biomechanical analysis and only limited studies have been published in this regard. One study measured acceleration using boxing gloves of different weights on a swinging pendulum which represented the striking fist, hitting another pendulum that represented an unrestrained head. The velocity of the 6 oz gloves was found to be approximately 2.7 times greater than that of the 16 oz glove.[13] It was also found that the higher accelerations were present in the last blow of a series of three or four blows.[13] This indicated to the authors that as the elastic material of the glove "fatigued" or "faded," or if a lighter glove was used, a greater acceleration could be achieved and potentially more severe impact forces delivered to an opponent.[13] The impact of this effect during a fight is however yet to be determined, but would provide some evidence for standardizing glove weight and material throughout the world.

### 6.4.2 Effect of Punch Force on Neurological Injury

The force of the punch will also have an effect on the outcome of neurological injury. While difficult to assess during a boxing bout, a number of laboratory-based tests to determine the potential force of punches in boxing and karate have been completed.[14–17] In general, higher skilled and higher weight-class boxers produce greater punch force in this setting.

## 6.5 Head Injuries in Combat Sports

There are three categories of head injuries that can occur to athletes:

- Non-neurological head injury
- Acute neurological injury (ANI)
- Chronic neurological injury (CNI)

The symptoms, etiologies, diagnosis, and severity of each of these types of head injury are different. Each of these head injury categories are considered separately, as the likely preventive measures will also be different.

## 6.6 Non-neurological Head Injury

Non-neurological injuries are those to the head or face region that do not involve injury to the brain. Rather, the nature of non-neurological injuries are often soft-tissue injuries or fractures to the facial, ocular, nasal, auricular, oral, or mandibular regions. While the data on these types of injuries are limited in the literature, due to a concentration on neurological injuries, it would appear that non-neurological head injuries are quite common, with studies reporting that they account for between 28.3% and 82.3% of all injuries to the head region.[2,3,5,6,18] In most cases, these non-neurological injuries appear to be lacerations/open wounds/contusions (37.5–97.5%) or fractures (0.0–55.7%).[2,3,5,6,18]

### *6.6.1 Eye Injuries*

Potentially, the most serious of the non-neurological injuries relate to injuries to the eye and/or orbit. Ophthalmologic injuries have not been specifically studied in combat sports other than boxing. The most common injuries reported in boxing are lacerations around the orbital region resulting from punches to the head, or from head clashes.[6] While it appears that injuries to the eye itself are relatively uncommon, the high amount of impact to this region may lead to problems with vision. Only six published studies have specifically looked at the incidence of injuries to the eyes in boxers and only three of these are prospective studies.[19–23]

The first prospective study of eye injuries in currently active boxers was a case-control study of boxers in New York State.[21] Every seventh boxer that presented for a medical to obtain a licence to box, or to be re-licenced over a 2-year period from 1984 to 1986, was referred for a complete ocular examination. Of the 74 boxers examined (mean age of 25 years), 66% had a minimum of one ocular injury present. Injuries that threatened vision were found in 58% of the boxers.[21] Retinal tears were found in 24% and cataracts in 19% of the boxers, a high prevalence for this age group.[21] No non-boxing-matched control had sustained either of these injuries. The number of retinal tears correlated with the total number of bouts and losses a boxer had.

In another case-control study of 25 active amateurs and 25 approximately age-matched controls, Wedrich et al. found that, while visual acuity was 20/20 or better in all but one of the subjects (a boxer), in 76% of the boxers, pathological findings attributable to contusion trauma were found.[22] This frequency of injury was significantly higher in the boxers when compared to the controls ($p < 0.01$).[22]

The most recent ophthalmological study in boxers was carried out on 75 boxers (45 active, including 44 amateurs; and 30 retired, including 12 amateurs).[23] The results of the examinations confirmed the existence of generally asymptomatic alterations of structures such as the orbital arch, conjunctiva, iris, lens, and retina.[23] While three of the four retinal detachments detected could be attributed to boxing, the older ages (and therefore greater potential for alterations related to age) of the retired boxers (aged 33–70 years) may have influenced the results shown.

## 6.7 Acute Neurological Injuries

Acute neurological injuries have an immediate onset of symptoms. Those in boxing include concussion, various types of intracranial hemorrhage, or diffuse brain swelling. Acute neurological injuries may be associated with transient neurological impairment such as of loss of consciousness, amnesia and/or loss of motor tone.[24,25] The most common acute neurological injury in any sport, including boxing, is concussion.[26]

### *6.7.1 Concussion*

In 2001, the Concussion in Sport Group developed a standardized definition of concussion. This group has defined concussion as a "complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces."[27] It typically results in the onset of a variety of neurological impairments, and these reflect a functional disturbance rather than structural damage. Despite the absence of neuroimaging abnormalities, concussion is associated with stereotyped clinical and neuropsychological symptoms that can be used to identify it.[28]

Currently, there is no grading system for sports-related concussion available, which has been scientifically tested and validated. The Concussion in Sport Consensus recommended that all anecdotal grading schemes be abandoned in favor of individualized measures of cognitive recovery.[27]

In boxing and other combat sports, a concussion may be reported as a medical diagnosis, or may be inferred by a bout ending as a result of a KO, TKO, or the referee stopping the contest as a result of a head injury. For amateur boxers, studies have generally reported the incidence of concussion to be approximately 8.4–18.7% of all injuries,[2,4,18,29] although at least one study has reported a concussion incidence of 51.6%.[5] This same study reported that a concussion occurred in 11.7% of fights.[5] Unpublished data collected by the International Amateur Boxing Association (AIBA) of senior world championship and Olympic fights since 1980 shows a decreasing trend in the number of fights that are ended by KOs, or the referee stopping the contest due to an injury.

In professional boxing, studies indicate that between 15.9% and 69.7% of injuries are concussions.[1,3,6] Two of these studies reported that over half of all reported injuries were concussions, which makes it one of the most commonly reported injuries for professional boxers.[1,3] In other combat sports, concussion accounts for approximately 25% of all injuries at competition level.[9–12] Again, minimal data on concussions occurring during training and sparring times for boxing or any other combat sport have been reported.

### *6.7.2 Acute Fatal Head Injuries*

Deaths during boxing and combat sports do occur, but fortunately fatal injuries appear relatively uncommon,[24] and are relatively uncommon in comparison to other sports.[30]

Information on the number of fatalities attributable to boxing in organized competition can be obtained from a variety of media sources, but are not available from a formal international dataset. In 1998, Ryan published a review of boxing fatalities since World War I, based primarily upon newspaper sources.[31,32] Between January 1918 and January 1, 1997, 659 boxing fatalities were recorded with an average of less than nine fatalities per year over this period.

In the martial arts, small numbers of catastrophic injuries have been reported, but no prospective studies have examined this issue in detail.[33,34]

## 6.8 Chronic Neurological Injuries

The presence of chronic neurological impairment or the "punch-drunk syndrome" is almost the sine qua non of the lay view of a retired boxer. In reality, such states are extraordinarily rare, and the published literature is contradictory in relation to this condition. Sporadic reports of such states in martial arts competitors may be reported,[35] but the diagnostic certainty in many cases is lacking. No large studies of chronic neurological injury in martial arts have been reported to date.

The published boxing literature related to chronic traumatic encephalopathy (CTE) suggests that it occurs only at the extremes of boxing exposure (as was seen in boxing in the nineteenth and early twentieth centuries), or where specific genetic risk factors exist rather than it being an invariable sequelae of current-day boxing participation.

### *6.8.1 Clinical Features of Chronic Traumatic Encephalopathy*

In the early stages of the condition, the clinical syndrome of CTE is a constellation of symptoms due to lesions affecting the cerebellar, pyramidal, and extrapyramidal systems.[36] In the latter stages, cognitive impairment becomes the major neurological feature.[37,38] Throughout the course of the condition, various neuropsychiatric and behavioral symptoms may occur at different times.[39–44] The published clinical evidence does not support the concept that this condition goes through a predictable and sequential series of stages, and only one third of cases are believed to be progressive.[37,39,45] The clinical, radiological, and neurophysiological features of this condition have been recently reviewed elsewhere.[46]

## 6.9 Reported Incidence of CTE in Boxers

There are few prospective epidemiological studies of CTE that enable an estimate of incidence or prevalence in either amateur or professional boxing.[36] The majority of the published studies are anecdotal case reports, which illustrate some of the clinical features of CTE rather than providing data as to the incidence of the condition.

Where studies have provided incidence data of CTE in boxing populations, incidence levels vary considerably. The main reasons for this are that many different definitions of chronic neurological injuries have been used, and many different methods have been used to detect the condition. While published almost 50 years ago, the best estimate of the prevalence of CTE in boxers is a study by Roberts, published in 1969.[39] Roberts randomly sampled 250 retired professional boxers from the total of 16,781 registered with the British Boxing Council for the years 1929–1955. All 250 of these boxers were traced and 224 were able to be studied (16 died, nine emigrated, and one refused to participate). The data collected included information obtained during physical examinations, psychiatric interviews, some

**Table 6.2** Stage of chronic brain injury when screening tests are able to detect neurological injury

| | Stage 1 (fully reversible) | Stage 2 (ranges from reversible/ transient to persistent) | Stage 3 (persistent) | Stage 4 (chronic brain injury – progressive) |
|---|---|---|---|---|
| | Pre-symptomatic stage | Mild stage | Severe stage | |
| Neuropsychological abnormalities | + | ++ | +++ | +++ |
| Neurobehavioral abnormalities | ± | + | ++ | ++ |
| Clinical exam findings | – | + | ++ | ++ |
| Neuroradiological changes | – | – | + | + |

+ Indicates where screening tests would be useful; – indicates where screening tests would not be useful neuropsychological tests, and an electroencephalography (EEG). Severe CTE (defined by multifocal damages to the pyramidal, extrapyramidal, and cerebellar systems) was found in 5% of these boxers.[39] Seventeen percent ($n$ = 37) were classified as having clinically demonstrable lesions of the nervous system, although these could not with any certainty be attributed to boxing participation.[39] Roberts also reported that the severity of the condition was directly related to the length of the boxer's career and the number of bouts they had participated in.[39] The use of this data as a reference point for current-day boxers is limited due to large changes that have occurred in the nature of the sport since this paper was published.

In amateur boxers, Casson et al. conducted a cross-sectional study of 13 retired and five active boxers in the USA.[47] These 18 boxers underwent a neurological examination, an EEG, a computed tomography (CT) scan, and neuropsychological testing. Results indicated that all three of the active amateurs tested had normal results on all but one of the tests (neuropsychological performance).[47] Of the remaining 15 boxers, 87% had abnormal results on at least two of the four tests.[47] The author concluded that this was indicative of CTE.

Compared to professional boxers, amateur boxers show milder neurophysiological and neuroimaging evidence of CTE.[48–52] Reduced exposure to head trauma through shorter bouts, the use of headgear, and the increased padding of gloves used during amateur competition probably account for this difference.[36] However, no formal testing of the effectiveness of protective headgear in boxing has been carried out, and only limited lab-based assessments of the effects of glove weight on punch force have been carried out.[53]

Chronic brain damage has been documented in other sports, and therefore trauma-related brain damage is not a condition unique to boxers.[54,55] Participants of American football, ice hockey, rugby, horse racing, and soccer have all been anecdotally reported in the literature as having CTE.[53,56] Unfortunately, prevalence data of CTE in other sports has not been documented, with reporting limited to case reports only. Therefore, the risk of developing the condition during participation in different activities cannot be determined for comparative purposes.

### *6.9.1 Pathophysiology of CTE*

Surprisingly few detailed reports of neuropathological changes in ex-boxers have been performed.[56–58] There have been a number of individual case reports with varying degrees of clinical and pathological information provided.[59–61] The largest of the pathological studies examined the brains of 15 ex-boxers (including 12 professionals).[56] In this study, Corsellis detailed a number of neuropathological features that have become the sine qua non of CTE in boxing populations. These include:

1. Abnormalities of the septum pellucidum associated with fenestration and forniceal atrophy (potentially associated with behavioral disturbances)
2. Cerebellar and other scarring of the brain (associated with dysarthria and ataxia)

3. Substantia nigral degeneration (associated with Parkinsonian features)
4. Occurrence of neurofibrillary tangles in the cerebral cortex and temporal horn areas[56]

## 6.10 Proposed Genetic Basis for Chronic Neurological Injury

Recent research in both boxing and non-boxing populations with all levels of traumatic brain injury has suggested that adverse outcomes may be associated with the Apolipoprotein E ε4 gene (ApoE4) genotype.[56,62–66] The same genotype may be associated with an increased risk of chronic neurological injury in boxers.[62,63,67]

The Apolipoprotein E ε4 gene is involved in the transportation of lipids used to regenerate neurons, and the repair and construction of new cell membranes, neurites, and synapses.[63,64] In patients with ApoE4, a head injury acts as a trigger for amyloid-γ protein deposits to form.[64,68]

This association requires confirmation in prospective studies before routine ApoE testing could be recommended as a routine pre-participation screening tool in combat sports.

### *6.10.1 Neuroanatomical Evidence of CTE*

#### 6.10.1.1 Radiological Evidence

Modern neuroradiological imaging techniques have been unsuccessful to date in demonstrating any systematic evidence of CTE in boxers. Early anecdotal reports using pneumoencephalography (PEG) and CT scanning have not been validated by newer and more sensitive magnetic resonance (MR) technologies. This subject has been recently reviewed elsewhere,[46] and a discussion of magnetic resonance imaging (MRI) only will be presented here. Common abnormalities assessed at imaging include ventricular enlargement, sulcal enlargement, a cavum septum pellucidum (CSP), and vermian and/or cortical atrophy.

Jordan and Zimmerman found that, while all abnormalities detected by CT were also detected by MRI, there were abnormalities detected by MRI not shown by CT.[69] In this study, 11 boxers had normal findings on both scans, seven had both scans with abnormal findings, and the remaining three boxers had CT scans with “equivocal” findings verified by MRI as artifacts.[18] No analysis with fight records or career, etc. was completed for any of these participants.

Previous to this study, Jordan and Zimmerman had performed MRI on a small sample of nine amateurs with no evidence of any injury apparent in the MRI scans for all boxers.[70] Similarly, Levin et al. did not find any evidence of brain injury on MRI scans in a sample of 13 active boxers (two amateurs, 11 professionals).[71]

Neuropsychological tests were also completed at baseline and again at 6-month follow-up, and again no evidence of brain damage was apparent at either time-point, or when compared to age-matched controls. Other prospective studies have also not demonstrated any MR abnormalities related to boxing.[72,73]

One of the earliest studies using MRI in boxers was by Cabanis et al., who noted abnormalities in 20% of scans.[74] No correlative clinical data were presented, and technical limitations were likely to limit any conclusions that may be drawn from their findings.

A major limitation of all studies using imaging techniques to detect and assess brain injury is that they were all cross-sectional, and it cannot be determined whether any abnormalities present were as a result of or preceded participation in boxing. Further, the findings of studies in young, active boxers, appears to indicate that evidence of neurological damage as a result of boxing in these younger age groups is limited (potentially due to the smaller amounts of exposure experienced by these samples).[70,71]

### 6.10.2 Biochemical Markers of CTE

Three studies have concentrated on measuring the concentrations of particular substrates in the blood before and after an exercise bout. One of the most commonly measured substrates is creatine kinase isoenzyme BB (CK-BB), which is found in high concentration in the brain, but blood levels are normally quite low. The hypothesis was that if higher levels of this substrate were found in the blood after boxing-related activities, it may indicate brain injury through disruption of the blood–brain barrier. Other markers that have been measured include cardiac muscle-specific creatine kinase (CK-MB); neuron-specific enolase (NSE); and *N*-acetylaspartate (NAA) concentrations. When compared to cyclists and oarsmen, serum levels of CK-BB and NSE were significantly increased in boxers after a bout ($p < 0.01$, and $p < 0.02$, respectively).[75,76[ This was shown in one study to be significantly correlated with an increasing number of blows to the head ($p < 0.05$).[75] No elevation in CK-MB levels was found.[76] For NAA concentration, all three boxers' studies showed reductions in the absolution concentration compared with both Parkinson's patients and age-matched controls.[77]

### 6.10.3 Neurophysiological Evidence of CTE

Neurophysiological studies have shown variable results. EEG is commonly used as a diagnostic tool for assessment of brain injury in boxers.[25] EEG assessments, while often used as part of a pre-participation screening tool by boxing authorities, have not been shown to be a consistent measure of boxing-related CTE.[46]

Other neurophysiological measures including, brain electric activity mapping, brainstem auditory-evoked potentials, and P300-evoked responses are usually normal in boxers although only limited studies have been performed to assess these.[48,78]

## 6.11 Relevance of Previously Reported CTE to Modern Boxing Culture

The most important change in boxing since these studies reporting the incidence of CTE in boxers were completed is the exposure experienced by participants.[36,79] In the 1930s–1950s, when many of the boxers reported in these studies were fighting, it was common for boxers to have careers that lasted 10–20 years, often as a result of employment opportunities secondary to the depression. Many boxers had up to 1,000 professional fights, as well as a long amateur career prior to turning professional.[39] In contrast, the majority of boxers in the modern era of boxing have a professional career that lasts less than 10 years, and many will only have one, or two fights per year.[36,80] A recent publication has noted that professional boxing exposure has decreased since the 1930s both in terms of career length (mean of 19 years reduced to 5 years) and bout number (mean of 336 fights to 13 fights).[36]

It was also common during that earlier era for ex-boxers to become sparring partners for other boxers, and/or become tent (booth) boxers at carnivals.[39] Bouts could also be up to 20 rounds, while, in the modern era, 12 rounds are the maximum allowed for any professional fight and four for amateur competition. Furthermore, limited matching of opponents based upon skill or weight, no medical supervision, no mandatory exclusion times following head injury or KOs, and fighting with lighter gloves (6 oz) were also common features of boxing at that time.[36,79]

## 6.12 Available Evidence for Risk Factors for Injuries Resulting from Boxing

Although a wide variety of factors has been suggested as being risk factors for injury (e.g., age at commencement, currently, and at retirement); rapid weight loss prefight; an unprepared or undefended blow; glove weight used, etc.), limited formal evaluation of these factors has been completed, although a number of cross-sectional, retrospective studies have attempted to confirm these as injury risk factors. Given the differences mentioned throughout this chapter in reference to the exposure experienced by modern-day boxers compared to previous eras, the risk factors assessed since 1980 (therefore, including more modern-day boxers) are documented in Tables 6.3 and 6.4. Table 6.3 summarizes the available evidence of risk factors for acute injuries, while Table 6.4 summarizes the current evidence for risk factors for chronic injuries.

**Table 6.3** Summary of available evidence since 1980 for risk factors for acute injury in boxing (Adapted from [83])

| Risk factors for acute non-neurological injury | Evidence |
|---|---|
| Rapid weight loss[16,84] | ± |
| Exposure | |
| training/sparring[2] | – |
| Boxing skill/experience/fighting style[85] | – |
| Risk factors for acute neurological injury | |
| Age[86] | ± |
| Exposure | |
| Number of bouts[5,24,47,48,50,51,73,86–92] | ± |
| Duration of career[5,24,47,48,50,93] | – |
| Training/sparring[2,5,24,51] | – |
| Number of knock-outs[24,93,9]4 | + |
| Boxing skill/experience/fighting style[74,85,88,90,91] | – |

+, Studies that have been completed indicate an increased susceptibility/risk
–, Studies that have been completed indicate there is no evidence of increased risk
±, Conflicting, but possible increased risk or studies in other sports/areas indicate possible risk

**Table 6.4** Summary of available evidence since 1980 for risk factors for chronic injury in boxing (Adapted from [83])

| Risk factors for chronic neurological injury | Evidence |
|---|---|
| Age[24,86,90] | ± |
| Weight class (division)[88] | – |
| Exposure | |
| Number of bouts[5,24,47,48,50,51,73,86,88–92] | ± |
| Duration of career[5,24,47,48,50,93] | – |
| Training/sparring[2,5,24,51] | – |
| Number of knock-outs[24,9495] | + |
| Boxing skill/experience/fighting style[74,85,88,90,91] | – |
| Genetics[68,89] | + |

+, Studies that have been completed indicate an increased susceptibility/risk
–, Studies that have been completed indicate there is no evidence of increased risk
±, Conflicting, but possible increased risk or studies in other sports/areas indicate possible risk

## 6.13 Available Evidence for Risk Factors for Injuries Resulting from Martial Arts

Demonstrated risk factors for overall injury in martial arts include age, gender, body weight, and experience.[12] Suggestions regarding injury countermeasures have been presented, albeit with limited supportive evidence from prospective studies (see Table 6.5).

**Table 6.5** Injury countermeasures in combat sports (Adapted from 83)

| Injury countermeasures for neurological injury | Evidence |
|---|---|
| Education of coaches, athletes, officials[11,33] | ± |
| Minimum standards of referee certification[96,97] | ± |
| Minimum referee experience requirements[98] | ± |
| Reducing head blows[11,33,99] | ± |
| Allowing foot padding and other protective equipment[11,99,100] | ± |

## 6.14 Conclusion

Combat sports are pursuits in which the objectives give rise to a potentially high risk of injury for participants. While the costs and associated impacts of these injuries are largely unknown, at a minimum they can reduce the amount and type of physical activity. Substantial international public and medical debate about boxing and other forms of martial arts is apparent, with many believing that the level of injury risk for participants is unacceptable, at least for boxing.[81]

At present, the injury data held by the various boxing and martial arts authorities worldwide is not sufficiently detailed and/or not in an appropriate form for injury surveillance and prevention purposes as information on the cause of injury is often not documented.[82]

Evidence in the scientific literature for the risk factors associated with the development of both acute and chronic injuries does not exist. Updated and reliable information is thus urgently needed about the risk of both neurological and non-neurological injuries occurring to combat sports participants.[40]

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# Chapter 7
# Blood-Borne Infections in Combat Sports

**Ramin Kordi and W. Angus Wallace**

## Learning Objectives

- To explain different possible pathways of transmission of "blood-borne infections" (BBI) in combat sports
- To explain the risk of transmission of different BBI in combat sports
- To review preventive methods

Blood-borne infections are defined as those infections, which exist in one person's blood and are transmitted to others through blood or body fluids contacts. The prevalent and important BBI, which cause concern in the sports setting, are hepatitis B virus (HBV), hepatitis C virus (HCV), and the human immunodeficiency virus (HIV). BBI are major, global health problems.[1,2] They create important and complex problems for sports medicine practitioners.[3]

Most of those infected with HIV and most chronically infected with HBV and HCV remain asymptomatic for many years. However, these people can transmit BBI through blood or body fluid contact, if their infected blood or body fluids enter another person's blood system.[4]

The contaminating fluids for BBI are blood, vaginal and menstrual fluid, and semen.[2] It is believed that viral BBI cannot be normally transmitted through tears, sweat, urine, sputum, saliva, and respiratory droplets. Therefore, in practice, blood is the most important contaminating fluid likely to transmit BBI in a sports setting.[5] Saliva contaminated with blood, for example, after mouth injury, can be infections.

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## 7.1 Possible Ways of Transmission in Combat Sports

A small number of studies have been published in this field. These are mainly case reports, the opinion of experts, and consensus statements. BBI might be transmitted in different situations related to combat sports as discussed below.

### *7.1.1 Bleeding Injuries*

There is a theoretical risk of BBI being transmitted during sporting activities, from bleeding wounds or exudative skin injury of an infected athlete, to injured skin or mucous membrane of other athletes. It is generally reported that this risk is extremely low.[3,5–9] It is suggested that this risk might be higher in contact and collision sports especially in combat sports.[3,7,10,11] Among combat sports, sports that have prolonged body contact (e.g., wrestling) and those that have high incidence of bleeding injuries (e.g., boxing) might be at higher risk of BBI. This risk in judo is suggested to be moderate and similar to sports such as basketball, soccer, and team handball.[5,11]

### *7.1.2 Human Immunodeficiency Virus*

According to researchers in the Centre for Disease Control and Prevention (USA), the risk of transmission of HIV during sports, except boxing, is small with less than one potential transmission in one million games.[6] This risk is calculated by other researchers to be one transmission in 43 (range 1–85) million games, based on the following factors: (a) the estimated prevalence of HIV among athletes; (b) the risk of percutaneous HIV transmission in the health care setting; and (c) the risk of a bleeding injury in American football.[12,13] However, this calculated risk may still be an overestimate because the risk of HIV transmission has been back-calculated from the risk through needlestick injuries, and this risk is likely to be much greater than the risk that occurs as a result of skin injury in sports.[13]

There is currently no confirmed report of HIV and HCV transmissions during combat sports. However, it might be very difficult to confirm a case of transmission of BBI during a sports activity. Transmission of HIV during bloody street fights has been reported in the literature.[14,15]

HIV cannot be transmitted through normal body contacts such as touching and sharing sports equipments or using facilities such as locker rooms or bathrooms, or by contact with contaminated surfaces such as wrestling mats.[6,8]

### *7.1.3 Hepatitis B Virus*

The concentration of HBV in blood is known to be higher than HIV, and HBV is more stable in the environment. Therefore, the risk of transmission of HBV is 50–100 times higher than HIV.[9,16] HBV is resistant to drying, ambient temperatures, simple detergents, and alcohol, and could be stable on environmental surfaces for at least 7 days.[17,18] Hence, transmission of HBV can occur via inanimate objects (e.g., environmental surfaces).[18] HCV is less likely to be transmitted through environmental contamination with blood containing HCV.[19,20] Therefore, it seems that the risk of transmission of HBV in the sports setting is likely more than the risk for other BBI.

Kashiwagi et al.[21] reported an outbreak of hepatitis B infection within a high school sumo wrestling club. Five of the ten members of the club developed hepatitis B during 1 year. The authors identified an asymptomatic HBV antigen-e (HBeAg)-positive carrier as the source of the infections. They suggested that the HBV was transmitted from the carrier to others through the skin cuts and abrasions caused by wrestling. The wrestlers of that club were known to continue to wrestle even when they were injured and bleeding from skin wounds.

### *7.1.4 Doping and Drug Abuse*

There is a risk of BBI from sharing needles or syringes, which may be associated with drug abuse in sport. No case of transmission of BBI through this method in combat sports has been reported. However, there are some reports of transmission of HIV and HCV from other sports such as bodybuilding and football.[22–26]

Athletes who inject drugs for the first time without planning might be at the higher risk. An athlete may offer to have an injection with a teammate when they do not have another single-use syringe or needle. Therefore, all athletes should be educated about this risk.

BBI can be transmitted via blood doping from transfusion of nonautologous infected blood or blood components. However, this kind of doping is probably uncommon especially in combat sports.

### *7.1.5 Sexual Activity*

BBI (HBV, HIV, and less commonly HCV) can be transmitted through sexual activity. Men who have sex with men and those with multiple sexual partners are at increased risk of these infections.[27,28] There is currently no firm evidence to prove that transmissions of BBI among athletes through sexual activity are more common than for the general population. There is limited literature in this controversial area. However, there are some studies, which have suggested that some high-risk sexual activities might be more common among male athletes compared to nonathletes and athletes may perform more sexual activity[29], less-safe sex[30], have a greater prevalence of sexually transmitted diseases,[31] and have a greater number of sexual partners.[31,30]

### 7.1.6 Traveling

According to the World Health Organization (WHO) "living in regions or traveling to regions with endemic hepatitis are risk factors for the HBV infection."[27] This is because the number of carriers is higher in these regions and high-risk activities are more likely lead to infection. Some athletes, especially at the professional levels, travel regularly to different areas of the world; therefore, these groups of athletes may be at significantly higher risk of contracting BBI.

### 7.1.7 Lack of Trained Health Care Providers

BBI may be transmitted during treatment procedures for a bleeding sports injury from infected athletes to other injured athletes or to the health care providers, for example, though a needlestick. In the same way, coaches, referees, and athletes who perform first aid for bleeding injuries are also at risk. Examples of these situations are when coaches or referees in boxing clean blood from the wounds of injured boxers. Bourliere et al.[32] reported a case of infection of HCV because of sharing a handkerchief to dry the bleeding wounds after a bloody fisticuff. This example of transmission could occur in the sports setting when the first aider is not an "expert." Therefore, all coaches, referees, and athletes should be educated about first aid, infection control, and hygiene.

## 7.2 Prevention

Several position statements and recommendations regarding BBI and sports have been published.[3,5,7,8,33] Prevention of BBI in combat sports setting including a summary of these guidelines is presented below.

### 7.2.1 General Prevention

The main methods of transmission of BBI in athletes are not via sporting activity, but are similar to those for the general population such as unsafe sexual activity and sharing needles.[3,6,34] Therefore, efforts to prevent BBI among athletes should also be focused on the prevention of these "non-sporting" methods.[9,10]

Prevention plans in sexual activity should be focused on the 'ABC' strategy.[35]

(A) **A**bstain and delay sexual initiation
(B) **B**e safer by **B**eing faithful or reducing the number of sexual partners
(C) Use **C**ondoms **C**orrectly and **C**onsistently

Education is the most important task to achieve prevention of BBI. Athletes, their families, health care providers, coaches, and officials should be educated.[3,5,10,36]

### 7.2.2 Prevention of BBI in Combat Sports Setting

The theoretical risk of BBI in combat sports is because of contact with blood and other fluids containing blood. Therefore, prevention in the combat sport setting should focus on prevention of bleeding injury and appropriate management of bleeding injuries and related hygiene measures.[3,5]

### 7.2.2 Prevention of Bleeding

Athletes should use appropriate protective equipment all times. Equipment designed to prevent open wounds should be considered for combat sports such as mouthpieces, which reduce the risk of bleeding and also penetration of another participants skin.[8] Fist padding might decrease the risk of bleeding injuries of the hands caused by contact with the opponents teeth in combat sports such as karate.[37] It is reported that wearing head guards decreases the number of cuts and lacerations.[38] These injuries, which could lead to bleeding, are the most common boxing injuries.[38]

Before starting sports activity, appropriate care for exiting wounds, abrasions, cuts, or weeping wounds is important. These lesions may serve as a source of bleeding or as a port of entry for BBI, and hence should be covered by an appropriate occlusive dressing with respect to the rules and demands of the sports.[3,10]

### 7.2.3 Dealing with Bleeding Injury

During sport activity, any bleeding should be promptly detected by athletes and coaches as well as medical personnel. These people should be aware of this responsibility.[3,10] Athletes with bleeding should be removed from the event when there is a risk of contact with others, as it is often the case in combat sports events. Bleeding must be stopped and the wound should be cleaned by soap and water, or an antiseptic.[3] Wounds must be covered with an occlusive dressing that will remain intact during further play before athletes return to practice or competition.[3,7,8] Minor cuts or abrasions that are not bleeding do not require interruption of play, but can be cleaned and covered during scheduled breaks.[3,7,8]

If bleeding cannot be stopped, the injured athlete must stop competing or training. Regulations about ending the game when bleeding is recurred or cannot be stopped are different among combat sports. The following is an example from the rules of the International Judo Federation:

> [T]he same bleeding injury may be treated by the doctor on two occasions. The third time that the same bleeding injury occurs, the referee, after previous consultation with Judges, shall end the contest for the contestant's own safety and he shall declare the opponent to be the winner by Kiken-gachi. In any case where the bleeding cannot be contained and isolated, the opponent shall be the winner by Kiken-gachi.[39]

However, according to the International Federation of Associated Wrestling Styles (FILA) rules:

> if the laceration is rather severe and the injured competitor cannot be cared for in the two minutes allowed time, the competition should be terminated for this competitor and he or she should be sent to the emergency room.[40]

All health care providers must follow the guidelines of "universal precautions" (search http://www.who.int/en/ for these guidelines). Other persons who deal with bleeding in sports setting such as coaches or referees must follow these principles. For example, "guidelines for bleeding injuries" provided by the Medical Commission of the International Amateur Boxing Association is summarized in Box 7.1. Similar principles should be followed in all combat sports when it is applicable.

**Box 7.1** Infection control guidelines for bleeding injuries provided by Medical Commission of the International Amateur Boxing Association[38]

- *Coaches and referees must use sterile gauze when examining cuts or lacerations. The used gauze should be burned or possibly flushed down a toilet. Sponges, which have been immersed in dirty water or have been on the floor should never be used to wipe the boxer's face.*
- *In the case of bleeding, it is recommended that the referee consult the Medical Jury.*
- *The use of disposable gloves is advisable when examining an injured boxer.*
- *Splashes of blood on the skin should immediately be washed away with soap and water.*
- *Splashes of blood in the eyes or mouth should immediately be rinsed away with plenty of water.*
- *If other surfaces are accidentally contaminated (e.g., the floor of the ring) they should be cleaned with fresh solution of 1 part household bleach to 10 parts water. Such solutions must not come into contact with the skin.*
- *Each boxer must have his own sponge, towel, and clean water.*
- *The practice of wiping the opponent's face after a bout should be discontinued. It is not only unhygienic, but can also lead to serious infection; above all there is the possibility of contracting AIDS.*

Emergency care for life-threatening injuries such as uncontrolled bleeding and mouth-to-mouth resuscitation must not be delayed because gloves or other protective equipment is not available.[3,5,7]

Any organized combat sports activity and organization such as clubs, leagues, or sports associations should adopt appropriate policies and guidelines to appropriately deal with bleeding injuries. Adequate equipment and supplies should be available at each sporting event to comply with "universal precautions" and other related aspects of hygiene.[4,5]

### *7.2.4 Inanimate Objects Contaminated with Blood*

Blood on equipment, clothes, and the sporting area should be considered as potentially infectious for BBI, especially HBV. When equipment and playing areas such as the floor mat are contaminated with blood all visible blood must be cleaned with paper towels or disposable cloths. Then, the area must be disinfected by an appropriate germicide such as a bleach solution containing 1 part bleach in 10 parts of water. This solution must be fresh and prepared daily. The decontaminated equipment or area should be in contact with the bleach solution for at least 30 s. Then, the area should be dried by wiping with a disposable cloth or by air-drying.[3,7]

Blood-contaminated clothes, regardless of the source, must be changed before returning to sports activity.[3,5,8,10] Any clothes and towels soaked with blood should be placed in a plastic bag and washed in hot water and soap or detergent.[3,5,8,10]

### *7.2.5 Vaccination*

Within the abovementioned group of BBI only HBV can be prevented by immunization. HBV vaccine is safe and 95% effective.[17,41] Different immunization strategies have been recommended for different regions of the world because of the different epidemiological patterns of HBV infection. Since 1992, WHO has recommended that all countries should integrate hepatitis B vaccination into their national immunization programs.[17]

Athletes as a group have not yet been categorized as high-risk groups for BBI "to be vaccinated" against HBV.

The International Federation of Sports Medicine (FIMS) and the WHO have suggested that immunization against HBV for athletes is not recommended.[5] Vaccination of combat sports athletes does not address a major public health problem in general population of athletes. However, it might be justified to give personal protection. If the resources are available, athletes of combat sports, especially wrestlers, boxers, and kickboxers, as well as the following groups of athletes should be vaccinated against HBV.[42]

- Non-infected athletes living in regions with endemic hepatitis B
- Athletes who live in low-endemic region and travel frequently to high-endemic regions
- Athletes who practice first aid in the absence of health care providers, including coaches
- Athletes who are suspected of doping (injecting drug abusers)
- Athletes who have other risk factors such as sexual/household contact with infected persons
- Children and adolescents athletes

### *7.2.6 Testing*

The recommendations for testing of athletes for BBI are as follow:

(a) Mandatory testing

According to the statements of the FIMS and WHO, and some other sports medicine associations, mandatory testing or widespread screening of athletes for BBI is not recommended because these tests could not be used effectively for prevention, the costs would be excessive and there are additional legal and ethical issues.[3,5,8] However, some combat sports organizations, such as the International Federation of Associated Wrestling Styles and the International Boxing Federation among other professional boxing organizations, have now regulated that HIV testing is compulsory for participants in their sports. In addition, the International Amateur Boxing Association has recently recommended that an HIV test should be carried out in pre-participation physical examinations.[6,38,43,44]

(b) Voluntary testing

Voluntary testing should be recommended for all high-risk athletes, in the same way as it is offered to nonathletes (e.g., in the case of having multiple sexual partners and sexual contacts with at-risk persons).[3] Knowledge of athletes infected with BBI is helpful for several reasons. Effective treatment can be offered to the infected athletes. Preventive actions can be taken such as modification of patient behavior or HBV vaccination for people who have sexual or household contact with patients.[3,10]

Some legal and ethical issues can arise when a physician knows that an athlete is positive for BBI. This information should be confidential. Specific actions to be taken by the physician will be based on the rules and regulations in each country. However, the joint statements of FIMS and WHO are helpful in this area (see Box 7.2).

Testing for HIV should be encouraged for athletes who may be at risk and should be done for any athlete who specifically requests it.

**Box 7.2** Legal considerations, joint statements of the International Federation of Sports Medicine and the World Health Organization on AIDS and Sports[5]

*Confidentiality dictates that medical information is the property of the patient. Exceptions include medical conditions that are reportable by regulation and statute. Therefore, the responsibility of the physician is very clear. The physician is not liable for failure to warn the uninfected opponent. That legal responsibility lies with the HIV-infected athlete. However, the uninfected athlete must be aware that he or she assumes some of the risk (albeit small) of contacting HIV or other blood-borne pathogen disease in sports activities because it cannot be assumed that his or her competitors are HIV (or other blood-borne pathogen) free. This does not differ from other injuries that are inherent in sports.*

*The responsibility for the sexual transmission of HIV lies with the HIV-infected person. As yet, there has been no legal activity regarding transmission of HIV in sports competition. The physician is advised to be aware of local and federal statues, and regulations concerning confidentiality.*

### *7.2.7 The Infected Athletes*

According to the FIMS and WHO, and some sports medicine associations, the risk of transmission from infected athletes with BBI to other athletes is very low. Therefore, they have stated that, based on risk of infection, most infected athletes with these viral infections should be allowed to participate in all sports.[3,5,7,45] However, it is sensible to recommend to the combat sports athletes who are infected to BBI to change their sports activity to a noncontact sport. It is especially true for sports such as wrestling and boxing with higher risk of bleeding injury or prolonged body contact.

Some combat sports organizations have now passed regulations that athletes infected with HIV can NOT compete in their sports such as those organizations mentioned above who have regulated for mandatory HIV testing. USA Wrestling, the National governing body for wrestling in the USA, also regulated that:

Athletes known to be infected with the HIV/HBV virus cannot compete in any USA Wrestling sanctioned event.[46]

This rule is not similar to the rule of FILA. It seems that the law in each country is also important in this regard. A court in the USA ruled that a karate school was not obligated to accept an HIV-positive teenage boy into its sparring classes.[47] Sports medicine practitioners should be aware of relevant local rules and regulations.

### *7.2.8 Conclusion*

There is a small risk of transmission of BBI in combat sports via bleeding injuries or injection doping with shared needles or syringes. To prevent BBI among athletes, prevention of nonsporting risky behaviors such as unsafe sex and sharing needles and syringes are essential. In the sport setting, prevention of BBI includes prevention of bleeding injury and appropriate management of these injuries. Education is the most important task in prevention.

In sport, the transmission risk of HBV is higher than other BBI. Among combat sports, sports that have prolonged body contact such as wrestling and those that have high incidence of bleeding injuries such as boxing might be at higher risk of BBI. In addition, athletes who live or travel to endemic regions and athletes who are injecting drug abusers are at greater risk of BBI.

Some issues related to BBI in combat sports are controversial such as mandatory testing of athletes for BBI, vaccination of athletes against HBV, and prevention of infected athletes from continuing with their sports involvement.

## Further Reading

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# Chapter 8
# Skin Infections in Combat sports

**B.J. Anderson**

## Learning Objectives

- To realize the types of skin infections that plague contact sports
- To properly diagnose these skin infections and know proper treatment regimens
- To know the length of time these agents are infectious and how to expedite their clearance
- To understand the rationale of preventative measures to reduce their presence and risk of outbreak

By their very nature, contact sports, such as wrestling, martial arts, and football, put participants at risk for skin infections. Contact sports involve close physical contact between opponents, often with sweating, skin abrasions, and continued rubbing of the skin, all of which are factors that increase the likelihood of transfer of an infectious bacterial, fungal, or viral agent.

Over the past few years, there has been an explosive increase of reported outbreaks of various skin infections in contact sports. For example, one outbreak of herpes gladiatorum affected 64 wrestlers and coaches on 19 Minnesota high schools in January 1999.[1] That same month, multiple outbreaks occurred on high school wrestling teams across the country. In 2003, outbreaks of community-associated methicillin-resistant *Staphylococcus aureus* (CA-MRSA) occurred in several collegiate and professional football teams.[2,3] By comparison, skin infections are virtually nonexistent in noncontact sports such as golf or tennis.

With the increased interest in contact sports, the potential for more outbreaks exists. The risk is compounded by a lack of awareness within the medical community about how to control the infections and by athletes who "doctor shop" to get medical approval that allows them to compete with an active infection, disregarding the potential risk of spreading it to competing athletes.

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**Table 8.1** Proper hygienic practices

1. Wash practice clothing, bags, and gear after every practice
2. Shower immediately after every practice and match
3. Refrain from cosmetic shaving, i.e., chest, arms, legs, or pubic regions
4. Wash using liquid soap dispensers, not bar soap; use your own personal hygiene products and do not share them
5. Use own towels and shower before using whirlpools
6. All mats need to be cleaned before every practice and competition
7. Consider multiple cleanings of mat surfaces during tournament play
8. Refrain from walking across the mats with street shoes
9. Consider cleaning shoes before accessing the mat
10. Skin checks every day and before all meets
11. Any skin lesion should be evaluated and treated by your medical provider before any competition
12. Wear clothing to cover arms and legs; consider leggings as part of uniform for competition to reduce skin exposure
13. Maintain continuity in medical care; *statistics support the need for continuity over availability of health care to properly control skin infections*

**Table 8.2** SSTI-organisms and treatment regimens

| Bacterial | Organism | Treatment (for 7-10 days) |
|---|---|---|
| Impetigo, cellulitis, Folliculitis, carbuncle, Furuncle | Staphylococcus aureus Streptococcus pyogenes | Cephalexin 500 mg QID, Clindamycin 300 mg QID[a], TMP/SMX DS BID[a] |
| 'Hot tub' folliculitis | Pseudomonas sp. | Ciprofloxacin 500 mg BID |
| Fungal | Organism | Treatment (for 4-6 weeks) |
| Tinea corporus gladiatorum | Trichophyton tonsurans<br>T. rubrum<br>T. metagrophytes | Terbinafine 250mg QD, Itraconazole 100 mg QD, Fluconazole 150 mg q wk, Topical terbinafine, butenafine, Econazole |
| Viral | Organism | Treatment |
| Herpes Gladiatorum | Herpes Simplex Type 1 and 2 | Primary: Valacyclovir 1 gm BID 7-10 days. Recurrent: 500 mg BID for 7 days. |
| Molluscum contagiousum | Poxviridae | Curettage and Hyfrecator, +/-topical Imiquimod 5%[b] |
| Verrucous warts | Papillomaviruses | Salicylic acid, Cryotherapy, +/-topical Imiquimod 5%[b] |

[a] Preferred treatment with CA-MRSA, but TMP/SMZ will not cover S. pyogenes.
[b]Requires multiple treatments to eradicate.

Two specific occurrences underscore the seriousness of the problem. First, CA-MRSA caught the sporting community by surprise. Several deaths have occurred as a result of public outbreaks of CA-MRSA[4,5] and serious morbidity has occurred in several collegiate and professional players who contracted this infection.[2,6] Second, herpes gladiatorum has caused several wrestlers to develop herpes keratitis, a viral infection on the corneal surface of the eye. With viral reactivation occurring over a time span of 20 or more years, the athlete has a 63% chance of continued corneal involvement, potentially leading to scarring and blindness.[7,8] The legal implications of these incidents could be catastrophic with repercussions that could force society to reevaluate the viability of allowing these sports to continue.

Many infectious agents – bacterial, fungal, and viral – can cause skin and soft tissue infections (SSTI) in contact sports. Any abrasion, cut, or open sore can serve as a portal of entry for these agents to invade the skin. Hygienic principles, including wound cleansing and bandaging, when appropriate, must be followed to help prevent or minimize the spread of infections, as shown in Table 8.1. Failing to do so may increase the risk of these infections to grow and flourish, requiring medical treatment (see Table 8.2).

## 8.1 Bacterial Infections

According to the National Collegiate Athletic Association Injury Surveillance System, bacterial infections are the second most common skin infections (25%) in athletes. Bacterial infections rank behind herpes infection (39%) and just ahead of tinea (23%) as a cause for these athletes to miss practice or competition.[9]

### *8.1.1 Common Bacterial Infections*

*Cellulitis* (Fig. 8.1) is a superficial inflammatory reaction caused by bacterial invasion of staph or strep.[10] When due to *S. aureus*, the reaction is usually localized and accompanied by small follicular involvement or folliculitis. With *Streptococcus*

**Fig. 8.1** Furuncle (boil) with surrounding cellulitis secondary to a *Staphylococcus aureus* infection

*pyogenes*, the invasion can be more diffuse and widespread and usually is not associated with follicular or pustular involvement.

*Impetigo* (Fig. 8.2) is an infection characterized by marked pustules that become crusted and rupture.[9] Impetigo occurs when the skin's natural defenses are bypassed, usually due to an open cut or abrasion. Infection is usually caused by *S. aureus* or *S. pyogenes*.

*Folliculitis* (Fig. 8.3) is a localized inflammation of the hair follicles, with pustular formation in these structures and associated apocrine glands.[10] Typically, due to *S. aureus*, as the infection expands it develops cellulitis in the surrounding tissues. Folliculitis can also occur after exposure to hot tubs, but in those cases the infection is usually due to *Pseudomonas* sp.

*Furuncle* and *Carbuncles* (Fig. 8.1) are deep-seated follicular infections involving not only the apocrine glands, but also the surrounding adipose tissue.[10] A furuncle typically involves a single gland, whereas a carbuncle involves several glands. *S. aureus* is the usual agent, with the inflamed tissue developing an abscess or boil. Systemic signs include surrounding warmth, induration, regional lymphadenopathy, and fever. Treatment usually includes incision and drainage as a means of control.

**Fig. 8.2** Large, weepy, and crusty lesions indicative of impetigo due to *Staphylococcus aureus* infection

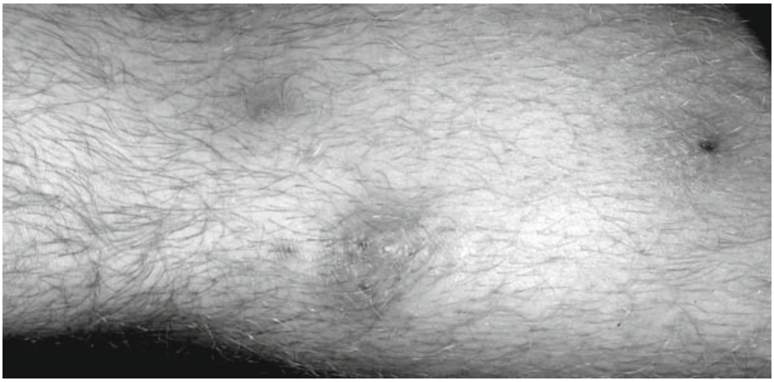

**Fig. 8.3** Folliculitis. Multiple, diffuse sites from infected hair follicles

Over the past several years there has been an increased occurrence of CA-MRSA as the causative agent in SSTI.[11] CA-MRSA currently accounts for 59% of SSTI seen in the emergency room,[12] and has also been more prevalent in contact sports. Infections presenting as a "spider bite" can rapidly progress to an abscess and invade deeper tissues. In fact, one study found that abscess formation was its usual presentation in 59% of the cases, with cellulitis accounting for 42% of cases and folliculitis 7% of cases.[13]

#### 8.1.1.1 Treatment Regimens and Impact on Sports

Treatment for bacterial infections usually requires oral antibiotics (Table 8.2) but with a deep tissue infection, such as furuncle or carbuncle, local debridement may be necessary. Local incision and drainage should be the primary means to control these infectios, with the addition of antibiotics to speed the clearance and help prevent the spread to other competitors. Abscesses should be cultured to ensure that appropriate antibiotics are prescribed. Proper medical judgment is necessary to balance treatment with a regimen that will eradicate the infection and yet allow the athlete to return to competition (RTC) at the earliest possible time.

In general, bacterial infections require a 7–10-day antibiotic regimen for eradication. Individuals may return to competition after 72 h of treatment provided the infection is improving and the areas are covered with bioclusive agents, e.g., Tegaderm. If CA-MRSA is found, the length of time until the athletes can RTC should be lengthened to 10 days, ensure the infection is eradicated. Due to the seriousness of this organism and its consequences, attempts to eradicate any carrier state should be considered. During treatment, intranasal application of mupirocin 2% cream BID and once a day body scrub with chlorhexidine gluconate 4% for the last 5 days of treatment will help to reduce the colonization of these infected individuals.[14,15] Persistent, recurrent CA-MRSA issues should be addressed with local public health departments.

## 8.2 Fungal Infections

The number of fungal skin infections has soared in the past 2 decades among the general population. The dermatophyte *Trichophyton tonsurans* causes most of the mycoses of cutaneous tissue and is responsible for 90% of tinea capitis seen in urban areas.[16] In wrestling, over a 10-year period from 1997 to 2006 at the Minnesota State High School wrestling tournament estimates are that tinea accounted for over 70% of the skin infections.[17] Screening examinations in 2001 found that 35–40% of participants in Japanese Judo Clubs showed signs of this infection.[18]

*Tinea corporis gladiatorum* (TCG) is considered a nuisance issue, yet can be difficult to treat, with eradication costs of medications as high as US$525. TCG usually develops within 3–5 days after direct skin-to-skin contact with an infected opponent, but can also occur with fomite contact. TCG presents as a small, erythematous, vesiculobullous lesion that grows in a circumferential pattern (Fig. 8.4). The outer border may have a flaky appearance with a clearing of the central region. Single lesions can reach up to 8–10 cm in diameter; however, the athlete will generally seek treatment before it reaches that size.

In most cases, TCG infection is superficial, with no deeper skin structures involved. When it becomes more invasive, the scalp is usually involved. Deeper tissue involvement may incite granulomatous development, especially around the hair follicles on the scalp, resulting in alopecia and the classic kerion formation. Pustules with weeping of serosanguinous fluid might also be seen, and regional lymphadenopathy may develop.

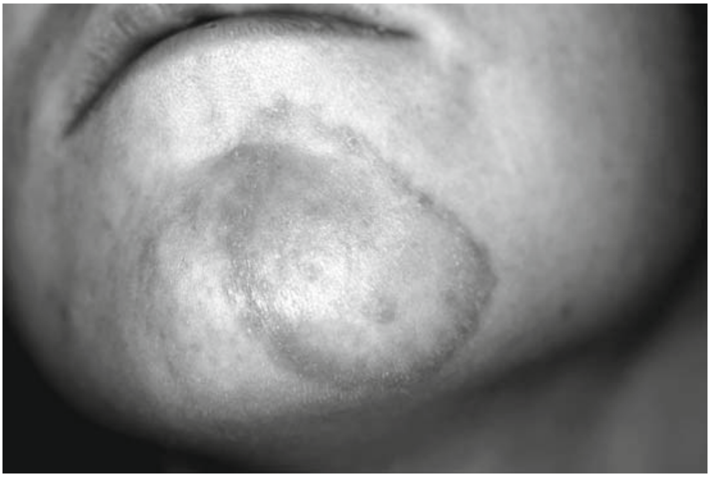

**Fig. 8.4** Surrounding redden, flaky perimeter with a central clearing indicative of tinea corporis gladiatorum

*T. tonsurans* is considered an anthropophilic species[16], i.e., specific to man. However, TCG outbreaks have been documented, in which the dermatophyte was spread from close contact with infected animals.[16,19] An issue of importance for athletes that work in a farming community and possibly contract the agent from a bovine or swine source.

TCG develops primarily on exposed areas of the skin, with preponderance towards the extremities. Most infections can easily be treated with topical agents, but oral agents must be used when lesions occur on the scalp or multiple skin lesions are present. Appropriate duration of treatment for TCG in contact sports has always been in dispute, with attempts to balance the need for the athlete to return to competition with the need to treat long enough to eradicate the fungus. In an earlier study Kohl[20] found culturable fungus present up to 21 days after starting oral antifungal medication.

Before athletes infected with TCG return to competition, the National Collegiate Athletic Association (NCAA)[21] and the National Federation of State High Schools Association (NFHS)[22] recommend the following:

- Athletes should receive 14 days of oral antifungal medication for scalp lesions and 72 h of topical or oral medications for all other lesions.
- Athletes without scalp lesions may RTC if the lesions are covered with a bioclusive agent for the remainder of the 2–4 weeks treatment regimen.
- Athletes with scalp lesions may RTC after 14 days of oral medications provided the scalp is washed with selenium sulfide shampoo before each competition, in order to minimize the sloughing off of fungal spores and reduce their spread.

Preventative measures focus on proper hygiene (Table 8.1), skin checks before competition, and appropriate treatment regimens. When these precautions are followed and outbreaks still occur, additional means of prevention may be needed. The use of skin barriers (e.g., Kenshield, Clear Shield) may be used as part of a hygienic regimen to reduce transmission and contraction of tinea, but one wrestling study showed that its efficacy may be no better than performing daily skin checks.[23] Prophylaxis with oral antifungal medications have been found to be effective in wrestlers and showed minimal adverse affects. In one study of 37 subjects, Hazen and Weil[24] used itraconazole 200 mg twice daily for 1 day every 2 weeks, and observed no occurrences of tinea over 8 weeks. A similar study by Kohl[20] was performed using fluconazole 100 mg daily, in a placebo-controlled study with 131 participants. Tinea developed in 6% of subjects on fluconazole compared to 22% of subjects on placebo ($P < 0.05$).

## 8.3 Viral Infections

*Herpes* prevalence is ubiquitous in humans. Herpes simplex type 1 and 2 are the usual agents transferred in contact sports, with HSV-1 accounting for 94–97% of infections.[25] Ocular involvement can result in significant morbidity, with the risk of herpes keratitis developing with recurrent outbreaks involving the eye. Corneal scarring develops with each outbreak on the cornea, leading to decreased vision and potential corneal transplant.[7,8] More serious, but rare, consequences of herpes infection include retinal necrosis and blindness in the affected eye.[26]

Herpes infection is transferred via direct skin-to-skin contact. The prevalence is estimated to be no different in competitors versus noncompetitors, but the location of outbreaks differs in the two groups.[25] For a noncompetitor, a primary outbreak usually develops around the oro-nasal region and the infection is called herpes labialis (Fig. 8.5). In contact sports, herpes outbreaks are primarily seen on areas of greatest skin-to-skin contact with an opponent. The infection that occurs in wrestling is called herpes gladiatorum, and more than two thirds of infections develop on the head, face, and neck regions.[27]

Primary herpes gladiatorum (Fig. 8.6) typically presents with systemic involvement and diffuse patches of 2 mm vesicles coalesced into groupings of 3–10 lesions. Erythema and warmth surrounding the lesions is common and usually lasts 10–14 days, during which time multiple sites and dermatomes can be involved. As the virus progresses along the sensory neuron, ganglions become infiltrated with the virus. Eventually, one ganglion will become infected and the virus will establish latency. Significant regional lymphadenopathy and multiple site involvement are commonly seen.

**Fig. 8.5** Primary herpes labialis (PHL). Vesicular formation crossing the vermillion border associated with regional adenopathy

**Fig. 8.6** Similar to PHL, but primary herpes gladiatorum has a different yet classic facial involvement

Recurrent outbreaks (Fig. 8.7) typically involve fewer and smaller vesicles, and the outbreak is shorter in duration. Only one ganglion serves as the source for latency and reactivation, and recurrences, usually lasting 5–7 days, will always develop along that ganglion's dermatomal pattern.

Treatment helps to expedite the clearance, but will never eradicate the virus from the nerve ganglion. Outbreaks are usually triggered by weight cutting, rubbing of the area, or stress. Athletes can RTC once there is no new vesicle formation, no new eschar formation and no regional adenopathy. Treatment will shorten the time until clearance, but the above criteria must be met to prevent transmission to an opponent.

Recurrent outbreaks require lower dosage and shorter duration than a primary outbreak. Usually after 120 h of treatment, the outbreak has cleared and the risk of transmission significantly reduced.

The prevalence of HSV-1 is greater than athletes recognize. Estimates in high school wrestlers differ significantly than recognized occurrence. Only 3.3% realize

**Fig. 8.7** Recurrent herpes gladiatorum involving a much smaller area and with less regional involvement

that they are infected, when actually 29.8% are carrying the virus.[25] Since the virus can be transmitted before vesicle formation, these athletes need to be aware that they may be shedding virus and transmitting it to susceptible opponents. Asymptomatic shedding of the virus is considered a significant source of transmission, with estimates that 1–5% of seropositive children and adults asymptomatically shed HSV-1.[28] Once an outbreak occurs in a competitor, the risk of transmission to an opponent may be a high as 30%.[27] With 90% of infected individuals not knowing they have the virus, yearly antibody testing for HSV should be considered for athletes with no history of herpes gladiatorum. That way all individuals who harbor the virus can knowingly be placed on antiviral prophylaxis and reduce the risk of transmission. Obviously, anyone with a known history of herpes gladiatorum should be on prophylactic antiviral medication throughout the competitive season. This author has found that valacyclovir 1 gm QD will reduce recurrent outbreaks in wrestlers to 7.7%, compared to placebo at 24.1%.[29]

*Molluscum contagiosum* is a nuisance infection, derived from the Poxviridae family. Typically, spread via direct skin-to-skin contact, it presents as 2–10-mm dome-shaped papules, often with a central depression (Fig. 8.8). They display no surrounding erythema and appear singularly or in a diffuse pattern. Usual locations are on the anterior chest, neck, arms, and axillary regions, but may also occur on the face. Treatment focuses on curette and hyfrecator for rapid removal. Usage of Imiquimod 5% cream applied topically is an alternative, but requires up to 12–16

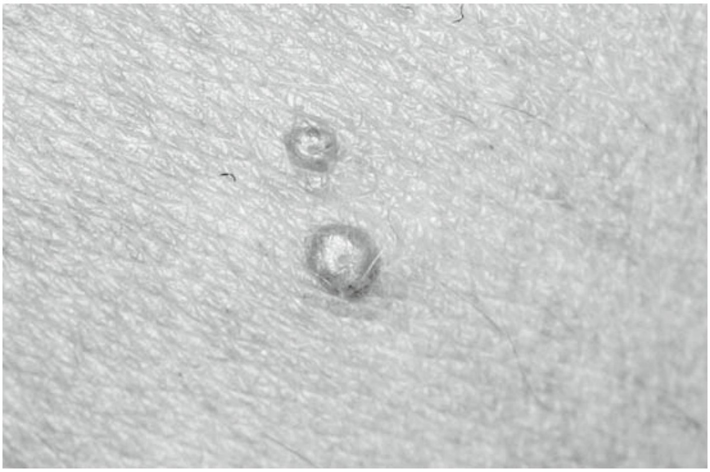

**Fig. 8.8** Molluscum contagiosum. Single lesion with umbilicated center and no surrounding erythema

weeks for resolution.[30,31] With facial involvement, proper discretion on treatment is needed to minimize scarring. RTC can be immediate after treatment, provided proper covering with a bioclusive agent.

*Verrucous warts*, another rather innocuous infection, is due to papillomaviruses. Infection typically involves keratinized surfaces, such as the hands and feet. Other areas include the elbows or knees. Common in childhood, they can spontaneously regress with age. Firm, papular 1–10 mm or larger in size, they may coalesce together or be diffuse in appearance. Lesions typically grow in an exophytic, vegetative fashion. Even though the majority will resolve in time, treatment should be performed to expedite their clearance. Involvement of the dorsal MCP joints renders adjacent skin susceptible to cracking and active bleeding. Treatment should be considered to help minimize the risk of bleeding and exposure to an opponent. Cryotherapy is effective, but requires several months to eradicate. Alternatives include topical imiquimod 5% cream applied each night.[30,32,33] This also requires a lengthy regimen of 12–16 weeks to be effective. Consider covering with bioclusive to prevent blood exposure and the spread of the virus.

At this time the majority of these infectious skin diseases have been evaluated and studied in the sport of wrestling. Due to the nature of these activities and their close physical contact, the principles for control and treatment remain the same. First, maintain proper hygienic practice at all times. When an infection develops, seek assistance from a knowledgeable health care provider that will give continuity of care throughout the season. With treatment, remain out of competition until it is safe and thus prevent transmission to an opponent. In special circumstances, consider pharmaceutical prophylaxis to reduce the spread of a fungal or viral infection.

## 8.4 Summary

Due to the potential seriousness of these infections, routine culturing of carbuncles and furuncles should be performed to determine if CA-MRSA is present.

The lack of recognition and understanding in the medical and athletic communities has allowed herpes gladiatorum to flourish and be commonly misinterpreted as recurrent bacterial folliculitis.

Lack of compliance with treatment is the most significant reason for failure in treating fungal infections.

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# Chapter 9
# Women in Combat Sports

**Charles B. Pasque**

## Learning Objectives

- To develop an understanding of the fundamental illnesses and injuries common to female athletes
- To understand the basic physiologic changes that occur in women during pregnancy and how this may affect their ability to participate in sports
- To learn common injury mechanisms and locations for women in the main combat sports
- To review the basic rules and equipment involved for women in the main combat sports

## 9.1 Introduction

Women's involvement in sport has exploded in the past 20 years in most areas of athletic participation. Sports medicine-related interest has focused largely on the "female athletic triad" of disordered eating, amenorrhea, and osteoporosis[1] and the higher incidence in some sports of anterior cruciate ligament (ACL) knee injuries.[2–6] Combat sports participation by women is an area ripe for both of these topics due to many of the events having weight classification restrictions as well as the inherent physical nature of the sports for all who participate. This chapter briefly reviews some of the different illnesses and injuries that female athletes may be more likely to encounter in combat sports.

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## 9.2 ACL Injuries in Female Athletes

Anterior cruciate ligament injuries are a persistent problem for both men and women who participate in athletics. Although some still debate on whether there is a true difference in the overall ACL injury rates between males and females, most agree that women have higher ACL injury rates than men in certain sports such as basketball and soccer.[2–6] ACL injury can occur due to many different etiologies including both extrinsic and intrinsic factors. Extrinsic factors lie outside of the control of the individual, such as the specific sport being played, environmental conditions such as weather and playing surface, and the equipment allowed for use such as uniform padding, joint braces, and shoe wear. Intrinsic factors include those things inherent to the individual such as skill level, body mass and strength, muscle coordination with certain activities,[7–10] anatomic factors such as intercondylar notch anatomy[5,11] and ligamentous laxity,[9] hormonal influences,[12,13,14], and psychosocial factors[.2] The most common mechanism for noncontact ACL injuries is a planting and pivoting motion, usually during deceleration, landing, or cutting activity.[2,4–6] Combat sports have many situations that can facilitate this type of mechanism such as the common single leg stance kicks found in the martial arts. Contact ACL injuries can also occur in combat sports due to such mechanisms as leg kicks, arm blows, or body blows to the lower extremities seen in the martial arts, and direct contact turning or twisting motions on the lower extremities seen in wrestling and judo.

Prevention of noncontact ACL injuries has focused mainly on jump training and proprioceptive coordination skills.[4,6,7,15] Direct applications to combat sports have not been reported in the literature, but many coaches and trainers have already incorporated the basic concepts of these exercise programs into their conditioning regimens for these athletes. Emphasis has been placed on jump landing or stopping technique, and on sport-specific proprioceptive maneuvers for the lower extremities. The direct benefit in combat sports is unknown at this time, but will hopefully provide positive results similar to those already found in volleyball, basketball, and soccer.[4,6,7,15]

## 9.3 The Female Athletic Triad

Menstrual cycle dysfunction and disordered eating can occur in females participating in any sport, but are more common in endurance, aesthetic, or weight classification sports.[5,16,17] Combat sports incorporate characteristics of all of these types of sports, thus making it a potential area for development of problems such as those found in the female athletic triad, namely disordered eating, amenorrhea, and osteoporosis. Disordered eating is more common in female athletes than the general population, occurring in 15–62% of college female athletes.[5] Disordered eating problems are considered psychiatric disorders with distortion of body image and significant medical and nutritional complications including mortality rates as high as12–18% if not treated.[5] Amenorrhea occurs in 2–5% of the general population and between 1–44% in exercising women.[18] Athletic amenorrhea has many potential etiologies in exercising women including low percent body fat, rapid weight loss, sudden onset of vigorous activity, nutritional deprivation, disordered eating, and psychological and physical stress of athletic competition.[18] The main reason to be concerned about amenorrhea in young female athletes is because of the potential risk of bone loss during the critical growing adolescent years that can result in low peak bone mass and premature osteoporosis. This is especially true when combined with other risk factors such as disordered eating and poor nutrition. Osteoporosis has obvious long-term health implications when the female is older, but also can place the athlete at significant risk for stress fractures while actively competing.[19,20] Common areas for stress fractures include the foot, tibia, fibula, femur, and pelvis.[5]

Once the problems of the athletic female triad have been recognized, proper evaluation and treatment should be instituted. This usually requires a team approach of athletes, parents, coaches, trainers, nutritionists, and multiple medical specialists. A team approach is especially important with disordered eating problems that can require training modifications, nutritional education, psychosocial screening, and even inpatient treatment for more serious cases. For amenorrhea, other causes need to be ruled out, including pregnancy, thyroid disorders, pituitary tumors, or polycystic ovarian syndrome. Hormonal therapy can then be initiated, and can include a 5-day course of synthetic progesterone (Provera 10 mg/day), followed by exercise modification, weight gain, and proper attention to nutrition, stress, sleep, and training practices. If the menstrual cycle does not resume spontaneously in women over 16 years old, combination hormonal replacement therapy such as oral contraceptives may be necessary.[16,18] Since many of the effects of low estrogen on bone mineral density are not completely reversible, team physicians and trainers must have proper screening and prevention programs in place, especially for adolescent athletes.[5,16,21]

## 9.4 Breast Trauma

Trauma to the breast can occur from several different mechanisms. Friction injuries usually result in localized trauma to the nipples and are usually caused by running, especially in men. Management usually consists of local skin care and rest. Prevention consists of lubrication with or without local padding or covering. Repetitive motion problems or “bouncing breasts” can cause diffuse soreness in the breasts and can occur with any activity or sport that requires total body or upper body motion, especially in unsupported breasts. This type of injury can also have the long-term effect of irreversibly stretching the supporting structures of the breast, Cooper’s ligaments. Treatment usually consists of rest and support with prevention usually consisting of a well-fitted sports support bra. Breast reduction surgery may also be necessary in some athletes, especially with associated chronic neck and upper back problems. Although not reported in the literature, blunt trauma is the most likely breast problem to be encountered in combat sports. Previous reports in the literature of blunt breast trauma have been mainly from motor vehicle trauma.[22–24] Direct breast trauma can cause edema, structural damage or distortion, dystrophic calcification, and fat necrosis.[24] Breast asymmetry can also occur, especially with trauma to the developing breast.[25] Acute management of blunt breast trauma consists of ice, elevation, support, and rest. Localized hematomas can be aspirated if needed. Close follow-up with serial examinations, with or without mammography, should be performed based on the clinical presentation. Women with long-standing palpable masses or other abnormalities on physical exam or screening mammography can sometimes present a more difficult situation, since many of them cannot remember a history of trauma. Similar serial follow-up examinations are warranted, with or without biopsy as dictated by the clinical situation. Prevention of blunt trauma includes a well-fitted, well-padded sports bra. Some sports also allow padded breast protectors, with or without hard plastic shells. Strict enforcement of governing rules and regulations prohibiting blows to the breast area must also be a high priority of competition officials.

## 9.5 Pregnancy in Combat Sports

Pregnancy causes a wide variety of changes to the women's body that can alter or affect her ability to participate in exercise and sports. Changes include weight gain and an upward and forward shift in the center of gravity that can result in loss of balance.[26,27] Increased forces across joints and increased ligamentous laxity can result in joint dysfunction or injury.[26,28] Other physiologic changes include decreases in systemic vascular resistance and increases in heart rate, cardiac output, blood volume, respiratory rate, and VO2.[5,26,29–31] Increases in overall caloric needs and fluid intake occur in pregnancy as well, and include specific increased needs for iron, calcium, and folic acid.[5,31,32] Finally, pregnancy results in increases in the basal metabolic rate, and thus increases in heat production. Core temperature can rise if heat production exceeds heat dissipation as can be seen in extreme heat conditions or high-intensity exercise. The potential harm to the fetus from high core temperatures has been documented in animal studies, and suggested in human studies.[31,33–36] The ability to dissipate heat is much more efficient in humans than animals,[37,38] but pregnant athletes still need to make sure they stay well hydrated and avoid extreme temperature environments.[26,39–41]

Pregnancy in actively competing athletes has become a very controversial subject given the many potential issues regarding not only the health of the mother and fetus, but also the medical–legal ramifications for coaches, trainers, physicians, and sponsoring institutions. Many organizations are just now developing policies regarding pregnant athletes given the ever-increasing participation of female athletes later into their pregnancies,[26] and situations such as scholarship collegiate athletes becoming pregnant.[42] Policies or position statements vary, but usually agree that one strict overall guideline or restriction is not practical or necessary, and that the decision to participate should be individualized. Factors to be considered include the type of sport involved, the overall health of the athlete, and the recommendations of the patient's health care provider.[26,43] Many sports medicine providers do not typically practice obstetrics, and thus usually defer to the expertise of the athlete's obstetrician or family practice provider.[5] Other factors include the rules and regulations of the governing body or institution, and specific legal risks of allowing or restricting participation of the pregnant athlete.

The conflict in sports occurs when limits or restrictions are placed on the pregnant athlete based on the type of sport involved, and how far along she is in the pregnancy.[26] In addition to the athlete's individual health and obstetric history, several other general recommendations should be considered by the health care provider. The supine position for exercise after the first trimester is often discouraged due to the relative obstruction of venous return resulting in decreased cardiac output.[5,31,44] Motionless standing results in significant decreases in cardiac output.[45] Other risk factors include extreme environments (hot, cold, altitude, etc.); potential for loss of balance and falls (bicycle, skating, gymnastics, etc.); and potential for blunt abdominal trauma from blows from contact with the opponent or objects (American football, hockey, combat sports).[32,41,44] The latter is controversial, since there are no reports in the literature of adverse injuries to the mother or baby from blunt trauma to a pregnant woman in an athletic situation.[26,46] Most medical reports on blunt trauma to pregnant women are from high-speed motor vehicular trauma or domestic violence.[26,47–49] Low-impact sports are usually permitted for most of the pregnancy and include speed walking, elliptical trainers, stationary bicycling, golf, tennis, and light jogging on a treadmill or other safe surface.[44] Contact sports are usually limited and include such sports as soccer, basketball, volleyball, softball, gymnastics, and snow or water skiing. Collision sports that have a high risk of falls and blunt trauma are almost always prohibited for full participation by pregnant women, especially after the first trimester, and include American football, rugby, hockey, and the combat sports including boxing, wrestling, and the martial arts.[5,44]

Exercise in general is usually considered safe and often encouraged during most pregnancies as long as the athlete and baby's overall medical conditions are stable and there are no major contraindications based on the athlete's obstetric history or sport being played.[26,31,44,50] The PARmed-X for Pregnancy[51] is a good screening tool to provide an exercise prescription and medical clearance form for organized athletic participation.[44] Exercise every day that includes 30 min of moderate-level activity has multiple benefits, including avoidance of excess weight gain, improved overall balance and flexibility, decreased back pain, increased endurance and strength, and improved postpartum recovery.[5,44] Exercise beyond 30 min may result in thermoregulatory complications, and should thus be carefully monitored.[35] Using training heart rate guidelines from nonpregnant females for pregnant females is generally unreliable: although there is an average increase of 10–15 beats per minute in the resting heart rate in pregnancy, there is a blunted heart rate response at maximal exercise levels.[44] Modified heart rate scales for pregnancy are available,[51] but maternal symptoms are usually recommended for monitoring and modifying exercise regimens using, for example, a perceived exertion scale.[52] The original 6–20-point scale and the new modified 10-point Borg scale allow for maternal variations in heart rate and symptoms. Typical recommendations allowing for maximal benefit include ratings of 12–14/16 or 3–5/10.[44] Competitive athletes that are trying to maintain the same level of exercise during pregnancy need to be warned that their bodies will begin to react differently. Overall coordination will be affected, including a progressive decrease in the ability to stop, start, and change direction, as well as decreased ability for finely tuned skill movements.[31] Endurance may also be affected due to the many physiologic changes to the cardiovascular system previously mentioned, and the physiological anemia resulting from increased blood volume during pregnancy.

Return to exercise and sport after pregnancy is also an important area of education for both athletes and health care provides. Many of the physiologic changes previously mentioned are present for 4–6 weeks after pregnancy, thus still presenting the same potential risks to the female athlete. Breast-feeding mothers should breast-feed prior to exercise to avoid the discomfort of activity with engorged breasts[39,44] and to decrease the potential for higher acidity in the breast milk due to lactic acid buildup.[31,44] A gradual return to exercise is encouraged, and should be based on the athlete's overall fitness and medical condition.[32] The importance of returning to exercise continues to be a foundational recommendation for improving overall postpartum health since the benefits far outweigh the risks, especially regarding loss of excess weight that can otherwise become a permanent problem for the female the rest of her life.[50·53–55]

## 9.6 Martial Arts

Martial arts participation by women has a longer history than any of the other combat sports. Female participation has markedly increased over the past 20 years mainly for increased fitness and self-defense purposes. Although many martial arts participants never actually participate in tournament competition, there is still significant injury risk during training and practice. The most common martial art forms practiced worldwide are taekwondo, karate, and judo. Other popular forms include aikido, kung fu, wushu, and Tai chi. Most injury studies on martial arts are retrospective, and thus rely on athlete recall of the number, type, and circumstances surrounding previous injuries. Relying on injury recall as well as the inherent strong will of martial arts participants to "play hurt" has resulted in probable underreporting of injuries.[56]

Taekwondo has been shown in a martial arts comparative study to have the highest risk of injury, and the highest risk for multiple injuries in the same athlete.[57] The same study also noted no differences in the overall rate or severity of injury between males and females. They suggested that earlier studies that found higher injury risk in males[58–61] were due to the higher rates of sparring in tournaments for men. Tournament sparring had been shown to be the main cause of injuries in taekwondo,[62] and thus would explain the earlier higher rates in men. Women now are more involved in tournament sparring, thus accounting for the now similar or higher injury rates compared to men.[63]

Preventive measures are very important in the combat sports of martial arts. Taekwondo, which typically has the highest injury rates, also is one of the only martial art forms that consistently requires protective equipment.[57] Competitors are required to use head gear, chest protectors, groin protectors, shin pads, hand and foot padding, and mouth guards. The equipment often protects the offensive athlete, but is less effective in protecting the defensive athlete receiving the blows.[58,60,64] Equipment use in pre-competition practices, however, has been shown to be very inconsistent.[65] Competitors used shin pads (92.9%) and chest protectors (78.6%) most of the time, but were less likely to use other equipment such as headgear and elbow pads (57.1%), shoes (35.7%), mouth guards (14.3), instep pads (10.7%), and gloves (3.6%). The only other martial art sport that consistently requires equipment of any kind is karate. Karate competitions usually require mouth guards and occasionally sparring gloves.

The remainder of the martial art forms typically do not require equipment. Teaching athletes improved blocking skills or evasive maneuvers can help decrease the number of injuries. The addition of padded floor mats to most types of martial art forms has also helped decrease the number of injuries, especially in the throwing forms such as Judo.

Other injury-preventive measures concern rule changes and strict enforcement of the rule changes.[66,67] Traditional taekwondo emphasizes fast and powerful kicks with a high potential for injury. Many taekwondo competitions now prohibit any blows to the head and neck, or limit to light contact any blows to the head, face, neck, and groin.[57,66,68] Light contact is usually limited to above the belt and anterior to the coronal plane.[66] In addition, some competitions allow kicks to the head, but no punches to the head.[69] Burke et al. felt that these rule changes in taekwondo significantly reduced the overall number and severity of injuries in a wide age group compared to previous studies that had included mainly elite athletes.[66] Another rule change example is the martial art form of shotokan karate, which emphasizes controlled technique kicks that pull back just short of the head, with lighter contact allowed to the body. Rule changes are only effective if strictly enforced by the governing bodies and competition officials. Having trained medical personnel on site who have the jurisdiction to stop competition when rules are not followed or athletes are being injured is also another means of protecting the athletes.[66]

Injury types for martial arts sports are fairly intuitive, as bruises or contusions are largely the main type of injury,[57–59,66,70–72] usually followed by sprains and strains,[64,65,69,73,74] epistaxis,[66,72] and concussions.[59,75] Fractures are not very common, and have similar occurrence rates in five different types of martial arts.[57] Kazemi et al. found fractures and concussions to be more common in elite participants due to their higher skill levels and more intense competitions.[69]

Studies reporting specifically female injuries also found contusions the most common injury type in taekwondo, and abrasions the most common in judo.[69] Pieter also agreed that contusions were the most common injury, but found that epistaxis was second in women compared to lacerations in men.[72]

The body location of injuries in martial arts varies with the different forms and with the rules used. Zetaruk et al. found that most injuries in taekwondo (31%) and aikido (32%) occurred around the head and neck area.[57] Only 10% of the injuries in karate occurred in this area, but karate accounted for the only concussion found among all types of martial arts.[57] Other studies on taekwondo[58,64,66,76–78] and karate[72,79] have also found the head and neck area to be the most common location for injury, with poor blocking and evasive maneuvers noted as a potential cause.[76] More emphasis on defensive technique has been cited as a cause of fewer head and neck injuries, as well as the implementation of new rules that prohibit or limit blows to the head in taekwondo and karate competition.[67] In addition to the head and neck, other common areas of injury have been to the lower limb in taekwondo,[58,59,65,69,70] and the upper limb in judo.[73,80] Martial arts studies specifically reporting on women have shown a higher incidence of injuries to the foot, especially the instep in taekwondo,[58,59,61,69] and the upper extremity in judo.[73,74] There is a higher incidence of concussions in taekwondo in males versus females (7.04 vs 2.42/1,000 exposures), with the dominant mechanism being receiving a blow.[81] At least in karate, the rates of injury to the head and neck between males and females are very similar.[72] Many believe that the more similar locations of injury between males and females now seen in martial arts are the results of the new rules prohibiting or limiting blows to dangerous areas such as the head and neck, and the increased participation of females in competitions.

The mechanism of injury in martial arts has also been studied in several sports. As expected, delivering or receiving a kick,[58,63,69] especially a roundhouse kick[59,61,69,70] is a common mechanism of injury in taekwondo. Participant contact is the most common mechanism of injury in taekwondo (61%), followed by falls (30%) and twisting injuries (3%).[66] In karate, punching is the most common mechanism of injury, also explaining why there are more injuries to the head and neck in this sport.[69] Comparing women to men, one study showed that the women's most common mechanism of injury in taekwondo was delivering a blow, especially to the elbow area as well as receiving kicks, especially knee kicks.[69] Findings such as these have resulted in rule changes to decrease injuries, specifically increased padding on the athlete and the floor, and increased limitation of blows to hazardous areas such as the head and neck.

## 9.7 Boxing

Unlike the martial arts sports, women's widespread involvement in the sport of boxing is relatively new. Male boxing has had a steady decline in public interest from fewer overall individual boxers, less media interest from the lack of interesting personalities, increasing stigma due to medical safety concerns,[82,83] and increasing pressure from promoters and venues to make it more exciting to compete with growing sports such as mixed martial arts. The involvement of women at the professional level initially began as a promotional attraction for male boxing events. This has resulted in many inexperienced female boxers being rushed through their amateur or professional bout training period to fill spots in higher profile fight cards.[84] The end result has been some severe mismatches in boxer quality, thus raising concerns for increased injury risk. The more widespread interest in women's boxing has partially resulted from the "boxing-based" exercise boom. Boxing as exercise has become more popular for both women and men due to health club fitness programs and fitness videos. As a result of this exercise industry boxing focus and the increased media coverage of women's professional boxing, female boxing participation is growing: USA Boxing women's membership has grown from 340 in 1996 to over 750 in 2006.[85]

Injury-preventive measures have been in place for quite some time for male boxers, especially in the amateur ranks. Almost all boxing associations require amateurs to wear protective headgear and genitalia padding as well as lighter 10–12 oz gloves.[86] Bouts usually consist of shorter rounds (2 min or less) and less rounds (three or less). The gloves are often marked on the end to designate the only areas where punches can be scored, emphasizing boxing technique over brawling. Some boxing governing bodies have been proactive in providing a safer environment specifically for female boxers, especially mandating shorter and fewer rounds. Another example is the Italian Boxing Federation, which has a strict set of criteria for participation, including passing a pre-participation physical as well as pre-competition and post-competition medical examinations focusing on the breast, abdomen, and pelvis.[87] USA Boxing recommends annual physical examinations to help monitor and identify any serious medical conditions.[86] Other common rules include limiting or prohibiting punches to the breast and pelvic area, and strict follow-up after knock downs or knockouts (KO).

The overall risk of injury in female boxing compared to their male counterparts has been reported as being similar[87] or less.[88] Males typically have more matches end in knockouts (KO) or technical knockouts (TKO), and thus are more likely to sustain head trauma.[88–90] A case report on a large subdural hematoma in a female boxer emphasized that coaches and trainers should be very careful when allowing males to spar or compete with females, as this may increase the risk of head trauma, even with protective headgear in place.[84] USA Boxing only allows male versus male and female versus female competition in sanctioned amateur events.[86] The remainder of injury types for females in boxing are very similar to males, and include facial contusions or lacerations, epistaxis, hand and wrist injuries, and eye injuries. Breast and pelvic trauma and menstrual abnormalities have been reported as absent or low in the few studies to date on female boxing,[87,88] possibly at least in part as a result of the protective rule changes and equipment, as well as the close monitoring by the boxing governing bodies.

Medical coverage for female boxing requires a thorough knowledge of the governing body rules, and the ability to care for mainly facial, head, and upper extremity trauma. USA Boxing restricts any female boxer from participation who has a confirmed pregnancy, painful pelvic disease such as endometriosis, abnormal vaginal bleeding of unknown etiology, recent secondary amenorrhea of unknown etiology, recent breast bleeding, recently discovered breast masses, recent breast dysfunction not previously present, and the presence of surgical breast implants.[86] Other rules specific to females include required or recommended protective equipment such as pelvic and breast paddings,[86] and rules limiting blows to these areas. Breast protectors must be well fitted, and cannot extend below the xyphoid process inferiorly and above the clavicle superiorly. Headgear and mouthpieces are also required for females, even sometimes at the professional level. Pre-competition and post-competition menses history, and pelvic and breast examinations are also often required. The remainder of medical care for female boxers is similar to males, and includes facial abrasion/laceration care, epistaxis care, and a systematic way to evaluate head trauma such as the Standardized Assessment of Concussion ("SAC")[91] or use of a concussion grading system.[92–94] Return to play criteria regarding head trauma is controversial, but may also be regulated by the governing body with minimum time period restrictions after concussions that must be strictly adhered to. When in doubt, medical care providers should err on the side of caution with head trauma to avoid second impact syndrome.

## 9.8 Wrestling

Female wrestling is growing in popularity, especially with the addition of four female weight classes in Olympic international competition and the increased prevalence of female wrestling teams and clubs at the collegiate level. Many younger female wrestlers continue to participate in predominantly male competitions as well as in more prevalent competitions for women only at the junior high, high school, and collegiate level. The National Federation of State High School Associations in the USA reported that, during 2004–2005, there were 4,334 girls participating in high school wrestling with total overall male and female participants numbering 243,009.[95] Many states are boasting their first ever female state high school champions or placers, especially in the lighter weights. Given this recent increase in female wrestler participation and success, medical care providers must be familiar with the rules and injuries specific to females.

For high school wrestling and below, there are several minor equipment and rule modifications, especially with co-ed participation. Weight certifications allow for a minimum body fat of 12% for females versus 7% for males. Females usually weigh-in dressed in their wrestling singlet, but can also request separate weigh-in facilities away from the males. Hair is required to be no longer than collar length or must be enclosed in a scalp cap and headgear combination without any metal clips. Females postpuberty are also recommended to wear "sports bras" or some other type of padded and supportive undergarments. No metal jewellery of any kind is permitted and no underwire bras. Female competitors are also encouraged to participate in female singlets with high arm pits and avoid male singlets with T-shirts underneath them. Regarding actual competition rules, competitors are not allowed to grab or punch the female breast area or the male or female genitalia area. Violations of these rules can result in penalty points or disqualification from the match or tournament. The remainder of the rules are similar to males.

Injuries to female wrestlers alone have not been reported in the peer-reviewed literature. Most reports have included various male wrestler populations.[96–99] Common injuries for both male and female wrestlers include shoulder strains or contusions, knee ligament sprains or cartilage tears, ankle sprains, and head or facial trauma. Catastrophic injuries such as cervical and lumbar fractures and severe head trauma are rare, and have only been reported in male athletes.[100] Breast or pelvic trauma to females has not been reported in the wrestling literature.

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# Chapter 10
# Children in Combat Sports

**Merrilee Zetaruk**

## Learning Objectives

- To understand the benefits of participation in combat sports in childhood
- To place the risks of participation in combat sports within the context of other popular youth sports
- To recognize injuries in combat sports that are unique to children
- To understand the effects of chronic medical conditions on participation in combat sports and to recognize conditions that preclude or limit participation

Participation of children in the martial arts, which constitute a substantial proportion of combat sports, has increased markedly over the past decade. Between 2000 and 2004, participation of children in martial arts increased 28.2%, with an estimated 6.5 million children in the USA involved in 2004.[1] In some regions, enrollment of children in specific martial arts such as karate has more than doubled over the past decade, while other styles such as judo have maintained an estimated 75% representation by children under 15 years of age (Sport Manitoba and Judo Canada, personal communications 2007). Children are often exposed to the martial arts through entertainment media,[2] with surges in enrollment following the release of popular martial arts films.

Parents have their own reasons to encourage their children to participate in martial arts. Increasing violence in society that manifests itself in the news, movies, video games, and even at school through bullying, makes the self-defense aspect of martial arts appealing to parents. The discipline in training, which in many schools may have a militaristic quality, attracts parents who wish to modify behavior in their children. Traditional martial arts incorporate a strong element of respect in training (Fig. 10.1), which parents may feel would be beneficial in daily life as well. With a recent push to increase regular physical activity against the growing epidemic of childhood obesity, parents may feel that martial arts participation will address this issue.

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**Fig. 10.1** Bowing to show respect to opponents is an integral part of traditional martial arts training

## 10.1 Types of Combat Sports for Children

Marked differences exist in the myriad of activities that comprise the "combat sports." Some martial arts, such as Olympic-style taekwondo, kyokushinkai karate, and muay thai kickboxing involve full body contact, and protective gear is frequently worn to prevent injury.[3] On the other hand, Shotokan karate and many kung-fu (wushu) styles are considered "noncontact" or "light-contact," where blows are controlled to within millimeters of the target. Martial arts such as judo and aikido involve throwing techniques or joint locks ("throwing styles"), while others such as karate, taekwondo, kung-fu, and muay thai kickboxing rely predominantly on kicks, punches, and blocking techniques ("striking styles").

Martial arts can be further categorized as "traditional" or "modern." In some martial arts, the rich tradition and heritage of the style are respected in the dojo or practice area. Bowing to instructors and opponents is deemed essential, and etiquette within the dojo is strictly enforced. Learning traditional principles, such as avoiding violent behavior and respecting others, is as important as acquisition of specific techniques in many traditional martial arts. "Modern" martial arts do not adhere to the traditional training and philosophy of a single style. Rather, they may incorporate fighting techniques from various styles to optimize the chances of success in a real-life fight. Traditional training drills such as basic techniques and katas may be absent from training in modern martial arts.[4]

Many styles have evolved to incorporate a more competitive aspect, transforming these martial arts into sports. Judo has been an Olympic sport since 1964, and taekwondo was first introduced as a demonstration sport at the Seoul Olympics in 1988. Karate, while not an Olympic sport, holds tournaments on local, national, and international levels. Schools that participate in competition may fall anywhere along the spectrum from traditional to modern. The risk of injuries in these competitive martial arts appears greater in a tournament setting.[5]

Another feature that distinguishes some martial arts from others is the use of weapons. Use of weapons plays a significant role in the various styles of kung-fu, while in many karate styles empty-hand techniques prevail. Although some research suggests that the risk of injury from use of weapons in the martial arts is low,[5] these vast differences make it impractical to consider the martial arts as a single entity when discussing risks and benefits of participation in childhood.

## 10.2 Programs for Children

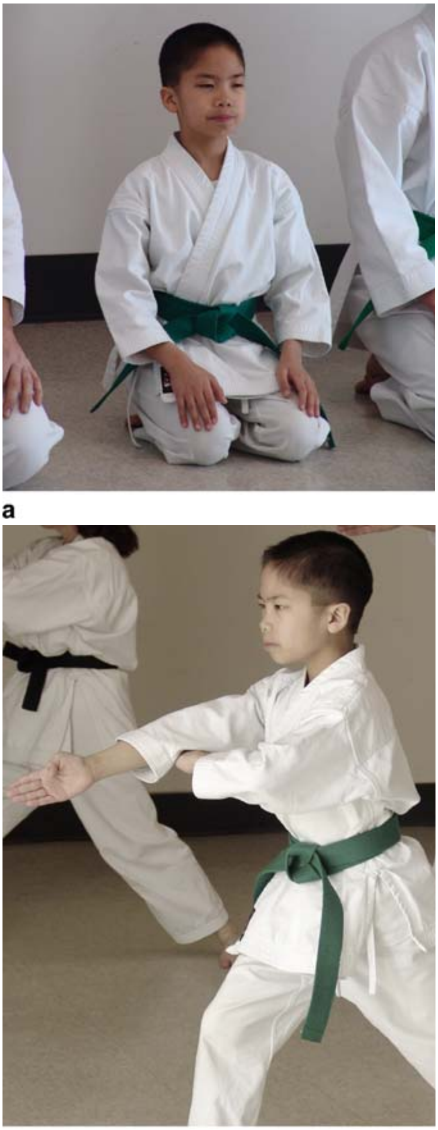
Many clubs offer martial arts classes for very young children, although they generally are not ready developmentally for martial arts training until 6–9 years of age.[6] At this stage, they have acquired fundamental basic skills such as running, kicking, and throwing. Their motor skills, posture, and balance, along with the acquisition of these fundamentals, permit the child to start combining and varying these fundamental skills. Training in striking martial arts must be noncontact.[6]

Clubs that offer classes for very young children (i.e., 2–5 years of age), often referred to as “Little Dragons” or “Little Tigers” programs, provide an opportunity for these youngsters to acquire some of the more fundamental skills appropriate for their age, such as running, jumping, rolling, and kicking. They can begin to develop balance, as well as socialization skills in a supervised setting, while being introduced to the martial arts culture. As in any organized activity for children, the ability of the instructor to positively engage young children must be evaluated by parents before considering enrollment. The focus of any program for this age group must be fun, playfulness, exploration, and experimentation. Competition should be avoided.[6]

## 10.3 Benefits of Combat Sports Participation in Childhood

There are many benefits to participation in the martial arts in childhood, such as development of discipline, respect, strength, muscular endurance, coordination, agility, balance, and flexibility.[7–9] Martial arts in the pediatric population may be used to develop self-defense skills, and to increase confidence and decrease risk of injury, particularly in children who must deal with a hostile environment.[10]

Some authors have reported beneficial effects of martial arts participation on behavior; Hostility[11,12] and aggressiveness[13] appear to decline with martial arts training. However, not all martial arts are equal. The nonviolent philosophy of many traditional martial arts and/or "meditative training" such as kata (Fig. 10.2)



a

b

**Fig. 10.2** Meditative aspects of martial arts. **(a)** "Seiza" is a formal kneeling position used at the beginning and end of training sessions; **(b)** kata or prearranged combinations of movements have a meditative quality when performed may help to mitigate the potential negative effects of participation in high contact sports and "power sports".[14,15] This effect may not be observed in combat sports such as boxing or other modern martial arts that focus solely on fighting.[14,15]

Flexibility, strength, and balance are an integral part of training in many martial arts, and improvements in these areas may occur as a result of participation. Within 6 months of embarking on training, children in karate experience improvements in all of these areas, but particularly in flexibility and balance when compared with peers who are active in sports other than martial arts.[7] These qualities may improve performance in the martial arts, as well as in other sports or physical activities, and may reduce the risk of overuse injury by modifying these risk factors.

## 10.4 Risks of Combat Sports Participation in Childhood

There are risks inherent in almost every form of organized physical activity. Table 10.1 compares the rates of injury in youth sports. In some popular children's sports, the incidence of injury ranges from 5% in softball[16] up to 33% in ice hockey.[17] Studies on martial arts injuries in children are scarce. One study of martial arts injuries found that younger participants (12–19 years of age) were at higher risk of injury than adults;[5] However, that study combined all martial arts, including full-contact, noncontact, traditional, and modern styles, as well as those which used weapons. When risk of injury in specific styles is evaluated, the risk varies greatly from one style to another.[18] Contact styles place the individual at greater risk of injury than noncontact styles.[5,18] A study of injuries in Shotokan karate found that children were at lower risk of injury than adults,[19] and one study of children in noncontact

**Table 10.1** Risk of injury in popular youth sports

| Sport | Injury definition | Injuries (%/year) | injuries/ 1,000A-E |
|---|---|---|---|
| Judo[37] | On-field evaluation | | 40 |
| (boys) | | | 52 |
| (girls) | | | |
| Shotokan karate[19] | Time loss | 6 | |
| Uechi-ryu karate[20] | Time loss | 0 | |
| | Self-reported | 28 | |
| Taekwondo[22] | On-field evaluation | | 58 |
| Baseball[16] | On-field evaluation or time loss | 11[a] | 17 |
| Softball[16] | On-field evaluation or time loss | 5[a] | 10 |
| Soccer[16] | On-field evaluation or time loss | 26[a] | 21 |
| Football[16] | On-field evaluation or time loss | 26[a] | 15 |
| Ice hockey[17],[24] | | 33 | |
| | On-field evaluation | | 26 |
| | Time loss; concussion; dental or facial laceration; substantive professional attention | | 11 |

[a]Recalculated from data provided in study

Uechi-ryu, another traditional martial art, found that none of the participants sustained time-loss injuries during the preceding 12 months.[20] Martial arts that incorporate close supervision with a sense of self-discipline, traditional teaching methods, philosophy, and meditation are associated with fewer and less severe injuries.[5]

Injuries in combat sports may be acute or overuse. Tournaments result in a higher injury rate than non-competition settings.[5] Although the mechanism of injury varies depending on the individual martial art practiced, acute injuries tend to occur as a result of being kicked or hit, kicking or hitting an opponent, falling, trying to break a board, or being thrown or flipped.[21]

### *10.4.1 Distribution of Injuries*

Distribution of injuries among young martial artists depends upon the specific style practiced. Taekwondo, karate, and kung-fu, which utilize kicking and punching techniques, have a preponderance of lower extremity injuries.[18,20,21] Styles which involve close contact grappling and throwing, such as aikido and judo, have a much higher proportion of upper extremity injuries.[18,21]

The distribution of injuries is also dependent upon the setting, with tournaments having a different distribution compared with training sessions. Among injuries presenting to a pediatric emergency room, head and neck injuries constitute 17% of taekwondo injuries;[21] However, this increases to 35% during junior taekwondo competitions.[22]

## 10.5 Specific Injuries

### *10.5.1 Concussion*

Any contact or collision sport carries the potential for head injury, with the risk varying greatly among different sports (See Table 10.2). The risk of concussion in soccer is 0.18–0.23/1,000 athlete exposures,[23] while in ice hockey the rate is 3.9/1,000 athlete exposures.[24] When one of the objectives of the activity is to specifically target the head, the risk of concussion increases.[25] In combat sports such as boxing or kickboxing, the risk of head injury is very high, as knockdowns and knockouts lead to success in competition. Martial arts vary in the degree of contact permitted and in the acceptable target areas of the body. Boxing has the highest incidence among males when compared with taekwondo and karate.[26] In women's individual contact sports, taekwondo had the highest rate of concussion.[26] The rate of concussion in junior taekwondo tournaments ranges from 5 to 50/1,000 athlete exposures,[22,25] and over one third of all injuries occur to the head and neck.[22] Eight percent to 10% of injuries sustained in junior taekwondo tournaments are concussions.[2,22]

**Table 10.2** Comparison of concussion risk in combat sports and other popular youth contact/collision sports

| Sport | Rate/1,000A-E (practices) | Rate/1,000A-E (games or matches) |
|---|---|---|
| Ice hockey [24] | | 3.9 |
| (boys) | | |
| Football [23] | 0.25 | 2.82 |
| Soccer [23] | 0.05 | 0.71 |
| (girls) | | |
| (Boys) | 0.04 | 0.57 |
| Wrestling [23] | 0.17 | 0.51 |
| (boys) | | |
| Taekwondo | | |
| [25] | | 50[a] |
| [58] | | 5.11 |
| (Boys) | | |
| (Girls) | | 4.55 |
| Judo [37] | | |
| (Boys) | 5.2 | |
| (Girls) | 18.5 | |

[a]All athletes with head blows were evaluated for concussion – underreporting much less likely

Noncontact or light-contact styles such as Shotokan or Uechi-ryu karate have a very low incidence of concussion among children and youth, with none reported in two studies.[19,20] Nineteen percent of all self-reported injuries occur to the head and neck region in those under 18 years of age participating in Shotokan karate,[19] and only 5% of injuries occur to the head and neck regions in Uechi-ryu karate in children.[20]

In a study of pediatric martial arts injuries presenting to emergency rooms, concussions comprised 4.1% of all judo injuries, compared with 2.8% of taekwondo injuries and 1.6% of karate injuries.[21] Judo also had the highest proportion of injuries to head/face/neck region (23.4%) compared with taekwondo (16.8%) and karate (15.8%).[21]

The rate of concussion among children and adolescents participating in taekwondo tournaments is alarmingly high, with middle-school athletes at greater risk than high-school athletes.[25] Many concussions in taekwondo occur when a technique, such as a kick to the head, is not blocked by the defender. Younger athletes may be less skilled at performing blocks, placing them at increased risk of sustaining a blow to the head.

Studies on injuries in muay thai kickboxing in general are extremely scarce. In one study of amateur muay thai kickboxers, age 15–26, the head was the most frequently injured body region in competition.[27] Thirteen percent of all injuries sustained in competition were concussions.[27] In a previous study by the same authors, beginners who were restricted to noncontact training sustained only 2.3% of all injuries to the head, while among amateurs and professionals who engaged in full-contact kick-boxing, 31–42.5% of all injuries were to the head.[28] This distinction highlights the impact that level of contact has on potential injury in martial arts.

Boxing has ignited many debates regarding the appropriateness of children to participate in a sport where the primary objective is intentional head injury. The American Academy of Pediatrics (AAP) recommends that pediatricians "vigorously oppose boxing as a sport for any child, adolescent, or young adult"[29] on the basis that repetitive, sub-concussive blows to the head may lead to chronic neurologic deficits in a sport where direct blows to the head are rewarded, and the ultimate victory may be to render the opponent senseless.[29] There have been no recent studies on head injuries in boxing in childhood. Among adult amateur boxers, the overall injury rate is comparable to other contact sports; however, the proportion of injuries to the head is very high (71%), with concussions representing nearly half (47%) of these head injuries.[30] No studies have assessed the potential long-term neurologic deficits of childhood participation in boxing. Many authors advise against head contact in youth combat sports.[2,22]

## *10.5.2 Injuries to the Extremities*

### 10.5.2.1 Contusions/Abrasions

Contusions are very common among children who participate in martial arts.[21] In striking styles such as karate, kung-fu, and taekwondo, the forearms are used to block punches and kicks, and, thus full-contact styles have a higher rate of contusions; Nevertheless, even at a beginner level in noncontact styles contusions may occur in children.[18,20] In some styles of karate (e.g., Uechi-ryu), body-toughening exercises may result in bruising of the forearms as well.[20] Contusions are frequently encountered in throwing sports such as judo and aikido.[18,21]

Breaking boards is a training technique and assessment tool used in taekwondo. It measures precision and strength of kicks or punches. In a properly executed technique, the board breaks easily, with little force transmitted to the extremity involved. Children typically break thinner boards than adults. Approximately half of injuries that result from breaking boards are contusions or abrasions in children presenting to emergency departments.[21]

### 10.5.2.2 Fractures/Physeal Injuries

Fractures occur in combat sports that focus on kicking and punching, such as karate and taekwondo, as well as those that involve throwing and grappling, such as judo and aikido. Approximately 25% of all martial arts injuries presenting to pediatric emergency departments are fractures.[21] One risk associated with breaking boards is fracture of the extremity involved in the breaking technique. In pediatric emergency departments, over one third of injuries due to breaking boards are fractures.[21]

If a technique is poorly executed, the board will not break, resulting in much of the force being applied to the tissues of the hand or foot. Physeal fracture of the proximal phalanx of the great toe has been reported in a young judoka performing a footsweep and falling onto a hyperflexed hallux.[31] Most fractures in children heal twice as fast as in adults, and purely epiphyseal separations tend to heal in half the time of long bone fractures in children.[32]

#### 10.5.2.3 Calcaneal apophysitis (Sever's Disease)

Most martial arts are practiced barefoot on mats or a hard floor. Children who practice martial arts are at risk for overuse injuries to the apophyses of the feet, with the calcaneal apophysis being the most frequently involved. Calcaneal Apophysitis typically affects children between 8 and 13 years of age.[33] This overuse injury presents with gradual onset of pain in the heel, exacerbated by training barefoot on a hard dojo floor. Repetitive movements such as jumping or basic techniques practiced stepping across the floor typically aggravate this condition. When symptoms of Calcaneal Apophysitis first present, there is pain during physical activities. As the injury progresses, the pain may last for some time after cessation of training, and ultimately even be present at rest.

On physical examination, there is typically pain with compressing the calcaneal apophysis medially and laterally (squeeze test). There is frequently tenderness at the insertion points of the Achilles tendon and the planter fascia into the calcaneal apophysis. In more severe cases, secondary Achilles tendinopathy or plantar fasciopathy may develop, possibly due to alteration in gait to reduce pressure under the heels. Pain with resisted plantarflexion may be present, localized to the calcaneus or Achilles tendon.

Management involves the use of heel cups attached to a neoprene sleeve[34] (Fig. 10.3) to allow the young athlete to wear the device while barefoot. This cushions


**Fig. 10.3** A heel cup attached to a neoprene sleeve (Cheetah™) helps to cushion and support the heel, reducing pain in Sever's apophysitis

the heel and provides some support for training. Ice may be applied to alleviate pain, and pain-free training should be encouraged, particularly in the early stages of treatment. A home exercise program directed towards stretching and strengthening the gastrocnemius – soleus complex is beneficial,[35] and may help to reduce recurrences. There is a risk of recurrence as long as the apophysis is open.

#### 10.5.2.4 Injuries to the Extensor Mechanism of the Knee

Extensor mechanism injuries are commonly encountered in young martial artists. Kicking and jumping techniques place these tissues under stress, leading to Osgood-Schlatter Disease (OSD) and Sinding–Larsen–Johansson syndrome (SLJ). These apophysitides present with pain over the tibial tuberosity (OSD) or over the distal patellar pole (SLJ).[34] OSD is frequently associated with significant localized swelling over the tibial tuberosity. The typical age of presentation of OSD (10–15 years) is slightly higher than that of SLJ (10–12 years).[35]

Physical examination typically detects focal tenderness over either the tibial tuberosity (OSD) or the distal patella (SLJ). Although swelling is frequently present over the tibial tuberosity in OSD, SLJ is not usually associated with localized swelling. Both conditions may produce pain with passive flexion of the knee or with resisted extension of the knee. In more severe instances, there may be pain with active extension against gravity. Patellar maltracking and tightness in the quadriceps muscles may contribute to these conditions.

Initial management is directed towards reduction of pain, as well as secondary swelling and inflammation that may be present. Regular application of ice, and restriction of aggravating activities such as jumps, kicks, and running, may be necessary to settle symptoms. The formal kneeling position common to many martial arts may place undue pressure on a swollen, tender tibial apophysis, and may need to be avoided.[36] A strap may be used to limit traction on the tibial tuberosity in OSD.[34] Patellar stabilization braces may be used in both conditions if patellar maltracking has been identified. Home exercises are usually directed towards stretching of the quadriceps.

#### 10.5.2.5 Medial Epicondyle Apophysitis

Repetitive traction of the forearm flexor muscles on the medial epicondyle apophysis results in medial elbow pain in young judoka and wrestlers.[36] Grappling with an opponent or gripping of the opponent's uniform in order to perform throwing techniques may contribute to medial epicondyle apophysitis. This injury presents most commonly between the ages of 10 and 14 years.[36]

Physical findings typically include focal tenderness over the medial epicondyle apophysis, pain with valgus stress of the elbow, and pain with resisted flexion of the wrist. Plain radiographs may be normal or may show delayed development of the ossification center.[34]

Management includes regular application of ice to reduce pain and secondary inflammation that may be present, avoidance of training techniques that aggravate pain, and exercises to stretch and strengthen forearm muscles once symptoms have begun to abate. A brief period of splinting may be required for symptomatic treatment or to enforce rest in recalcitrant cases.[34]

#### 10.5.2.6 Clavicular Fractures

Injuries to the shoulder are frequently encountered in throwing combat sports, and nearly half of all pediatric martial arts injuries to the shoulder and upper arm that present to emergency departments are fractures.[21] The most common mechanism of injury in young judoka is either being thrown or performing groundwork.[37] Clavicular fractures occur as a result of direct blows or falls onto the shoulder, both of which are encountered in combat sports.

Midshaft clavicular fractures, the most common injuries of the clavicle, heal well with little intervention other than sling or figure-of-eight bandage for comfort for 1–4 weeks. Reduction of the fracture is generally not necessary, unless the integrity of the overlying skin is compromised. Open fractures require orthopedic consultation. To reduce the risk of re-fracture, contact aspects of training should be avoided until evidence of bony healing is noted on radiographs. Inability to perform push-ups without pain suggests that healing is not complete; therefore, contact activities and throws should be deferred until push-ups do not provoke pain. Patients and parents can be reassured that the bump, which develops at the site of the healing fracture, will remodel and become less distinct over 6–9 months.[38]

Physeal fractures of the distal clavicle are more common in young athletes than disruption of the acromioclavicular joint, although these entities may be clinically indistinguishable. The mechanism of injury is typically a fall on or a blow to the point of the shoulder. Since the unossified epiphysis is radiolucent until approximately 19 years of age,[38] the radiographic appearance is easily mistaken for an acromioclavicular joint disruption.[38] In distal clavicular physeal fractures, the thick periosteal sleeve remains intact, with the epiphysis retained within the sleeve. Healing subsequently occurs within this periosteal sleeve. Management is directed towards reducing pain and movement at the fracture site via the use of a sling for approximately 3 weeks, followed by gentle rehabilitation.[38]

### *10.5.3 Overuse Injuries of the Spine*

#### 10.5.3.1 Posterior Element Overuse Syndrome

The posterior elements (muscle–tendon units, ligaments, joint capsules, facet joints, and pars interarticularis) of the lumbar spine are at risk of injury in some combat sports. The front-stance is commonly used in taekwondo, kung-fu, and karate (Fig. 10.4). Children with inadequate abdominal strength, poor stabilization of the trunk, or increased lumbar lordosis may develop low back pain by placing additional stress on their posterior elements in a front-stance position. Pain is typically present on spine extension, but some tightness in the lumbar region may be noted on flexion.

Physical findings include pain on hyperextension of the spine and focal tenderness over the affected level, just lateral to the midline. L5 is most frequently involved, followed by L4. Tenderness may be uni- or bilateral. There may be pain loading the posterior elements in a supine position with both extended legs actively lifted a few centimeters off the table. Sensation, strength, and reflexes are unaffected. Straight leg raise does not produce pain in posterior element overuse syndrome.

Children with lumbar pain that persists more than 3 weeks warrant further investigations.[39] Plain radiographs, including oblique views, can help rule-out stress fractures of the pars interarticularis (spondylolysis). If there is no response to treatment after 4–6 weeks, single-photon emission computed tomography (SPECT) bone scan should be considered to rule-out an occult spondylolytic lesion not detected on plain radiographs.

Management consists of abdominal strength exercises, antilordotic exercises, and hamstring and lumbo-dorsal fascia stretches.[34] Ice and nonsteroidal anti-inflammatories may be helpful in reducing inflammation. Activities that aggravate the pain

**Fig. 10.4** The front-stance. When properly performed, stress on the posterior elements is minimal. If the pelvis rotates backwards or the trunk tilts backwards, the resultant increase in lordosis places stress on the posterior elements of the spine. (Photo courtesy of Jennifer Eaton-Davis)

should be avoided or modified, and correct posture in front-stance should be attained to reduce stress on the posterior elements. A flexible lumbar support brace, which is often used for up to 6 weeks, may help reduce pain and muscle spasm associated with the injury.[34] Bracing also may facilitate return to training.[35]

#### 10.5.3.2 Spondylolysis

Spondylolysis, or stress fracture of the pars interarticularis, presents with similar symptoms to posterior element overuse syndrome. Typically, the onset of pain is insidious, and is localized to the lower lumbar region. L5 is most commonly involved,[35] followed by L4 and, much less frequently, L3. Symptoms are often present for several months before presenting for evaluation. Pain increases with extension of the spine. There may be an associated decrease in hamstring flexibility on the affected side.

The results of physical examination may be indistinguishable from that of posterior element overuse syndrome, with maximal pain on provocative hyperextension, focal tenderness over the site of the pars lesion, and pain loading the posterior elements in a supine position. Nerve root signs, such as positive straight leg raise test, may be present, particularly if spondylolisthesis (forward slippage of one vertebra over the next caudal segment) is present.

Although much less frequently encountered than posterior element overuse syndrome, any young athlete presenting with a history of at least 3 weeks of lumbar pain on extension should be assessed for spondylolysis. Radiographs of the lumbar spine should be obtained. Oblique views are best for evaluation of the pars interarticularis, although some authors[39] have advised against the routine use of obliques since only one third of lesions are identified due to orientation of the beam with respect to the defect.[40] A lateral view, coned to the suspected level of the lesion, may be more sensitive than regular lateral radiographs.[41] (Fig. 10.5)

Technetium-99 single-photon emission computed tomography (SPECT) bone scan is useful to assess activity at the site of the lesion or to detect stress reactions that are too early to be seen on plain radiographs. A positive bone scan suggests that the lesion is healing or has the potential to heal.[42] Computed tomography (CT) scanning may be used to assess degree of bony healing in a child who is not responding to management. Management is as for posterior element overuse syndrome; However, a custom thoraco-lumbar orthosis may be necessary to expedite safe return to modified training in some combat sports. Such a brace is typically worn 23 h/day until the lesion is clinically healed (up to 6 months).

## 10.6 Combat Sports in Children with Chronic or Infectious Diseases

Combat sports such as traditional and modern martial arts, boxing, and wrestling are all categorized as contact/collision sports by the American Academy of Pediatrics (AAP).[43] Although some martial arts are “noncontact,” some degree of contact may still occur, albeit in a more limited fashion. Table 10.3 lists some of the medical

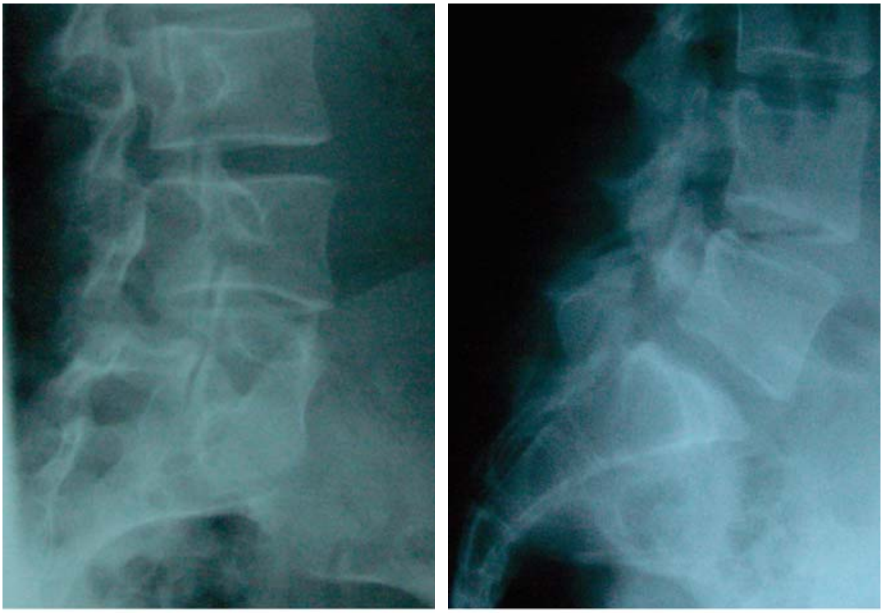



**Fig. 10.5** Radiographs of spondylolysis. (a) Oblique views best demonstrate the pars interarticularis; (b) coned lateral shows spondylolysis at L5

conditions that may impact on the contact aspects of combat sport participation. A more complete listing of medical conditions that may affect sport participation in general is available from the American Academy of Pediatrics.[43]

### *10.6.1 Down Syndrome (Trisomy 21)*

Children with Down syndrome have a defect in collagen synthesis, which leads to generalized hypotonia and ligamentous laxity. Laxity of the annular ligament of C1 may result in atlantoaxial instability (AAI).[44] The presence of bony abnormalities, such as odontoid hypoplasia, odontoid dysplasia, or the presence of os odontoideum increases the risk of atlantoaxial dislocation.[44]

Symptomatic AAI occurs in 1–2% of individuals with Down syndrome.[45] AAI may be detected on lateral cervical spine radiographs by measuring the distance between the odontoid process and the anterior arch of the atlas. Distances of 4.5 mm or greater are considered abnormal, with flexion views being the most sensitive.[44,46] While the American Academy of Pediatrics questions the value of routine radiographs, it recommends them nevertheless, since screening may be required for participation in the Special Olympics.[47] The American Academy of Pediatrics acknowledges that screening may be more important prior to contact sport participation and is indicated in children with neurologic symptoms.

**Table 10.3** Medical conditions that may preclude or limit contact in combat sports – (Athlete needs individual assessment)43

| |
|---|
| Atlantoaxial instability[a] |
| Bleeding disorders[a] |
| Single paired-organ[a] |
| Poorly controlled seizure disorder[a] |
| Infectious mononucleosis[a] (including acute hepatosplenomegaly) |
| Splenomegaly – chronic[b] |
| Hepatomegaly – chronic[b] |
| History of serious head or spine trauma, severe or repeated concussions, or craniotomy[b] |
| Sickle cell disease[c] |
| Contagious skin infections (see Chapter 7, Contagious Skin Infections) |

[a]See text for more information
[b]Needs individual assessment for contact/collision sports43
[c]No high-exertion, contact/collision sports43

Children with Down syndrome who have neurologic symptoms associated with AAI should be withheld from physical activities that may place undue stress on the cervical spine, such as gymnastics, diving, high jump, etc.[48] Throwing or grappling combat sports such as aikido, judo, and wrestling could place significant stress on the cervical spine of participants, and also should be avoided. It may be prudent to restrict those with asymptomatic AAI as well; However, the literature is less clear in this scenario.

## *10.6.2 Bleeding Disorders*

### 10.6.2.1 Hemophilia

Factor VIII (hemophilia A) and factor IX (hemophilia B) deficiencies are the most common severe inherited bleeding disorders.[49] Hemophilia is X-linked recessive, and is characterized by easy bruising, intramuscular hematomas, and hemarthroses. Even minor lacerations to the mouth may result in persistent bleeding for hours or days.[49] Life-threatening bleeding into the central nervous system can occur.

According to the Canadian Hemophilia Society, individuals with hemophilia are at high risk of injury in karate or judo if training with contact; However, training without contact may be beneficial by improving muscle flexibility, coordination, and balance.[50] Knees, elbows, and ankles are the joints at greatest risk of bleeding. The risk of serious intracranial hemorrhage exists if strikes to the head or throws are permitted. Children with hemophilia should not be permitted to engage in contact aspects of combat sports.

### 10.6.2.2 Von Willebrand Disease

Von Willebrand disease is the most common inherited bleeding disorder, affecting 1–2% of the general population.[49] It is an autosomally inherited deficiency of Von Willebrand factor (VWF) that results in mucocutaneous hemorrhage such as excessive bruising, epistaxis, and hemorrhage after tooth extraction.[49] In severe VWF deficiencies, joint and spontaneous central nervous system hemorrhages may occur.[49] In milder forms of the disease, increased bruising and prolonged bleeding with mouth lacerations or prolonged epistaxis may be encountered in contact combat sports. Recurrent thigh hematomas have also been described following minor trauma in mild Von Willebrand Disease.[51] Even in noncontact styles, bruising of the forearms occurs in children without bleeding disorders (Fig. 10.6); therefore, increased bruising could be expected in children with VWD. In more severe instances, the risk of serious central nervous system bleeding associated with throws or strikes to the head could be similar to that of factor VIII deficiency. Children with VWD should not participate in the contact aspects of combat sports. Noncontact training such as kata practice is appropriate. Nonsteroidal anti-inflammatories prolong bleeding; therefore, other treatment options should be considered when treating an injured martial artist with VWD.

### 10.6.3 Seizure Disorders

Children with well-controlled seizure disorders are not restricted from participation in combat sports.[43] Although a theoretical risk exists that recurrent minor head trauma could exacerbate the condition, there is little evidence to support this in the literature.[52] The main concern in combat sports is the risk associated with poorly controlled seizure disorders. Unanticipated falls, particularly on a hard training or competition surface, and unprotected blows pose the greatest risks in combat sports.[52] Atonic seizures, generalized tonic-clonic seizures, and partial seizures that become secondarily generalized may result in unprotected falls, placing the child at risk of injury from striking the playing surface.[52] Absence and complex partial seizures are both characterized by impaired consciousness, and may predispose children involved in martial arts to injury because of the inability to protect themselves from blows[52] (see Table 10.4). The American Academy of Pediatrics recommends that children with poorly controlled seizure disorders be restricted from participation in contact sports.[43]

### 10.6.4 Single Paired Organ

Children who have only one functioning kidney, a single testicle or one undescended testicle, or vision in only one eye have to take special precautions in martial arts. In individuals with two functioning paired organs, the risk of disability resulting from injury to one organ is lower. On the other hand, in the child with only one functioning kidney, injury to that one organ could precipitate the need for dialysis or renal transplant, and injury to the one eye with functional vision could leave a child blind. Single paired organ is not, by itself,

**Fig. 10.6** Even in "noncontact" martial arts, enthusiastic blocking techniques may lead to bruising of the forearms

a contraindication to sport participation; however, it would be prudent in these circumstances to take special precautions, or to modify training in the martial arts.

The child with a single testicle or one undescended testicle could avoid serious impairment of testicular function by wearing a protective cup for training and competition.[43] Most combat sports prohibit the use of eye protection in tournaments; however, the use of such devices may be permitted on an individual basis during regular classes. In addition, striking martial arts place the student at slightly increased risk of injury to the face (11% of taekwondo injuries seen in pediatric emergency rooms) compared with grappling martial arts (7% of judo injuries seen

**Table 10.4** Seizures and risk in combat sports/martial arts

| Type | Characteristics: Impaired consciousness | Characteristics: Motor impairment | Characteristics: Risk in martial arts |
|---|---|---|---|
| Generalized Seizures | | | |
| Tonic-clonic | + | + (Tonic/clonic contractions) | Risk of fall on hard surface |
| Atonic | + (Usually) | Abrupt loss of postural tone | Risk of fall on hard surface |
| Absence (simple) | + (Motionless; nondistractable) | Eyelid flickering | Unable to protect against blows |
| Partial Seizures | | | |
| Simple | – | + (Focal tonic or clonic; may spread proximally) | Minimal additional risk of injury |
| Complex | + | + (Same as simple) | Unable to protect against blows; risk of fall on hard surface |
| Secondarily generalized | + | + (Same as tonic-clonic) | Unable to protect against blows; risk of fall on hard surface |

in pediatric emergency rooms; therefore, the choice of martial art may impact the risk of injury to the child with a single paired organ.

The majority of pediatric nephrologists discourage children with a single functioning kidney from participating in combat sports.[53] However, a recent review suggests that this restriction may be unwarranted.[53] Unfortunately, while devices that may protect the kidney from trauma do exist, they are not permitted in competition in most combat sports. Kidney injury from sports is less likely to occur than catastrophic brain or spinal cord injury;[53] Nevertheless, parents of children with a single functioning kidney should be advised that renal injury could be devastating, and that the incidence of such injury in combat sports in childhood has not been determined.

### *10.6.5 Infectious Mononucleosis*

Infectious mononucleosis (IM) typically affects older children and young adults. Epstein-Barr virus is most commonly implicated in this condition, but other viruses may produce “mononucleosis -like” illnesses. IM is characterized by fever, exudative or membranous pharyngitis, generalized lymphadenopathy, and splenomegaly.[54] Splenomegaly occurs in 50–100% of patients of IM, while hepatomegaly occurs in 10–50% of patients.[55,56] The American Academy of Pediatrics recommends that children with acute splenomegaly or hepatomegaly refrain from sport participation to reduce the risk of organ rupture.[43] Splenic rupture is a rare but serious complication of IM from minor trauma to the left upper quadrant or from sudden increase in intra-abdominal pressure. Rupture has also occurred spontaneously in IM.[54] Clinical signs and symptoms of rupture include left upper quadrant abdominal pain, pain that radiates to the left shoulder, peritoneal irritation, and shock.

Although definitive studies on return-to-play in IM are lacking,[57] some authors have recommended algorithms based on the natural history of splenic rupture in this condition. Auwaerter suggests waiting a minimum of 3 weeks before returning to noncontact sports, and 4 weeks for return to contact sports if the child is clinically well, and normal spleen size is documented by ultrasound.[57] Laboratory values should return to normal prior to return-to-play.

## 10.7 Conclusion

There are risks and benefits to childhood participation in any contact or collision sport. In combat sports, measures must be taken to minimize risks, allowing the child to realize the benefits in a safe, fun environment. The author believes that children should not engage in full-contact sparring, and no contact should be permitted to the head. Careful supervision of children in practices and enforcement of rules of safety in tournaments may reduce the risk of injury while promoting enjoyment of the sport. In addition to the general benefits of sport participation, such as fun, fitness, and improved self-esteem, combat sports foster development of self-defense skills. Traditional martial arts, in particular, may have very positive influences on behavior.

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## Web site

http://www.totalfitnesssolutions.com/kidsmartialartsintro.html

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# Chapter 11
# Professional Athlete

**Margaret Goodman and Edwin Homansky**

## Learning Objectives

- To understand the ring physician's role regarding the fighter's fitness to compete; assessment before, during, and after the bout; and determining return to competition
- To understand the scope of injuries occurring in professional boxers and mixed martial artists
- To educate the physician as to how they can improve their ringside performance
- To provide educational resources for the ringside physician

The professional combat athlete presents a multitude of issues for the ring physician and athletic trainer not encountered in amateur competition. There is no medical specialty that will fully prepare a physician for this task. However, working with professional fighters can be one of the most rewarding experiences if one understands the complexities.

When starting, many rely on the classical medical aphorism that, as long as you care for your patient, no wrong can be done. This is not necessarily true, as many gray areas exist. When money, fame, and even the athlete's life can be lost in one bout, the physician's responsibility is immense. It is also easy to become the focal point when all one attempted to do was to be *a physician*.

To effectively work with fighters, you must consider what kind of involvement you wish to have. Do you want to simply attend the competitions and be called upon when a fighter is knocked out? Or do you wish to fully help the athletes and make a difference in the sport and expand your knowledge? We suggest the latter, and, although it can be filled with controversy, these endeavors need health care personnel that are not afraid to stand up for what will benefit the athletes, and improve safety measures.

This section will discuss the proper approach to the professional fighter, and a rare discussion of all that is involved to be a skilled ring physician.

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## 11.1 Assessment of the Professional Athlete

A license to fight professionally is not a right: it is a legal privilege. Although this may seem obvious, it is the crux of determining whether fighters should be granted a license in addition to proving their fitness and capability. There is more to determining if a fighter should be allowed to compete other than passing a series of medical tests. Often, when a fighter has reached the point when they will no longer pass testing, chronic problems have begun, and denying a license will save further punishment, but do nothing to prevent it. Retirement is discussed at the end of this chapter, although many professional fighters receiving a license should have long retired. Denying licensure can become a daunting task accompanied by a fighter and his team of lawyers when the physician is only trying to do the right thing.

Ring physicians and trainers must familiarize themselves with commission regulations and statutes for licensure, as turning a blind eye to the situation will perpetuate the problem. Requirements such as age are fairly standard, but there are exceptions. Typically, a fighter cannot turn professional before age 18, but an athlete can petition to have his case heard to fighter at 17. You should be wary of fighters turning professional in their 30s or 40s, especially if they have had no amateur experience.

Table 11.1 lists the recommended minimum medical requirements for competition. These differ greatly between commissions, should be addressed by members of the commission's medical advisory board, and include input from ring physicians who have the opportunity to directly witness the performance of a given fighter. Criteria should change for fighters with advancing age, or "ring age" (individuals that are showing signs of chronic punishment). It is important to review the fighter's history, and identify which fighters are at increased risk. If a physician neglects informing their commission regarding fighters that should consider retirement or undergo additional examinations, he is neglecting an important part of his duties. However, in the professional ranks, this happens all too frequently.

Physicians should acquaint themselves with the athletes. This may not seem a part of the job, but this process will enable one to make an informed decision during a fight. At the end of this chapter are resources and web sites containing athlete statistics and background.

**Table 11.1** Recommended minimum medical requirements

| |
|---|
| CT/MRI scan – baseline |
| Dilated eye exam by ophthalmologist – yearly |
| Hepatitis B/C and HIV – every 180 days |
| EKG – baseline (unless abnormal) |
| Complete history and physical – yearly |
| Prefight physical by ring physician – at weigh-in and before fight |
| Serum pregnancy test – 14 days prior to contest |

## 11.2 Weigh-ins

The weigh-in for professional athletes is typically conducted 24 h before the event. Many disagree as to the timing of the weigh-in. Historically in boxing, the weigh-in took place the day of the fight. A fighter would weigh-in, sip a cup of water, and then enter the ring. However, fighters used to fight several times a month, and had little time to gain large amounts of weight between bouts.

By having the weigh-in the day of the fight, the fighters came to the event so dehydrated and weak that they were not at their best mentally or physically. In only 6–8 h, a fighter could replace a significant amount of free water, but that period of time did not give the body enough hours to address cellular problems or intracellular electrolyte and ion imbalance. In the mid-1980s, one of the authors (EH) and the state of Nevada, USA, spearheaded an effort to change the weigh-in to the day before the event in an effort to educate promoters, managers, trainers, and fighters about the dangers of dehydration. Although this change has become the norm, the current situation is far from safe.

Fighters now fight less often in their career, and the number of weight classes has increased. As a result, the well-intentioned change in the timing of the weigh-in has resulted in an unfair advantage to many. In many instances, the weigh-in can actually take place up to 30 h ahead of a bout due to television and economic interests. Instead of fighters simply gaining excess fluid, they are actually gaining body weight. Certain weight classes are more profitable and garner more attention and television exposure. Contracts are no longer signed for the fighter's optimal condition, but for their *optimal earning power*. As a result, more and more fighters compete in weight classes where they do not belong, and, when that is combined with an available television date, poor dietary habits between fights, and inadequate conditioning, fighters frequently appear at the weigh-in extremely dehydrated.

Ring physicians have grown accustomed to overlooking fighters presenting to the weigh-in dehydrated. The correct action would be to not clear the athlete. However, just as pressures exist for athletes, pressures exist for commissions and physicians overseeing these events to allow a fight to take place unless a significant medical disability can be proved. Unlike most amateur events, cancellation of a card or even one bout can result in significant financial repercussions. Professional fights are big business, and *no* commission will lose sight of this fact.

The seriousness of dehydration among athletes cannot be underestimated. In the mid-1990s, three wrestling deaths occurred very close to each other: each was linked to dehydration. As a result, the National Collegiate Athletic Association changed their weigh-in policy from the day before, to the day of the contest. Since doing so, there have been no deaths.

There are countless arguments and issues on both sides. The truth is that, for a well-conditioned athlete, the timing of the weigh-in should not matter. Recently, a few US jurisdictions began requiring athletes to submit documented weights from a physician 30 days, and 7 days before a contest in order to prevent them from dehydrating themselves too close to fight time. Hopefully, this places the burden on the fighters to compete in an appropriate weight class.

It is ultimately up to medical personnel to make the right decision, and discussion of when the weigh-in should take place for professional fighters needs to be revisited by all involved. We believe the weigh-in should return to the morning of the fight.

## 11.3 Prefight Examination

The prefight examination is typically conducted before the fighter steps on the scale. It is a time for the ringside physician to learn as much as possible about the status of the fighters. It provides a baseline to better assess physical changes during the contest. Fighters are in a hurry to weigh-in. This unfortunately leaves little time for communication with the athlete, and can result in a cursory medical examination. *Note: If a serious injury occurs, the physician will be asked in detail as to how the fighter looked at their prefight physical, and that "cursory" exam will be scrutinized by the press and lawyers. So, be prepared.*

There are several key ways the ringside physician can prepare himself before a contest. It is crucial to know the athletes. You should watch as many televised fights as possible, and attend fight cards even when not assigned. It is valuable to speak to trainers and cornermen to gather details about the fighters you oversee. Journals such as *Ring Magazine*, *KO Magazine*, *Full Contact Fighter*, and *Boxing Monthly* will educate you on what is happening in boxing and mixed martial arts (MMA). Overall, your best education can stem from the Internet. Web sites such as www.boxrec.com allow anyone to evaluate a fighter's complete ring history, and will advise you on upcoming contests in your area.

Every year each fighter should have a separate comprehensive examination with a general physician or internist. At this time, they can undergo required testing for licensure, including hepatitis B/C screening, and human immunodeficiency virus (HIV). Table 11.1 includes a list of minimum requirements, although many commissions including the British Boxing Board of Control, the New York State Athletic Commission, and the Nevada State Athletic Commission require more. Additional testing could also be required depending on the fighter's medical and ring history. For example, a fighter who is over the age of 36 or 40 should undergo follow-up testing such as neurological examinations, magnetic resonance imaging (MRI), or cognitive testing.

Table 11.2 includes a valuable list of facts ring physicians need to know about each competitor on a card they will work. For example, if Fighter A has had several years off between fights, and they are competing against Fighter B, who has not only been successful, but has been active, Fighter A could be at an extreme disadvantage. If a fighter has a record of 15 wins and 5 losses, but his last few bouts have all been losses, he could be in danger irrespective of who he is fighting. The web site www.boxrec.com will provide these indicators. Your commission will have access to additional details, including medical evaluations and suspensions the fighter has had between bouts. Each medical suspension needs to be investigated and evaluated when approving a fighter to compete in your jurisdiction.

**Table 11.2** Preparatory facts to know about a fighter at the weigh-in

| |
|---|
| Total numbers of wins/losses |
| Specific dates of wins/ losses |
| Reason for loss (i.e., TKO/KO, head blow, cuts, etc.) |
| Level of opponents they have fought |
| Length of time off between fights, and reasons |
| How many rounds they have fought |
| Location of competitions |
| Types of injuries and follow-up testing received following fights |
| Amateur background, including numbers of fights |
| Recent injuries or illnesses before the fight |
| Medications |
| Allergies |

Unfortunately, medical tests are expensive in countries without national health insurance. Promotional entities and fighters have been known to find creative ways to cut costs, or avoid detection of a medical issue. There have been instances, probably more than we care to acknowledge, where fighters provide falsified medical results. If not included, request your commission to provide a copy of all the medical testing for your review at the prefight examination. If test results are unsigned by the fighter, or appear suspicious, there is nothing wrong with contacting the health care facility or medical professional to corroborate the results. *This could save a fighter's life*.

## 11.4 Examination of a Fighter During the Bout

As a ringside physician, you should be prepared for routine as well as emergency situations. Paramedics and an ambulance must be present at every contest at all times, whether or not they are required in your jurisdiction. Emergency Medical Technicians are less costly to a promotional company, but the level of training is quite different. A paramedic is able to not only start IVs, administer medication, but intubate. Irrespective of your specialty, we recommend at least one paramedic. While basic cardiac life support (BCLS) credentialing is typically required, additional training can be useful. However, a ring physician can only be in one place at a time, and there are many instances where a fighter has collapsed in the dressing room, or on their way to leaving the arena while another fight is taking place.

There should be at least two ring physicians present at every contest, and, for larger high-profile competitions, three to four can be necessary to maintain continuity of care. The physician should determine which hospital is appropriate for athlete transfer, and if at all possible, prearrange care with a Level 1 Trauma Center, where personnel, including neurosurgeons, and operating room staff are immediately available. In less-populated regions, it is advisable to make sure that a computed tomography (CT) scanner, neurosurgeon, and accessible operating room are available. In some cases, air transport needs to be arranged in advance.

Emergency equipment such as oxygen must be ringside and paramedics need easy access to the ring. Prior to the start of the card, the ring physicians should establish their role at ringside and in the dressing room, acquaint themselves with the emergency personnel, establish exit routes to remove a fighter from the ring and arena, and discuss the athletes history and medical issues with the referees and fellow health care staff.

It is impossible to overemphasize the referee–ring physician relationship. Sitting ringside is often akin to going into combat: the referee is your partner, and communication is tantamount. Whether you are an experienced or inexperienced ring physician, you soon realize the importance in recognizing the proficiency and limitations of the cornermen and referees. Your expertise will be respected once you fully establish a working relationship with all ringside personnel.

It is advisable to arrive at least 45–60 min before a card begins. This will give you adequate time to visit the fighters, the referees, and secure yourself an adequate ringside seat with clear visibility of the ring and emergency personnel. Your prefight examinations and review of the fighter's histories assist in providing you a baseline to follow during the fight. The doctor should have made a mental note of the fighter's speech patterns, gait and balance, alertness, and responsiveness to questions.

Once the fighters enter the ring, there is no time for distractions. As the contest progresses, the ring physician must follow the fight until the sound of the bell marking the end of round, quickly glance or exchange a nod with the referee to determine a plan of action as to whether or not you should enter the ring to visit the fighter between rounds. Always observe the fighters as they walk back to their stools. The referee and ring physician should always be on the same page regarding the athlete's condition.

If a fighter has been knocked down or taken a beating in a round, it is important to quickly examine him during the 1-min rest period without interfering with the cornermen. The 1-min rest period is the corner's time to work on a laceration, address a nose bleed or facial swelling, and offer valuable instruction to their fighter. It is simple to examine a fighter with a modicum of intervention by standing behind the cornermen utilizing the minute to hear the fighter speak, assess their alertness, and observe cranial nerve function, such as pupillary reactivity. A ring physician should always carry clean 4 by 4 gauze, an airway, and a pen light. Some carry a stethoscope, but, if a fighter's condition is so severe to necessitate a stethoscope, that athlete ought to be on his way out of the ring to the emergency room.

If there is a laceration (see *cuts* below), the ring physician should examine it, without treating it (i.e., no applied pressure), and then allow the corner to turn their full attention to stop the bleeding. Ring physicians can often become too obtrusive between rounds. This is detrimental to the corner and the fighter, and will make the physician too involved in the contest.

Following your evaluation, it is imperative to step away from the corner and fighter, and advise the referee of your findings. If the fighter has been taking punishment, which could soon necessitate a stoppage of the contest, the ring physician's presence in checking the athlete between rounds will give everyone time to adjust to the idea, and provide the referee needed support.

If the ring physician's evaluation indicates the contest needs to end, it is appropriate to step away from the corner, call over the referee, and in a few words make your recommendations. It is imperative to be calm, firm, and precise. Uncertainty is a sign of weakness not only to your credibility as a ring physician, but can also confuse the situation.

More and more professional competitions are televised. Therefore, anything said in the corner or to the referee can end up in a broadcast. Never get into an argument about your decision with the fighter or the corner, and use a paucity of words. The more you say the greater chance it could be misconstrued or used against you.

*Remember that the ring physician is there to enable a fight to proceed to its natural conclusion. Any time you enter the ring between rounds you are disrupting the action, so do this with as little involvement as possible unless you have it in your mind the fight should stop. A fight should continue if, to the best of your knowledge, neither fighter is at risk of permanent or life-threatening injury, and, if the contest continues, neither competitor is at an unfair disadvantage.*

*A ring physician must understand the implications in stopping a contest. Irrespective of the type of injury, the fighter who loses may never have the same opportunity to further his career. Therefore, even a small non-televised show before a few hundreds can make or break a career.*

Experience will teach you there is a *flow to a fight*; there exists a beginning, middle, and end that can often resemble an opera or ballet. Combined with good judgment, understanding this flow will enable the ring physician to make the right decision most of the time. In working a professional contest, few decisions are made solely on the number of head blows or the extent of the cut. The flow of the fight can also dictate that the physician evaluate the fighter between rounds, even though there may not be an exact reason. It can offer reassurance to your commission, the referee, the corner, and even the fighter. The ring physician and referee must interpret the interchange between the competitors round to round, and under most cases, the decision will be simple.

## 11.5 The One-Eyed Fighter

Invariably during a fight card, the ring physician will have to make a decision regarding a fighter with periorbital edema. This can be handled in a multitude of ways. First and foremost, if a fighter cannot see, *or adequately protect himself from punches*, the contest must stop immediately. However, during a fight, decisions are rarely this simple and uncomplicated.

Why is the eye closing? Is the eye closing from too many jabs, an orbital fracture, nasal fracture, or prior injury? The ring physician should examine the fighter if he is "pawing" at his eye with his glove or excessively blinking. If the edema is not interfering with the fighter's performance, but is steadily advancing, the key is to examine the orbit and extraocular muscles before the eye can no longer be easily opened. It the orbit appears to be intact, there is no suggestion of diplopia, and the fighter's vision is not impaired, the fight may continue as long as the athlete is protecting himself. Under these circumstances the edema can actually protect the eye. Each case must be handled individually, as there is no single hard-and-fast rule. Obviously, if there is an orbital fracture, the contest must stop to avoid entrapment. Many fighters occasionally train with an eye patch to guard against their contest stopping from a closed eye.

### *11.5.1 Lacerations*

It is rare to have a fight card without at least one laceration. A fight must be stopped on a cut for the following: (1) the fighter is at an unfair disadvantage should the fight continue; (2) allowing the fight to continue could cause significant irreparable harm to the fighter; or (3) the fighter is losing most of the rounds and taking too much punishment *irrespective* of the cut.

If the laceration occurs in the last round or two of a championship bout, and the fighter is not otherwise hurt, the ring physician should provide the fighter every opportunity to continue. On the other hand, if you have a young athlete in a four-rounder with a huge gash, the ring physician should intervene. Lacerations means time off from training, and the last thing an up and coming fighter needs is months away from the gym.

The following is a list of bleeding sites of concern:

1. All cuts near the eye. If inside the orbital rim this type of laceration can:
   (a) Affect the eye muscles or nerves resulting in a ptosis (lid droop).
   (b) Limit extraocular movement.
   (c) Affect the tear duct.
2. "Pumper" or arterial bleeder. These are difficult to stop during a fight, and typically require a stoppage even in mixed martial arts with the fighters on the ground.
3. Vermillion border. Cuts on the colored part of the lip are tough to repair, and can result in significant scarring and cosmetic difficulties.
4. Inside the mouth. Swallowing or inhaled blood can cause vomiting or choking.
5. Edge of the eyelid (near the lashes) or the upper or lower lid. These are rare, but could require immediate surgery, and if the fight continued could result in blindness.
6. Other deep lacerations or butt cuts. Forehead or scalp (not too close to the brow), cuts across the nose (unless fractured), and cuts on the cheek (unless through and through) may bleed for a while, but can be controlled and are typically not dangerous.

The key to treatment, especially during a fight is pressure, time, and cold. The cornermen must begin treatment immediately at the sound of the 1-min rest period. An ice-cold Enswell (flat piece of metal) applied with *direct* firm pressure to a laceration may work wonders. The Enswell is not to be used to push swelling away, as this exacerbates tissue damage. Many cutmen still do not understand this concept, and use the Enswell as a weapon. Vaseline makes the skin slippery and reduces tearing of the skin.

There are three legal medications that are used separately and may be incorporated into Vaseline to stop bleeding:

1. Adrenaline (epinephrine 1/1,000 concentration) will be absorbed easily into the skin and decrease blood flow.
2. Avitene, once in contact with a bleeding surface, causes platelets to form a clot.
3. Thrombin is an agent for dry (not actively bleeding) cuts.

In the gym, the fighter should wear good-fitting headgear to guard against cuts and facial swelling. In a fight, a good cutman can make the difference between a fighter winning or losing. A cutman should know his fighter, should understand facial anatomy, and does not need to wait to see blood before treating his fighter. A fighter prone to cuts should stay away from any medicine that can increase bleeding time (such as Aspirin), and have their skin iced in the dressing room before the contest begins.

If the ring physician is overseeing a fight where the fighter was cut during his last contest, it is advisable to make certain the laceration is medically cleared before the fighter presents to the weigh-in.

## 11.6 Head Blows

Table 11.3 enumerates important changes that can occur in a fighter's demeanor that are clear indicators to the ring physician that he should take a serious look between rounds or recommend a stoppage. Some of these materials have been covered in the previous discussion of when to examine a fighter between rounds.

A ring physician can employ a mental checklist once the fight begins. Deterioration in balance, gait stability, alertness, or confusion are all easily observable from your seat. A physician should not hover over the fighters from fear or their own insecurity. But, if obtaining a better look at an athlete between rounds will appease your conscience and tell you more of what you need to know, by all means, mount the ring apron. Several physicians use this obligatory action to *appear* they are evaluating the fighters, but instead hang outside the ropes. In this position they are only able to visualize the trainers or cutman. *It serves little purpose*. If you wish to examine the fighter,

**Table 11.3** Things to look for during the fight and between rounds that might necessitate a contest stop

| |
|---|
| Worsening balance and coordination |
| Fighter having difficulty returning to his corner |
| Diminished alertness between rounds |
| Slowed reflexes during the round such as missing punches and difficulty avoiding being hit |
| Slurred speech |
| Facial asymmetry or unilateral weakness |
| Complaints of headache, dizziness, incoordination, or vision loss |
| Awareness of the cornermen's ringside conversations during the fight that might indicate their fighter is injured |

climb between the ropes and look at the fighter head on. Otherwise, how will you be able to adequately assess cranial nerve function and speech, and insure that the fighter is not complaining of a headache, dizziness, or loss of vision; all things that would compel you to jump in and recommend the contest end?

Some fighters have wills of iron and a skull to match. The same standards hold true for head blows as they do for lacerations and eye injuries. If the fighter appears to have no chance of victory, and allowing him to continue could result in irreparable harm, there is no reason for additional punishment.

## 11.7 Post-fight Examination

Perhaps the most crucial thing a physician or trainer can do for an athlete after a fight is ensure they have been appropriately diagnosed and triaged. All too often a fighter's adrenalin will take over, and it will be minutes to hours before they recognize symptoms and complaints that could indicate serious or life-threatening injuries. The process becomes equally difficult for the ringside physician who has little time with the combatant to perform a complete examination.

A physician should accompany the fighters to their dressing rooms when they leave the ring as this is precious time to document neurological changes in their condition. This becomes of greater significance if the contest was stopped due to head blows. We recommend a post-fight checklist that documents symptoms, injuries, recommendations, and the suspension.

### *11.7.1 Remember That Even the Winner Can Suffer Serious Injuries*

Table 11.4 lists the signs and symptoms that may indicate a serious injury and require further evaluation in an emergency room. First and foremost, any athlete

**Table 11.4** Post-fight signs and symptoms indicating a serious head injury

| |
|---|
| Headache |
| Nausea or vomiting |
| Dizziness |
| Amnesia |
| Confusion |
| Blurred vision/diplopia/pupillary inequality |
| Ataxia/gait unsteadiness/loss of coordination |
| Hearing loss/tinnitus |
| Unilateral weakness/sensory deficits |
| Decreased alertness |
| Seizure |
| Personality changes/irritability |

complaining of a headache should receive a post-fight head CT. Fighters are accustomed to being struck in the head, and following a contest they almost never complain of head pain. Therefore, this is a hallmark of at least a concussion, and often indistinguishable from a cerebral hemorrhage. Additional complaints of dizziness, balance issues, confusion, or nausea necessitate immediate hospital transport.

The fighter's cornermen or family can be extremely helpful in identifying changes in a fighter's condition. If the fighter speaks a foreign language, if possible have an independent translator present. If the athlete is not sent to the hospital, make certain that someone will remain with them over the following 24 h, and that they are also aware of the signs and symptoms to look for that could indicate a serious head injury. This should be in writing and given to the contestant.

"The suspension" refers to the time away from training and competing given to the athlete as a result of what occurred in the ring. Ring physicians are often reluctant to give an athlete a long enough suspension. Nothing is more important for a fighter than rest. Professional fighters and their trainers are often the last to understand this concept. Furthermore, the ring physician may be the only health care professional the athlete sees. It is invaluable to give them an honest opinion. Ring physicians, in the process of determining a suspension, may often ask the fighter: "When is your next bout scheduled?" This should be the last question on their mind. If a fighter has suffered many head blows in just a four-round contest, especially if they have been knocked down or stunned, they need time for their brain to recover. Giving them an adequate suspension between fights can also prevent them from sparring.

The length of the suspension is difficult to determine, and requires some experience of the ring physician. However, any athlete who receives a technical knockout for a laceration or significant head blows should not be permitted to fight again for at least 30 days. If there is a significant technical knockout (TKO)/ knockout (KO), the suspension should be a minimum of 45–60 days. It is also possible to give the fighter a recommendation of time before they return to sparring. In the USA, if a fighter receives a 60-day suspension, they are advised not to return to the gym for 45 days; 45-day suspension is given as 45/30, or no scheduled contest for 45 and 30 days – no sparring. This information can be relayed on a sheet containing a list of nearby medical facilities and potentially serious neurological symptoms in their native language.

Several jurisdictions also provide automatic suspensions. For example, a fighter who has completed 10–12 rounds, irrespective of the outcome and the degree of difficulty of the fight, is advised that he cannot fight again for at least 30 days.

Many fighters are prone to bleeding because they have received inadequate treatment for a cut or insufficient time to heal. A laceration should be sutured as quickly as possible, but definitely within 24 h. In some cases, waiting more than 6 h can make wound closure difficult. A laceration should reach maximum tensile strength at 3 months. Cuts around the orbital bone or mouth can take longer.

Suspensions for lacerations vary greatly. A minimum of 30 days is suggested, and if the laceration requires two layers of sutures, we recommend 45–60 days. Irrespective of the time off, requiring the cut to be medically cleared before their next fight will eliminate much of the guesswork, and some athletes heal more quickly.

## 11.8 Drug Testing

Drug testing is necessary to maintain fairness and integrity in all sports. In unarmed combat contests, it will be undertaken if the fight is a championship contest. However, at some time many fighters entertain using performance-enhancing agents or illicit drugs. Although drug testing is covered elsewhere in this text, it is important for those involved in all aspects of boxing, martial arts (MA), and mixed martial arts to understand the pervasive use of such substances, and that all too few athletes understand the potential side effects and risks involved. It is the duty of the ring physician and commission to educate as many athletes as possible regarding this issue. It is untrue that only heavyweights or fighters moving up in weight use anabolic steroids. This is a problem in all weight classes.

Testing cannot become a deterrent unless widely utilized. We recommend similar protocols to those used by World Anti-Doping Association (WADA) and the Olympics, where athletes can be tested during their training or as soon as a bout contract is signed. Fighters should be educated regarding medications that could place them at additional harm before or during a contest. A complete list of prohibited medications can be provided to fighters and their trainers in advance of the fight. Over the counter medications such as Aspirin can be overlooked as something potentially harmful to a fighter. Fighters need to understand that they must take personal responsibility for every type of supplement or medication used, and that ignorance is not an excuse for a positive drug screen. In advance, the fighters' camp must provide the commission the names of any medications they are currently taking.

## 11.9 Hand Injuries

Hands are a fighter's first line of defense. Every hand injury in a fighter is important. If ignored, a minor injury will become a major one. According to Dr. Charles Melone, a prominent New York hand surgeon who has treated hundreds of fighters, "One-third of all boxing injuries involve the hands. The high incidence relates to unsupervised punching and unlimited sparring especially at an early age." Wrapping hands properly during every training session is as important as during a fight. Dr. Melone notes: "Too many trainers make the hand wraps too bulky and neglect protection of the knuckles where most of the injuries occur."

If a fighter continues to have hand pain for more than a few days following sparring or a fight, he should seek medical attention. The doctor, preferably an orthopedic hand specialist, will examine the fighter for painful joint laxity, deformities, and limited joint motion. This is typically followed by plain radiographs. However, computerized axial tomography (CAT) scans or magnetic resonance imaging (MRI) may be useful in select cases of ligament or tendon injury.

Initially, hand injuries may benefit from elevation, anti-inflammatories, ice, and splinting. As per the discretion of the hand surgeon, others may benefit from local injections of anti-inflammatories. Repeated injections should be avoided or they could weaken the area and contribute to subsequent injury. The treatment objective is complete rehabilitation before resuming sparring/training.

## 11.10 Frequent Fighter Hand Injuries

1. "*Boxer's knuckle*" (Fig. 11.1a/b, 1) is the most common, and results in partial or complete extensor tendon rupture of the second digit. It is treated by splinting or casting, and sometime surgery.
2. *Metacarpal boss injury* (Fig. 11.1a/b, 2) results in complete or partial disruption of the joints at the base of the metacarpals. It usually involves the index or long fingers. Typically, there is a painful bump over the dorsal aspect of the hand, and it is often confused with a fracture.
3. *Fractures* (Fig. 11.1a/b, 3) usually involve the metacarpal bones (often the ring finger). If displaced, it will require surgery, as opposed to a non-displaced fracture, which can be managed with casting or splinting.
4. *Bennett fracture-dislocation* (Fig. 11.1a/b, 4) is a most common fracture, and usually requires surgery.
5. *Collateral ligament thumb injuries* (Fig. 11.1a/b, 5) typically called a "Gamekeeper's Thumb" " occurs at the MCP joint of the thumb. Depending on its severity, surgery may be required.

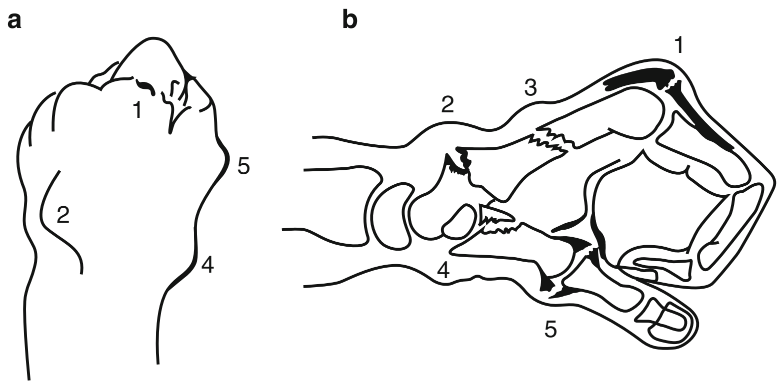


**Fig. 11.1** Hand injuries among boxers: types and sites
(a) Top view of the hand (b) Side view of the hand
1. Boxer's knuckle
2. Metacarpal boss
3. Metacarpal fracture
4. Bennett fracture-dislocation of thumb
5. Collateral ligament injuries of the thumb

Each commission has rules and regulations regarding hand wraps and gloves. This includes the amount and types of gauze and tape allowed in addition to approved glove brands. Commissions, trainers, and fighters should examine the gloves to make certain that they are not broken down. If possible, a fighter should choose the brand of glove he uses. Glove brands are very different. Some manufactures stay away from using any horse hair, as it can break down and separate, and have switched to specialized foams that will mold to the shape of the hand. Some gloves have seams, others have more concentrated padding in the front, and some offer more support for the wrist.

Prevention is the key. Fighters can do conditioning exercises, and make certain that the glove he chooses protects the knuckles and provides proper energy absorption when punches are landed. Dr. Melone does not accept the concept that some athletes have “brittle hands.” However, some athlete’s hands are more durable than others. No fighter goes into any fight 100%. Injecting a fighter’s hand too close to competition is illegal, will alter his sense of pain, and can result in more permanent issues.

## 11.11 Eye Injuries

Former professional middleweight champion and Olympic Gold Medalist from the USA, Sugar Ray Seales, fought legally blind until he retired after a first-round technical knockout win over Max Hord in 1983. He was the first boxer to shed light on the abuses and neglect surrounding eye injuries in combat sports. Nevertheless, many commissions do not require annual eye exams. Dr. Jeffrey Parker, Las Vegas, Nevada, retinal specialist, who has consulted on fighters for over 20 years states: “Up to 85% of boxers suffer some sort of eye injury during their career, and must undergo a yearly <u>dilated</u> examination with an ophthalmologist. Without dilatation, the exam is inadequate.”

The cornea is a transparent surface covering and protecting the front of the eye. The pupil allows light into the eye, while the colorful iris controls the amount of light entering. The lens (very much like the lens in a camera) focuses light on the retina. The retina is a thin layer of nerve cells lining the back of the eye. It changes light images into electrical impulses, which are then carried via the optic nerve (a thick cable of millions of wires) to the brain for interpretation.

A fighter’s vision cannot be worse than 20/200 in each eye (without glasses) or 20/60 in both eyes (without glasses). Worsening visual acuity in a fighter is serious, requires immediate attention and may be from the following:

1. *Glaucoma* is a blockage of the drainage channels in the eye resulting in increased pressure on the optic nerve. Unfortunately, as much as 40% of vision can be permanently lost before symptoms are experienced.
2. *Cataracts* can happen in boxers from trauma or steroid use, and refers to the clouding of vision over the lens blocking light entry.
3. *Corneal* abrasion is a scratch on the eye’s protective covering and can come from a punch or a glove. If ignored, it may lead to permanent damage or infection.

4. *Retinal detachment, holes, or tears* are often painless and are accompanied by a loss in peripheral vision. Other symptoms of retinal injury include dark floaters or bright flashes of light. More than 90% of retinal detachments are successfully corrected if treated within the first 7 days.

A dilated ophthalmologic examination will include an evaluation of visual fields, pupillary abnormalities, and extraocular muscle movements. The ring physician will include some of these as well, but subtle abnormalities are often missed at a weigh-in, and fighters will often try to conceal an injury, even one as serious as one involving the eye.

The main recommendation a fighter should receive is that a "shiner" is *more* than a superficial bruise if it does not resolve within 7–10 days.

The necessary time to recover from eye surgery is controversial. Retinal holes or tears, if treated by laser or insertions of specialized gas bubbles to press the retina back, can require as short as 1 month away from sparring. Cataract repair recovery can require 4 months healing time. As expected, less invasive methods require less time off. Sugar Ray Leonard was the first boxer allowed to return to the ring after retinal detachment surgery in the 1980s. Prior to this time a fighter was forced to retire. Successful surgery requires at least 4 months to heal, and a fighter should obtain clearance by a retinal specialist before every fight.

## 11.12 Cerebral Injury

This is being covered in detail in Chapter 6.

Through our years in the sport we have seen the following as predisposing factors to cerebral injury in fighters:

1. Undisclosed/ignored injuries. Many fighters who collapse in the ring actually entered with a preexisting injury from either a prior fight or sparring. Perhaps the fighter has been dropped or even knocked out in the gym. Often a fighter does not wish to show weakness and confide in those closest to him regarding health issues. Equally detrimental is his trainer advising him to fight through it.
2. Second impact syndrome (SIS). SIS refers to an athlete suffering a seemingly insignificant head injury, and soon thereafter he is struck again. The second injury, also at times minor, quickly results in death usually as a result of severe cerebral edema.
3. Medical history. Too few fighters are regularly examined by private physicians. Prefight exams are cursory, and many commissions require little testing. Potentially life-threatening problems are undiagnosed. These can include: hypertension, diabetes, heart disease, Lupus, and bleeding disorders. Family history can be equally important regarding incidence of heart disease, stroke, or cerebral hemorrhages.
4. Cerebral abnormalities. These include: aneurysms, arteriovenous malformation, angiomas, arachnoid cysts, contusions, and subdural hematomas. Every fighter should undergo a baseline MRI/MRA when becoming professional with follow-up comparison scans as needed, if possible, every 5 years.

5. Weight loss/dehydration. Many fighters who die are those who had trouble-making weight, or lost significant amounts of weight prior to a fight. Although the correlation may not be directly related, this factor repeatedly comes up.
6. Weight class. Statistically heavyweights are the least likely to die in the ring. Many theorize this due to the fact they do not have to make weight.
7. Age (see *When Should a Fighter Retire* below).
8. Medications. Certain medications can contribute to cerebral hemorrhages by either increasing clotting time or blood pressure. Aspirin will contribute to bleeding and bruising, including within the brain. Caffeine or other stimulants can increase blood pressure and pulse.
9. Alcohol/steroids. These substances are frequently overlooked as risk factors for death in fighters.
10. Inadequate rest. Rest is significantly overlooked by fighters. It stresses the importance of adequate suspensions, and time off from sparring between contests.

## 11.13 Differences Between Injuries Encountered in Boxing, Martial Arts, and Mixed Martial Arts

These differences exist on several levels. Many competitors in boxing and martial arts start at an earlier age than mixed martial artists. The punishment taken in the amateurs accumulates, and is just as dangerous as that sustained in the professional ranks, especially as current headgear will not protect a fighter from cerebral injury. The less punishment a fighter absorbs, the better off they will be as they age.

The numbers of rounds and the length of the rounds differ. Professional MA and boxing contests have 3-min rounds, although women's rounds are typically 2 min. In MMA, the rounds are often 5 min, and in certain organizations, the first round is 15 min in length. Boxers start out professionally in four-round bouts, while an MMA fight is never longer than five rounds.

Given the differences between the disciplines, there are differences in injuries. MMA and MA athletes will suffer a greater number of orthopedic injuries, including dislocations and fractures. All of these endeavors may cause hand injuries, especially in MMA where the athletes are receiving reinforcement for fighting upright. MMA competitors throw punches using 5-oz gloves, which provide less hand protection. However, this small glove size, in comparison with an 8- or 10-oz boxing glove, requires the MMA fighter to lessen the number of punches used and instead take their opponent to the ground where much less force can be generated.

Lacerations differ between MMA/MA and boxing, where in the first two endeavors a knee, kick, or elbow results in deeper cuts. In MMA, a fighter working on the ground during a lengthier round can extend a cut, and bleeding is more difficult to control for the cutman. An elbow is the ideal weapon to open a large facial laceration.

Knockouts occur in all three, but in MMA and MA the force of a blow to the head via a leg as opposed to an arm is significantly increased. Quick knockouts occur more frequently than in boxing. In MMA, there is no eight-count as there exists in boxing where a fighter is hurt or knocked down the referee will count to allow the fighter time to recover In other words, if a fighter is knocked down or dazed, the fight stops immediately as opposed to MA or boxing where the fighter is allowed to continue if he regains his composure.

## 11.14 Conflicts of Interest

Conflicts of interest can destroy any official's career. A ringside physician must follow the same code of ethics as a referee and judge. Commissions have various regulations and statutes regarding this issue. However, if a physician wishes to have strong credibility, they should avoid all contacts on a social or professional level with a fighter, his trainer, manager, or promotional entity *outside* the confines of a fight. This is often not easy. If one works in the sport long enough, they receive the inevitable calls to care for a fighter in training or before a bout. It is easy to understand the conflict for a referee or judge, but imagine making a determination if a fight should continue if the ring physician is also the athlete's private physician. This presents an inescapable fiduciary relationship with a competitor, and could confuse the physician's decision-making process. At the very least it will present an obvious conflict that could raise an array of questions that will ultimately interfere with credibility on this and future decisions.

Perception is reality in professional combat sports, and what is done cannot be undone. Becoming too close with athletes may advance your popularity, but is a line that should never be crossed irrespective of what is or is not allowed by your commission.

## 11.15 When Should a Fighter Retire?

No one can deny the aging process brings an inevitable decline in physical capabilities. Professional fighters often push the edge of the athletic envelope too far for their own medical good. Nevertheless, promoters, networks, and commissions typically turn a blind eye especially if a boxer is marketable. Advancing age does not parallel deterioration of a fighter's capabilities and health status. However, the ring physician must understand that just because an individual can pass the required commission medical testing does not necessarily make them fit to box.

The US Age Discrimination in Employment Act (ADEA) of 1967 prohibits discrimination in hiring, promotions, termination or any other term, condition, or privilege of employment because of a person's age. This includes individuals at age 40 and above. Legally, a fighter may be protected, but should someone fight at age 40, 50, or even 60? What if the fighter looks punch drunk at age 35?

Commissions never deny a license to fight solely on the basis of age. If concerned, they invoke additional medical testing requirements in a vague attempt to factor in skill. Although fans would follow Arnold Palmer around a golf course until he could no longer play, *boxing is not golf*! No one should really fight over the age of 40; in fact most fighters over 35 are at increased risk of acute and chronic injury. In this instance, common sense is as valuable as fact.

James Michener's 1976 book, *Sports in America* examines at what age reflexes slow. Statistics on World War II jet fighter pilots discovered that their optimal age was close to 17. When this was combined with optimal judgment and character, the age was 23. Things have changed a bit over the years, but not that much.

The mechanisms underlying the aging process are not well understood, and many believe that "wear and tear" exceeds the reparative capacity of tissues. Obviously, great individual differences exist, and there is no test to determine one's true biological age. Each of our organ systems respond differently to advancing years. Muscle strength peaks at 25, and thereafter we lose some of the abilities to control muscle firing, which eventually leads to a loss in strength and coordination. No physician could argue that the bridging veins connecting the brain to the dura are more apt to rupture in an older boxer. The brain shrinks with age in everyone, these veins stretch, and, when the head is struck, a subdural hematoma can occur more readily. Musculoskeletal problems and bone loss are unavoidable leading to detrimental repeated injuries in a fight or training.

Of course there are exceptions.

Sugar Ray Robinson knew that he was slipping after age 29. He fought a total of 202 fights and ultimately retired at age 44, but 16 of his 19 defeats occurred after age 34. Many would debate Ray Robinson was an exception, and so far above other champions at the beginning and end of his career. In the USA, George Foreman repeatedly comes to mind when older fighters attempt to rationalize continuing their career. However, he initially stopped boxing at age 28; returned at 38, and recaptured the heavyweight championship at 45. Foreman benefited from the time off, but his success never depended on speed and movement. He had great knockout power, and this protected him against repeated punishment. His "ring age" was much younger than his chronological age. We cleared Foreman to fight for his 1994 comeback against Michael Moorer at age 45.

For a fighter there are objective criteria that can indicate a fighter should retire. One of the authors (Edwin Homansky) has developed a simple index, the Boxing Severity Index (BSI). This index, specific to boxing, employs simple criteria to determine when a fighter needs [2] further evaluation prior to continuing their career (Table 11.5).

## 11.16 Summary

Working with fighters is a gift that in many ways can enhance your medical area of expertise. In our experience, fighters are grateful patients that truly appreciate the need for your assistance even at times when they might disagree with your decision.

**Table 11.5** Boxing Severity Index (BSI)

| | |
|---|---|
| *Activity (fights in the last 2 years)* | |
| 1 (or less) | +1 |
| *Recent record* | |
| Lost 5 or more in a row | +2 |
| Lost 3 of last 4 | +1 |
| Won 3 of last 4 | −1 |
| *KO/TKO* | |
| More than 4 in last 2 years | +3 |
| 3 or less in last 2 years | +2 |
| Last fight by KO | +1 |
| *Age* | |
| Greater than 44 | +2 |
| Greater than 35 | +1 |
| *Ring age* | |
| Greater than 500 rounds | +1 |
| (Amateur experience Each fight = 1 pro round) | |
| Greater than 5 years as an amateur | |
| | +1 |
| *Total Score:* | +3 – +4 = High Risk Category "A" |
| | +5 – +6 = High Risk Category "B" |
| | +7 – +9 = High Risk Category "C" |

Categories A, B, and C indicate the fighter needs further clinical evaluation before licensure. If a fighter falls into Category A, he should have additional review by the licensing commission; if Category B, he should undergo extensive neurological evaluation and testing; and if Category C, he should be refused a license to compete. This scale is not meant to replace good judgment, but to be utilized as one objective tool to determine suitability to compete.

*First and foremost, you are an advocate for the athlete.* When a fighter will not quit, a cornerman will not stop a contest, or the referee is unable to step in, *you* are the one who must make the right decision, and if necessary, recommend the fighter to return to action another day. Accompanying this grave responsibility you must never lose sight of the fact that you have the athlete's future and life in your hands. Many factors play into this decision, and it is imperative to weigh each through your knowledge of the competitors fight and medical history, in addition to an understanding of the flow of the fight.

## Web sites

http://www.boxrec.com/
http://www.fightfax.com/
http://www.wada-ama.org/en/

## Internet Boxing and MMA Sites

http://www.secondsout.com/
http://www.fightnews.com/
http://www.braggingrightscorner.com/
http://sports.ESPN.go.com/extra/mma/index
http://sports.ESPN.go.com/sports/boxing/index
http://thesweetscience.com/
http://sherdog.com/

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# Chapter 12
# Boxing

**Peter Jako**

## Learning Objectives

- To understand the medical control and the safety measures of amateur boxing
- To recognize the physiological demand of boxing
- To recognize the injuries in boxing

## 12.1 History of Boxing

The written history of boxing starts in Ancient Greece; however, Egyptian artifacts dating back to 3000 BC show boxing events and maybe boxing appeared in Ethiopia as early as 6000 BC. In Ancient Greece, there were few rules but wrestling and grappling were not allowed. The boxers initially fought bare fisted. Later they bound their hands with soft leather thongs. Boxing first appeared as an Olympic sport at the Olympiad in 688 BC. Later, boxing was taken to Rome and became a gladiatorial contest. After the collapse of the Roman Empire there are few records of boxing until the eighteenth century.

"The noble science of defence" as it was called by James Figg, an Englishman, was advertised in 1719 as a part of a show where not only boxing, but also use of sword and quarter staff were included. John Broughton started a revolution in boxing by fighting on a raised stage under new rules (barefist fighting, no time limit for a round, and the end of the fight declared if one of the boxers could not return in the ring). The biggest change occurred when the Queensbury Rules were introduced in 1867. The father of this new era in boxing was John Sholto Douglas, Marquess of Queensbury. Boxing became a gloved sport, with fixed duration of rounds and rest periods. Points were awarded to boxers in each round to determine the winner if neither boxer had been knocked out nor become unable to continue the competition. There were only three weight categories (up to 60, 70, and over 70 kg). "Amateur Boxing Association" was founded in England in 1880.

The first time boxing was on the programme of the Olympic Games was in St. Louis in 1904 with seven weight categories. Since 1920, boxing was on the

R. Kordi et al. (eds.), *Combat Sports Medicine*,
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programme of the Olympic Games without interruption. International Amateur Boxing Association (AIBA) was founded in 1946 in London and since then AIBA has been the official world organization of amateur boxing.

At present AIBA has 196 affiliated national federations [1].

## 12.2 Medical Boxing History

The AIBA Medical Commission was founded in 1948. The first chairman of this commission was Professor A. Kennedy from England. The Medical Commission has 25 members representing each continent, all doctors of medicine. The commission arranges meets at least twice each year and organizes scientific symposia and conferences. Its members publish articles in medical journals on the medical aspects of boxing. The Commission also initiates and coordinates medical research projects and make recommendations to the International Amateur Boxing Association Congress with regards to the health, protection, and well-being of boxers. In 2004, the Medical Commission published the sixth edition of the *Medical Handbook of Amateur Boxing*, which sets guidelines for all those doctors who are involved in boxing. In 2006, the Commission edited *Doctors at Ringside*. This book collected the experiences of the commission members accumulated during many years of experience.

The members of the commission were specialists in various fields of medicine, including general practitioners, surgeons, orthopedic surgeons, neurologists, neurosurgeons, sports physicians, and psychiatrists.

The Medical Commission's Anti-doping Sub-Commission is responsible for enforcing the doping regulations at national, continental, and world level. The members of the commission serve in the Medical Juries of the world championships, AIBA tournaments, and Olympic Games.

During the last 20 years several new rules were introduced in amateur boxing for the safety of the boxers and thereafter amateur boxing has become one of the safest contact sports [2].

The most important health protective rules and measures are the following:

- Compulsory using of the low blow protector, gum shields, and headguard
- Reduction of the duration of the round from 3 to 2 min
- Power of the medical jury to stop the bout
- Minimum and maximum age limit of boxers
- Mandatory medical evaluation of boxers at least once in a year
- Medical examination prior to a bout
- Compulsory rest after knockout or RSCH (the boxer is unfit to continue the bout having received several hard blows to the head), and a thorough medical examination before he/she starts boxing again
- Compulsory using of the International Record Book of Boxers with a complete technical and medical records of the boxer
- Very strict and effective doping control

In 1994, the Medical Commission of the International Olympic Committee made the following statement: "[W]e have reviewed past retrospective studies and have now completed our review of major prospective studies regarding Olympic-style boxing and the question: does Olympic –style boxing cause chronic brain dysfunction?

Presently these studies indicate that there is no apparent scientific evidence of chronic brain dysfunction demonstrated in Olympic-style boxing. … Due to AIBA evolution in its rules, goals and medical controls, Olympic-style boxing is a completely different sport that professional boxing." [3]

## 12.3 Equipment

*The ring* – the minimum size is 4.90 $m^2$ and the maximum is 6.10 $m^2$. The corner posts must be well padded. The floor is covered with felt, rubber, or other suitable material, not less than 1.3 cm thick and not more than 1.9 cm. Canvas covers the entire platform. Three or four ropes connect the corner posts. Two steps in opposite corners are for the use of the boxers and seconds, one in the neutral corner for the use of referees or doctors. In the two neutral corners outside the ring, a small plastic bag is fixed in which the referee shall drop the cotton pads, or gauze used to wipe the bleeding

*Gloves* – the boxers wear red or blue gloves according to his/her ring corner. The weight of gloves is 284 g (10 oz) of which the leather portion weighs not more than half of the total weight and the padding not less than half of the total weight. The regular hitting surface must be marked on the gloves with a clearly discernible color. For sparring in the gym heavier gloves should be used.

*Bandages* – bandaging not longer than 2.5 m and 5.7 cm wide on each hand must be used.

*Dress* – boxers box in light boots, shorts, and vest covering the chest and back.

*Gumshields* – use is compulsory and must be form-fitted. Ideally they are made by a dental surgeon.

*Cup protector* (low blow protector) – the wearing of a cup protector is compulsory for male boxers.

*Headguard* – the headguard is an individual and form-fitted item of the boxer's equipment The color of the headguard is red or blue.

## 12.4 Decisions in Amateur Boxing

*Win on points*. At the end of the contest, the boxer who has been awarded the decision by a majority of the judges declared the winner.

*Win by retirement.* If a boxer retires voluntarily his/her opponent shall be declared the winner.

*Win by referee stopping contest* (*RSC*). If a boxer in the opinion of the referee is being outclassed or is unfit to continue the bout shall be stopped and his/her opponent shall be declared the winner.

*Compulsory count limit.* When a boxer has three counts in the same round or four times in the whole bout, the referee has to stop the contest (RSC). In female or cadet boxing, the bout must be stopped after two eight-counting in one round or three eight-counting during the whole bout.

*Injury.* If a boxer in the opinion of the referee or the medical jury is unfit to continue because of the injury sustained from correct blows the bout shall be stopped and his/her opponent declared the winner.

*Win by knockout (KO).* if a boxer is "down" and fails to resume boxing within ten seconds, his/her opponent shall be declared the winner.

*Win by RSCH* (referee stopped the contest because of head blow). To be awarded if a boxer is unfit to continue having received hard blows to the head.

*Win by walkover*. If a boxer presents himself in the ring and his/her opponent fails to appear, the referee shall declare the first boxer to be the winner.

## 12.5 Weight Classes

For senior and junior (under 19 years) boxers there are 11 weight classes: 48, 51, 54, 57, 60, 64, 69, 75. 81, 91, 91+ kg.

For female and cadet boxers (15–17 years) there are 13 weight classes: 46, 48, 50, 52, 54, 57, 60, 63, 66, 70, 75, 80, 86 kg.

## 12.6 Pregnancy Declaration

Female boxers should produce before each bout a declaration form signed by herself and an official of the national federation in which she declares that when entering the boxing event, she is not pregnant, and that she has had a pregnancy test done within the last 14 days, and that result of the test showed no pregnancy.

## 12.7 Principles of Conditioning for Boxing

An amateur boxing bout consists of four 2-min rounds with a 1-min rest period between rounds. The object is to score points with clean, correct punches (with the hitting surface of the gloves) and at the same time to avoid the blows of the opponent. To deliver scoring blows and to avoid getting blows, this style of boxing requires skill and conditioning. The skill can be developed by the practice in the gym (shadow boxing, sparring, punching heavy and speed bags, skipping rope), while the most important phase of physical conditioning is aerobic exercise.

There is a strong correlation between the rate of injuries and the fitness level. Although the technical and tactical elements play an important role, the endurance capacity of a boxer has particular importance because offensive and defensive aspects of boxing have become more dynamic in the recent years.

In boxing, the role of anaerobic alactic acid energy system (anaerobic energy process without lactic acid production) can be disregarded because of the longer duration of the rounds and the contest. Maximal oxygen uptake (VO2 max) is an important endurance component and is determined commonly during laboratory conditions by measuring gas exchange. The other powerful predictor of the performance is the anaerobic (blood lactate) threshold, that is, the exercise intensity at the point of lactate accumulation. In highly trained athletes the blood lactate threshold occurs at a higher percentage of aerobic capacity, as a consequence of physiological adaptations to training. In an earlier study we proved that 3 × 3 min bouts were accompanied by significantly higher aerobic effort than 4 × 2 or 5 × 2 min. A further significant difference was found between the 3- and 2-min rounds. In 3 × 3 min bouts the lactate values in the rest between the rounds, were above the anaerobic threshold, while if the duration of the round was 2 min the lactate levels were in aerobic range. Taking into consideration our results AIBA switched the 3 × 3- to 4–5 × 2-min bouts. A retrospective analysis of the injury statistics of seven Olympic Games and ten Senior World Championships registered by the AIBA Medical Commission between 1980 and 2003 showed that after the replacement of 3-min rounds by 2-min ones the prevalence of KO and RSCH dramatically dropped from 9.47% to 2.15%. (Fig. 12.1 and Table 12.1). At the Olympic Games, the change in the rate of KO and RSCH from 17.4% to 0.0% by the period of 1980 and 2004 (Table 12.2) was presumably the consequence of the mandatory use of headguards, improved refereeing, and strict medical control of amateur boxing [3, 4].

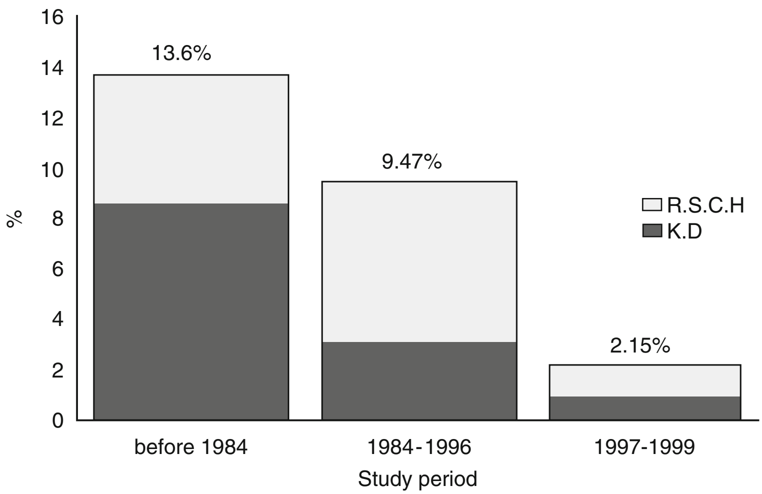


**Fig. 12.1** Contests finished KO or RSCH related to time periods where rules were modified (KO-H = knockout on the head, RSCH = referee stopped the contest because of head blow, RSCI = referee stopped the contest because of injury)

**Table 12.1** Rate of bouts stopped by knockout on the head (KOH), referee stopped the contest because of head blow (RSCH), or referee stopped the contest because of injury (RSCI) at the World Championships, 1982–2003 (%)

| Year City | KO-H | RSC-H | Subtotal | RSC-I | Total |
|---|---|---|---|---|---|
| 1982, Munich | 5.9 | 3.9 | 9.8 | 12.7 | 22.7 |
| 1986, Reno | 4.9 | 6.3 | 11.2 | 0.0 | 11.2 |
| 1989, Moscow | 1.3 | 6.2 | 7.5 | 1.8 | 9.3 |
| 1991, Sydney | 1.5 | 3.5 | 5.0 | 1.5 | 6.5 |
| 1993, Tampere | 1.6 | 1.9 | 3.5 | 1.5 | 5.0 |
| 1995, Berlin | 1.7 | 0.6 | 2.3 | 1.4 | 3.7 |
| 1997, Budapest | 0.8 | 1.7 | 2.5 | 1.4 | 3.9 |
| 1999, Houston | 0.3 | 1.5 | 1.8 | 0.3 | 2.1 |
| 2001, Belfast | 0.3 | 0.6 | 0.9 | 0.9 | 1.8 |
| 2003, Bangkok | 0.3 | 1.8 | 2.1 | 4.0 | 6.1 |

**Table 12.2** Rate of bouts stopped by knockout on the head (KOH), referee stopped the contest because of head blow (RSCH), or referee stopped the contest because of injury (RSCI) at the Olympic Games, 1980–2004 (%)

| Year City | KO-H | RSC-H | Subtotal | RSC-I | Total |
|---|---|---|---|---|---|
| 1980, Moscow | 11.0 | 6.4 | 17.4 | 12.2 | 29.6 |
| 1984, Los Angeles | 5.8 | 10.4 | 16.2 | 1.6 | 17.5 |
| 1988, Seoul | 7.9 | 16.3 | 24.2 | 1.4 | 25.6 |
| 1992, Barcelona | 1.9 | 8.4 | 10.3 | 3.2 | 13.5 |
| 1996, Atlanta | 1.1 | 4.6 | 5.7 | 3.2 | 8.9 |
| 2000, Sydney | 0.6 | 3.3 | 3.9 | 1.0 | 4.9 |
| 2004, Athens | 0.0 | 0.0 | 0.0 | 1.5 | 1.5 |

## 12.8 Cardiovascular Fitness (Endurance Capacity)

Building cardiovascular fitness or endurance capacity is one of the most important parts of physical conditioning in amateur boxing. A “well-conditioned” cardiopulmonary system helps the boxer to be fit in the last round.

Regular aerobic exercise (e.g., running) improves the functional capacity of the heart and the lungs.

Running or footing is an integral part of training for boxers. Running uphill is a good way to increase intensity and get a better workout. Running on the hard surface of a street may cause injuries to the legs and back. Therefore, it is better to run on sand or on soil. Wearing gumshields while running helps the boxer get used to the deep breathing needed during boxing.

Interval running (running at varied speeds during the workout) is a combined aerobic and anaerobic exercise. A quick recovery of the cardiovascular and respiratory systems is sought for and needed. In this manner he/she is able to progressively increase his/her endurance by increasingly stressing the cardiorespiratory system [5].

## 12.9 Developing Strength and Skill

Strengthening the arms, the neck muscles, and the abdominal muscles is of vital importance in boxing.

The neck muscles can be strengthened by an exercise known as wrestler's bridge. A strong neck helps to fix the skull and in that way the linear or rotational acceleration caused by a blow will be diminished. If the neck muscles are tensed in the moment of the impact, the boxer's head can sustain far greater forces without brain injury.

To deliver scoring punches to the opponent requires very good strength in those muscles that snap the punch to the opponent. There must be a very delicate balance in the weight training of boxers: the goal is to increase muscle mass without losing speed of movement and flexibility. A sensible plan of weight training is one of the tasks of the coaches.

There are several ways to gain the necessary skills in the gym: shadow boxing (boxing with an imaginary opponent), sparring (boxing in the gym with an opponent), punching bag (a heavy bag to learn the correct delivery of the different blows), and speed bag (to train the reflexes and to provide speedy movement).

## 12.10 Nutrition of Boxers

In general, the boxer's diet should conform to the basic dietary guidelines of healthy well-balanced sport nutrition. The energy intake has to meet to the energy demands of training, competition, and to maintain – or if it is necessary to reduce – the body weight. There are several factors, which influence the daily diet of a boxer: season of training, pre-event or post-event nutrition, environmental factors, weight making, etc. The basic principles of the boxer's diet are: the daily energy intake 70–75 kcal (293–314 kJ)/kg body weight/day; carbohydrates 60–65% (mixed low, moderate, and high glycemic foods), fats 25–30%, and proteins 15–20% of total energy consumption.

A well-balanced diet contains sufficient amount of vitamins and minerals. Therefore, nutritional supplements should be taken only by medical advice.

It is recommended to ingest 15–30 ml/kg body weight/day fluid to avoid dehydration. If fluid losses are not replaced, performance deteriorates. One percent to 2% loss of body weight from dehydration can decrease aerobic performance and has a negative effect on anaerobic performance and strength as well [6].

## 12.11 Medical Control of Amateur Boxing

*Initial medical examination.* A boxer should undergo a thorough medical examination when he/she joins a club. The exam should include: family and past medical history, complete clinical examination, and urinalysis. Electrocardiogram (ECG), cranial computed tomography (CT), or magnetic resonance imaging (MRI) are recommended. The conditions, which render the boxer unfit to box are referred to in the Medical Handbook of Amateur Boxing.

*Annual medical examination.* A medical evaluation should be conducted at least annually. It should include: past medical history, complete clinical examination, neurological examination, and if possible urinalysis and resting ECG.

*Medical check-up prior to a* tournament. The boxer must be passed before weighing in every day on which he/she is to fight during a tournament by a qualified ringside physician.

*Post-bout medical examination*. Each boxer must be examined by the ringside physician after the bout (mental orientation and status, quick survey of head, face, neck, upper extremities).

## 12.12 Boxing Injuries

### *12.12.1 Types of Boxing Injuries*

The types and frequency of boxing injuries at the US Olympic Training Center (1981–1982) was published by Jordan, Voy, and Stone in 1990: head and face 20.6%, upper extremity 32.9% lower extremity 23.9%, back 6.9%, cerebral 6.5%, cervical spine and brachial plexus 5.1%, chest 3.8%, and kidney 0.2% [18].

In the period 1992–2005 at the World Championships and Olympic Games the following distribution of injuries occurred: lacerations on the head in 3.5% and nasal bleeding in 2.8% of the bouts. Fractures: two mandibular, one jaw, one zygomatic, five nasal bone, two ribs, and seven metacarpal.

Other injuries: one anterior cruciate ligament (ACL) rupture and one rupture of the tendon of the right thumb [15].

### *12.12.2 Brain Injury*

The frequency of deaths or severe injuries in boxing is 1.3 in 10,000 boxers, which is lower than that reported in American football (3.0 in 10,000). The risk of brain injury in amateur boxing differs significantly compared with professional boxing due to stricter rules and regulations. The pertinent rules have been discussed in this chapter.

Brain injuries caused by boxing are classified into acute and chronic injuries. The impact of a blow causes an acceleration – linear or rotational – of the brain, which can reach up to 100 G. Impact to the head by an external force can cause the cranium to move more rapidly than the brain. Inertia of the brain to maintain the initial position causes damage in the frontal lobe, temporal lobe, the inferior surface of the temporal lobe, and occipital lobe, sometimes in the regions around the cerebral falx and cerebellar tentorium. Linear acceleration induces positive pressure in the directly stricken site and the brain collides with the cranium resulting in a coup injury. This linear acceleration causes gliding contusions of the cerebral cortex, ischaemic lesions in cerebellum,

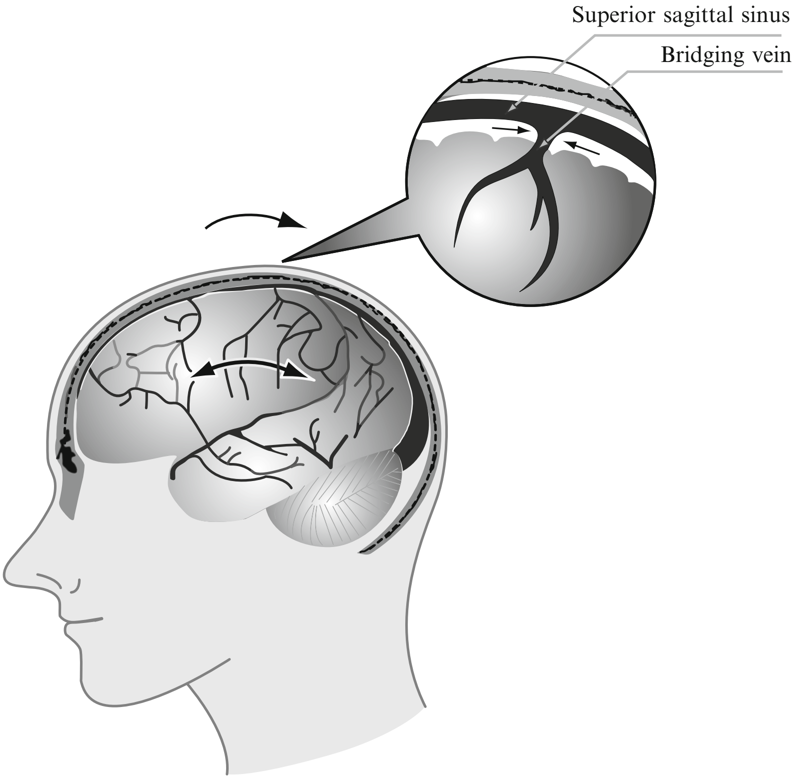


**Fig. 12.2** Rupture of bridging vein. Rotational acceleration/deceleration causes acute subdural hematoma by rupture of the bridging vein

and axonal damage in the brainstem. When a punch causes rotational acceleration of the head, the veins and long axon fibers are stretched and may be torn, resulting in subdural hematoma and axonal damage, respectively (Fig. 12.2). Falling against the ropes or the floor of the ring causes impact deceleration to the head and may result in contrecoup lesions as well as gliding contusions. Blows to the neck can injure the carotid artery and compression of the carotid sinus may cause generalized ischaemia of the brain. The severity of acute damage varies from transient alterations of cognitive function to irreversible brain damage and death.

#### 12.12.2.1 Acute Brain Injuries

Subdural Hematoma

The bridging veins connect the brain with the superior sagittal sinus of the dura mater. When the skull accelerates, these veins are stretched and if they torn, blood accumulates in the subdural space, causing compression, edema, and herniation of the brain. In boxing most fatalities are caused by subdural hematoma and its complications.

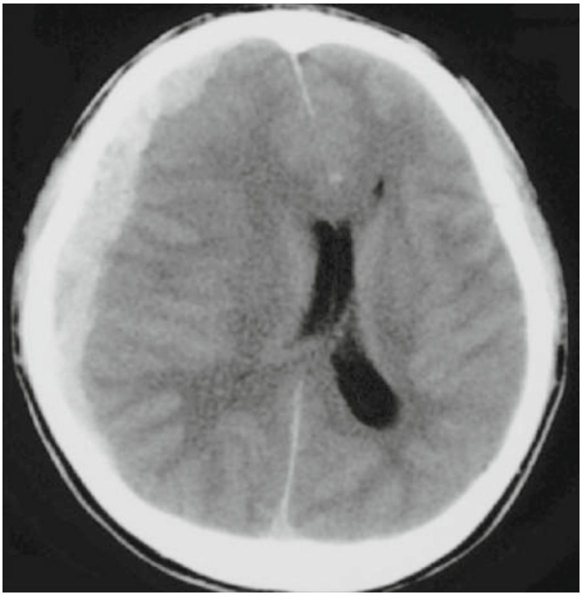

**Fig. 12.3** Acute subdural hematoma

Acute subdural hematoma can be diagnosed by plain CT alone. A crescent-shaped high-density area can often be observed below the cranial bone. In severe cases, brain contusion, ventricular displacement, median deviation, or cerebral edema is seen (Fig. 12.3).

### Intracerebral Hemorrhage

The rotational or gliding movement of the brain within the accelerated skull may tear vessels within the brain. Such hemorrhages occur most frequently in parasagittal regions of the cortex and subcortical white matter, but may also occur in the deeper white matter, the corpus callosum, and cerebellar peduncles.

The diagnosis can be made by CT.

### Diffuse Axonal Injury

Damage in the white matter is common in the trauma to the head. Axonal injury, because of lack of bleeding or gross disruption of fiber tracts, is easily missed in postmortem examination. A few severed axons may not be sufficient to produce clinical symptoms, but their number will increase with each bout.

Generally, CT is useful for diagnosis in the acute stage and MRI is useful for diagnosis in subacute to chronic stage, but in diffuse axonal injury MRI is more sensitive than CT.

### Second impact syndrome

If a boxer receives an initial head injury (e.g., concussion) and returns to play before all symptoms (headache, dizziness, difficulty in thinking, balance, etc.) clear and receives again a second head blow, even minor, the second impact syndrome may occur.

Posttraumatic cerebral swelling occurs due to two proposed pathophysiological mechanisms. The first is a failure of cerebral autoregulatory mechanisms, followed by an increased cerebral blood volume. The second mechanism of posttraumatic brain swelling is due to true cerebral edema. This condition can increase the intracranial pressure, resulting in brain herniation, and sometimes death. Both of these mechanisms can occur within hours of head trauma, but typically are seen after several days.

The prevention of this syndrome is most important: even a mild head injury must be very carefully examined by the medical doctor. If a boxer has any sign or symptom of concussion, he should not be allowed to return to competition until symptoms disappear [8, 9].

### Concussion

Concussion is the most common head injury not only in boxing, but in many other sports.

Concussion is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces [10]. Several common features that incorporate clinical, pathological, and biomechanical injury constructs may be used in defining the nature of a concussive head injury. Concussion may be caused either by a direct blow to the head, face, neck, or elsewhere on the body with an “impulsive” force transmitted to the head.

Concussion typically results in the rapid onset of short-lived impairment of neurological function that resolves spontaneously.

Concussion may result in neuropathological changes, but the acute clinical symptoms largely reflect a functional disturbance rather than structural injury. Concussion results in a graded set of clinical syndromes that may or may not involve loss of consciousness. Resolution of the clinical and cognitive symptoms typically follows a sequential course.

Concussion is typically associated with grossly normal structural neuroimaging studies [11].

Beside the clinical history a sideline evaluation of the boxer, including neurological assessment and mental status testing, is an essential component of the diagnosis. In the acute assessment of a concussive injury brief neuropsychological test batteries that assess attention and memory function have been shown to be practical and effective [12].

In the management of the concussion the most important rule is that when a boxer shows any symptoms or signs of a concussion (Table 12.3) return to play should not be allowed.

Regular monitoring is essential. Return to play must follow a medically supervised stepwise process [13].

In boxing the knockout (KO) or repeated knockdown (KD) with or without unconsciousness from medical point of view is a concussion. In the *Medical Handbook of Amateur Boxing* a very detailed guideline can be found for the management of concussion.

The grading of the concussion is based on the evaluation of the boxer. AIBA grading system corresponds to the grading system of the American Academy of Neurology (Table 12.4).

**Table 12.3** Symptoms of concussion

| |
|---|
| Early (min and h) |
| – Headache |
| – Dizziness or vertigo |
| – Lack of awareness of surroundings |
| – Nausea or vomiting |
| Late (day to week) |
| – Persistent low-grade headache |
| – Light-headedness |
| – Poor attention and concentration |
| – Memory dysfunction |
| – Easy fatigability |
| – Irritability and low frustration tolerance |
| – Intolerance of bright lights or difficulty focusing vision |
| – Intolerance of loud noises, sometimes ringing in the ears |
| – Anxiety and/or depressed mood |
| Sleep disturbance |

**Table 12.4** Representative grading of concussion (From [8]. With permission)

| System | Grade 1 (mild) | Grade 2 (moderate) | Grade 3 (severe) |
|---|---|---|---|
| American Academy of Neurology (1997) | Transient confusion; no LOC; symptoms or abnormalities resolve in less than 15 min | Transient confusion; no LOC; symptoms or abnormalities last over 15 min | Any LOC, either brief (s) or prolonged (min) |
| Colorado Concussion Classification (1991) | Confusion without amnesia; no LOC | Confusion with amnesia; no LOC | LOC |
| Cantu (1986) | No LOC; posttraumatic amnesia lasting less than 30 min in duration | LOC for less than 5 min in duration, or posttraumatic amnesia lasting longer than 30 min but less than 24 h in duration | LOC for more than 5 min in duration, or posttraumatic amnesia lasting longer for more than 24 h in duration |

**Table 12.5** Neurocognitive testing

| | |
|---|---|
| **Mental status testing** | |
| Orientation | Time, place, person, and situation (circumstances of injury) |
| Concentration | Digits backward (e.g., 3-1-7, 4-6-8-2, 5-3-0-7-4) |
| | months of the year in reverse order |
| Memory | Names of teams in prior contest |
| | Recall of 3 words and 3 objects at 0 and 5 min |
| | Recent newsworthy events |
| | Details of the contest (plays, moves, strategies, etc.) |
| **External provocative tests** | 40-yard sprint |
| | 5 push-ups |
| | 5 sit-ups |
| | 5 knee bends |
| | (any appearance of associated symptoms is abnormal, e.g., headaches, dizziness, nausea, unsteadiness, photophobia, blurred or double vision, emotional lability, or mental status changes) |
| **Neurologic test** | |
| Pupils | Symmetry and reaction |
| Coordination | Finger–nose–finger, tandem gait |
| Sensation | Finger–nose (eyes closed) and Romberg |

*Grade 1* – transient confusion, no loss of consciousness, symptoms, and signs resolve in less than 15 min. *Grade 2* – same as grade 1, but symptoms and signs last over 15 min. *Grade 3* – loss of consciousness, either brief (s) or prolonged (min).

The physician in the ring needs to promptly secure the airway, remove the gum-shield, and check the respiration, pulse, hand, and foot movement. If the boxer fails to regain consciousness, continue airway management, immobilize the neck in a cervical collar, place the boxer on a stretcher, and remove him from the ring. Oxygen is administered, even if respiration seems adequate. If the boxer regains consciousness and demonstrates full use of all four extremities, he/she may be allowed to sit up, but not to stand immediately. When he/she has full muscle tone, they are assisted to standing and moved to the corner where he/she should sit down until fully capable of leaving the ring.

In Grade 1 concussion the boxer should be examined in the locker room immediately and at 5 min intervals to detect any postconcussion symptom or mental status abnormalities (Table 12.5). If the boxer is asymptomatic, he may go home, but it is necessary to remind him that in case of any complaint the doctor is to be called without delay.

In Grade 2 concussion the boxer should be transported to the nearest hospital to perform a neurological examination or CT.

In Grade 3 concussion the boxer must be transported by ambulance immediately to the nearest emergency/neurosurgery department [7, 14].

As a consequence of improved refereeing, stricter health-protecting rules, and extended medical coverage, the rate of concussion between 1980 and 2005 decreased from 17.4% to less than 1.0% at the World Championships and Olympic Games [15].

#### 12.12.2.2 Chronic Brain Injuries

The *punch drunk syndrome* (dementia pugilistica) was first described by Martland in 1928. The syndrome is characterized by speech difficulties, clumsiness of movement, progression to disabling ataxia, dementia, spasticity, and Parkinson's –like extrapyramidal disturbances. Anatomical manifestations are: cerebral atrophy, enlarged ventricles, cavum septum pellucidum, cerebellar changes, loss of nerve cells in the substantia nigra, and neurofibrillary tangles.

Since Martland's description, many authors have reported chronic degeneration in mental function of former boxers (Critchley, Unterharnscheidt, Corsellis, Spillane, Ross, Casson, and others).

All of these studies had limitations: retrospective and cross-sectional in design, lack of an appropriate control group, inadequate size of study groups, subjective interpretation of the data (e.g., EEG) and other confounding factors (drug, alcohol, aging, accidents) neglected.

Recent studies (Johns Hopkins, Haglund) showed a more controversial picture about the chronic brain dysfunction in boxing. While studies indicate that the incidence of chronic traumatic brain injury in professional boxing is 17%, this syndrome is infrequently encountered in amateur boxers unless they have excessive exposure to the sport. Studies documenting the prevalence of brain dysfunction among amateur boxers are few, but it is believed that this syndrome rarely occurs among amateurs. A review of ten studies (Butler) assessing 289 amateur boxers found that amateur boxers did not exhibit any significant signs of neuropathologic dysfunction. This review suggests that a long boxing career might reduce fine motor ability movements, but these findings were statistically within the normal range. Maybe in the future, widespread use of standardized mental status assessment and neuropsychiatric testing will give more definitive information [16]. The role of genetic susceptibility is also unclear [17]. It is unquestionable that during the last 2 decades amateur boxing has changed dramatically. The sight of blood and the unconscious boxer has almost disappeared from the ring. This is due to headguards, limited numbers of rounds, and the proper refereeing eliminating one-sided, dangerous mismatches. Amateur boxing now is a quite different game than professional boxing.

### *12.12.3 Head and Face Injuries*

Since the advent of the headguard, few cuts on the head or on the face are seen (1% of the bouts are stopped because of cuts on the face).Nonetheless the physician at ringside must be prepared to handle cuts. The basic principle of handling cuts around the eye is that if a cut causes enough bleeding to impair vision, the bout should be stopped.

Even with headguards, a punch improperly thrown to the ear with the palmar part of the gloves can create an increase in pressure and rupture to the eardrum. Cauliflower ear is extremely rare with the protection of headguards.

Nasal bleeding is quite common, but in the most cases it occurs without nasal fracture. In the case of repeated epistaxis the boxer should be examined by an ear–nose–throat specialist to detect whether there is any anatomical deformity (septal deviation, superficial plexus of veins).

## *12.12.4 Eye Injuries*

The incidence of eye injuries in amateur boxing is low, although very few data are available concerning eye injuries in Olympic boxing. The eye is relatively well protected by the orbit except the frontal part of the eyeball. Possible injuries caused by boxing are: ruptured or perforated eyeball, hyphema, cataracts, retinal tears or detachment, and macula injuries.

### 12.12.4.1 Ruptured or Perforated Eyeball, Laceration of the Cornea

A normal eye cannot usually be perforated or ruptured by the blunt forces involved in boxing. Theoretically, the thumb of the gloves could cause this type of injury, but in practice, few case reports have appeared about this kind of injuries during the last decades. Epithelial laceration of the cornea is not uncommon, but usually heals without any complication. Rest is needed to complete healing.

### 12.12.4.2 Hyphema

Bleeding into the anterior chamber of the eye due to the tearing of vessels at the iris root is rather common in professional boxers but not in amateurs. All boxers who have had hyphema need gonioscopy to evaluate the possibility of late onset glaucoma.

### 12.13.4.3 Cataracts

The incidence of cataracts in professional boxing is between 5.9% and 15% in the various studies. In amateur boxing valid data is lacking. The resultant opacity of the lens and concomitant decreased vision is often treated by surgery. In amateur boxing, history of cataract or intraocular and refractive surgeries render the boxers unfit to box.

### 12.12.4.4 Retinal Tears and Detachment

Blows to the eyeball may cause either tears or complete detachment of the retina. Treatment of tears with laser or cryotherapy may prevent their progression. Retinal detachment is caused by retinal tears when through the tear the liquified vitreous leaks into the space between the retina and the retinal pigment epithelium. Surgical repair is usually successful, but in amateur boxing if a boxer has retinal tears or detachment in his/her past medical history, they are declared unfit to box.

#### 12.12.4.5 Injuries of the Periorbital Tissues and Orbit

Lacerations of the lid and soft tissues are common in boxing. Lacerations on the lid sometimes need surgical repair. Injury of the extraocular muscles may cause motility problems and diplopia. When motility problems are identified, the injury may also have involved the III, IV, or VI cranial nerve intracranially from closed head trauma.

Orbital fractures, edema, and hematoma may also restrict extraocular muscle motion.

#### 12.12.4.6 Ocular Safety in Boxing

Ocular safety is a priority in the medical safety program of AIBA. Initial and annual examination is recommended to check the state of the eye, to detect preexisting lesions of the retina, to check the visual field, intraocular pressure, and visual acuity.

The *minimal visual requirements* in amateur boxing should be: a corrected visual acuity 20/60 or better in each eye, myopia not more than –3.5 diopters in each eye, a full central visual field of not less than 30° in each eye, no intraocular or refractive surgery on the past medical history, no glaucoma, macular abnormalities, major lens abnormality, or dangerous peripheral retinal lesions [19, 20].

### *12.12.5 Extremity Injuries*

#### 12.12.5.1 Traumatic Shoulder Injury

Musculotendinous *injuries* of the shoulder are not uncommon in boxing. They are caused by different mechanisms: direct trauma to the shoulder, a fall of the boxer in the ring, a traumatic hyperextension or external rotation of an abducted arm. *Rotator cuff injuries* include hemorrhagic subacromial bursitis, acute rotator cuff tears, and subscapularis ruptures. A rare injury is pectoralis major rupture. Hemorrhagic subacromial bursitis can be treated by subacromial injection of local anesthetic and corticosteroids. Surgical treatment is often necessary in other rotator cuff injuries.

More serious shoulder injuries in boxing are *dislocations*. Anterior dislocation happens when the arm is abducted and externally rotated. There are other types of dislocations: posterior glenohumeral, acromioclavicular, and sternoclavicular dislocations. The majority of dislocations are treated with closed reduction. Open reduction is rarely necessary (Fig. 12.4).

*Fractures* of the scapula, proximal humerus, and clavicle are rarely seen in boxing.

**Fig. 12.4** An anteroposterior x-ray revealing subcoracoid dislocation. The superior aspect of the head of humerus is below the coracoid process

#### 12.12.5.2 Elbow Injuries

*Dislocation* or *fracture* of the elbow is not common in boxing unless the boxer falls onto the upper extremity. The majority of injuries are caused by the hyperextension of this joint, combined with a missed punch. *Epicondylitis* is commonly encountered.

Medial epicondylitis (golfer's elbow) is less frequent than lateral (tennis elbow). These are overuse syndromes. Microtrauma leads to injury of the tendinous origin of the flexor pronator mass. Elbow pain accompanies wrist flexion and pronation. Surgery is indicated only after failed nonsurgical treatment (local steroid injection, physical therapy, NSAID).

#### 12.12.5.3 Wrist and Hand Injuries

Amongst the *carpal fractures* (scaphoid, hamate, triquetrum, capitate, lunate, pisiform, trapezium) the most common in boxing is the scaphoid fracture. The diagnosis of these injuries needs x-ray, MRI, or other imaging technique (Fig. 12.5).

**Fig. 12.5** A transverse waist fracture of scaphoid

The wrist is an important link between the upper arm and the hand when the boxer delivers a blow; therefore, it is customarily supported by the use of bandages or wraps. The use of bandages in amateur boxing is mandatory.

*Distal radius fractures* make up 8–15% of all bone injuries in boxing. There are two mechanisms of injury: falls on the outstretched hand, causing dorsal displacement (Colles fracture), or falls on the flexed hand causing volar displacement of the fragment (Smith fracture).

*Ligamentous injuries and chondral lesions* in the wrist can be a source of significant disability because boxing requires a stable wrist with good mobility. Examination of the wrist including stress testing, standard radiography, stress radiography, bone scan, arthrography, MRI, and arthroscopy are tools available to the physician who treats wrist injuries of boxers.

*Metacarpal fractures* are much easier to diagnose because of localized swelling, and point tenderness. An x-ray is usually sufficient to diagnose this injury. In boxing it is quite common to fracture the first metacarpal base without displacement.

*Boxer's knuckle* is a characteristic injury that occurs from direct blunt trauma either as a single episode or from repetitive blows, causing a longitudinal tear in the extensor digitorum communis tendons and dorsal joint capsule, and involving the radial or ulnar sagittal bands. The boxer usually presents with pain over the metacarpophalangeal joint. Treatment involves surgical exploration and side-to-side repair of the defect.

Return to boxing after the injuries of wrist and hand usually is between 4 and 12 weeks.

#### 12.12.5.4 Knee, Ankle, and Foot Injuries

The injuries of the lower extremity in boxing are not particularly common and the majority can be prevented by careful supervision of the ring: are the ropes at the proper height and tension, is the floor of the ring covered by canvas (the plastic materials can be very slippery if they are wet), and is the canvas tightened appropriately?

*Ligamentous injuries* are not common in boxing. MRI is a useful diagnostic tool. *Meniscal injuries* are more common. MRI is an accurate noninvasive diagnostic tool, but arthroscopy offers the advantage of allowing immediate treatment.

*Ankle ligament injuries* are the most common injuries in sport, but are not a typical boxing injury. The lateral ankle ligaments are the most frequently injured structures. Ankle sprains have been classified as Grade 1 (mild), Grade 2 (moderate), and Grade 3 (severe). In the Grade 1 injury the ligaments were stretched without tear, and only minimal swelling and tenderness.

Grade 2 sprains represent partial tear, with moderate swelling, tenderness, limited loss of motion, and instability. Grade 3 shows a complete rupture, clinically severe swelling, hemorrhage, and tenderness. Ankle function and stability are lost. There is a general agreement that Grade 1 and 2 injuries should be treated conservatively (rest, ice, compression, elevation). Some authors recommend acute repair of lateral ligament injuries with Grade 3 sprains.

*Achilles tendon injuries* may occur during conditioning (jogging, running), and can be an acute trauma or a chronic overuse syndrome. Achilles tendon rupture is unusual in boxers. Acute tenosynovitis is treated conservatively. In chronic cases and in Achilles tendon rupture the best treatment is surgical.

F*racture of the fifth metatarsal* usually occurs with the contraction of the peroneus brevis muscle (Fig. 12.6). For the proximal metaphysis (Jones) fracture early surgical treatment, open reduction, and internal fixation are recommended [21–23]. Avulsion fractures are generally treated nonoperatively.

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**Fig. 12.6** Avulsion fracture of the base of fifth metatarsal with proximal displacement of the fragment caused by the attached peroneus brevis tendon

## Web sites

http://www.aiba.org/
www.abae.co.uk

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# Chapter 13
# Wrestling

**Randall R. Wroble**

## Learning Objectives

- To review the important elements of wrestling pertaining to health care providers
- To identify the most common injuries that occur in amateur wrestling
- To understand the acute care of wrestling injuries
- To describe risk factors and preventive measures

## 13.1 Introduction

Wrestling is one of the most ancient sports. Artifacts recovered from a 5,000-year-old Sumerian temple depicted wrestlers in action. In an ancient Egyptian wall painting from 1850 BC, a "manual of wrestling" documented the course of a match and demonstrated knowledge of many holds still used today. In *The Iliad*, Homer gives a detailed description of a wrestling match. In classical Greece, wrestling was one of the sports contested in the Olympics and was an important part of the physical training of every young man. Early roots of wrestling are also found in Central Asia, Japan, and China.

Currently, wrestling is a popular sport at the youth, high school, college, and senior level. Part of its popularity relates to the opportunity for participation by men and boys of all sizes. Wrestling has evolved into three distinct styles. In the USA, high school and collegiate athletes practice what is termed American Folkstyle. Competitions are also held in Freestyle wrestling, which is practiced throughout the rest of the world and in Greco–Roman wrestling, another international style that

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allows holds only above the waist. Each style of wrestling requires similar training methods, but match length differs by level and by style.

Wrestling is one of the most physically demanding sports and thus results in some of the widest variety of injury types seen in any sports setting. Health care providers must be ready to deal with injuries that are similar to other contact and collision sports, but also with problems unique to wrestling, such as diet, weight loss, nutrition issues, ear injuries, and skin infections.

Wrestling rules ban certain holds and moves that obviously exert potentially injurious force to the extremities or spine (National Federation). A variety of holds are banned: (a) twisting of the fingers, (b) any hold with intent to injure or cause pain, (c) holds that may cause dislocation, (d) twisting of the neck or back, and (e) headlocks without an arm included. Should these situations arise during a match, any advantage gained is nullified in the scoring, and the referee takes one of the following actions. The referee may (a) break the dangerous hold without stopping the action; (b) stop the action, break the hold, and award penalties: the opponent of the offending wrestler may be given one or two points, or the offender assigned a caution; (c) if the wrestler is injured by the opponent's illegal action and is ruled medically unfit to continue, the wrestler at fault is disqualified or; (d) a wrestler can be immediately disqualified for flagrant misconduct.

The rules also address other important areas of competition. Competition is conducted by weight class, ensuring that athletes are size-matched. The rules also require safety in positioning mats, scoreboards, and tables during a competition, as well as mandating that medical personnel are present at all major competitive events.

If an injury occurs during the match and time is called, the referee instructs the scorer to start an injury time clock. Once the clock starts, the wrestler has only a minute and a half to resume wrestling or default the match. The time is cumulative throughout the match. During that time, the health care professionals make a decision regarding participation. If bleeding is present, a 5-min time limit applies.

## 13.2 Epidemiology

In virtually all reports examining injury rates in sports, the number of injuries in wrestling is significantly high, often second only to American football (Requa and Garrick 1981). In three large prospective studies, injury rates for high school wrestlers ranged from 22.7 to 50 injuries per 100 wrestlers (Estwanik and Rovere 1983, Garrick and Requa 1978, *National High School Injury Registry*). Pasque prospectively examined injury patterns of high school athletes over the course of one season. The overall injury rate was 6.0/1,000 athlete-exposures. This high injury rate occurs for several reasons. First, wrestling is a contact sport and contact in wrestling occurs virtually 100% of the time. Second, wrestling is also a collision sport. Collisions occur when a wrestler "shoots" or attempts a takedown. Takedowns are the highest risk situation in college wrestling (Wroble 1986 a and b). In three high school studies, takedowns were associated with 42–50% of all injuries (Strauss and Lanese 1982, Requa and Garrick 1981, Estwanik 1983).

Injury rates increase with the age of the wrestler. Lorish et al. (1992) studied injuries in two wrestling tournaments for boys of age 6–16. The 14- to 16-year-old boys had an injury rate of 22.1 per 100 wrestlers, while the 6–8-year olds had an injury rate of only 9.7 per 100 wrestlers. Strauss and Lanese compared four wrestling tournaments. In the youth tournament, the injury rate was 3.78 per 100 wrestlers. At high school level, the injury rate was 11.5 per 100 wrestlers; and in two collegiate tournaments, the injury rate was 13.86 per 100 wrestlers. The youth wrestlers had the lowest injury rates, but also spent the shortest amount of time exposed to injury, with matches lasting only 3 min. The high school matches lasted 6 min, and the college matches lasted up to 8 min. Wroble (1996) reported that college injury rates were 25% higher than those occurring at the high school level. Yard et al. (2008) used the High School Reporting Online (RIO) and NCAA Injury Surveillance System to compare high school and college injury rates during one season. College injury rate was over three times that of high school rate (7.25 vs 2.33 injuries per 100 athlete-exposures).

Many studies report on the incidence and rate of injury occurring in practice and competition. Incidence rates are higher during competition, but more injuries occur during practice because significantly more time is spent in practice. At the high school level, 60–70% of injuries occur during practice (*National High School Injury Registry* and Garrick and Requa 1978). Injury rates, however, are much higher in matches: nearly double at the high school level. Boden et al. (2002) reported a significantly greater amount of catastrophic injuries occurring during competition (80%). Jarret reports a competition rate of 30.7 injuries per 1,000 athlete-exposures, and only 7.2 per 1,000 athlete-exposures in practice. Pasque reported that 63% of their injuries occurred in practice. When injuries were expressed in terms of exposure, a rate of 5 injuries per 1,000 practice-exposures as compared to 9 per 1,000 match-exposures occurred. Powell (1981) studied injuries at the collegiate level over a 5-year period, and found a rate of 7.8 injuries per 1,000 practice-exposures and 27.0 per 1,000 match-exposures. Wroble (1986a) found the same trend with knee injuries, 7.25 injuries per match-exposure and 2.4 per 1,000 practice-exposures. Yard also showed a higher match than practice injury in high school and college wrestlers.

## 13.3 Training

Training for wrestling is a year-round task. Rewards in terms of injury prevention and wrestling success can be obtained, however, by adherence to a good training program. Deficits in flexibility, muscle strength, and cardiovascular conditioning are major causes of poor wrestling performance and likely increase the risk of injury. A well-trained wrestler is more likely to be successful and less likely to fatigue and suffer the setbacks of injury and illness.

Flexibility is paramount as increased range of motion of a joint may decrease the risk of sprains and strains. Development of flexibility is a gradual process that requires daily maintenance. The recommended form of stretching is a sustained static stretch. It is important during the stretch that the athlete does not push the joint through a range of motion that causes pain. Ballistic stretching should be avoided because of the risk of muscle injury. Every wrestler benefits from a good overall flexibility program, but should pay particular attention to the shoulder girdle, groin, hamstrings, and lower back.

The association between muscular strength and wrestling performance is obvious. All-round development can be accomplished through a general weight-training program, focusing both on concentric and eccentric exercises. Both free weights and machines can provide exercises specific to wrestling. The athlete's program should focus on activities that require pulling and lifting similar to that required on the wrestling mat. Activities that will pay off on the mat include pull-ups, rolling shoulder shrugs, back extensions, leg press, leg adduction, and biceps curls. The wrestler should be encouraged not only to have an off-season weight-training program, but also to continue to work on strengthening throughout the season.

The energy requirements for wrestling and training can be considerable. It is important that wrestlers are conscious of and in control of their body weight. Maintaining a body fat of 5–7% appears to provide optimal performance on the wrestling mat. This requires careful attention to diet and exercise, the two variables that affect the wrestler's weight. A careful, well-thought-out plan will allow the wrestler to train effectively and require only small adjustments in weight prior to a competition. Inattention to proper weight control will result in practices detrimental to the wrestler's performance and health. Detailed discussions of diet, nutrition, and weight loss can be found elsewhere in this volume (Chapters 1 and 2).

During rehabilitation after an injury, it is important for a wrestler to continue to be as active as possible, because at the same time he is recovering, he is also trying to keep his weight down to the required weight class. As calorie expenditure and weigh-in frequency go down, naturally weight rises. It is important to keep the wrestler in contact with his team and burn calories by combining traditional rehab, aerobics, such as biking or swimming, and wrestling room functional activities. Wrestling activities can be divided into those which are unloaded including shadow wrestling, wrestling with a dummy, or with a passive partner and those which are loaded, having an opponent putting pressure on top of the wrestler's body weight.

## 13.4 Wrestling Injuries

### *13.4.1 Anatomic Location*

#### 13.4.1.1 Head and Neck

Head Injuries

Injuries to the head occur by head-to-head or head-to-knee collisions during takedowns. Concussions are also produced by contact with the wrestling mat or the floor surrounding the wrestling mat area. The fact that slamming an opponent to the mat is illegal makes serious head injury less likely via this mechanism. Recognition of concussions appears to have improved. Concussions and other head injuries have occurred from 1% to 8% of all wrestling injuries documented in a variety of studies (NCAA 1993a, b, Roy 1979, Snook 1982, Patacsil 1955, Estwanik 1978, Lorish et al. 1992, Pasque and Hewett 2000). The NCAA (1998) documented a 13-year high of concussions in wrestling during the 1997–1998 season, with a rate of one concussion for every 38 wrestling matches. Most concussions seen in wrestling are mild or Grade I.

Bruce documented the low incidence of major head and spine trauma in children, but showed an increase in the 15- to 18-year-old age group. Powell (1999a, b), in a 3-year high school study, showed that concussions occur more frequently in matches and that takedowns were the high-risk situations for concussion. The time lost for wrestlers with concussion averaged 2 days.

## Neck Injuries

A common mechanism for a neck injury occurs during a takedown. In this, the wrestler drives into their opponent with their neck, hyperextending it while "shooting." This can cause sprains, strains, and neurologic trauma such as stingers. Bruce considered that neck injuries were a result of a combination of poor training, inexperience, poor coaching, or equipment and felt that wrestlers were injured when competing against larger and stronger wrestlers.

Wroble and Albright reviewed injuries over an 8-year period on a college wrestling team. The neck was the second most frequent anatomical location injured. Most of these 104 injuries were sprain/strain injuries and stingers. Estwanik et al. (1980) also noted the predominance of sprains and nerve injuries. In prospective and retrospective epidemiologic studies of wrestling injuries, neck injuries were reported to make up to 0.8–14.9% of the total number of injuries (Konrad 1951, Patacsil 1955, Estwanik 1978, Lorish et al. 1992, NCAA 1993a, b, Jarrett et al. 1998, Lok and Yuceturk 1975, Roy 1979, Snook 1982, Acksel 1966, Wroble and Albright 1986)

Non-catastrophic injuries to the neck are common despite generally superior neck muscle strength among wrestlers. The cumulative effects of neck injuries are seen in some wrestlers as evidenced by an increased incidence of degenerative changes on radiographs and by long-term symptoms reported by ex-wrestlers.

### *Cervical Strain/Sprain*

A cervical strain is a tear of one of the musculotendinous units in the neck. The spectrum of injury ranges from mild to moderate, with rupture being extremely rare. These injuries all result from mechanical overloading when the force is too great for the anatomical structure to withstand. Sprain injuries to ligaments and capsular structures of the cervical spine are frequently seen concomitantly, thus often making it difficult to differentiate between the two. The usual mechanism for sprains/strains is a hyperextension twisting injury. These account for approximately 50% of neck injuries in wrestling.

### *Stingers*

Stingers occur in wrestling second only in frequency to American football. Most commonly, due to traumatic stretching or compression of the brachial plexus or nerve roots, they occur almost exclusively during takedowns. The most common mechanism is forced hyperextension-ipsilateral flexion when a wrestler "shoots" a takedown with their neck extended, striking their opponent's chest or thigh with their forehead. Oblique neck extension results in narrowing of foramina, which corroborates the mechanism of the compression-type stinger seen in wrestlers (Feinberg et al. 1997). The vast majority of these are neuropraxic lesions.

The clinical picture of these injuries is as follows: severe, electric, shock-like pain occurs at the time of impact and extends from fingertips to shoulders. These momentary dysesthesias are replaced by a dull ache and numbness and weakness of the arm and hand lasting from a few seconds to a few minutes. The wrestler is noted to have the arm hanging limply at their side or with a flexed posture of the cervical spine, elevating the shoulder of the involved side. Both of these maneuvers alleviate tension and pressure on the neurologic structures (Feinberg 2000).Often the wrestler shakes the wrist and rubs the affected arm. Tenderness is noted in the ipsilateral paraspinous muscles and trapezius. Range of motion tends to be decreased in all planes and guarding occurs. Changes in neck range of motion, particularly lateral bending, are persistent. Ipsilateral lateral bending and extension coupled with axial loading reproduce the pain. Neurologic deficits are most commonly found in the upper brachial plexus distribution (C5–C6), but, in contrast to American football, low brachial plexus lesions (C7–T1) are not uncommon. The lower trunk of the brachial plexus or the lower cervical nerve roots are more vulnerable to injury with the arm abducted overhead. This corresponds to the position that the wrestler adopts during the takedown and the clinical findings of more frequent lower brachial plexus injury among wrestlers than of American football players (Feinberg). Deficits in motor strength, particularly of the biceps, deltoid, and external rotators of the shoulder are the rule, but these usually normalize within 5 min. Occasionally, weakness persists for an extended period of time and less often becomes chronic with noticeable muscle atrophy. Changes in sensation and deep tendon reflexes are also noted only transiently.

If complete recovery without symptoms occurs within 1–2 min, immediate return to action is permitted. If any neurologic abnormality exists after that time, the wrestler is restricted from participation.

If the wrestler returns to action before pain, tenderness, and range of motion have returned to normal, the likelihood of recurrence is extremely high. However, wrestlers who return with no symptoms or radiographic changes have no obvious increased risk over their teammates. Repetitive acute injuries in the same season will often lead to persistent rather than just transient weakness. Repeated trauma appears to cause osteophyte formation and resultant foraminal narrowing. We have seen several wrestlers with severe radiographic changes and permanent neurologic loss on this basis. Despite stopping the repetitive trauma of wrestling, 28–37% of ex-wrestlers with history of neck injury report continued symptoms (Mysnyk and Albright 1988).

Electrodiagnostic testing is generally not needed because of the relatively short duration of symptoms. Rehabilitation initially focuses on range of motion and reducing irritation of the neural structures. Next, strength considerations are important, as these are the dynamic stabilizers of the cervical spine, and thus will allow complete restoration with reduced risk.

#### *Cervical Cord Neuropraxia*

Axial loading with hyperflexion or hyperextension causes cervical cord neuropraxia or transient quadriplegia. Symptoms are seen in the upper and lower extremities bilaterally and can consist of sensory or motor components, or both. Symptoms typically last 10–15 min. Return to play criteria depends on the mechanism of the injury, the anatomic site, imaging findings, and the time to full recovery.

Both Torg and Boockvar have discussed cervical cord neuropraxia in athletes. Torg found that 87% of the cases occurred in American football and 2% in wrestling (Torbetal 1997). He documented that stenosis of the cervical spine was the causative factor, but that there was no association with permanent injury. Nonetheless, there was a 56% recurrence of the phenomenon in contact sports. Boockvar found 13 children, aged 7–15 years, with cervical cord neuropraxia (Boockuar 2001) Two of them were wrestlers. None of their cases had stenosis. They considered this as resulting from the hypermobility in the child's spine.

### Nosebleeds/Epistaxis

Nosebleeds occur commonly due to a combination of trauma and drying of the nasal mucosa secondary to relative dehydration and generally low ambient relative humidity in gymnasia and wrestling rooms. Most occur in the anterior chamber of the nose and arise from the lower portion of the septum (Stevens 1988, Kvittem et al. 1988). Digital compression is usually employed, followed by introducing a cotton plug soaked in 1% phenylephrine (Neo-Synephrine) into the nose. After 1 or 2 min, when the athlete is ready to resume wrestling, the nostril is packed with a cylindrical gauze plug or cut down tampon covered with petroleum jelly.

### Lacerations

Lacerations occur commonly to the eyebrow region and to the lips, usually during takedowns. Eyebrow lacerations occur when the supraorbital ridge impacts against the opponent's head or knee. Lip lacerations result when the lip is violently struck against the teeth upon contact with the opponent's head or knee.

If a laceration occurs during a match and bleeding is more than minimal, the referee will call time out promptly. In order for the match to continue, the blood flow must be stopped. Time does not permit suturing the wound, although the 90-s injury time limit does not apply. For bleeding, wrestlers are allowed 5 min of time out. To treat bleeding, first a brief period of compression is attempted. If the bleeding stops, this action is followed merely by application of small amounts of petroleum jelly. Pressure dressings offer the advantage of keeping the wound clean, but must be applied properly or they fall off. They must be applied to a dry, sticky surface. To achieve this condition on a profusely sweating wrestler requires the use of an adhesive spray to the forehead. The dressing is applied circumferentially below the greatest diameter of the skull, below the occiput and frontal prominence. It must be put on extremely tightly to prevent slipping. The ears and supraorbital ridge help prevent downward migration of the bandage. Primary suture is performed as soon as practical after completion of the match. Facial lacerations can be safely closed up to 24 h post-injury. Besides standard suture technique, small surgical staples or Dermabond skin adhesive can be used for lacerations on the face.

Involvement of the deep layers of the lip is reasonably common. Best results are achieved by closure in layers after adequate anesthesia obtained by infiltration of 1% lidocaine with epinephrine. Muscle is closed with #3-0 absorbable suture, while the subcutaneous tissue and mucosa are closed with #4-0 absorbable suture. With large deep lacerations within the mouth, penicillin or similar antibiotic is given orally for 1 week.

## Dental Trauma

Dental injuries have been reported in relatively small numbers. In the epidemiologic studies previously cited, dental injuries ranged from 0.2% to 2.5% of total injuries. Lee-Knight et al. (1992) reviewed dental injuries at the Canada Games. Among 101 wrestlers aged 14 –21, only one sustained dental injury. Persson found that wrestlers had more frequent severe injuries located to the frontal region of the maxilla, but found no increased incidence of temporomandibular joint disorders or dental caries. (Persson 1994) Kvittem et al. (1998) reviewed orofacial injuries at seven high schools during 1 school year. They found that 69.9% of wrestlers sustained some type of orofacial injury. Most of these were lacerations and contusions. Dental injuries amounted to 10% of the overall total. Kvittem documented a very slight increased risk of orofacial injuries with orthodontics.

The mechanism of dental injuries is collision: head-to-head contact between the two wrestlers. The most common injuries that occur are subluxations or crown fractures. Complications of dental injuries include necrosis, pulp canal obliteration, and root resorption. More severe facial injuries such as mandible fractures also occur, but are rare.

The role of mouthguards in dental injuries in wrestling has been explored. Mouthguards are not mandatory equipment, and therefore their use is infrequent. In Lee-Knight's study, no wrestler used a mouthguard. Kvittem et al. documented that only 5.6% of their wrestling population wore mouthguards. Wrestlers cite several reasons for not wearing mouthguards. These include poor retention secondary to fit, discomfort, and interference with breathing or speech.

## Eye Injuries

Ocular trauma has been found at very low rates in epidemiologic studies. Marton et al. (1987) however, reported on eye trauma in college athletes over a 10-year period. 152 injuries occurred in wrestling. Wrestling had the highest average injury rate per year of 18.4%. Lacerations and corneal abrasions were the most common injuries. No permanent injuries were sustained. Powell (1981) studied eye injuries in college wrestling from 1975 to 1979. He reported one to two injuries per team per year, with 90% of the injuries being minor including mostly lacerations and contusions. Forrest et al. (1989) reported two cases of orbital blowout fractures in wrestlers.

## Ear Injuries

The classic problem of the wrestler's ear is the auricular hematoma. The auricular hematoma or "cauliflower ear" results from blunt trauma to the ear, either on direct impact with another wrestler's head or knee, or by abrasive, friction-causing forces, as when wrestlers "tie up" head to head. The anterior or lateral surface of the auricle with its multiple depressions and eminences has skin which is thin and tightly adherent to the underlying fibrocartilage. Conversely, the posterior medial skin is thicker and more mobile. Hematomas form anteriorly where the skin is most adherent and rarely extend posteriorly. The skin does not "slide," which results in high shear forces in response to blunt trauma. Blood vessels tear and blood accumulates in the space separating the cartilage and perichondrium forming a hematoma (Giffin 1985, Templer and Renner 1990).

The clinical picture initially includes erythema, tenderness, and swelling. Progression occurs to a fluctuant swelling. As the blood supply to the perichondrium is cut off by the expanding hematoma, the cartilage undergoes necrosis and in time is replaced by fibrocartilaginous scar tissue, producing the deformity known as "cauliflower ear" (Kelleher et al. 1967).

The traditional wrestler's headgear, which covers the ears, is designed to minimize the risk of these injuries. While most often hematomas result when wrestling headgear is not being worn, hematomas can and do happen with headgear on (Schuller et al. 1989a). Once the wrestler begins to sweat, the headgear can slide and cause the hematoma itself by abrading the external ear. Several design features contribute to this problem – shallow depth of the earpieces, inadequate number of straps for fixation, and construction with slick plastic materials that allow sliding of the headgear. We recommend headgear with a sufficient number of straps to fix the headgear firmly upon the head and with deep enough earpieces so that there is no contact between the ear itself and the headgear. We often add a ¼–½ in. thick high-density foam "donut" around the earpiece to further increase its depth.

Schuller et al. (1989a) sent questionnaires to all Division I NCAA wrestling programs regarding headgear use. Only 189 of the 537 respondents (35.2%) wore their headgear all the time. Of those who wore headgear, 25.5% developed hematoma. Of those who did not wear headgear, 51% developed hematoma, and

38.7% of wrestlers had a permanent ear deformity. Approximately one fourth of those with deformity incurred their injuries while they were wearing headgear. In an early study of high school wrestlers, only 2 of 49 coaches (4.1%) required their wrestlers to wear headgear (Acksel 1966). Estwanik and Rovere found that 88% of high school wrestlers wore their headgear in less than 50% of practices. Estwanik et al. (1980) documented that 70% of hematomas they treated occurred while headgear was not being worn. In the few studies that documented ear injuries as percentage of total, these have comprised from 1.7% to 24.6% of the total number of wrestling injuries (Konrad 1951, Patacsil 1955, Estwanik et al. 1978, 1980, Lorish et al. 1992, Requa and Garrick 1981, NCAA 1993a, b, Roy 1979, Snook 1982, Brown 1951, Acksel 1966, Wroble 1996).

Historically, treatment has been apparently ineffective for several reasons. First and most unfortunately, is that some wrestlers regard the "cauliflower ear" as a mark of distinction that identifies them immediately as a wrestler. Second, treatment may be avoided because of anticipated pain. Third, a wrestler may shy away from treatment for fear of being told he needs to take time off.

Treatment goals include: restoring the normal appearance and pliability of the ear, early return to wrestling activity, and low recurrence rate. The acute hematoma requires prompt needle aspiration by or under direct supervision of a physician. We must emphasize the strict use of aseptic techniques. Should infection arise in the subperichondrial space, cartilage necrosis with loss of a portion of the external ear may ensue. Approximately 2–3 cc of blood can be aspirated from the typical acute hematoma. It is routinely sent for aerobic and anaerobic culture and sensitivity. A 1-in. 19-gauge short bevel thin-wall needle works well. It provides a large inner diameter, which seems less apt to clog and allows removal of more viscous fluid.

Many methods have been described to prevent reaccumulation of fluid. Contemporary techniques use different types of suturing over materials including dental rolls and different silicone materials (Schuller et al. 1989b, Dimeff and Hough 1989, Eichel and Bray 1978, Kelleher et al. 1967). Our preference is the through-and-through suture technique over silicone sheeting described by Lane et al. (1998) The principal advantage of this technique is allowing the wrestlers to return to participation within 24 h. Antibiotic ointment and a short course of oral antibiotics are used immediately after the application. Sutures are left in place for 14 days with frequent rechecking for any signs of infection. More complex cases require referral to an otolaryngologist for open debridement of the ear. Infection is a more serious scenario and requires immediate intervention.

## *13.4.2 Upper Extremity*

### 13.4.2.1 Shoulder Injuries

Shoulder injuries account for 3.5–24% of all wrestling injuries in prospective studies. The shoulder is injured by three principal mechanisms. When being thrown to the mat from a standing position, a wrestler may attempt to brace his fall with his extended arm. Alternatively, the fall may be taken directly on the shoulder. The third important mechanism of the shoulder injury occurs during takedown maneuvers. When the wrestler attacks his opponent's legs and gets caught in a position with the body overextended, the head down, and the arm elevated above the head, the opponent's body is positioned above the attacker's shoulder. As the opponent throws his hips back and increases the weight upon the wrestler's shoulder, hyperflexion, and external rotation ensues, causing anterior subluxation.

The most common problems found in the University of Iowa study were anterior shoulder instability (subluxation/dislocation), and acromioclavicular (AC) sprain (Wroble 1986b). Subluxation is much more frequent than dislocation. Most commonly, the wrestler cannot identify a single inciting event. All wrestlers are subject to forces that tend to stress or stretch the anterior structures of the shoulder, such as the half nelson, arm bars, or landing on a ""posted"" arm, all activities which place the shoulder in abduction and external rotation. MRI reveals a high incidence of anterior labrum tears, which often respond well to surgical repair.

The wrestler with shoulder instability is advised to modify his technique. He is instructed specifically to avoid maneuvers that put the shoulder in a subluxation position. The overextended takedown position described previously is a good example. The wrestler is taught to use other options: using the other arm, using the upper body rather than attempting leg attacks, or employing a defensive or counter strategy.

Acromioclavicular (AC) sprains happen nearly as commonly as anterior instability. They occur almost exclusively due to a fall on the unprotected shoulder. This happens when a wrestler, taken down by his opponent, is brought to the mat with his arm trapped. Occasionally, the force is transmitted medially along the clavicle and causes simultaneous sprains of the ipsilateral sternoclavicular joint. Almost all AC injuries are type I or mild type II.

Should a type I or II AC sprain occur during a match, the wrestler is allowed to continue as long as he can tolerate the pain. After an AC injury resulting in time loss, early return to competition is the goal. The probability of repetitive direct trauma and multiple aggravations by direct traction on the affected arm makes early return problematic at times. In the case of type I or mild type II injury the wrestler returns should his symptoms permit, although in mild type II injuries typically this averages 2–3 weeks.

In more severe type II and all type III injuries, we accept any deformity present, allow early range of motion (as soon as tolerated), and emphasize scapula and shoulder rotational strengthening. Return criteria include: no tenderness, 90% strength of deltoids and external rotators, and no pain with downward traction of the adducted arm. Laxity and deformity persists in many of these patients. We occasionally see a wrestler with posttraumatic osteolysis of the distal clavicle, which can cause nagging persistent pain.

Pectoralis major rupture occurs by sudden forceful overload to the maximally contracted pectoralis muscle. The shoulder is usually in a position of adduction, internal rotation, and forward flexion. A sudden pop may be heard and is accompanied by severe pain and weakness. Swelling and ecchymosis develop rapidly. The finding of a painful defect accentuated by strong adduction against resistance as well as weakness in adduction, internal rotation, and flexion are pathognomonic (Berson 1979). Bak reported on 87 athletes with pectoralis major ruptures, ten of whom were wrestlers (Bak 2000). Outcome of surgical treatment was substantially better than in conservatively treated cases. Pavlik et al. (1998) reported on seven athletes, four of whom were wrestlers. All patients had successful surgical treatment.

#### 13.4.2.2 Elbow Injuries

Elbow injuries are sustained less frequently than shoulder injuries but appear to be more severe. Estwanik and Rovere reported that almost half of their wrestlers with an injured elbow missed an entire season. Eight of the 23 elbow injuries were dislocations. The most common elbow injury, however, is the hyperextension abduction sprain affecting the ulnar collateral ligament (UCL) and the anterior capsule. In prospective and retrospective studies, elbow injuries accounted for 1.0–9.3% of all wrestling injuries.

Elbow injuries most commonly occur when the wrestler is forcibly brought down to the mat with an arm extended or "posted." At low-to-moderate force levels, hyperextension–abduction sprains occur. With higher forces, an elbow dislocation can result. All these injuries present with medial pain, with or without concomitant anteromedial pain. If an ulnar neuropraxia has occurred, the wrestler may describe paresthesias or numbness in the ulnar two fingers.

On examination, tenderness is found along the ulnar collateral ligament (UCL) and anterior capsule. Pain increases with passive extension and valgus stress. Neurologic findings may include intrinsic weakness, decreased light touch sensation, and a positive Tinel's sign in the ulnar groove.

In a match, the wrestler may continue if tenderness is minimal, range of motion is full, and he tolerates moderate valgus stress without pain. If symptoms and findings are more severe, he is withdrawn from competition. In the case of a dislocation, if the clinician is certain of the diagnosis, gentle closed reduction should be attempted on the mat before muscle spasm and swelling are severe. Detailed neurovascular assessment must be performed before and after reduction. Furthermore, the wrestler must be sent for immediate radiographic evaluation.

Treatment of these injuries follows the RICE algorithm with addition of a sling or hinged elbow brace in more severe cases. The brace is initially locked in an angle comfortable to the wrestler (about 60°–90°). Mobilization begins immediately with mild sprains and after about 7 days with elbow dislocations. It is important to resume motion early. Prolonged immobilization invariably leads to limited range of motion and difficult rehabilitation.

Return to competition occurs when range of motion is full and pain-free, strength is equal to the opposite side, and tenderness and pain with valgus stress are absent. Phased return to wrestling after elbow dislocation occurs at about 4–6 weeks with careful monitoring of symptoms and findings. Mild sprains may result in only a few days time loss.

Ulnar collateral ligament (UCL) reconstruction may be required in wrestlers with chronic insufficiency, which is manifested by numerous recurrent sprains. After UCL reconstruction, wrestling is curtailed for at least 6 months and prognosis for return to wrestling at the pre-injury level is guarded.

#### 13.4.2.3 Forearm, Wrist, Hand, and Finger Injuries

Relatively commonplace, injuries to the hand are almost always minor. Fractures or dislocations are uncommon. Nonetheless, in Whiteside's series of fractures in intercollegiate athletes, 50% of wrestlers' fractures occurred in the hand (Whiteside et al. 1981). Nearly all hand injuries happen in the same way, typically during the takedown when the wrestler is being thrown to the mat. They land putting out their hand in an effort to break their fall. Because wrestling rules dictate that prying back of the individual digits is illegal, injuries due to this mechanism are rare.

The most common injuries are metacarpophalangeal (MP) sprain, proximal interphalangeal (PIP) sprain, and thumb MP ulnar collateral ligament sprain (gamekeeper's thumb). Most are first or second degree. Occasionally, we see mallet fingers. We maintain a very low threshold for obtaining radiographs in hand injuries. All dislocations require radiographic study and an evaluation by an orthopaedist to rule out an unstable injury that could redislocate (e.g., dorsal dislocation with an associated fracture at the articular surface or any volar dislocation). Nondisplaced fractures need proper care to avoid conversion to more serious debilitating displaced fractures. Radiographs allow differentiation between bone and soft tissue injury, and between bone injuries requiring casting (a large minimally displaced avulsion fracture at the attachment of the ulnar collateral ligament and thumb MP joint, for example), those requiring only splinting and taping (small volar plate avulsions), and those requiring surgery (flexor digitorum profundus avulsion).

The primary treatment methods of hand problems consist of splinting and taping. Although up to the referee of each match, no splint is allowed that has sharp, unprotected edges or that has the potential for causing injury itself. Taping alone is often ineffective in gamekeeper's thumb. For MP and PIP sprains, however, buddy taping is adequate in most instances. Wrestlers with a dorsal dislocation without associated significant fracture may return to action in approximately 2–3 weeks with the fingers buddy taped.

### *13.4.3 Trunk and Spine*

#### 13.4.3.1 Lumbar Spine

Lower back injuries commonly take place during takedowns. While sparring for position, wrestlers push against each other with the lumbar spine in slight hyperextension. This extension, coupled with twisting, results in injuries. Extension against resistance, as in lifting an opponent off the mat, and hyperflexion, as in rolling, are also mechanisms that account for low back sprain or strain. On the other hand, low back injuries may result not only from a single episode, but also from repetitive use. Low back injuries are less frequent and are generally less severe than corresponding cervical injuries.

Low back injuries involve 1.2–18.6% of total wrestling injuries in prospective and retrospective studies. Wroble and Albright (1986b) reviewed 41 low back injuries over an 8-year period. Virtually all were sprains and strains. Rossi and Dragoni (1990) found that wrestlers with back pain had a 29.8% incidence of spondylolysis (17 of 67 wrestlers). Hellstrom et al. (1990) and Sward et al. (1990) reviewed back pain and radiographic changes in Swedish wrestlers aged 17–25. Sixty-nine percent exhibited low back pain, but only 34% had severe low back pain; 56.7% were found to have radiographic abnormalities. Estwanik et al. (1980) also noted that 25% of their wrestlers presenting with back pain had spondylolysis or spondylolisthesis; 58% of their patients were diagnosed with lumbar strain.

Iwai et al. (2002) found that, in 55 collegiate wrestlers, those who had low back pain had lower extensor strength than controls. This finding corroborates the need for strengthening and conditioning as part of the wrestlers preventive program.

Lundin et al. (2001) performed a long-term follow-up exam of 134 former top athletes, including 28 ex-wrestlers. Severe back pain was more common in wrestlers (54%) than in other groups of athletes or nonathletes. In a study of 32 retired wrestlers, 59% exhibited low back pain that was greater than controls (Granhed and Morelli 1988).

In the usual sprain/strain, athletes describe a sensation of "something twisting" or their back "going out." Pain may be unilateral or bilateral, and is usually localized to a muscle belly or its insertion. Typically, the pain reaches a maximum 24–48 h after the injury. Examination reveals decreased range of motion in the lumbar spine, normal neurologic examination, and negative sciatic tension signs.

Antero-posterior and lateral radiographs of the lumbosacral spine are routinely obtained if symptoms are severe enough to bring the wrestler to the clinic. Oblique views show pars interarticularis lesions best and are obtained if low back pain is persistent despite treatment. A bone scan is useful if plain radiographs are normal and a high index of suspicion exists for posterior element pathology.

Management of the acute low back injury is divided into three general areas: rest, reduction of pain and spasm, and patient education. We prescribe relative rest in which we allow the conditioning and strengthening portions of the wrestler's routine. We eliminate weight-training exercises in which a significant load is transferred through the lumbar spine (military press or hang cleans, for example). Actual wrestling is curtailed for a short period.

Modalities used for pain control include ice, massage, ultrasound, TENS, NSAIDs, immobilization, and epidural steroid injections (if radicular symptoms are present). An anti-lordotic back brace or elastic lumbar support may be helpful in controlling pain during the period of activity modification, but is not practical once the wrestler returns to competition. Most injuries are self-limiting, with return based on criteria of full range of motion and strength.

Prevention is an essential concept in the management of back injuries in athletes. Conditioning and stretching comprise the key elements of preventing back injuries. A stretching program should include not only stretching of the low back, but also of the hamstrings and hip flexors.

#### 13.4.3.2 Rib and Chest Injuries

Injuries to the rib cage result from direct trauma during takedowns when the opponent's head or shoulders strike the anterior chest with considerable force. The most common mechanism is when a wrestler takes his opponent down with a waist hold, and the victim's ribs land on the dominant wrestler's arm. When the opponent lifts or throws the wrestler while in a bear hug, the force generated by the opponent's grip can be enough to cause chest wall injury.

Injuries to the rib and chest comprise 3.6–14.3% of total injuries in prospective studies. Most of these injuries are contusions or costochondral sprains, but rib fractures also occur. Injuries to the costochondral junction range from contusion to sprain to dislocation. The injuries are located at the anterior margin of the ribs, about 3–4 fingerbreadths lateral to the sternum, where the ribs articulate with the costal cartilages.

Clinically, the wrestler complains of anterior chest pain, worse with coughing, sneezing, and because the anterior abdominal muscles also attach at the lower costochondral junctions, with twisting motions. Physical findings include localized tenderness and swelling at the costochondral junction. Pain occurs with direct pressure over the injured area, with pressure over the same rib laterally (in the axillary line), and with sternal pressure. With subluxation or dislocation, a step-off may be felt or a click may be elicited by palpation. Symptoms worsen with increasing severity and injury. In general, this injury is quite painful. Radiographs provide no help as the injury rarely can be visualized unless a bony rib fracture has occurred lateral to the costochondral junction.

Costochondral sprains are difficult to treat because the site is extremely vulnerable to reinjury. Treatment is symptomatic with ice, NSAIDS, and TENS used for pain control. The wrestler stays out of action until symptoms permit return, rarely more than 7–10 days, and more commonly 2–3 days. At first, deep breathing alone may be painful, which makes even conditioning difficult. Taping and splinting are ineffective and tend to draw the opponent's attention to the injured rib cage. However, a circumferential compression dressing about the trunk with an elastic tape, an elastic bandage, or corset, can be tried for symptomatic relief. We have on rare occasions employed injections of local anesthetics. Occasionally, this injury is complicated by the late development of calcifications in the injured costochondral junction. This condition produces a painless mass at the area and is usually only a cosmetic problem.

#### 13.4.3.3 Abdomen Injuries

Abdominal injuries have rarely been reported in wrestling. Among the prospective and retrospective studies documented, abdominal injuries account for only 0.4–0.7% of the total number of injuries. Diamond (1989) described abdominal wall contusions as the most common injury, characterized by tenderness only in the area affected with no referred pain. If an athlete exhibits rigidity, involuntary spasm, guarding, rebound tenderness, or referred tenderness, along with aggravation by activities of daily living, consultation with an abdominal specialist is indicated. The symptoms of abdominal trauma may be immediate or may appear later.

The most common solid organs traumatized are the spleen, liver, and kidneys. If the kidney is injured, there may not be much associated pain if the injury is confined to the substance of the kidney. The only finding may be hematuria. Renal injuries occur when there is a blow to the back or flank below the last rib, such as being struck by a knee. Athletes with gross hematuria should be thoroughly evaluated. A broken rib can puncture either the liver or spleen.

### *13.4.4 Lower Extremity*

#### 13.4.4.1 Knee

The knee is the single most commonly injured anatomic region. Knee injuries range from 9.3% to 38.4% of wrestling injuries in prospective studies. Knee injuries constitute an even larger proportion of serious time loss injuries (greater than 7 days' lost). In one prospective study, 56% of knee injuries were significant (Powell 1981). In two retrospective studies, 39% and 46% of knee injuries had significant time loss (Roy 1979, Wroble et al. 1986a). Jarrett, in a study of college injuries, found that of all injuries resulting in 7 or more days off, 30% involved the knee. Of all injuries resulting in surgery, 65% involved the knee. In Powell's study (1999), knee surgeries represented 52.6% of the total number of surgeries performed on wrestlers. Pasque showed that of season-ending injuries in high school wrestlers, the most common occurred to the knee and represented 44% of the total.

Takedowns are involved in the majority of knee injuries of all types. Usually, the wrestler on the defense sustains the injury. Meniscus injuries occur most commonly during takedowns via a twisting injury to a weight-bearing extremity. Collateral ligament sprains occur when a varus or valgus force is applied to the weight-bearing extremity of the defending wrestler. These mechanisms far more commonly cause injuries than application of holds that intentionally apply twisting forces. The latter techniques are considered illegal and are penalized.

The most common type of knee injury is the sprain, which make up to 30–65% of the total number of knee injuries. Meniscus injuries are the most common knee injuries leading to surgery. Another common injury is prepatellar bursitis. There is a very low incidence of ACL and other catastrophic knee injuries. Nonetheless, we are aware of two knee dislocations occurring in wrestling matches.

### *13.4.5 Prepatellar Bursitis*

Prepatellar bursitis is associated with frequent recurrences, occasionally requires surgery, and accounts for substantial time loss. Prepatellar bursitis can be caused by a single traumatic event (e.g., forceful impact of the knee to the mat) or by chronic repeated trauma. In both, takedowns are frequently implicated. Mysnyk et al. (1986) discussed prepatellar bursitis in detail. Twenty-eight cases were documented, representing 21% of all knee injuries. Fifty percent of these were recurrent injuries. Eight cases of septic bursitis were reported.

The diagnosis of prepatellar bursitis usually is not difficult. There is usually a history of trauma, even though the exact inciting incident is often unknown. Swelling occurs superficial to the patella. Effusion may or may not occur. The range of motion is relatively painless (even in cases of sepsis) except with maximum flexion.

Conservative management is difficult since repeated irritation is inherent to the sport. Aggressive initial treatment is indicated in wrestlers with prepatellar bursitis. This is important, not because the initial episode is disabling, but because early aggressive management gives the best chance to prevent progression to chronic bursitis. In chronic bursitis, the bursal wall is thickened and becomes irritated by minimal trauma. Excision of the bursa is generally required. When a wrestler presents with typical symptoms and signs, we start iontophoresis with 5% hydrocortisone and an NSAID. Wrestling is rarely curtailed; we send them back to the mat with a Neoprene knee sleeve with extra Neoprene anteriorly. Petroleum jelly is applied to the anterior aspect of the knee before the sleeve is put on, which decreases friction between the skin and the sleeve, thereby decreasing irritation of the prepatellar bursa. Most wrestlers respond to this routine.

If there is a recurrence, we will repeat the same procedure often increasing the rest period. If a second recurrence arises, we recommend bursectomy. Bursectomy can be performed easily using arthroscopic techniques, minimizing down time even further. We do not find any direct effect on recurrence or time loss with intrabursal corticosteroid injections, and thus do not use them.

Septic bursitis may present with typical local evidence of infection, but is often bereft of these signs (Roland et al. 1992). *Staphylococcus aureus* is the most common offending organism. Most cases are believed to result from direct penetration through the skin even though a wound is rarely obvious. Knee trauma and minor mat burns may allow bacterial seeding to occur. Because the systemic or even local symptoms are often lacking, early septic bursitis is often more difficult to diagnose than septic arthritis. However, since the prepatellar bursa is a closed space, not communicating with the joint, complications of septic bursitis are rare, especially when compared with those of septic arthritis. Aspiration, gram stain, and culture should initially be done in all cases of bursitis whether they appear infected or not. The aspirate is not always grossly purulent. Once the diagnosis is established, and even before if clinical suspicion is high, antibiotics, preferably a first-generation cephalosporin or a penicillinase-resistant penicillin should be started. Antibiotics may be given orally if the infection is not severe. The athlete may need parenteral treatment if the infection is severe or if oral treatment fails. Incision and drainage with irrigation using local anesthesia are necessary only if the bursa appears loculated and clinical improvement does not occur with repeated aspirations.

We encourage all of our wrestlers, but particularly those with a history of prepatellar bursitis, to wear kneepads. Even though our retrospective study of wrestling knee injuries failed to show any relationship between wearing kneepads and the occurrence of prepatellar bursitis, it is our impression that kneepad usage is of benefit (Wroble 1986a).

### *13.4.6 Meniscus Injuries*

A higher ratio of lateral to medial meniscus tears occurs in wrestling than in any other sport (Baker et al. 1985). In most sports, lateral meniscus tears comprise 25% of all meniscus tears. In two wrestling studies, lateral meniscus tears made up to 46% of the total (Estwanik et al. 1980, Wroble et al. 1986a). Baker et al. also noted 45% lateral versus medial meniscectomy in their study of 56 meniscectomies in wrestlers.

### *13.4.7 Ligament Injuries*

Taken together, ligament sprains comprise the most common knee injuries in wrestling. The overwhelming majority of ligament injuries, however, occur to the medial and lateral collateral ligaments tears. Once again, a relatively high number of lateral injuries are seen. The cruciates are injured less often, in contrast to American football. Anterior cruciate ligamentears were noted in only 4 of 136 injuries in one series (Wroble et al. 1986a) and 14 of 256 cases in another (Estwanik et al. 1980). Not surprisingly, most injuries occur during takedowns with the defending wrestler being injured most often.

Some wrestlers may function reasonably well in the short term with anterior cruciate-deficient knees because the demands of the sport are such that the knee is uncommonly in a position where tibial subluxation could occur. Nonetheless, most wrestlers will not have satisfactory function in their sport, and, in most wrestlers the ACL-deficient knee will produce long-term problems. We, therefore, generally recommend ACL reconstruction with return to wrestling at about 6 months.

Functional braces are of questionable value. Psychologically, it seems to cause a big disadvantage to the wrestler, making them more aware of their own disability. They also know that their opponent is aware of it and may try to exploit it. In addition, we are skeptical that a brace will afford any substantial protection. On the other hand, those wrestlers who do use functional braces must have them taped and padded for matches and practice. Wrestling rules dictate that any device must be protected so that it cannot cause injury to the opponent by sharp corners or exposed metal, etc. The rules also state that braces may not limit motion.

#### 13.4.7.1 Foot and Ankle Injuries

The most common ankle injury is the lateral ligament sprain, which most often occurs during takedowns. We have identified two specific mechanisms. First, when a wrestler attempts to throw his opponent and rises onto his toes and twists, a momentary loss of balance may cause him to roll over his ankle into an inverted position. The second occurs to the defensive man during the takedown. When his opponent lifts one of his legs, his support remains on a single foot. As his opponent attempts to bring him to the mat by various combinations of rapid changes in direction or trips, inversion stress can occur. Most often, these sprains are first degree.

Overall in prospective studies, ankle injuries have ranged from 3.9% to 9.7% of total wrestling injuries. In a 2-year study of seven college wrestling teams, ankle injuries were 11.2% of all wrestling injuries (Garrick 1975). In the same report, the author described the results of the first year of the Seattle High School injury study. Ankle injuries constituted 6% of wrestling injuries in that portion of the study.

The design of standard wrestling shoes affords little protection to the ankle. They have rubber soles causing very high friction with the mat along with virtually no give. Although they extend above the ankle, the uppers consist of nylon or soft leather, and offer little support.

### *13.4.8 Dermatological Conditions and Treatment*

Due to the extensive physical contact inherent to wrestling, participants are exposed to transmissible diseases, especially of the skin. Skin to skin contact, facilitated by the cuts and abrasions that are part of the sport, in combination with the heat and humidity of the typical wrestling facility and the general inattention to hygiene of wrestlers, provide an ideal milieu for infectious skin flora. The etiology of skin infection in wrestling encompasses bacterial, viral, and fungal agents. Early recognition of common dermatological problems is required so that prompt and appropriate treatment may be rendered. Proper management not only hastens the resolution of skin lesions, but also serves to protect teammates and opponents from exposure to the infectious agent.

Wrestling rules recommend that a physician be present at weigh-ins in all tournaments and meets to examine contestants for communicable diseases. Referees serve this function when physicians are not available. Disqualification of an individual from competition may occur if, in the opinion of the examining physician, there is the presence of a communicable disease that makes participation inadvisable.

In most studies of wrestling injuries, skin diseases are not reported or rarely investigated in detail. As a percent of total reported injuries, skin problems have occurred from 5% to 26%. (Konrad 1951, Lorish et al. 1992, Roy 1979, Snook 1982, Brown 1951, NCAA 1993a, b, Jarrett et al. 1998, Pasque and Hewett 2000) Roy found that, of 332 injuries, 56 were skin infections. Konrad reported that skin infections comprised 21.6% of all injuries. The NCAA reported that skin infections accounted for almost one third of practice time loss events.

A comprehensive discussion of skin infections can be found in Chapter 8.

## 13.5 Injury Severity

### *13.5.1 Time Loss*

Several large studies have assessed the proportion of injuries by the number of days missed from competition. In general, injuries are classified as minor if time loss is up to 7 days. Minor injuries occurred in all studies at rates of 43–68% (NHSIR 1988, 1989, Garrick 1978, Powell 1981, NCAA 1993a, b, Roy 1979, Wroble et al. 1986a, Wroble 1986b, Yard et al. 2008). Time loss from neck, back, and knee injuries tends to be higher than that found in the overall injury group.

### *13.5.2 Catastrophic Injury*

Amateur wrestling at the high school and collegiate levels very rarely results in fatality or paralysis. Understandably, most catastrophic injuries in wrestling occur to the head and cervical spine. Mueller et al. (2002) described 46 catastrophic high school injuries, two of which were fatal, and one catastrophic college injury. The rate of direct catastrophic injury in high school was 0.97 per 100,000 and 0.72 per 100,000 wrestlers for college competition. Mueller et al. (1990) also documented indirect (caused by systemic failure as a result of exertion while participating in a sport) fatalities over that 20-year period, 14 in high school and 3 in college. The rate of indirect fatality was 0.3 per 100,000 for high school wrestlers and 2.16 per 100,000 for college wrestlers. The deaths in college wrestling were of note because they all occurred during a 3-month period in 1997 and all were related to hyperthermia, dehydration, and weight loss.

Laudermilk and Boden analyzed NCCSIR data specific to wrestling. Laudermilk (1988) reviewed 1982–1987 data from the NCCSIR. Fifty percent of the 24 injuries were found to involve the cervical spine, spinal cord, or head. 42% of the injuries occurred during takedown, and 71% during matches. Boden reviewed the NCCSIR data from 1981 to 1989. He documented 35 cases of catastrophic injuries, 34 among high school wrestlers and one among college wrestlers. He estimated the rate of catastrophic injuries as being about 1 per 100,000 participants. Twenty-seven cases involved the cervical spine. Of the 27 cervical spine injuries, 15 were permanent and 12 achieved full recovery. There were four cases of transient quadriplegia, three severe head injuries, one herniated disk, and one death. They defined the at-risk settings: the wrestler defending on a takedown, and matches as opposed to practice.

Clarke (1977) sent surveys to state high school associations and to individual colleges. From 1973 to 1975, eight catastrophic injuries were found, all at the high school level. All resulted in permanent spinal cord injury, none in death.

Bailes and Maroon (1989) reported on cervical spine injuries in athletes. Four percent of the total admissions to their spinal cord unit were related to sports injury. Wrestlers suffered accidents when they fell to the mat, with the usual mechanism of injury being hyperflexion. They described the cervical spine being subjected to tremendous forces, putting great stress on the intervertebral disks, ligaments, and facet joints from rotational and horizontal vectors during certain maneuvers and holds.

In 1991, Bailes described a series of 3,200 spinal cord injuries at two centers over a 12-year period from 1975 to 1987 (Bailes 1991). There were 13 wrestling injuries. Of the 13 cervical injuries in wrestlers, 10 were spinal cord injuries and 3 were fractures or subluxations without neurologic injury. Five of the cervical cord injuries were permanent and five achieved a full recovery.

Bruce et al. (1984) documented a very low incidence of major head and spine trauma in children, but noted that the incidence increased in the 15- to 18-year-old group. Wrestling injuries were produced by direct blows to the head or by falls in which the head or neck was twisted. Other mechanisms include the twisting and flexion activities and motions that are part of takedown maneuvers.

### 13.5.3 Clinical Outcome/Residual Symptoms

One investigation studied the long-term consequence of wrestling injuries. Mysnyk and Albright (1988) interviewed 542 males, 30 or more years of age (average 44.1 years) at the 1986 NCAA Wrestling Championships. Three hundred and seven former wrestlers were compared to a control group who competed in no sports or only in noncontact sports. Forty-two percent of ex-wrestlers had current musculoskeletal problems, whereas only 24% of controls did so. Neck problems occurred nearly three times as frequently and knee problems occurred nearly four times as frequently among ex-wrestlers.

## 13.6 Injury Risk Factors

Table 13.1 summarizes injury risk factors. Many of these factors are intuitively obvious. Even though they appear to have a positive relationship, they are often derived from retrospective studies or case series, and thus do not have the same value as if they were obtained from prospective work.

**Table 13.1** Injury risk factors in wrestling

| Intrinsic risk factors | Extrinsic risk factors |
|---|---|
| Physical factors | Exposure |
| • Weight (?) | • Level of competition (+) |
| • Age (+) | • Takedowns (+) |
| • Weight loss (?) | • Position on mat (+) |
| • Skill (?) | Training conditions |
| • Previous injury (+) | • Inadequate supervision (?) |
| Motor/fitness factors | • Inadequate technique (?) |
| • Fatigue (?) | • Abrasive shirts (+) |
| • Timing in match (?) | • Unwashed workout clothing (?) |
| • Matches/day(?) | • Poor nutrition/dehydration (?) |
| Psychosocial factors | Environment |
| • Noncompliance (+) | • Time in season (+) |
| | • Mat condition (?) |
| | • Mat cleanliness (+) |
| | • Temperature, humidity of wrestling room (?) |
| | Protective equipment |
| | • Head gear (+) |
| | • Knee gear (+) |
| | • Mouth guards (?) |
| | • Shoes (?) |

The + sign indicates a positive relationship as suggested by current research. The question mark signifies that either the findings have been ambiguous or that no empirical data are available.

### 13.6.1 Physical Characteristics

There is a slight trend for wrestlers at higher weights to be injured more frequently. This is perhaps due to the greater force that can be exerted by athletes of greater size. The relationship of age to injury shows that young wrestlers tend to be injured less frequently than their older counterparts. This is probably a factor of their physical immaturity, size, and strength. The principle of the weight class system is to reduce risk of injury by eliminating vast discrepancies in size and strength between opponents. However, rapid and drastic weight loss performed to “make weight” may itself be a risk factor for injury, given the adverse physiologic changes induced by dehydration and fasting. Nonetheless, Horswill (1992) found that a wrestler who loses fat may enhance power and strength capacities relative to body weight. This suggests that the wrestler who practices rapid weight loss can compete against a relatively weaker opponent. This in turn may be reflected in increased injury rates in the weaker of the two wrestlers. Wroble and Moxley (1998) demonstrated that, among high school wrestlers, those with the lowest body fat tend to have a higher chance of success than those who wrestle at a higher percent body fat. McGuine (1989) showed that the injury rate in placers was equal to the injury rate in non-placers in his study of the 1985 Northern Open. In contrast, Requa found that 70% of the match-related injuries in their study occurred in the wrestler who is behind at the time.

An athlete’s skill level can have a great effect on injury. Boden’s study on catastrophic injuries suggests that inexperienced wrestlers may get themselves into precarious situations that predispose them to serious injury. Boden also reports that poor officiating, rules infractions, and dangerous moves were probably to blame for 11 of the 54 catastrophic injuries in that study.

Reinjury rates in wrestling have been noted to be high; for example, in the Iowa study, a wrestler had a 30% chance of sustaining a first-time knee injury. Once the knee was injured, the chance of a second injury rose to 57% (Wroble et al. 1986a).

### 13.6.2 Motor/Functional Characteristics

As fatigue may play a role in injuries, the timing of injuries in matches and in tournaments has been evaluated. If injury rates rise in the third period compared with the first and second periods, this may be in part due to fatigue. Hartmann (1978) and Wroble et al. (1986a) found no relation between injury rates and timing in the match in their studies.

If more injuries occur as the number of matches in a day increases, fatigue may play a role. Strauss and Lanese (1982) studied two large wrestling tournaments. They compared injury rates in the first, second, and aggregate of the third and later matches and concluded that injury rates seemed to be similar in all categories. McGuine (1989) reviewed the injuries in a large 1-day collegiate wrestling tournament. He found that the injury rate tended to decrease after the wrestler had competed in several matches. Kersey and Rowan (1983) examined the results of successive matches in a 3-day, six-round tournament. In the first three rounds, the injury rate was 12%, and in the final three rounds, it was 9.7%.

Pasque reported a trend toward more injuries in the latter half of practice and during the second and third periods. This finding, however, was not statistically significant

### *13.6.3 Exposure*

The intensity of wrestling exposure in large part determines the risk of injury. For example, at successively higher and thus more competitive levels, injury rates increase. Match injury rates are always higher than practice injury rates.

The more explosive collision-oriented maneuvers involved in the takedowns result in higher injury rates as well. A variety of authors have noted the frequency of takedown injuries among their overall number of injuries in each study (Hoffman and Powell 1990, Requa and Garrick 1981, Strauss and Lanese 1982, Estwanik et al. 1978, 1980, NCAA 1993a, b, Kersey and Rowan 1983, Snook 1985, Wroble et al. 1986a). Knee injuries occurred more commonly during takedowns in both high school (Estwanik et al. 1980) and college (Wroble et al. 1986a). The only study that evaluated wrestling at the international level (Estwanik et al. 1978) studied injuries at the 1976 Olympic trials. Takedowns accounted for 75% of the injuries. This high frequency is perhaps accounted for by the different styles, because in Freestyle and Greco-Roman wrestling a greater percentage of time is spent in the standing neutral position than in high school or college wrestling. It appears to be a risk factor to take a defensive role while in the standing position. During takedown injuries, 60% of the time the defensive man was injured (Wroble et al. 1986a).

In a few studies, the position of the wrestler at the time of the injury has been analyzed. Injury rates are higher for the wrestler in the down or disadvantage position in both college and high school studies (Requa and Garrick 1981, Patacsil 1955, NCAA 1993a, b, Kersey and Rowan 1983, Acksel 1966, Wroble et al. 1986a).

### *13.6.4 Training Conditions*

Inadequate supervision of a wrestling team may increase injury risk by lack of monitoring potentially dangerous situations and techniques and the inability to discourage horseplay.

Inadequate wrestling technique may increase injury risk. One good example is how shoulder injuries occur during takedowns. If a wrestler gets caught in the over-extended position with their shoulder maximally forward flexed and externally rotated, subluxation or anterior sprains commonly occur.

Dermatologic problems stem from the close body contact integral to the sport in combination with warm conditions, humidity, sweaty workout clothes, and mat contact. Contact with an opponent with a cold sore or facial rash is also a risk factor. Strauss et al. (1989) identified that abrasive shirts were risk factor in spreading herpes gladiatorum. Following a collegiate wrestling team for 3 years, they found a variation in herpes episodes coincided with changes in shirts. In the first year of the study, wrestlers wore 100% cotton shirts, and 9.8 episodes per 100 wrestlers were identified. In the second year, when 50% cotton/50% polyester shirts were used, 73.8 episodes per 100 wrestlers were documented.

Systemic illnesses are endemic for these reasons in addition to the fact that the hot, sweaty wrestler often emerges to a cold wintry evening after practice. Also, poor nutrition and dehydration have been suggested to compromise the immune status of wrestlers who are cutting weight.

### *13.6.5 Environment*

The overall pattern of training during the season may affect injury rates. Patacsil found that most injuries, 123 of 200 (61.5%), occurred in the first half of the season. In a study of six college wrestling seasons, more than three times as many injuries occurred during the first month as any other month during the wrestling season (Wroble et al. 1986a).

The condition of the wrestling room is important. Jarrett reported that 1% of the injuries occurred when a wrestler struck a surface other than the wrestling mat (clock, table, and floor). Unpadded walls, obstacles such as columns or bleachers, inadequate space, and extreme heat or humidity are obviously detrimental. A mat in good condition is essential for aiding in the prevention of serious injuries. Mysnyk et al. (1986) found a much higher incidence of prepatellar bursitis in the off-season when compared to the regular season. The use of older, deconditioned wrestling mats during the off-season is cited as the potential reason. If mats are in poor condition, their ability to absorb shock may deteriorate and thus increase injury risk when wrestlers land on them. Another item is cleanliness of the mats. Without daily disinfection, the counts of microorganisms on the mat would rise and so increase the chance of transmission of dermatologic infections from mat to wrestler.

### *13.6.6 Protective Equipment*

The amount of protective gear worn in wrestling is minimal. Headgear has been investigated, and not wearing headgear is a risk factor in sustaining auricular hematoma. Nonetheless, these injuries do occur with headgear on (Schuller et al. 1989a). This suggests that proper fit and proper choice of headgear are also important. The role of knee pads and shoes has not been evaluated, but in other sports they have been effective in preventing injuries. Mouthguards are not a required piece of equipment for wrestling. Considering that American football, ice hockey, and rugby players have seen a drastic decrease in dental injuries with mouthguard use, wrestlers would also likely see a decrease with their use.

## 13.7 Suggestions for Injury Prevention

Wrestling is an aggressive contact sport, and will never be free from potential injury situations. However, by examining how injuries occur, we gain insight into their prevention. Few sports provide such a varied challenge to the sports medicine team as wrestling. Acute trauma, overuse injuries, medical illness, nutrition, and training problems are all present in these athletes. The combative nature of the sport makes injury prevention difficult. However, rule changes, monitoring of training, nutrition, and management of medical problems are all areas that can result in lowering injury rates in wrestlers. The challenge for the wrestling team physician and trainer is to implement these changes and so prevent many of the athletes' injuries.

The suggested preventive measures are summarized in Table 13.2. As is apparent from the discussion of available studies, very few, if any, studies on wrestling are rigorous enough to draw definitive conclusions about risk factors. Given that, it is still possible to suggest measures that reflect the best and most current information in the literature. Naturally, these suggestions await confirmation in well-controlled prospective studies.

**Table 13.2** Suggestions for injury prevention in wrestling

| Preventive measure | Examples/suggestion |
|---|---|
| The wrestler | |
| Proper warm-up | Begin by movements to increase muscle temperature, then stretching to increase range of motion. |
| Strength training | Maximize muscular power and endurance with sport-specific program. |
| Cardiovascular conditioning | Fatigue suggested to increase inujuries in some studies but not others |
| Correct technique | Shoulder injuries caused by poor technique |
| Size/ability matching | No gross discrepancy in practice partners. |
| Limits on weight reduction | Horswill recommends limits of 5% body fat: no firm data available. |
| Proper hygiene | Dermatologic illness transmitted skin to skin. Daily washing of workout clothes/after practice shower. |
| Adherence to rules | High school and college rules ban holds that exert potentially injurious forces to the spine and extremities. |
| The sport | |
| Adequate supervision (coach/wrestler ratio) | Optimal ratio not defined. Minimize horseplay, monitor dangerous techniques. |
| Coaching education/certification | Courses should include medical components. Enhance relationship with health care team. |

(continued)

**Table 13.2** (continued)

| Preventive measure | Examples/suggestion |
|---|---|
| Officials education/certification | |
| Require use of proper headgear | Shown to decrease injury when wom. Not mandated by most coaches at practice Four strap type best. |
| Mouthguards | Dental injuries incommon but often irreversible. |
| Early start of practice/delayed start of competition | Injuries more common in early competition |
| External environment | |
| Removal or padding of hazards | Already mandatory for matches. Enact for practice. |
| Adequate space | Snook suggests 50 $ft^2$ per pair of wrestlers. If not available group wrestlers and provide off-mat activities such as strengthening or conditioning for other groups. |
| Appropriate temp/humidity | Avoid dehydration/heat injury, optimal temperature not known. |
| Quality mats | Need optimum biomechanical properties (not as yet defined) Resurface if wom or damaged. |
| Mat disinfection | Shown to decrease bacterial infections. |
| Nonabrasive shirts | Strauss showed increased herpes infection with abrasive shirts |
| Health support system | |
| Preseason evaluation-physical exam, body composition, muscle/fitness testing | Identify conditions that preclude competition and abnormalities that predispose to injury; allow optimal weight reduction planning. |
| Medical coverage | Physician and trainers at all competitions. At minimum, trainers available for practices. |
| Emergency protocols | Well defined so they can be implemented in any competitive environment. |
| Skin hygiene | Soap shower after practice, adequate drying of skin. Exclusion of infected wrestlers/occlusive coverage. |
| | Coaches to perform routine exams; wrestler/coach education |
| Precise treatment protocols | This will reduce the incidence of reinjury and long-term sequelae eg., (neck). Monitor noncompliance |
| Strict return criteria | |
| Proper rehabilitation | |

### *13.7.1 The Wrestler*

Many wrestlers are inexperienced, especially at the grade school and high school level, and close attention to proper technique is essential for safe competition. Boden recommends that coaches teach wrestlers to keep their heads up when performing takedowns to avoid axial compression of the spine leading to serious injury.

### *13.7.2 The Sport*

Good-quality equipment such as wrestling shoes, kneepads, and headgear are likely to be helpful. Mysnyk suggests that use of kneepads may decrease the cases of prepatellar bursitis, though this has never formally been studied.

Wearing properly fitted headgear for practice and competition is also recommended. Although headgear does not prevent all ear injuries, it greatly reduces the incidence of serious ones. Although wearing headgear is mandatory for competition, and most coaches believe headgear to be effective in preventing serious auricular injury, many do not mandate their use for practices. We recommend they be worn by all wrestlers at all practices.

Mouthguards have never been a standard piece of equipment used by wrestlers, and most wrestlers do not wear them. Use of well-fitted mouthguards during practice and competition may prevent irreversible dental injury. Custom-fitted mouthguards appear to offer the best protection and the best compliance.

Pasque and Hewett (2000) suggest that limiting the amount of time spent on practicing live wrestling may decrease the incidence of injuries occurring during practice. Wroble (1996) recommends beginning practices earlier in the season, and delaying the onset of competition to allow for wrestlers to be better prepared for competition. Puggelli (1981) made specific recommendations, emphasizing careful drilling of steps in a technique, organization of practice so that all bodies move in generally the same direction and teaching moves commensurate with the physical capabilities of the athletes.

Referees must remain in control of the match at all times. Better attention by wrestling officials to rules infractions and dangerous moves is crucial in preventing serious injury. The referee must know illegal or potentially dangerous moves, and how to anticipate them. This is especially important in preventing improper slams to the mat. Such moves must be prevented when possible and penalized heavily when they occur. Further education of referees into the mechanism of injury will enhance their ability to assess a potentially dangerous situation on the mat and to prevent injuries.

### *13.7.3 External Environment*

Having adequate practice space for the wrestlers can lead to avoidance of many injuries. Snook (1980) recommends providing at least 100 $ft^2$ per wrestling pair whenever possible. Placement of objects close to the mat must be carefully monitored. Jarrett found that 1% of the injuries in his study may have been avoided if non-padded items such as clocks, scoring tables, and chairs were placed further from the mats. In addition, proper padding should be placed over any hard objects around the mat. High-quality mats of proper material and thickness (1½–2 in.) are crucial to the overall safety of the wrestler. It is important to replace or recondition wrestling mats when they become worn.

### *13.7.4 Health Support System*

Having an appropriate health care system in place prior to the start of the season is important. The health care team should consist, at minimum, of a team physician and an athletic trainer. Ideally, an athletic trainer should be present at all practices and competitions, and the team physician at all competitions. Prior to the start of the season, all athletes should undergo a preparticipation evaluation to detect any preexisting conditions. Protocols should be established for handling emergency situations. Wroble (1996) suggests outlining treatment protocols and having strict guidelines for return to competition following injury.

A professional medical team and good communication with other health care professionals in the community are essential. The medical team should enlist the services of a dentist to assist with properly fitted mouthguards. Consulting with a local dermatologist may also be beneficial in handling some of the skin infections that will invariably occur.

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# Chapter 14
# Judo

**Craig White and Pippa Rollitt**

## Learning Objectives

- To have an understanding of the rules and techniques involved in judo
- To be aware of the physiological requirements of judo
- To know the requirements for the provision of medical coverage at a judo event
- To understand the common injuries involved in the sport
- To have an understanding of the acute management as well as the rehabilitation process of these injuries

## 14.1 History of Judo

Judo is now an established Olympic sport practiced in nearly every country in the world. It is, however, more than just a sport. It is also viewed as an art form. It is seen to some as simply a form of hand to hand combat, probably as it has its roots in Jujitsu. This is a misconception. The sports founder Dr. Jigoro Kano added a strict code of ethics and humanitarian philosophy to the system.[1] This is not surprising as Dr. Kano gained a degree in philosophy after first achieving a degree in English Literature from Tokyo Imperial University in 1881.[1]

Jujitsu was practiced as a form of combat sport during Japan's feudal era. Various forms of jujitsu were created and developed during the Sengoko (1477–1603) and the Tokugawa (1604–1868) periods in Japanese history.[2] The restoration of the emperor in 1868 saw the end of the samurai and feudal lords and threatened the extinction of jujitsu. Dr. Kano had already studied several schools of jujitsu. He then went on to look at many other schools and by combining the practical and theoretic aspects of his learning, developed a safe sport that could be enjoyed by everyone. He excluded or modified the potentially dangerous techniques and holds in order to

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keep a safety first policy yet provide a challenge to players. This produced what we know as Kodokan Judo.[2,3]

In order to gain acceptance of Kodokan Judo in Japan, representatives traveled around Japan giving lectures. During this time many of the back street gyms (machi dojo) thought the Kodokan conceited and challenged the Kodokan to contests. The Kodokan invariably won. The lecture tour ended with a contest to see which form of jujitsu should be adopted by the military, police, and schools. A team of 15 Kodokan defeated the opposition and judo became a government-approved sport.[4]

The first judo world championships were in Tokyo in 1956. It was introduced to the Olympics Games in Rome in 1964 (although it was due to be a demonstration event in 1940). Women could compete for Olympic medals for the first time in 1992.

## 14.2 Rules and Regulations

A judo contest is fought over 5 min for senior men and women. There are seven weight categories each. For men the weight categories start at under 60 kg (lightweight) to over 100 kg (heavyweight). Women start at under 48 kg and go up to over 78 kg. The competition takes place in a hall (dojo). The fights take place on the mat (tatami). The fight area is 10 × 10 m. There are three referees: one in the middle and two sitting at opposite corners.

There are four scoring values. An ippon is a full score and will win a contest outright. A waza-ari is a half score. There are also two lesser scores: a yuko and a koka. A contest is won either by one opponent having a full score (ippon) or two half scores. If the contest has gone the full distance without a full score the judo player (judoka) with the highest scores will win.

There are four basic judo techniques.

*Throwing technique (Nagewaza)*. A judoka will throw another judoka from a standing position. Throws should be executed with control in order to land the opponent on his or her back. There are a large number of throwing techniques: shoulder throws (e.g., seoinage), hip throws (e.g., o goshi), leg hooks (e.g., osoto gake), leg sweeps (e.g., deashi harai); sacrifice throws (e.g., tomoe-nagi). In each of these techniques there is a risk of injury to the thrower (tori) and the athlete being thrown (uke).

*Mat techniques (Katame-waza)*. If a contestant is held on his back (osaekomi) for 25 s, then an ippon is awarded. If the hold is for 20 s, then a waza-ari is awarded.

*Choke technique (shime-waza)*. If an opponent is choked until unconsciousness or submits to avoid the choke, then a full point is awarded and the contest is won.

*Joint holds (kansetsu-waza)*. This can be applied to the elbow only. When an opponents elbow is held in extension and is endangered they will submit and a full ippon is awarded.

Each judo technique can give rise to specific injuries, which will be discussed later.

Each judo player will be granted a license by their country's governing body in order for the athlete to be allowed to compete. There is a grading system, which indicates increasing mastery in the sport. The grading starts at white belt and progresses through to black belt. Some competitions allow only certain grades to compete in order to prevent mismatches and hence reduce the potential injury rate.

When taking up judo for the first time, athletes are taught the break fall (ukemi). This is designed to reduce the risk of injury to the uke. When landing on their back they have their head flexed and one arm horizontally extended to prevent injuries to the head and neck and also to the outstretched hand. Injuries during poorly executed break falls are not uncommon.[5]

## 14.3 Regulations Regarding Competitions

In accordance with the European Judo Union (EJU) Medical Handbook only medical doctors are allowed onto the tatami. They are requested to attend the mat by the referee. Since 2004 they are only allowed onto assess and treat blood injuries, and to assess head and spine injuries. Physicians can use hemostatic agents to control bleeding. Before resuming competition, the bleeding area must be covered and any blood cleaned from the tatami using either absolute alcohol or a 10% bleach solution. Physicians are only allowed to assess other injuries. Treatment is not allowed. In view of this, physicians should ask permission form the referee to touch the athlete as an examination may be interpreted as a treatment. An athlete is only allowed two visits to the mat by the doctor for the same injury. If the doctor has to attend the third time the contest is awarded to the opponent. If an athlete requests a doctor to attend the mat for any other reason the contest is awarded to the opponent. If, however, the athlete is injured due to an illegal move from his opponent, a doctor may be requested to attend. If the doctor feels that the athlete is able to continue, they are awarded the contest. If the doctor feels that he cannot continue, the contest is awarded to the opponent. This is in accordance with International Judo Federation Rule Article 29.[6]

Also in accordance with the EJU handbook the following are essential for the competition area:

- One medical room
- Hospital within 15 min
- Ambulance on site with full resuscitation equipment and spinal board
- One doctor per mat with assistants to administer first aid
- Alcohol and wipes to clear blood

## 14.4 Physiology of the Judoka

Judo demands a lot of the athlete. The competition takes place over 5 min and contains periods of explosive effort, sustained activity, strength, and agility. It is a true test of fitness. Thus, the physiological attributes of a judoka need to take into account the need for glycolytic energy production in energy bursts and well as the need for an aerobic capacity to maintain activity over 5 min.[7] Judo training in players, both male and female, leads to good aerobic and anaerobic capacities.[8] A number of studies have looked at the physiological profiles of both elite and nonelite judokas. Not surprisingly there are different characteristics in varying weight categories.

The maximum aerobic power (V02 max l/min) of a judoka increases with weight in both elite and nonelite athletes.[7,9] However, the maximum aerobic power per kilogram bodyweight (V02 max/kg) is inversely proportional to weight.[7,9–11] Maximal aerobic capacity has been seen to vary from 5 to 7 l/kg/min in some studies.[7,9,10] This suggests that there is a large aerobic component to the sport of judo. The anaerobic capacity of the upper and lower limbs has also been shown to be high [7,9]. The lower limb anaerobic capacity compares favorably with those of wrestlers, power lifters, gymnasts, and other athletes.[11] Strength has also been measured using grip strength, maximal bench press. In one study of Canadian judoka the average maximal bench press was 100 kg with a range of 70–140 kg across the weight categories. This correlated with a high upper body anaerobic capacity.[7] General flexibility using measures such as the sit and reach test has been shown to be superior in judo players compared to the general population[12] and in wrestlers in one study.[13] In a study that compared Canadian Judoka to national swimmers, the two were seen to have similar sit and reach scores; however, the judo players were seen to have less shoulder hyperextension.[14] Other studies have also shown that judokas have above-average endurance capacity, good upper body anaerobic power and capacity, and above-average strength and flexibility.[12]

The percentage body fat varies between elite and nonelite judokas, as well as between weight categories and sexes. Elite male judokas can have a percentage body fat of 5% and can drop to below 4% to make weight for a competition. The average can vary up to 12% or higher in some older studies.[8,10,15,16,17]

## 14.5 Strength and Conditioning

In competition fighters will face an opponent of similar weight (unless in the heaviest weight division where there is no weight limit), so it is important that the ability to match the power of your opponent is established by a good strengthening program.

Judo training involves technique training (kata) and the application of this into a freestyle setting (randori). Strength and conditioning is very important to the modern judoka and needs to be specific to the demands of judo, as well as having a significant role in injury prevention. There is an excellent article written by Amtmann and Cotton,[18] which looks at the strength and conditioning requirements of Judo. It looks at the requirements of a strength and conditioning program and identifies key areas:

1. What specific muscle groups need to be trained?
2. What energy sources need to be trained?

3. What are the muscle actions that are required?
4. What are the main sites of injury[18]?

In addition, it is also very important to look at the core stability requirements required in the various techniques.

Generally, weight training programs use Olympic lifts, which are often supplemented by exercises such as power cleans. They also use explosive types of exercises such as weight squat jumps, power squats, and medicine ball work. Grip strength is extremely important, so exercises are used to improve grip strength and endurance. In addition to using wrist curls, farmer's walks, in which the athlete will walk holding weights, judo-specific exercises such as pull-ups holding onto judo jackets (gi) are used.[18] When looking at the energy systems utilized we have seen that there is mixture of aerobic activity with bursts of anaerobic effort. Conditioning training needs to be able to enhance both of these. Often a coach will employ a mixture of circuit weight training and interval training in an attempt to mimic the demands of judo.[18] Another way is to use judo-specific interval training. This uses judo-specific techniques at high intensity,[18] for example, multiple repetitions of throwing techniques. This can be mixed with exercises such as pull-ups and squats. This "metabolic" conditioning can then be added into a judo training session that includes technique and randori.[19] When considering the types of muscle action, the conditioning coach needs to work on isometric contraction as used in gripping as well as concentric and eccentric work.[18] Judo is a sport, which is performed often when the player is off balance and hence it is important to work on the core stability around the major joints. The athlete can be taught to activate these muscles with simple exercises; however, the exercises need to become functional to demands of the sport. These are particularly important in injury prevention and need to be carried out alongside a strength and conditioning program.

## 14.6 Judo Injuries

Judo is a sport and an art that combines brute force with the physical coordination, flexibility, and fine motor control of a gymnast with the body balance and fast reflexive action and reactions of a boxer. It requires a sharp attentive mind well coordinated with a similar body.

Elite judokas have usually been in training since the tender age of 5, learning movement patterns and refining these reactions for attack and defence strategies in a fight. These will be engraved in their neuro motor pathways.

Judo is a weight-controlled sport and the competitors will often lose a significant amount of weight over a short period of time in order to make their weight category. Bear in mind that some of these athletes have a percentage body fat of around 5%. Losing a small amount of weight does not seem to predispose to injury; however, a weight loss of 5%, if achieved over a short timescale, has been shown to increase the risk of injury.[24] This is an important fact that both athletes and coaches need to be aware of. This particularly applies to juniors who are growing and developing. They should be encouraged to move up weight categories rather than struggle to keep their weight down by diet and rapid weight loss programs prior to competition.

The most common injuries are cuts and abrasions. The doctor is likely to be called to the mat to assess and cover blood injuries. Injuries to the nose are common.[29] All cuts and abrasions must be covered and the bleeding stopped in order for the player to continue to fight. The method of covering the affected area must be able to stand up to the rigors of the fight without coming off as a third visit to the mat for the same injury will lead to that player forfeiting the fight. Sometimes one needs to be quite imaginative with tape!

### *14.6.1 Injuries Related to Specific Techniques*

It is interesting that the first thing taught in a Judo lesson is how to break a fall. The competitor will then spend the rest of their competition life trying to avoid this. A poorly executed break fall is a common source of injury. The competitor will often land on the outstretched hand to prevent landing on their back. This can lead to hand injuries, wrist impaction, forearm fractures, elbow, shoulder, and acromioclavicular joint disruptions.

Injuries can occur in all aspects of judo. Injury rates for Judokas in competition has been shown to vary between 25 and 136 injuries per 1,000 athlete exposures for both adults and children.[20–24]

*Throwing techniques* (nagewaza) can lead to injuries to both the thrower (tori) and the athlete being thrown(uke). As discussed before a poorly executed break fall can lead to injury. Landing on the point of the shoulder can also lead to acromioclavicular joint disruptions. Also the athlete may land on their back and then hit their head leading to a head injury. In my experience major head injury is unusual, but minor concussions are more common, especially in the nonelite and junior competitors. An athlete who sustains a concussion should undergo a strict return to activity rehabilitation process and be reviewed by a qualified doctor prior to return to competition using psychometric testing.

The tori is not immune from injury. It is common for the athlete to be on one leg when executing a throwing technique. There is often a rotational force applied to the knee joint combined with either a valgus or varus strain. This can lead to meniscal injuries, collateral ligament tears, and anterior cruciate disruptions. Injuries to the ankle mortise are also not uncommon.

*Mat techniques* (katame waza). Mat burns are quite common. Also "cauliflower ears" are common from direct contact with opponent or with the mat in hold down techniques.

*Joint holds* (kansestu-waza). These are of the elbow only as discussed earlier. During the execution of this technique structures around the elbow are put under a large amount of stress. Medial collateral ligament damage is common, the anterior band being put under particularly high strain. All grades of tears can occur including avulsion. The common flexor origin can also be strained. Impaction can occur on the lateral structures such as the capitellum. A posterior impingement syndrome can arise, from a synovitis, joint degeneration and loose body formation.

*Choke techniques* (Shime waza). It is hoped that a player will submit prior to losing consciousness when a stranglehold is applied to them. However, this is not always the case. The athlete may have a few anoxic jerking movements. The referees will generally raise the player's legs in the air and the medical attendant will make sure the airway is patent. The affected judoka will recover quickly. Junior (under 16) judokas are not allowed to compete in judo for 2 weeks if they have been choked to unconsciousness. Adult judokas are not allowed to compete for the rest of the day unless they have been assessed by a doctor who is familiar with shime-waza and they clear the athlete to compete. There have been a few studies looking at the electroencephalographic changes after a choke. They found that subclinical electroencephalogram (EEG) changes were seen despite no overt neuropsychological symptoms for up to 40 to 70 s after a choke, which did not lead to loss of consciousness.[25]

Gripping and the breaking of grips can also lead to potential injury. Heberden's nodes are a common site on the hands of the older judoka.

As indicated earlier, it is logical to surmise that most major injuries sustained in judo involve the shoulder girdle, elbow, and knee. This has been shown by a number of studies.[1,21,26–29]

## 14.7 Rehabilitation Principles for Common Acute and Chronic Injuries in Judo

Principles and goals of judo can be applied to our injury pre- and rehabilitation programs where a thorough understanding of the demands of judo competition as well as training is essential for a successful outcome. The principle of flexibility in technique application where the efficient use of balance, leverage, and movement in the performance of judo grips and throws can assist in development of a rehabilitation program.

Judo encompasses all joints of the body often being pushed, pulled, and stretched through extreme ranges of motion from many complex positions. Injuries can occur to almost any joint in the upper and lower limbs, as well as to the spine. This section will focus on a few of the more typical judo injuries and the application of rehabilitation in the clinic and on the mat. It is important to understand that in returning these athletes to high-level competition the whole kinetic chain is addressed with a view to the athlete performing winning technique. A small loss in range at a hip joint may be the difference between a successful Uchi-mata or not!

## 14.8 Basic Principles of Injury Management

1. An accurate diagnosis is essential – this will help guide the rehabilitation as well as help the athlete to plan the next stage of training.[30]
2. Arrange further investigations – X-ray, ultrasound imaging, computed tomography (CT), and magnetic resonance imaging (MRI).
3. PRICE – protection, rest, ice, compression, and elevation –should be followed in the initial, early stages of the injury.
4. Where surgery is indicated referral to an appropriate specialist must occur promptly.
5. Early mobilization under strict instruction of the physiotherapist should occur as allowed. Regaining full range of movement as the injury repairs and allows is essential to a good outcome. Muscle control around proximal joints can be started early and then appropriate muscular activation can be regained at the injury site.
6. Review of other structures that may have been involved during the injury.

### *14.8.1 Shoulder Girdle Injuries*

- Gleno-humeral (GH) joint dislocations
- GH joint instabilities
- Acromio-clavicular (AC) joint injuries: sprains – complete ligamentous rupture (Grades I–VI)
- Sterno-clavicular (SC) joint injuries: sprains – disc damage
- Rotator cuff tears – strains – impingements

1. EARLY: 48–72 h as described in the basic principles
2. INTERMEDIATE: 72 h – 2(3) MONTHS for dislocations, instabilities, and rotator cuff tears. GH joint/humeral head control is a primary goal with appropriate scapula stability providing a secure platform for the shoulder to operate from.[30] Caution must be taken if the physiotherapist is aiming solely for scapula control without gaining any GH joint stability especially with an unstable shoulder. A mix of the two must be achieved steadily in order to reduce further instability and pain. The "Stanmore Triangle"[31] can be a useful diagnostic tool. Using the principles explained by this group, by Gibson's approach at The Liverpool Upper Limb Unit, and by a specialist such as Elphinston, it is possible to regain a range of movement in the shoulder joint before embarking on the advanced shoulder rehabilitation stages.[31–34] Failure to complete these early and intermediate stages will lead to a failed outcome in rehabilitation.
3. ADVANCED: 2(3) MONTHS AND BEYOND. Shoulder rehabilitation that takes an athlete from the treatment room into the gym or the training arena. The chart below outlines some of the necessary levels that a judoka who wishes to resume full competition needs to achieve. Some of these levels may

only occur at 2–3 months following the injury especially if surgery has been required. Attention must be paid to all levels of spinal, scapula, and GH joint control. It may be necessary for the athlete to continue with some baseline exercises prior to performing these higher-level exercises.

| Advanced levels of shoulder girdle rehabilitation |
| --- |
| 1. Closed kinetic chain (CKC) – concentric/eccentric/isometric techniques |
| 2. Plyometric and speed, agility, and quickness (SAQ's) drills for the upper limb |
| 3. Grip power and speed |
| 4. 'Throwing' techniques built into rehab drills |
| 5. Break fall confidence |
| 6. Full range of movement: stability and power through range |

#### 14.8.1.1 Closed Kinetic Chain Exercises

**Press Up**. Once a good rotator cuff control is achieved with scapula stability throughout the full range of motion, a press-up can be used to gain proprioceptive control of the shoulder girdle. It can be adapted in many ways and is essential for return to judo. The '**Press Up**' is essential to judo during ne-waza when the fight has gone to ground or during a breakfall. It would seem appropriate to use the judo mat (tatami) as the training surface for some of these exercises. It requires good control of all segments of the upper limb and can also highlight weaknesses and confidence in the chain.

– By changing the stance the muscle requirements will change dramatically. Try wide versus narrow hand placement and then alter the amount of rotation at the shoulder by turning the hands in or out.
– The speed of the press-up can vary – quick and slow.
– The depth of the press-up can vary – full range or shortened inner or outer range press-up.
– Use resistance tubing around the shoulders and under hands to add resistance to the press-up ensuring that at the lowest level of the press-up it remains under tension.
– Vary the lowering pace – i.e., slow down the eccentric component of the press-up.
– Vary the upward pace to become more explosive, but keep the hands on the floor (concentric).
– Add in half way holds! (isometric).
– Progress to a single arm press-up.
– Placing the athlete's torso on a fit ball and progressively move the ball further away below the hips and then knees increasing the demands on the spinal and scapular stability system.
– Adding some extra weight to the patients back while performing a press-up.

– **Walking on hands** – similar to press-up – as in a "wheel barrow" with a partner needs good co-ordination and shoulder girdle stability.
– **Walking Plank** – from forearm support on two arms to full press-up position by moving up on to one arm at a time and then back down to the start position requires coordination and power in the upper limb and torso.
– **Plank rotations** – stabilizing on one forearm and externally rotating at the supporting shoulder, and then reaching the other hand to point up into air vertically above the athlete progresses the plank into dynamic weight-bearing stability of the shoulder, ac, and sc joints. It also requires good trunk stability.[35]

*Plyometric and SAQ drills*. These are essential to judo. The change in direction of a "grip and pull in" to a "grip and push away" combined with a throw attempt in one direction to the sudden foot sweep in another happens at such an incredible pace that a recovering injury in the upper limb requires not just a strong set of muscles and joints but ones that react rapidly and strongly to attack and counter an opponent. Specific courses are available to train a therapist in these SAQ drills.[36,37]

Some examples of such training are as follows:

– 'Jump press-ups' with varying landing positions from wide to narrow stance within a set of 15 reps
– 'Jump press-ups' while the lower half of the body is resting on a fit ball allows the athlete to jump forwards and sideways (two hands together) as well as in a wide to narrow stance.
– 'Jump' press-ups from a stability disc or other unsteady surface with hands on the disc
– Fast "wheel barrow" walk – the length of the tatami
– 'Commando' crawl – pulling body along the tatami using only elbows
– Two-handed Medicine Ball throws from overhead to twisting torso throws, as well as on the upward movement of a sit-up and then receiving in the downward movement
– Single-arm medicine ball throws
– Fit ball throws/bouncing on a wall in an overhead position – varying speed of bounce and distance from the wall of the athlete. Timing for a minute up to 3 min.
– Progress these throwing/catching techniques by standing the athlete on an unsteady surface.
– Rope climbing – in some Dojos there will be ropes used for conditioning training to improve grip strength.
– Rock Climbing – another style of conditioning training at indoor rock climbing centres.

**Grip power and speed drills** – during rehabilitation, routines can be specifically worked out to enhance the athlete's reaction speed.

– Take hold of their opponents jacket – gripping including cross-gripping and over-the-shoulder grips

– Break grips made by their opponent on their jackets

These gripping patterns can take the form of a 2-min drill (1 min making grip and 1 min breaking grip), then resting for 1 min before repeating the set again 5–6 times. It is hard work and also incorporates continual changing stance. Accuracy is essential and if combined with the plyometric drills described in the previous section provides a fun-sports-specific session.

Standing Uchi komi – gripping your opponent's jacket and turning into them preparing to throw repeated at speed for 15– 20 times in a set (6–10 sets). This is a warm-up pattern used for judo and can be ideal as a basic-level judo-specific rehabilitation – it incorporates grip, extension at the hand and wrist, supination of the Inferior R–U joint, elbow flexion, shoulder extension, and external rotation and some scapula retraction. It is a CKC pulling exercise, requiring speed from the lower and upper limbs in a coordinated manner.

#### 14.8.1.2 Throwing Techniques

There are many types of throws that can be made in judo and they can start from a standing position, a dropped knee position, and from the floor. So it is important to incorporate all of these positions in rehabilitation.

Medicine balls
Resistance tubing
Cable systems
Dumbbells
Sand bags

All of these can be used to train components of a throw allowing the physiotherapist to focus the judokas attentions to isolated rotator cuff activity and scapula control. The throw can then be reconstructed using an Uke of varying weights – start with Uke's in lighter weight categories before moving to the heavier ones including those in categories above the athlete's.

**Break fall confidence** – this can only be achieved once the athlete is comfortable lying on the shoulder and will build with the CKC and SAQ, and plyometric drills. At some point they will need to spend some time learning to fall on to crash mats first and then on the Tatami. It is an important part of rehabilitation.

**Full range of movement: stability and power through range** – achieving full range of movement is important while achieving scapula and GH joint stability throughout the range. The outer range of movement control is often allowed to slip by causing the athlete problems later in their careers.

These are two ways in which this can be achieved:

– PNF patterns against resistance tubing, cable systems, or holding dumbbells
– Pilates reformers or other similar equipment

### 14.8.2 Elbow Joint Injuries

As mentioned in Section 14.8.1.2 these injuries are generally sustained when put under enormous strain during kansetsu – waza when the anterior band of the medial collateral ligament can be damaged along with bony structures.

EARLY: UP TO 72 H. As in the basic principles of injury management. Early physiotherapy will also include assessment and treatment of the neural system as well as reviewing the cervical and thoracic spine as part of the chain.

INTERMEDIATE: 72 H–2 MONTHS. In assessing and treating these injuries it is important to mobilize the elbow joint through full flexion and extension if the injury allows, with the superior radio-ulnar joint in pronation, supination, and in midposition.

The shoulder girdle must also be assessed before embarking on the more advanced rehabilitation techniques already outlined.

This intermediate level can start on:

– Basic arm curls using resistance band and dumbbells with attention on the eccentric load of the curl.
– PNF patterns are great at isolating the rotation component of the grip and especially the supination and pronation element, and these can be worked through differing parts of the range with varying resistance according to pain.
– Triceps and the remaining posterior muscles of the upper limb must not be ignored as they are stabilizers of the shoulder and elbow.
– Scapula control.
– Grip strength can be started using differing equipment and the grips in the differing starting positions of neutral, pronated, and supinated forearm or differing wrists positions with the varying elbow angle. Gripping and pulling in or gripping and keeping opponent out at arms length require differing muscle groups and could both be worked on in training.

ADVANCED: 2 MONTHS AND BEYOND

– These do not differ much from the shoulder and upper limb-advanced rehabilitation stages.

### 14.8.3 Knee Joint Injuries

– Medial collateral ligament tears
– Anterior cruciate ligament disruption
– Meniscal damage
– Fat pad bruising

Early postsurgical protocols need to be followed with attention to healing times and joint stability exercises. Once the athlete has established full range of movements with progressively improving muscular control and reducing pain and swelling, then advanced stages can be followed.

| **Advanced levels of knee joint rehabilitation:** |
|---|
| 1. Closed kinetic chain (CKC) |
| 2. Plyometric and speed, agility, and quickness (SAQ) drills for the lower limb |
| 3. Sprinting – and backwards running |
| 4. proprioception drills |
| 5. throwing drills |

These are not too dissimilar to the upper limb-advanced rehabilitation and in fact performing gripping drills as outlined in the shoulder program requires a certain amount of footwork agility and therefore could be used in "re-programming" the judoka after major lower limb damage whether it is a knee, an ankle or hip joint, or muscular damage.

**Closed kinetic chain exercises** – it is important to remember that judo is a barefoot sport; so, although much training may be done in the gym and at the track a high percentage of the rehabilitation must take place on the tatami and in bare feet.

Attention to proximal control at the hip can start early stages. Rehabilitation is continued down the chain to encourage optimal stability of the lower limb. Proximal weakness can lead to problems at the foot; so it is essential to ensure that the lumbar spine has good baseline control and that the gluteus medius and the hip abductors are activated, supporting a neutral pelvis. It is essential to gain good efficient hamstrings, adductors, and foot control for this rehab to be successful.

Footwear for the gym and the track must be assessed – fashionable trainers can be the cause for a delay in the healing times as they can provide poor support. Judokas often present with overpronated feet and with a knee injury can be exacerbated causing further strain to the medial structures.

These CKC exercises must be performed pain-free and with good form before embarking on any plyometric and SAQ drills as these high-level/performance exercises can cause damage if the athlete is not strong enough to do them.[37,38]

Squats, lunges, stair walking, stepper, cycling, leg press, and single-leg balance exercises are all examples of CKC exercises and can be performed in varying degrees in a range of movements and with increasing load if the injury allows. The use of fit balls, profitters, Pilate's reformers, and balance boards can heighten the stability demands of the exercise. Attention must be paid to calf function and hamstring activity in concentric and eccentric actions – these will allow the judoka to return with confidence to the mat to perform "pick ups," such an essential component of judo. Such exercises may include single-leg calf raises. These are best performed under guidance of a strength and conditioning coach.

Attention must be paid to any swelling with exercises as this will not allow for good vastus medialis oblique (VMO) activity and therefore knee stability.

**Plyometric and SAQ drills** – there are many different drills, but it is essential to explain to the athlete that attention to technique is critical to improvement. Similar takeoff and landing styles in all drills will ensure a safe pain-free outcome.

These are high-risk exercises that must not be performed sloppily or every day.

Regaining the explosive power and confidence to leap, bound, hop, and jump in sagittal and lateral planes on a tatami to resume fighting is the key to a successful rehabilitation program.[36–38]

Asking the simple question '**do you trust your knee on the mat?**' is a quick way of establishing how good the rehabilitation program has been. Being able to achieve the pre-injury 1 rep max in a squat is a marker of success, but if that athlete cannot perform multiple single-leg hops on the injured leg, they will find it hard to get back to the highest level of competition.

Being able to get from a close compacted position in the knee in a deep squat to fully extended position while lifting their opponent and rotating to execute a throw requires immense explosive power through a full range of movements in a stable knee.

**Sprinting and backward running** – these are important skills for judokas to have.

Acceleration and deceleration over short distances establish good knee/lower limb power.

Backward running and changes of direction or tight cutting actions is good for training hamstrings, gluteals, and gastrocnemius.

This goes together with the SAQ drills and can be done at the track or on the tatami if the dojo is big enough.

**Proprioceptive drills** – disturbances in joint position sense need to be trained from an early stage in rehabilitation in both weight-bearing and non-weight-bearing situations. The use of balance boards and stability discs, profitters, trampets, and resistance tubing are common in physiotherapy treatments and are helpful.

Judo requires an enormous amount of careful footwork and these patterns are often used in warm-up techniques. By breaking these patterns down, physiotherapists can utilize them as proprioceptive drills. Gradually building up into the full pattern and then loading it with resistance with an Uke or resistance tubing facilitates progression.

**Throwing drills** – this is one of the final stages of rehabilitation before moving into full randori and then competition. Executing a full complement of throwing techniques, ensuring a confidence in break falling, and being a Uke for someone in training will tick all the right boxes of successful rehabilitation.

Within this category injuries to the infrapatella fat pad have been mentioned. They do not create the instability that other injuries do, but they do occur often and can be very painful. Repeated landing on the knee can cause a local swelling and some bruising to the fat pad and on some occasions to the patella cartilage The use of knee pads is highly recommended for training only. Fat pad bruising is treated with the application of a cold pack ensuring not to place ice directly on the skin to prevent ice burns. If symptoms persist, then a consultation with a sports medicine physician may be necessary.

This chapter has briefly outlined some of the injuries that are sustained in judo. Achieving the highest level of recovery from these injuries is often limited by a lack of sports-specific knowledge.

As sports doctors and physiotherapists we must try to address these patients with our clinical skills of mobilization and massage, muscle balance retraining, knowledge of healing times, appropriate use of electrotherapy and acupuncture, proprioceptive exercises, and clinical plyometric/SAQ drills. We need to move out of the treatment rooms and on to the training arena, and use our imagination and knowledge of the sport to develop an appropriate rehabilitation program. With the athlete's consent we should utilize the coach and the strength and conditioning staff to help the athlete recover.

Summary of main points:

- Judo is a unique sport, which requires combination of anaerobic strength and aerobic fitness combined with above-average flexibility.
- There are specific regulations regarding when a doctor can attend an athlete on the mat.
- Injuries to the shoulder girdle, elbow, and knee are common.
- Rehabilitation involves the principles of immediate management followed by a functional rehabilitation program working towards judo-specific exercises before a return to competition.

## Further Reading

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# Chapter 15
# Taekwondo

**Willy Pieter**

## Learning Objectives

- To gain a basic evidence-based understanding of the historical background of taekwondo
- To be able to identify the physical, physiological, biomechanical, and psychological characteristics that, as of this writing, have been shown to be related to taekwondo performance
- To recognize the most frequent as well as time-loss injuries in taekwondo
- To be familiar with the injury mechanisms and preventive measures for both general and time-loss injuries in taekwondo

## 15.1 History and Rules

Taekwondo is a modern sport from the twentieth century. It is based on karatedo, which was introduced to Korea after World War II by Koreans who came back from Japan. They called it either *tangsudo* (the way of the Tang hand) or *kongsudo* (the way of the empty hand) with its concomitant technical arsenal and philosophical orientation, the latter of which was basically Chinese in origin [1].

Taekwondo's "history" always refers to the Korean *hwarang*, a youth group suggested to have practiced a forerunner of the sport. According to Rutt [2], the best translation for *hwarang* is "flower boys,", for it is a literal rendition and does not violate Korean and Chinese grammar. Other translations, such as "flower of youth" [3], "flowering knights" [4], or "flower of manhood" [5] are grammatically incorrect. The concept of the *hwarang* as a military cult did not become well known until after World War II when the Japanese started to promote their idea of *bushido*, the Way of the warrior [2].

Our knowledge of the *hwarang* is mainly based on the Samguk Sagi (*History of the Three Kingdoms*), compiled in 1145 by the soldier-statesman Kim Pusik (1075–1152), and the Samguk Yusa (*Memories of the Three Kingdoms*), written by the Zen monk Iryŏn (1206–1289) in 1279. Neither the Sagi nor the Yusa claims

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that the *hwarang* was an exclusively military group. Only the Sagi, compiled by a general, makes mention of the *hwarang* producing military leaders. Both the Sagi and the Yusa recount the religious character of the group, which is taken to indicate that any reference to them as mainly a military institution should be viewed with extreme caution [2].

*Taekkyon* is usually presented as being related to taekwondo (e.g., [6]). It is commonly translated as (an art of) "kicking" [3] or "foot technique" [6]. More than 2 decades ago no Chinese characters could be found for the name [7]. The significance of this is that classical Chinese was the written language for the Koreans for centuries, while the spoken language was Korean. It was not until the mid-fifteenth century that the Korean alphabet was created and, over time, purely Korean words entered the language, i.e., with no Chinese characters with which to write them. In other words, if the word *taekkyon* had been used in ancient texts from before the mid-fifteenth century, it should have Chinese characters. Since none were found, it most likely is a new Korean term. It was not until Henning's [8] authoritative article that it became clear that the original word was *takkyon* ("push the shoulders"). The author related that the use of *taekkyon* was probably "based on a lack of knowledge of the Chinese characters or an attempt to disassociate it from possible foreign origins" (p. 11). *Takkyon* was a game that was also known in Japan in which the participants tried to unbalance or trip each other by leg sweeps or by pushing [9].

Gradually, Confucianistic values were ascribed to the popular game of *takkyon*, so that modern *taekkyon* could be more highly regarded, since it was originally associated with criminals [10]. Research has shown, however, that *takkyon* probably disappeared as a game soon after the change from the nineteenth to the twentieth century [10].

According to Capener [1], the need to Koreanize karatedo was expressed by changing the name, the development of a set of techniques different from the Japanese original and by attempting to come up with a "history" to legitimize the new sport as uniquely Korean. The name was changed to "taekwondo" in 1955. Choi Hong Hi (1918–2002), who claimed to be the instigator of the new name, was a member of the committee that agreed to use "taekwondo" instead of such names as "tangsudo" or "kongsudo" [11]. Choi himself said that there was no taekwondo before Christ [11], thereby confirming what historical research has shown (e.g., [2, 8]).

In 1966, the International Taekwon-Do Federation (ITF) was established. Its rules of competition stipulate no contact, while the athletes wear a helmet as well as hand and foot protective gear to help prevent injuries. Sparring bouts last two rounds of 2 min with a 1-min break between rounds for the eliminations and three rounds of 2 min for the finals.

In 1973, the World Taekwondo Federation (WTF) was founded, which follows full-contact competition rules. Protective padding includes a helmet, hand and shin padding, body armor, and a cup. Matches are for three rounds of 2 min with 1-min breaks in between rounds. Full-contact kicks are allowed to the head and face and designated areas of the body. No punches are permitted to the head and face.

## 15.2 Performance Characteristics in Taekwondo

Heller et al. [12] reported heart rate and blood lactate values in young (20.9 years) adult male and female taekwondo athletes (*taekwondo-in*). The bouts lasted two rounds of 2 min each according to ITF rules. The winner of the women's competition recorded a lactate value of 15.8 $mmol.l^{-1}$ and her male counterpart, 13.4 $mmol.l^{-1}$.

Slow recovery heart rates after a simulated full-contact match in 15-year-old boys and girls were reported by Bercades et al. [13] with a similar pattern for recovery lactate after 10 min [14], possibly due to the subjects being involved in a training camp at the time of testing. Lee [15] reported slow recovery (after 1 h) lactate concentrations after the third round of a match (three rounds of 3 min each with a 1-min break in between) in male Korean university *taekwondo-in* (20.5–21.0 years). No explanation was given for the findings, however. Preliminary results of blood lactate production in young Malaysian taekwondo athletes at the end of a competition bout showed values ranging from 6.6 to 15.8 $mmol.l^{-1}$ and 5.3–15 $mmol.l^{-1}$ in 18-year-old boys and girls, respectively (W. Pieter and J.S. Thung, unpublished data). It was logistically not possible to assess the lactate recovery.

International-level taekwondo athletes are most similar in somatotype to triathletes, orienteers, and race walkers, and show the same leanness as endurance athletes, but are taller and heavier [16]. British female recreational *taekwondo-in* were endomorphic, while their male colleagues were endo-mesomorphic [17]. Taaffe and Pieter [18] reported low percent relative total body fat in international elite male (7.5%) and female (12.0%) *taekwondo-in*. Croatian elite female *taekwondo-in* had 15.3% body fat [19], whereas recreational adolescent Malaysian girls (18 years) recorded 31.2% and their male colleagues, 19.2% [20].

Greater height facilitates reach in kicking and punching, and low body fat allows for more rapid acceleration [16]. Significant but inconsistent relationships were reported by Pieter [21] and Pieter and Pieter [22] among body mass, lean body mass, momentum, force, and speed in a range of kicks and punches.

Toskovic et al. [23] found that all groups participating in their taekwondo study achieved the recommended stimulus for effective initiation of cardiovascular adaptations and conditioning as prescribed by ACSM. Thompson and Vinueza [24] revealed that the cardiorespiratory, strength, and flexibility characteristics of their recreational athletes were generally poorer, except for flexibility, as compared to a sedentary but healthy population of the same age and sex. However, as Pieter et al. [25] and Toskovic et al. [23] showed, if taekwondo training is based on sufficient frequency, intensity, and duration, it will benefit cardiorespiratory fitness.

Hong [26] suggested that taekwondo athletes should not only emphasize strength training, but also the aerobic and anaerobic components in their daily practice. Several researchers have reported both aerobic and anaerobic endurances in elite male and female *taekwondo-in* with max $VO_2$ values ranging from 54 to 61 $ml.kg.^{-1}min^{-1}$ (males) and 42–50 $ml.kg^{-1}.min^{-1}$ (females) [12, 18, 19, 26, 27]. Table 15.1 summarizes the research done on aerobic endurance in taekwondo athletes.

**Table 15.1** Max $VO_2$ ($ml.kg^{-1}.min^{-1}$) in taekwondo athletes

| Study/level | Males | Females |
|---|---|---|
| Taaffe and Pieter [18] – elite | 55.8 | 47.0 |
| Thompson and Vineuza [24] – recreational | 44.0 | – |
| Núñez and Iglesias [28] – elite | 59.3 | 47.4 |
| Drabik [27] – elite | 60.7 | – |
| Hong [26] – elite | 59.6 | – |
| Heller et al. [12] – elite | 53.9 | 41.6 |
| Toskovic et al. [23] – recreational | 58.9 | 50.5 |
| Lee [15] – level not indicated | | |
| Lightweight | 57.7 | – |
| Middleweight | 59.6 | – |
| Heavyweight | 53.4 | – |
| Erie et al. [29] – recreational | 49.0 | 39.5 |

Heller et al. [12] indicated that taekwondo practitioners tended to show high anaerobic capability relative to body mass, which was also reported by Taaffe and Pieter [18]. Melhim [30] concluded that taekwondo may be used to improve anaerobic power and capacity.

Flexibility, strength, speed, and reaction time are more important to taekwondo practitioners according to Heller et al. [12], which was also suggested by Thompson and Vinueza [24]. Pieter et al. [31] found that recreational *taekwondo-in* showed higher values for isokinetic peak torque during knee flexion in both absolute and relative terms compared to controls, as taekwondo practitioners need to be relatively strong to prevent injuries to these muscles [32]. However, Pieter and Taaffe [32] did not find the hamstrings to be as strong as expected in elite senior male and female *taekwondo-in*. Contrary to expectation, recent research did not reveal an interaction between gender, leg extension/flexion, and angular velocity in absolute isokinetic strength and relative to lean body mass [33].

Heller et al. [12] reported that elite Czech *taekwondo-in* were more flexible and had higher explosive leg power than their sedentary counterparts. Thompson and Venueza [24] also found that recreational taekwondo-in were more flexible than sedentary individuals and had more muscular endurance. Suzana and Pieter [34] revealed that general motor abilities, such as flexibility, explosive power and muscular endurance, tended to improve over time as a result of training, while Marković et al. [19] reported higher explosive power in more successful female *taekwondo-in*.

The most often used kick in competition was found to be the roundhouse kick, mostly executed with the back leg (e.g. [35]), although Kong et al. [36] showed that kicking with the leading leg was faster: 0.720 and 0.800 s with the front and back legs, respectively. Performance time (reaction plus movement time) was investigated by Sung et al. [37] in Korean elite male *taekwondo-in*. The roundhouse kick to the midsection of the body with the back leg had a performance time of 0.645 s and to the face, 0.666 s. Performance time for the axe kick was 0.921 s. American female elite athletes had a performance time of 0.686 s for the back leg roundhouse kick to the midsection of the body [38].

Boey and Xie [39] recorded average durations of the roundhouse kick of 0.35 and 0.30 s for male and female Singaporean elite *taekwondo-in*, respectively, with velocities of 18 $m.s^{-1}$ (males) and 13 $m.s^{-1}$ (females). Pieter and Pieter [22] found velocities of 15.9 $m.s^{-1}$ (males) and 13.3 $m.s^{-1}$ (females) for the same kick in American taekwondo athletes, whereas Sung et al. [37] reported a value of 19.2 $m.s^{-1}$ for Korean elite male *taekwondo-in*.

The average velocity of swing kicks, such as the roundhouse and spinning roundhouse kicks, was 80% greater than so-called thrust kicks, such as the side kick [40]. Serina and Lieu [40] also suggested that kicks with an initial spin, such as the spinning roundhouse kick, will have a greater chance of causing injuries: injury potential was strongly related to kick velocity [41].

Psychological profiling revealed that elite Canadian *taekwondo-in* contributed commitment, belief, full focus, positive images, mental readiness, distraction control, and constructive evaluation to their success at the international level [42]. Although they showed individual differences in the way they prepared for competition, they all used imagery [43].

Two weeks before the world championships, American elite male and female *taekwondo-in* were more depressed, fatigued, confused, and scored higher on anger than recreational counterparts. They were also more cognitively anxious, but there were no differences in trait and state anxiety [21]. Trait anxiety in elite Filipino *taekwondo-in* 1 week before competition explained 71% of the variance in somatic state anxiety in the men 1 h before competition and 63.2% in the women. One hour prior to competition, self-confidence was inversely related to somatic state anxiety in the women and explained 53% of its variance [44].

## 15.3 Predicting Taekwondo Performance

Research on predicting taekwondo performance has only recently started. Experience has been suggested to be a more important factor than physique-related determinants in improved taekwondo performance [16]. This was supported by Pieter et al. [45], who determined the extent to which somatotype and experience contributed to performance in Filipino national and varsity *taekwondo-in*. The advantage in experience does not appear to translate into a more favorable physique for the national athletes, however, which would corroborate the conclusion by Olds and Kang [16] that anthropometric correlates, although necessary, may not be sufficient for success in international competition. Pieter [46] and Kazemi et al. [47] confirmed this for Olympic *taekwondo-in*.

In another study, Pieter et al. [48] showed that in male Filipino varsity taekwondo athletes, mood could correctly classify winners and losers, but this was not statistically significant. Depression and fatigue were most influential in distinguishing between winners and losers. However, in women, none of the mood predictors was found to be related to the discriminant function. The heterogeneous skill of the varsity athletes may be responsible for the low and insignificant predictive value of mood states in terms of performance.

Following up on the aforementioned investigation, Wong et al. [49] revealed that female adolescent winners in the non-depressed-mood group scored higher on vigor than their losing counterparts. They also displayed more vigor than the winners and losers in the depressed group. Ampongan and Pieter [50] found depressed-mood losing boys (13 years) to be more confused than the winners, although there was no difference in the depressed-mood girls. Since their subjects were younger than those used by Wong et al. [49], the association between mood and performance might be mediated by age.

Pieter et al. [51] revealed that in 15-year-old boys, 55.6% were correctly classified as winners and 64.9% as losers. The correlation matrix between the discriminant function and the predictor variables showed that taekwondo experience ($r = 0.71$) and anger ($r = 0.67$) were most influential in distinguishing between winners and losers. In 14-year-old girls, 60% were correctly classified as winners and 78.7% as losers. The predictors related to the discriminant function showed that competition experience ($r = 0.86$) and anger ($r = 0.44$) were most influential in distinguishing between winners and losers. Anger may have been used by the winners to psych themselves up as was shown to be the case in karate (e.g., [52]). The relationship between mood and performance in taekwondo might be mediated by experience, which, to a certain extent, is dependent on age as mentioned above.

Five weeks before competition, winning *taekwondo-in* (males and females combined) showed less depressed mood than the losers. They also scored lower 1 week prior to competition. Although the multivariate analysis did not reveal a significant performance effect for anger, the winners nevertheless scored lower on anger 5 weeks prior to competition [53].

Winning male *taekwondo-in* had higher self-confidence and lower cognitive and somatic anxiety than their losing colleagues with 62.7% correctly classified as winners or losers [54]. Ampongan and Pieter [44] showed that self-confidence was related to somatic state anxiety in the women but not in the men. It explained 53% of the variance in somatic state anxiety in the women.

Yiau et al. [55] reported that the female winners collapsed over weight division jumped higher (39.10 cm) than the losers (35.13). The light/welterweight males (2.35 m) jumped farther than their middle/heavyweight counterparts (2.14 m). There were no differences in estimated $VO_2$ max by weight division and performance within gender, which led the authors to suggest that taekwondo competition may rely on other energy pathways, as was also put forward by others (e.g., [12, 27, 30]).

In an attempt to investigate predictors of taekwondo performance, Ampongan and Pieter [56] used a psycho-physiological model. In the physiological model, situps ($r = 0.684$) and right hip flexion flexibility ($r = -0.482$) correlated with performance with 69.6% correctly predicted. Using the psychological model, 69.6% were correctly classified, but this was not significant. When the combined model was used, situps ($r = 0.565$), fatigue ($r = 0.414$) and right hip flexion ($r = -0.392$) entered the analysis with 87% correctly classified as winners or losers. In other words, a multi-factorial model was found to yield better predictive power in young athletes relative to taekwondo performance.

## 15.4 Taekwondo Injuries

The vast majority of studies on taekwondo injuries deals with acute injuries and almost all of them are concerned with those incurred in competition. The literature search was limited to retrospective and prospective studies due to the inherent methodological weaknesses of numerator-based designs [57]. Since a review of pediatric martial arts injuries was recently published [58], this chapter will only focus on adults.

To the best of this author's knowledge, there are hardly any studies on injuries involving ITF participants. An overview of potential injuries that could occur in ITF taekwondo was presented by Birrer et al. [59]. A retrospective international survey on martial arts injuries included taekwondo, but no separate injury rates were reported. It is also not clear which style of taekwondo (ITF or WTF) was covered. In addition, the survey included practice and competition injuries in participants differing in age and skill level [60].

Of 29 sports surveyed in a study on injuries sustained in training and competition over a 4-month period in Korea, those in which all participants were injured included modern pentathlon, biathlon, basketball, and taekwondo [61]. The frequency of reporting an injury over the study period was 5.62 for taekwondo, thereby topping the list. The *taekwondo-in* ($n = 8$) incurred a total of 45 injuries with the lower limbs being the most often affected body region, followed by the trunk. Kazemi et al. [62] confirmed the lower extremities to be most often injured in taekwondo training.

Full-contact taekwondo was also part of a study on injuries at a multi-sport tournament [63]. Although no injury rates by gender were provided, the results indicated that 66.3% of all those who participated in taekwondo incurred an injury. The most often occurring injuries were contusions (56% of total injuries) and sprains (26%).

Some studies were conducted on full-contact taekwondo injuries without reporting injury rates by gender. For instance, Oler et al. [64] reported that of approximately 700 adult competitors, 41 presented to the first aid station at a national tournament in the USA incurring a total of 52 injuries. Most injuries were sustained to the head and neck (49% of total) followed by the lower (23%) and upper extremities (21%).

Braun [65] covered full-contact taekwondo at a World Cup and one German national championship. The national tournament also included junior participants. Collapsed over gender, the athletes at the World Cup sustained 95.52 injuries per 1,000 athlete-exposures (A-E). Most injuries were contusions: 74.63/1,000 A-E. One athlete-exposure refers to one individual competing in a bout where he/she is exposed to the possibility of being injured.

Injury rates collapsed over gender were also reported by Phillips et al. [66]: 86.59/1,000 A-E for African *taekwondo-in*. Sprains/strains were the most often occurring injury type (47.49/1,000 A-E), followed by contusions (27.93/1,000 A-E). The lower extremities were the most often injured body region (61.3% of total), followed by the upper extremities (32.3%).

The purpose of this part of the chapter is to review injuries in taekwondo according to WTF rules. Only two studies that included practice injuries in adults could be located [61, 62], so the review will focus on those incurred in competition. Data collection covered the period 1980–present and was accomplished using the following procedures: (a) ancestry approach: retrieval of research cited in the published literature; (b) computer searches using the keywords “taekwondo injuries”: the Sport Discus database, Ovid, Google Scholar Advanced, PubMed, and ProQuest.

### *15.4.1 Total Injury Rates*

Table 15.2 shows comparative injury rates per 1,000 A-E in mostly elite *taekwondo-in*. The studies were conducted in the USA [67, 68], at the European Cup in Russia [69], in the UK [70], at the World Championships in Canada [71], in Greece [72], Canadian nationals [73], and Malaysia [74]. All were done using a prospective design. An injury was defined as any circumstance for which the athlete sought the assistance of the on-site medical personnel.

It is not clear why the Greek male competitors [72] had significantly fewer injuries than the others, except when compared to the British recreational *taekwondo-in* investigated by Pieter et al. [70]. One reason might be that the athletes were less inclined to report an injury (e.g., [75]). Interestingly, the Greek women only had a lower injury rate compared to those investigated by Koh et al. [71]. An earlier explanation was that females tend to report injuries more readily than their male counterparts (e.g., [76]), which may not be true for serious injuries, such as cerebral concussions [77]. This assertion was based on what was suggested for judo injuries [78]. It was also based on injury rates per athlete-exposures, rather than the 95% confidence interval (95%CI), as is done in this chapter.

When considering the 95%CI, the above line of thinking is contradicted when comparing men and women in the studies represented in Table 15.2. Within each

**Table 15.2** Distribution of total injury rates per 1,000 athlete-exposures (95%CI)

| Study | Level | Sample size | Males | Females |
|---|---|---|---|---|
| Zemper and Pieter [67] | Elite | M = 48; F = 48 | 127.4 (79–175) | 90.1 (51–130) |
| Pieter et al. [69] | Elite | M = 67; F = 30 | 139.5 (94–185) | 96.5 (40–154) |
| Pieter et al. [70] | Recreational | M = 46; F = 24 | 51.3 (1–102) | 47.6 (18–114) |
| Pieter and Zemper [68] | Elite | M = 1,665; F = 742 | 95.1 (85–105) | 105.5(90–121) |
| Koh et al. (71) | Elite | M = 330; F = 233 | 120.8 (96–150) | 90.1 (65–122) |
| Beis et al. [72] | Elite | M = 533; F = 216 | 20.6 (12–29) | 36.4 (18–55) |
| Kazemi and Pieter [73] | Elite | M = 219; F = 99 | 79.9 (53–106) | 25.3 (3–47) |
| Pieter et al. [74] | Recreational | M = 106; F = 100 | 168.4 (111–226) | 153.0 (124–182) |

M = males; F = females

study, there are no differences in injury rate between gender. When the studies are combined, there again is no difference: men sustained 88.89 injuries/1,000 A-E (95%CI: 81.29–96.49) and women, 90.34 injuries/1,000 A-E (95%CI: 79.62–101.06). The overall conclusion would be that, based on the evidence to date, there is no difference in injury rate between men and women.

### *15.4.2 Injury Location*

The prospective studies included in Table 15.3 seem to confirm the lower extremities as the most often injured body region in taekwondo. Given the almost exclusive use of kicking techniques in competition (and training), this is hardly surprising. The instep of the foot is especially susceptible to injury (e.g., [73, 79]). What is of more concern, however, is that the head and neck is the second most frequently injured body region.

Koh and Watkinson [80] revealed that 10 out of every 100 competitors may run the risk of receiving a blow to the head. The authors also suggested that since the helmet became mandatory in 1985, the frequency of head blows may have increased. A rule change in 2002, which awards two to three points for head blows, may additionally have contributed to more injuries to the head and neck as reported in recent investigations [80].

Unfortunately, epidemiological data are scant from competitions prior to the rule change and introduction of the helmet. Siana et al. [81] provided medical coverage at the 1983 Taekwondo World Championships and reported time-loss injuries. At one of the hospitals where these injuries were presented, the authors recorded 11 of them to the head and neck region for an estimated injury rate of 4.34 injuries/100 athletes. No information was provided about the gender of the injured competitors. More accurate injury rates cannot be computed, because of the absence of exposure data for the 1983 World Championships [81]. Subsequent head and neck injuries incurred at the 1999 World Championships yielded a rate of 5.15/100 athletes for men and 1.29/100 athletes for women for a total of 3.55/100 athletes [71].

With exposure data taken into account, the overall rates for head and neck injuries reported by the studies in Table 15.3 are 25.23/1,000 A-E (95%CI: 21.18–29.28) and 17.21 (95%CI: 12.53–21.89) for men and women, respectively. The rates for the lower extremities are 44.02 (95%CI: 38.67–49.37) and 52.95 (95%CI: 44.75–61.15) for men and women, respectively. The upper extremities sustained 7.11 injuries/1,000 A-E (95%CI: 4.96–9.26) and 9.27 injuries/1,000 A-E (95%CI: 5.84–12.70) in men and women, respectively. These injury rates confirm what is displayed in Table 15.3, especially for the men, i.e., the head and neck are the second most frequently injured body region in taekwondo after the lower extremities.

**Table 15.3** Percentage distribution of injuries by location

| | Zemper and Pieter [67] | | Pieter et al. [69] | | Pieter et al. [70] | | Pieter and Zemper [68] | | Koh et al. [71] | | Beis et al. [72] | | Kazemi and Pieter [73] | | Pieter et al. [74] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Total # injuries | 27 | 20 | 36 | 11 | 4 | 2 | 324 | 174 | 71 | 38 | 21 | 15 | 35 | 5 | 33 | 28 |
| Head and neck | 22.2 | 20.0 | 33.3 | 9.1 | 75.0 | 50.0 | 30.3 | 25.9 | 23.9 | 7.9 | 33.3 | 13.3 | 34.3 | – | – | – |
| Trunk | 14.8 | – | 5.6 | 18.2 | – | – | 6.2 | 5.2 | 1.4 | 2.6 | 14.3 | 6.7 | 17.1 | – | 3.0 | – |
| Upper extremities | 18.5 | – | 8.3 | 9.1 | 25.0 | 50.0 | 13.0 | 16.3 | 26.8 | 18.4 | 19.1 | 13.3 | 8.6 | – | 3.0 | 21.4 |
| Lower extremities | 44.4 | 80.0 | 52.8 | 63.6 | – | – | 48.5 | 51.6 | 47.9 | 71.1 | 33.3 | 66.7 | 40.0 | 100 | 93.9 | 71.4 |
| Other | – | – | – | – | – | – | – | 1.2 | – | – | – | | – | – | – | 7.1 |

### 15.4.3 Injury Types

Table 15.4 displays the percent distribution of injury types. The category "other" includes such injuries as eye irritation, joint hyperextension [67], blister, internal injury [68, 70], or (partial) ligament tears [68, 74]. As expected, the contusion was the most often occurring type of injury across all studies summarized in Table 15.4.

Regardless of the definition used to classify the injury, early and recent research has highlighted the cerebral concussion as an area of concern in the epidemiology of taekwondo injuries. For instance, Siana et al. [81] recorded one cerebral concussion (0.29/100 athletes) for the combined sample of men and women at the 1983 World Championships. Concussion rates at the 1999 World Championships were 1.82/100 athletes (men) and 0.86/100 athletes (women) for a total of 1.42/100 athletes [71]. The concussion rates at the 1991 World Championships were 2.93/100 athletes and 0.63/100 athletes for men and women, respectively, for a total of 2.08/100 athletes [82]. As alluded to above, more accurate injury rates cannot be computed because of the absence of exposure data for the 1983 World Championships [81]. Nevertheless, cerebral concussions seem to have increased from 1983 through 1991 and 1999, thereby confirming Koh et al.'s [71] contention.

Table 15.5 depicts injury rates for cerebral concussions per 1,000 athlete-exposures. Zemper and Pieter [83] estimated that there was about 1 concussion for every 100 junior and senior competitors combined. Although males seem to have a higher rate than females (e.g., [83]), Table 15.5 suggests that this may not be statistically significant. However, more males sustained the higher grades of concussion [77, 83]. Of great concern is that, based on current evidence, the incidence of cerebral concussions in taekwondo competition is more than three times as high as that found in American football (e.g., [83]). Compared to other contact sports, including combat sports, taekwondo ranks among the highest in terms of concussion injury rate [77, 84, 85].

Koh and Watkinson [80, 85] investigated head blows and occurrence of cerebral concussions in taekwondo. At the 1999 World Taekwondo Championships, the authors analyzed head blows sustained in the semifinals and finals. Collapsed over gender, the rate of head blows was 365/1,000 A-E. More than 50% of participants incurred two or more head blows during the period of observation, but no loss of consciousness was recorded. The welterweight division (72.1–78 kg for men and 63.1–67 kg for women) sustained most of the head blows in both men (30.0% of total head blows) and women (33.3% of total head blows) [85].

Head blows were also studied at the 2001 Canadian National Taekwondo Championships as well as their relationship to possible cerebral concussions [80]. The rate for head blows was 213.24/1,000 A-E and 387.32/1,000 A-E for men and women, respectively, for a total of 272.95/1,000 A-E. About 75% of all head blows in the men and women combined did not lead to a concussion. The injury rates for cerebral concussions are depicted in Table 15.5. About 35% of men and 54% of women sustained two or more head blows without concussion. Almost 14% of women incurred six head blows without concussion. Most of the males (73%) and half of all females had a

**Table 15.4** Percentage distribution of injuries by type

| | Zemper and Pieter [67] | | Pieter et al. [69] | | Pieter et al. [70] | | Pieter and Zemper [68] | | Koh et al. [71] | | Beis et al. [72] | | Kazemi and Pieter [73] | | Pieter et al. [74] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Total # injuries | 27 | 20 | 36 | 11 | 4 | 2 | 324 | 174 | 71 | 38 | 21 | 15 | 35 | 5 | 33 | 28 |
| Abrasion | 3.7 | – | – | – | – | – | 1.9 | 2.3 | 4.2 | – | – | 33.3 | 2.9 | – | – | – |
| Concussion | 3.7 | 5.0 | 11.1 | 9.1 | 25.0 | – | 7.4 | 2.3 | 8.5 | 5.3 | 4.8 | – | 8.6 | – | – | – |
| Contusion | 63.0 | 75.0 | 50.0 | 90.9 | 50.0 | 50.0 | 48.5 | 53.5 | 28.2 | 50.0 | 52.4 | 46.7 | 14.3 | 60.0 | 66.7 | 57.1 |
| Dislocation[a] | – | 5.0 | – | – | – | – | 0.6 | 2.3 | 2.8 | – | 4.8 | 6.7 | – | – | – | – |
| Epistaxis | – | – | 5.6 | – | – | – | 1.9 | 5.2 | – | – | 4.8 | 6.7 | 2.9 | – | – | – |
| Fracture[b] | 14.8 | – | 11.1 | – | – | – | 10.5 | 8.1 | 22.5 | 7.9 | 14.3 | – | – | – | 3.0 | 10.7 |
| Laceration | 3.7 | – | 8.3 | – | 25.0 | – | 10.8 | 8.6 | 4.2 | 5.3 | 14.3 | 6.7 | 14.3 | – | 3.0 | – |
| Sprain | 3.7 | 5.0 | 11.1 | – | – | – | 11.1 | 8.6 | 14.1 | 23.7 | 4.8 | – | 28.6 | 20.0 | 6.1 | 3.6 |
| Strain | 3.7 | 5.0 | – | – | – | – | 1.5 | 3.5 | 9.9 | 7.9 | – | – | 11.4 | 20.0 | – | – |
| Other | 3.7 | 5.0 | 2.8 | – | – | 50.0 | 5.8 | 5.6 | 5.6 | – | – | – | 17.1 | – | 21.2 | 25.0 |

[a] Includes subluxation [b] Includes suspected fractures

**Table 15.5** Distribution of injury rates per 1,000 athlete-exposures (95%CI) for cerebral concussions

| Study | Males | Females |
|---|---|---|
| Zemper and Pieter [67] | 4.72 (4.53–13.97) | 4.51 (4.32–13.34) |
| Pieter and Lufting [82] | 15.27 (4.69–25.85) | 3.23 (3.09–9.55) |
| Pieter et al. [69] | 15.50 (0.31–30.69) | 8.77 (8.42–25.96) |
| Pieter et al. [70] | 12.82 (12.31–37.95) | – (–) |
| Pieter and Zemper [77] | 7.04 (4.22–9.86) | 2.42 (0.04–4.80) |
| Koh et al. [71] | 10.07 (6.04–26.18) | 4.47 (2.10–11.04) |
| Beis et al. [72] | 0.98 (0.94–2.90) | – (–) |
| Koh and Watkinson (80) | 55.15 (27.24–83.06) | 49.30 (12.78–85.82) |
| Kazemi and Pieter (73) | 6.85 (0.90–14.60) | – (–) |
| Pieter et al. (74) | – (–) | – (–) |

**Table 15.6** Distribution of rates per 1,000 athlete-exposures (95%CI) for time-loss injuries

| Study | Males | Females |
|---|---|---|
| Zemper and Pieter (67) | 23.58 (5.09–52.25) | 13.51 (1.78–28.80) |
| Pieter and Lufting [82] | 22.90 (9.94–35.86) | 9.68 (1.27–20.63) |
| Pieter [86] | 33.45 (27.31–39.59) | 23.03 (15.71–30.35) |
| Pieter et al. (69) | 27.13 (7.03–47.23) | 8.77 (8.42–25.96) |
| Pieter and Bercades [87] | 25.64 (9.90–61.18) | 23.81 (22.86–70.48) |
| Koh et al. (71) | 33.56 (18.85–48.27) | 14.22 (2.84–25.60) |
| Beis et al. [88] | 6.85 (1.78–11.92) | 2.43 (2.33–7.19) |
| Pieter et al. [89] | 20.41 (0.41–40.41) | 21.74 (0.44–43.04) |

concussion after one head blow with 17% of women sustaining a concussion after three head blows. None of the athletes lost consciousness [80].

### *15.4.4 Time-Loss Injuries*

A measure of the severity of injuries is typically expressed in time-loss injuries, i.e., those that result in the athlete having to miss practice or competition for 1 day or more after the injury [67]. Table 15.6 displays rates for time-loss injuries in taekwondo. Although some rates within gender are higher than others, they are not necessarily statistically significant. The Greek women recorded the lowest injury rate [88], which is statistically different from their American [67, 86] and European colleagues [69, 87], as well as those competing in the 1999 World Taekwondo Championships [71]. The injury rate for the Greek men [88] was significantly different from that of their American counterparts [86] and those participating in the 1999 world championships [71].

Although several studies have reported time-loss injuries (see Table 15.6), only some have specified the exact time loss involved. For instance, Pieter and Zemper [77] revealed that most cerebral concussions led to 7 days or less away from practice or competition: 3.23/1,000 A-E for men and 1.82/1,000 A-E for women). However, the men also sustained concussions that led to time loss of 21 days or more: 1.17/1,000 A-E. The women did not incur such injuries. Most head and neck injuries led to time loss of 7 days or less (7.63/1,000 A-E and 5.46/1,000 A-E for men and women, respectively). Both males (2.05/1,000 A-E) and females (1.21/1,000 A-E) sustained time-loss head and neck injuries of 21 days or more [90]. More than one third (35.7%) of all foot injuries in men and 50% in women led to 21 days or more of time loss [79].

At the recreational level, time-loss injuries were found to lead to 7 days or less away from practice or competition with rates of 25.64/1,000 A-E and 23.81/1,000 A-E for men and women, respectively. No time-loss injuries were recorded necessitating more than 7 days off from practice or competition [87]. In Malaysian males, all time-loss injuries (20.41/1,000 A-E) led to 21 days away from training or competition, while the females recorded a rate of 16.30/1,000 A-E for 21 days or more lost [89]. In view of the available evidence, the contention that taekwondo is a safe sport [59] will have to be reviewed [91].

### *15.4.5 Injury Situations and Mechanisms*

Early research showed that the situations that led to injuries were attacking with a kick and unblocked attacks, with the injury mechanisms being delivering a blow and receiving a blow [67, 68, 92]. For head and neck injuries, the main situation was the unblocked attack with receiving a blow as the mechanism [90]. The same patterns were apparent for serious injuries in general [82], including cerebral concussions [77]. The dominant situation leading to foot injuries was, not unexpectedly, attacking with a kick and delivering a kick as the mechanism [79]. Kicking the elbow with the instep of the foot with a roundhouse kick was among the main mechanisms [73].

Subsequent research revealed the exact techniques involved in the injuries. Beis et al. [72] reported the roundhouse kick as the one most often involved in injuries in general, while Pieter et al. [69] found attacking with a roundhouse kick and unblocked roundhouse kicks the main injury situations in both men and women. Delivering a roundhouse kick and receiving this kick were the main mechanisms in men. The main mechanisms in women were receiving a roundhouse kick and receiving a spinning back kick [69]. Koh et al. [71] identified delivering a kick as the main injury situation in both men and women, followed by unblocked kicks. The authors subsequently reported the roundhouse kick to be the most often used technique leading to injury (Table 15.7).

The main injury situation and mechanism of time-loss injuries were found to be unblocked roundhouse kicks and receiving them in men, while the situation for the women was attacking with a roundhouse kick and receiving a spinning back kick. The same patterns were reported for cerebral concussions [69].

**Table 15.7** Percent distribution of techniques most often involved in injury

| | Pieter et al. (1995) | | Pieter et al. (1998) | | Koh et al. (2001) | | Beis et al. (2001) | | Pieter et al. (2005) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F |
| Roundhouse kick | 66.7 | 63.6 | 25.0 | 50.0 | 56.5 | 65.8 | 47.6 | 20.0 | 90.9 | 89.3 |
| Spinning hook kick | 2.8 | – | – | – | 1.5 | 5.3 | 9.5 | – | – | – |
| Spinning back kick | 8.33 | 36.4 | – | – | 1.5 | 2.6 | 9.5 | 6.7 | – | – |
| Axe kick | 2.8 | – | – | – | 2.9 | 2.6 | 4.8 | 6.7 | – | – |
| Side kick | – | – | – | – | 11.6 | 7.9 | – | – | – | – |
| Other | 19.37 | – | 75.0 | 50.0 | 26.0 | 15.8 | 28.6 | 66.6 | 9.1 | 10.7 |

A detailed study on head blows sustained during semifinal and final matches at the 1999 World Championships was undertaken by Koh and Watkinson [85]. In the total sample of men and women, 51.4% of total head blows were by the axe kick, followed by the roundhouse kick (25.7%). The axe kick was also dominant (70%) in the second head blow, followed by the roundhouse and spinning back kicks: 20% and 10%, respectively. From the perspective of the receiver of the head blow, no action was the main injury situation (51.4%), followed by the counterattack (37.1%). From the perspective of the attacker, most head blows occurred while attacking (62.9%). The closed fighting stance most often led to a head blow (65.7% of total head blows), followed by the open stance (31.4%).

The injury situation and mechanism of head blows and possible subsequent cerebral concussion were investigated by Koh and Watkinson [80]. In those cases where head blows did not lead to a concussion, no action (i.e., no block or evasive maneuver was attempted) was the dominant situation, followed by a counterattack in the men. In the women, the reverse was found: the main injury situation was the counterattack, followed by no action. In cases where the head blow led to a cerebral concussion, more than half of all situations (57.1% of total for both men and women) were no action. The techniques involved in head blows with no subsequent concussion were the axe kick (42.5% of total techniques in men and 56.8% in women) and roundhouse kick (35.0% in men and 36.4% in women). When the head blows resulted in cerebral concussions, it was the roundhouse kick that was involved (42.9% for both men and women), followed by the axe kick (28.6% in both genders).

To shed more light on the circumstances under which head blows and concussions occur, Koh and Watkinson [80] also examined the specific sparring stance of the competitors. For head blows not leading to concussion, the men were in the closed stance (35%) with the clinched stance (32.5%) coming in second. The women were mostly in the clinched stance (36.4%), followed by the closed stance. When a concussion ensued after the head blow, the men were either in the closed or open stance (35.7% each), while the women were mostly in the closed stance (71.4%).

Valuable information was provided by Koh and Watkinson [80] when they also identified the exact side of the head and face that was hit. Without subsequent concussion, the head blows were mainly directed at the side of the head: 80% in the men and 86.4% in the women. This was also true when a cerebral concussion followed the head blow: 35.7% in the men and 85.7% in the women. The men were also concussed by blows to the center of the face and lower jaw: 28.6% each.

Pieter et al. [89] found attacking with the roundhouse kick in males and blocking this kick in females to be the main situation in time-loss injuries with delivering the roundhouse kick and receiving the kick the main mechanisms in males and females, respectively. As mentioned above, spinning kicks, such as the roundhouse kick, were suggested to have the greatest injury potential, especially soft tissue injury, by virtue of the higher velocities generated with these kicks [40]. It is estimated that velocities of 11 m $s^{-1}$ have a negligible probability of leading to severe, i.e., time-loss injury, while those exceeding 19 m $s^{-1}$ have a 100% chance of causing damage [41].

Although females recorded roundhouse kick velocities of around 11.0–13.3 m·$s^{-1}$ and those of males ranged between 15.9 and 22.9 m.$s^{-1}$ [22, 37–40], it was also suggested that velocities of 8 m.$s^{-1}$ would result in peak acceleration of the head of 200 G, provided there is no deflection [93]. Foot padding was found to increase peak acceleration of the head, especially when kicking the side of the head [94], which was reported by Koh and Watkinson [80] to be the impact site of the majority of head blows leading to cerebral concussion. The roundhouse kick to the midsection of the body was faster than to the head. Sung et al. [37] reported a velocity of 21.61 m.$s^{-1}$ for the kick to the head, although, as expected, it will take longer to execute [95, 96].

Rotational techniques, such as the roundhouse kick and spinning kicks, are suggested to lead to higher head accelerations [93, 94] and subsequent cerebral concussions [97]. About 48.5% of all techniques involved in head blows at the 1999 World Championships were rotational kicks [85], while 63.6% of all head blows resulting in concussion were the result of rotational kicks at the 2001 Canadian national championships [80]. Pieter et al. [69] reported similar findings for both time-loss injuries and cerebral concussions, i.e., rotational kicks were involved in the majority of those injuries.

The injury potential of the axe kick is suggested to depend on the execution of the kick. In the classical version of the kick, the leg is kept straight in both the upswing and downswing phases, which may lead to injury [98]. As alluded to above, the axe kick was involved in head blows as well as concussions [80, 85]. Pieter and Zemper [90] suggested that cervical hyperextension may occur as a result of the axe kick, which may lead to cervical spine injuries. The spinning back kick may, in its translational phase, also lead to cervical hyperextension and subsequently to cerebral concussion as was reported by Pieter et al. [69].

Koh and Watkinson [85] revealed that 51% of all head blows came from the axe kick, which may be performed by either the front or back leg. Most second head blows were the result of the axe kick (70%), as mentioned above. More than half of all head blows (57%) were executed with the leading leg. Korean elite male *taekwondo-in* recorded a performance time of 0.921 s for the back leg axe kick with a maximal foot velocity of 11.3 m.$s^{-1}$ [37].

Tsai et al. [99] analyzed the front leg axe kick in male *taekwondo-in* and found reaction and movement time contributing 56% and 44% to performance time, respectively. As expected, the front leg axe kick (0.750 s) recorded a faster performance time than the back leg version (0.886 s). Tsai and Huang [100] found a faster performance time for the modified, flex-stretching, axe kick (0.37 s) compared to the classical version (0.42 s). The modified axe kick was also faster: 5.55 vs 4.70 m.s$^{-1}$. However, the impact velocity on target was 7.74 m s$^{-1}$ for the classical axe kick compared to 5.97 m s$^{-1}$ for the modified version. Research has also revealed that the velocity of the classical axe kick during the downswing was 12.44 m.s$^{-1}$ with a force of 1143.54 N [101].

## 15.5 Risk factors

It seems logical to assume that the heavier one is, the more force one will produce. In other words, one would expect the heavyweights to incur more injuries as was found in males but not in females [69]. Several authors have attempted to relate weight division, as a risk factor, to injuries in taekwondo. Pieter et al. [102] found the men bantamweight and heavyweight competitors (2.36/1,000 A-E each) to record the highest injury rates, as did the welterweight division (2.70/1,000 A-E) in the females. Koh et al. [71] reported the men's welterweight division to record the highest injury rate (25.17/1,000 A-E), followed by those competing in the finweight (≤54 kg for the men and ≤47 kg for the women) (20.13/1,000 A-E). In the women, the lightweight division had the highest injury rate (18.96/1,000 A-E), followed by the finweights and middleweights (14.22/1,000 A-E each).

In Greek male taekwondo athletes, the highest injury rates were recorded by the bantamweights (37.74/1,000 A-E), followed by those competing in the welterweight (36.15/1,000 A-E). In the females, the bantamweight division by far had the highest injury rate (125.00/1,000 A-E), followed by the heavyweight (62.50/1,000 A-E) [73]. Although the evidence is limited as of this writing, the welterweight division might be at higher risk, including sustaining more head blows [85], which not necessarily led to more cerebral concussions [80]. More research is needed to elucidate the relationship between weight division and occurrence of injury in taekwondo.

Although skill level has been suggested to be implicated in taekwondo injuries [103], research to establish this relationship is lacking [76]. Perusal of Table 15.2 seems to indicate no statistical difference in injury rates between elite and recreational *taekwondo-in*. However, with limited research on recreational taekwondo athletes available or on those below black belt level, it is not possible at this time to make any meaningful comparisons.

Pieter et al. [104] revealed a relationship between mood and injury in recreational *taekwondo-in*. In depressed-mood female losers, the injured group scored higher on anger (3.33 vs 0.76), fatigue (4.33 vs 2.13), and confusion (5.33 vs 2.61). Eighty-three percent were correctly classified as injured or not injured. In the depressed-mood male winners, those who were injured were more fatigued (4.33 vs 1.87). As many as 62.5% were correctly classified as injured or not injured based on fatigue.

## 15.6 Suggestions for Injury Prevention

More than 15 years ago, lack of blocking skills was identified as being related to injuries and preventive measures suggested [67]. Research immediately subsequent to this also emphasized improving blocking skills to help prevent injuries, including those leading to time loss [64, 92]. However, recent research seems to indicate that no changes for the better in blocking skills have been made over the years, i.e., deficient blocking skills were still among the mechanisms of both injuries in general [71], as well as severe injuries (e.g., [85]). Koh and Watkinson [80] reported that lack of blocking skills or evasive maneuvers was involved in 99% of total concussion cases. All of the head blows incurred during the semifinals and finals of the 1999 World Championships were related to the absence of blocking skills [85].

Alternatives to blocking skills include evasive maneuvers [67], such as defensive sparring steps [71] or ducking as used in boxing [85]. A possible reason for the persistent lack of blocking skills is believed to be related to the competition rules. The current rules favor offensive skills and no points are given for defensive actions [80]. Suggested rule changes may include awarding more points to technically more difficult kicks and those that do not lead to injury [71]. Another change would be to discontinue the match after more than two head blows [80, 85].

The negative effect of the recent rule change to award more points to head blows was mentioned above. Reevaluating the rule of allowing head blows was suggested more than a decade ago [69, 76], reinforced recently (e.g., [80, 85]), and should be considered seriously. Rule changes such as those awarding more points for kicks to the head/face area have been suggested to be implemented without proper consideration of their effects [105]. Rule changes are also decided upon by the world governing body (World Taekwondo Federation) without consulting its members, who are left with the impression that the changes are made to benefit Korean *taekwondo-in* [105].

Additional preventive measures include the use of mouthguards (e.g., [69, 71]), improving kicking skills (e.g., [67, 71]), tactical awareness of when to use offensive or defensive techniques (e.g., [70, 86]), introducing a so-called k.o. passport (e.g., [82]), adopting suspension rules similar to amateur boxing (e.g., [77]), continued research to improve protective equipment in terms of its attenuation rate and lifespan (e.g., [67, 69]), as well as relative to its design (e.g., [80]) and follow-up research to assess the effectiveness of these and other preventive measures (e.g., [69]). Since most injuries may be reported at the elimination stages of a competition [106], preventive measures may include medical coverage nearby the competition area (ring) to be able to speed up the diagnosis and treatment of any injuries.

Preventive measures should also include assessing pre-competition habits, such as weight cycling, social support, psychological readiness, and premature return to training or competition after injury [62]. Education of athletes, coaches, referees, and tournament directors relative to injuries has been recommended (e.g., [69, 85]). For instance, coach education programs should routinely include information about the results of epidemiological research on taekwondo injuries and coaches should subsequently assist in educating their athletes.

Just like in other subjective sports (e.g., [107]), regional and nationalistic bias are also present in taekwondo, which impact on the occurrence of potential injuries.

Moon [105] revealed that despite overwhelming problems in judging taekwondo matches at national and international tournaments, no effort has so far been undertaken to arrive at a fair and more objective method to score competitions. For instance, the certification of referees, whether at the national or international level, is nothing more than learning a set of hand signals and updates on rule changes unilaterally decided upon by the world governing body, as alluded to above. There is no place for such subjects as referee philosophy, ethics, education on injuries, or match management. There is also no review of past referee performance at the end of each competition to rectify any problems. Moon [105] is of the opinion that a comprehensive program should be developed to overhaul the current "education" of referees and that a committee should be established independent of any organizations or groups within organizations to curb the widespread abuse of the referee system.

## 15.7 Suggestions for Further Research

Future research should include *taekwondo-in* of all levels and a range of ages. A uniform definition of injuries should be used, so that comparisons may be more easily made. More prospective studies should be conducted, the effect of preventive measures investigated [76], and randomized controlled trials attempted. For instance, McLatchie et al. [108] has so far conducted the only study known to this author in which, over a 10-year period, karate injuries were first investigated, preventive measures were introduced, after which the incidence of injuries was studied again. Van Mechelen et al. [109] suggested a model upon which future (longitudinal) research could be based.

A multifactorial approach should be used to identify potential risk factors. For instance, intrinsic factors, such as somatotype, strength, psychological profile, weight cycling, and sexual maturity, should be investigated in conjunction with extrinsic factors such as exposure and protective equipment [76]. In addition, the risk factors should be assessed at various levels of skill and age, and stratified by gender.

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# Chapter 16
# Karate

**Rafael Arriaza**

## Learning Objectives

- To understand the evolution of karate as a sport
- To place the risks of participation in karate competition within the context of other popular youth sports
- To recognize the physiological demands of karate competition

## 16.1 The History of Modern Karate

Although the island of Okinawa is regarded as the birthplace of karate, its origins can be traced back further to China. The island of Okinawa has always held a position of strategic and military importance between China and Japan. For this reason, the island has witnessed many cultural, political, and military exchanges between both countries. Perhaps Okinawan sailors were exposed to Chinese fighting techniques during their travels to neighboring ports. Alternatively, Chinese families who settled in Okinawa, in 1392, may have brought the knowledge of Chinese kung fu. These fighting methods were adapted and further developed by the Okinawans as a way of fighting with the bare hands (the meaning of kara-te in Japanese is "empty hand"), or with several farming instruments (as a part of the so-called kobudo), as the only way to overcome the successive weapons bans imposed by invading rulers between the fourteenth and seventeenth centuries. Tode or Okinawan-te (the original name of what we call today karate) developed secretly to keep the Japanese from killing the practitioners and teachers of the fighting art. In that sense, karate has never really been a "martial art," as it did not evolve to be used on the battlefield, but rather as a self-defense method against armed opponents. Karate remained underground until early 1900 when it was brought into the Okinawan school systems to be incorporated into physical education methods.

Over time different styles of karate developed to suit practitioners with different physical attributes. The style that evolved from the town of Naha (known as Naha-te) focused on strong, heavy techniques, while the style that evolved from the

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town of Shuri (known as Shuri-te) specialized in light, fast techniques. Two renowned experts, Ankoh Azato (1827–1906) and Ankoh Itosu (1832–1915), practiced Naha-te and Shuri-te, respectively. These two experts had a student in common named Gichin Funakoshi (1868–1957), who called himself by the pen name "Shoto." He became known as the father of Shotokan karate. He combined the principles of both styles in an attempt to create a well-balanced style that could be easily learned by all. Gichin Funakoshi was a school teacher, and in conjunction with Itosu and others, had karate introduced to the Okinawan school system. In 1921, he led a demonstration for the then Crown Prince Hirohito who was passing through Okinawa on his way to Europe. As a result of the interest shown by the Crown Prince, Funakoshi received invitations from various groups in Tokyo to demonstrate his art. These demonstrations led to the establishment of many clubs, most notably in Japan's universities. In order to accept karate as a Japanese art (and not an Okinawan import) certain changes were necessary. One of these was to change the characters used to spell karate so that the meaning became "empty hand" rather than "Chinese hand." Other requirements were the adoption of a standardized grading system and a standardized training uniform. As Japan gradually recovered after the war and formal training resumed, it became apparent that much knowledge had been lost. In 1948, a meeting was held between some of the remaining top karate practitioners in Japan to pool their knowledge and standardize what was being taught. This meeting resulted in the formation of the Japan Karate Association (JKA) in 1949. From the 1950s on, karate began to receive increasing international attention, mainly through exposure to American servicemen stationed in Japan after World War II, as also through Japanese students traveling abroad to study. Martial arts organizations in countries around the world began to request visits from instructors from the JKA, and so the internationalization of karate began. It is important to note that while Funakoshi was developing and promoting his Shotokan style in Okinawa and Japan, others were, at the same time, developing and promoting their own, equally valid styles, for example, Kenwa Mabuni's Shito-ryu, Chojun Miyagi's Goju-ryu, and Mas Oyama's Kyokushin.

Karate was introduced in many countries as early as 1950, by Japanese masters mainly from the Japan Karate Association (JKA). They taught but did not create national and international organizations as in other sports. In 1961 in France, a lawyer, 4th dan black belt and karate teacher named Jacques Delcourt was elected President of French Karate Federation (by then, an associated member of the French Judo Federation). After having organized Karate in France from 1961 to 1963, he invited the few federations known in Europe to hold the First European Karate Congress in France. This was the first International Karate Event of all time involving Belgium, France, and Great Britain, on the 15th of December 1963. After that first meeting, others followed and the First European Championship took place in 1966. In 1970, Mr. Ryoichi Sasakawa, President of the Japanese Federation, travelled to Paris to meet Mr. Delcourt and they signed an agreement stating that both organizations would work together for the development of karate worldwide. For that, a new organization was created, the World Union of Karate-do Organizations (WUKO). The First World Championships were held in Tokyo in October 1970.

In 1993, WUKO changed its name to World Karate Federation (WKF). Nowadays, 174 countries are affiliated to WKF, and is recognized by the IOC as the governing body for karate worldwide [1].

## 16.2 Karate Competition

In Karate, there is kumite (or combat) and kata (or forms) competitions. It is not compulsory to enter both at a single tournament, and in fact, due to the extensive and intensive training required by each specialty, competitors tend to focus early on one of them, disregarding the other (except for gym or "dojo" training). Katas are usually described as prescribed sequences of steps, strikes, and blocks that simulate a fight against several opponents, combined in such manner as to allow the karate-ka to learn the techniques and principles of the martial art. Kata competition takes the form of team and individual matches. Team matches consist of competition between three-person teams. Each team is exclusively male, or exclusively female. The individual kata match consists of individual performance in separate male and female divisions. In the Finals of team kata competition, the two finalist teams will perform their chosen kata from a free kata list in the usual way. They will then perform a demonstration of the meaning of the kata (the so-called bunkai). The time allowed for the bunkai demonstration is 5 min. The use of traditional weapons, ancillary equipment, or additional apparel is not allowed. The kata must be performed with competence, and must demonstrate a clear understanding of the traditional principles it contains. In assessing the performance of a contestant or team the judges will look for: a realistic demonstration of the kata meaning; understanding of the techniques being used (bunkai); good timing, rhythm, speed, balance, and focus of power (kime); correct and proper use of breathing as an aid to kime; correct focus of attention (chakugan) and concentration; correct stances (dachi) with proper tension in the legs, and feet flat on the floor; proper tension in the abdomen (hara) and no bobbing up and down of the hips when moving; correct form (kihon) of the style being demonstrated; the performance should also be evaluated with a view to discerning other points such as the difficulty of the kata presented; and in team kata, synchronization without external cues is an added factor. For kumite, the competition area will be a matted square with sides of 8 m (measured from the outside) with an additional 2 m on all sides as a safety area. The mats used should be nonslip where they contact the floor, but have a low coefficient of friction on the upper surface. They should not be as thick as Judo mats, since these impede karate movement. The referee must ensure that mat modules do not move apart during the competition, since gaps could cause injuries and constitute a hazard. They must be of approved WKF design.

The kumite competition may be further divided into the team match and the individual match. The individual match may be further divided into weight divisions and open category. Male teams comprise seven members with five competing in a round. Female teams comprise four members with three competing in a round. Duration of the kumite bout is defined as 3 min for senior male kumite (both teams and individuals) and 2 min for women's, junior, and cadet bouts. The clock is stopped each time the fight is called to a halt by the referee. In karate kumite competition, attacks are limited to the following areas: head, face, neck, abdomen, chest, back, and side. Sweeping and projection techniques are allowed. Open hand techniques to the face are forbidden due to the danger to the contestant's sight. A score is awarded when a technique is performed according to the following criteria to a scoring area: good form, sporting attitude, vigorous application, awareness, good timing, and correct distance. It is important to remember that – according to the competition rules – contact must be controlled in every moment in order to create a valid technique: a punch or kick that comes somewhere between skin touch and 2–5 cm from the face, may be said to have the correct distance; no contact to the throat is permitted, although a score may be awarded for a properly controlled technique, which does not touch; and a greater degree of contact is allowed to the body, but always, below injury limit. Quoting the WKF competition rules: "Karate competition is a sport, and for that reason some of the most dangerous techniques are banned and all techniques must be controlled. Trained competitors can absorb relatively powerful blows on muscled areas such as the abdomen, but the fact remains that the head, face, neck, groin, and joints are particularly susceptible to injury. Therefore any technique, which results in injury, may be penalized unless caused by the recipient. The contestants must perform all techniques with control and good form. If they cannot, then regardless of the technique used, a warning or penalty must be imposed" [2].

The level of contact allowed is different for seniors, juniors, and cadets: "For Senior and Junior competitors, non-injurious, light, controlled "touch" contact to the face, head, and neck is allowed (but not to the throat). Where contact is deemed by the referee to be too strong, but does not diminish the competitor's chances of winning, a warning (chukoku) may be given. A second contact under the same circumstances will be penalized by Keikoku and Ippon (one point), given to the opponent. A third offence will be given Hansoju chui and Nihon (two points), to the injured competitor. A further offence will result in disqualification or Hansoku. For Cadets, all hand techniques to the head, face, and neck must have absolute control. Should the glove touch the target the Referee Panel will not award a score. Kicking techniques to the head, face, and neck are allowed to make a light "skin touch" only. In the case of techniques which make contact considered to be more than a "glove" or "skin" touch, the Referee Panel will give a warning or penalty. Any technique to the head, face, or neck, which causes injury no matter how slight, will be warned or penalized unless caused by the recipient" [2].

The new competition rules that were fully implemented in 2002 consider three levels of scores: sanbon (three points) is awarded for kicks to the head and for throwing or leg sweeping the opponent to the mat followed by a scoring technique. Nihon (two points) is awarded for kicks to the body, punches on the back, including back of the head and neck, combination hand techniques, the individual components of which each score in their own right, and unbalancing the opponent and scoring. Ippon (one point) is awarded for punch techniques to the body or the head/face. Logically, a tendency among competitors has been created to favor their use of kicking and sweeping/throwing techniques, which has changed the injury profile of the competition.

## 16.3 Protective Equipment

During kumite competition, the following WKF-approved protective equipment is compulsory: mitts, one contestant wearing red and the other wearing blue; gum shield; female chest protector; shin pads and foot protection, one contestant wearing red and the other wearing blue. Groin guards are not mandatory, but if worn must be of approved WKF type. Glasses are forbidden. Soft contact lenses can be worn at the contestant's own risk. The use of bandages, padding, or supports because of injury must be approved by the referee on the advice of the official doctor

## 16.4 Medical Aspects of Karate Competition

During karate competition, the presence of a medical doctor is compulsory. The standard is one doctor per two tatamis, plus one assistant (nurse/paramedic, etc.) per tatami. When a contestant is injured, the referee shall at once halt the bout and call the doctor. The doctor shall treat the injury and inform the referee about its severity. A competitor who is injured during a bout in progress and requires medical treatment will be allowed 3 min in which to receive it. If treatment is not completed within the time allowed, the referee will decide if the competitor shall be declared unfit to fight, or whether an extension of treatment time shall be given. An injured contestant who has been declared unfit to fight by the tournament doctor cannot fight again in that competition. A contestant may win through disqualification of the opponent for accumulated minor infractions, without sustaining any significant injury; in such a case, he/she will not be allowed to fight again in the competition without permission from the doctor. A second win on the same grounds must lead to withdrawal, even though the contestant may be physically able to continue.

In the event that a competitor falls, is thrown, or knocked down and does not regain his or her feet immediately, the referee will signal to the timekeeper to start the 10 s countdown by a blast on his whistle, at the same time calling the doctor if required. If the competitor is not able to fully regain his/her feet within the 10-s count, they will be considered unfit to continue fighting by the referee panel. The importance of this rule is that it protects competitors who have suffered injuries, and discourages competitors from faking or feigning injuries. As fair play is a crucial part of karate competition, a competitor who is felt by the referee panel and the tatami doctor to be feigning injury will receive a shikkaku (disqualification) and will be taken from the competition area and put directly into the hands of the WKF Medical Commission, who will carry out an immediate examination of the competitor. The Medical Commission will submit its report before the end of the championship, for the consideration of the Referee Commission. Competitors who feign injury will be subject to the strongest penalties, up to and including suspension for life for repeated offences [2].

## 16.5 Physiological Demands of Karate

Competitive karate is a high-intensity, intermittent activity, relying basically on the immediate (ATP, PCr) and short-term (anaerobic glycolysis) systems for the resynthesis of ATP, although some authors suggest that competitive sparring stresses the aerobic energy pathways [3–5]. The intensity level of karate combat is highly variable, depending on the strategic approach of the contestants, with periods of observation and "dancing around" and sudden bursts of maximum intensity punching, kicking, and blocking. Kata performance also combines periods of higher and lower intensity performance. The intensity level of karate competition can be highly variable among different fights: the intensity levels have been classified as level 1: observation; level 2: simple or preparation techniques; and level 3: interaction. Even at World Championship level, some fights can be considered as "physical" and others as "tactical," with a great range of variations (Fig. 16.1). A study [6] on the number of high-intensity (or level 3) periods during 50 World Championship fights showed that only in 1% of the fights there were less than 4 level 3 bursts; in 45% of the fights there were between 4 and 10; in 29% of the fights there were between 11 and 20; in 26% there were between 21 and 29; and in 9% there were more than 29 level 3 bursts. The lactate blood levels in elite kumite karate competitors (measured in blood obtained through a finger prick immediately after the completion of the fight in the World Championships) showed an average level of 11.1 mM/l ($n$ = 20; range: 8.7–12.7), which reflects the high demands of the competition (Fig. 16.2). As for kata elite competitors, the lactate blood levels (measured in blood obtained through a finger prick immediately after the completion of the kata in the World

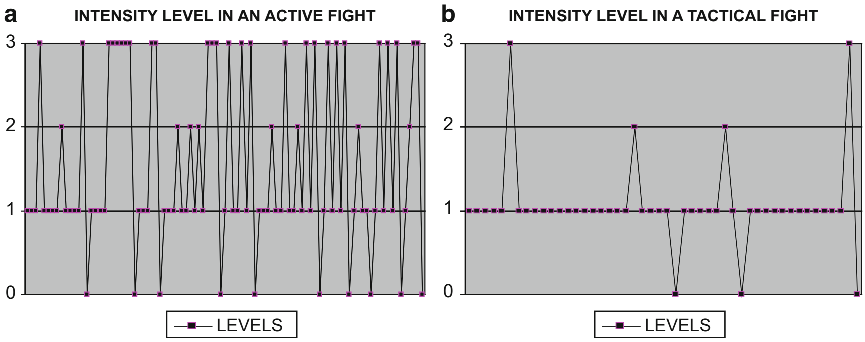


**Fig. 16.1** Intensity level of two World Championship finals fights showing the enormous intensity difference possible in karate competition

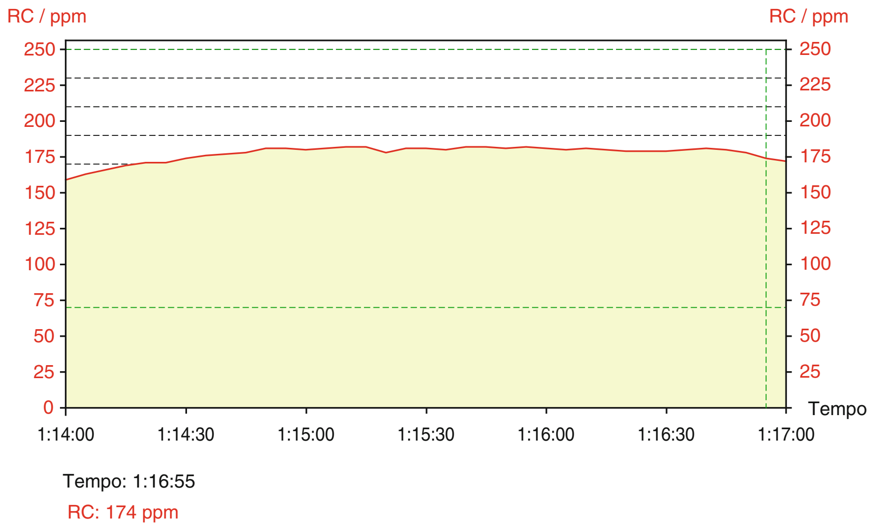


**Fig. 16.2** Heart rate of a national team kumite competitor during a 3-min high-intensity fight in one of the qualification rounds for the European Championships. The heart rate remains above 175 bpm for most part of the time

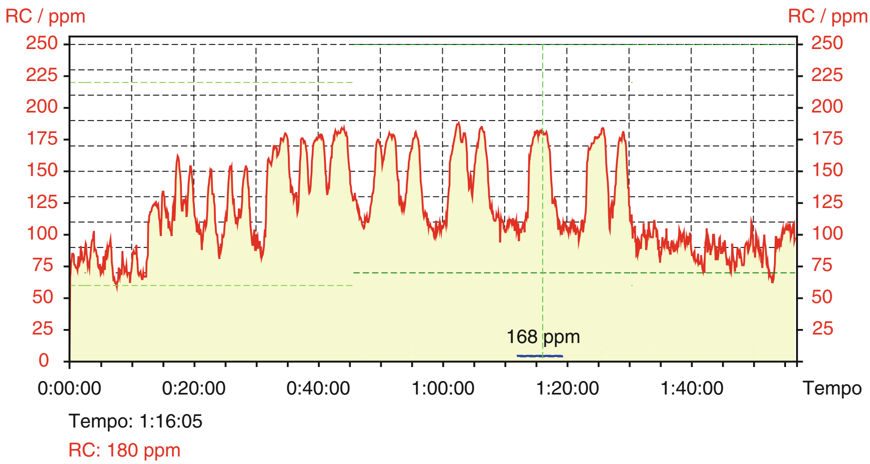


**Fig. 16.3** Heart rate (as measured with a Polar monitor) during a 2-h training session of a kumite competitor of the Spanish Karate Team. Notice the high intensity of the 3-min fights

Championships) showed an average of 8.79 mM/l ($n$ = 9; range: 6.8–10.6). These variations probably reflect the different demands of the different katas (which can vary in duration from 40 s to 2 min. Figures 16.3 and 16.4 show the heart rate of a kumite and a kata competitor (measured with a heart rate monitor worn under the karate-gi) during the selection competition for the Spanish National Karate Team. This

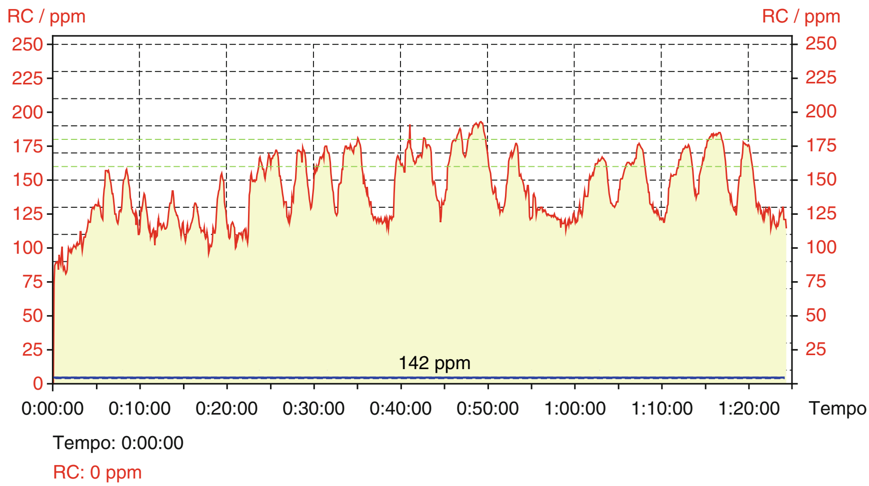


**Fig. 16.4** Heart rate (as measured with a Polar monitor) during an 85-min training session of a kata competitor of the Spanish karate team. Notice that the bouts of high-intensity work reach levels similar to the ones of kumite competitors

competition was limited to the five top national competitors in each category, in order to select the ones that would represent Spain in the 1996 World Karate Championships. It is evident that the shape of the curves can be completely different under different competition situations, but both clearly stress the importance of the anaerobic energy pathway during top-level competition.

## 16.6 Karate Injuries

After the rule changes implemented in 2002, a prospective recording of injuries resulting from 1,785 matches in two consecutive World Karate Championships (WKC), the 16th WKC in Madrid (Spain 2002) and the 17th WKC in Monterrey (Mexico 2004), was done following the same protocol that was already used to document the injury rate of top-level karate competition in the past [7]. The injuries were graded as major, moderate, or minor according to the World Karate Federation Injury Severity Classification in use since 1990 (Table 16.1). It was impossible to track all the competitors after the tournaments were over to find out the exact number of days off training or work to classify the injuries accordingly. A total of 280 injuries were recorded, with an incidence of 0.157 injuries per match or 78.43 injuries per 1,000 athlete-exposures. The cumulative injury rate in male athletes was 0.172 injuries per match and 0.123 in female athletes. When comparing matches with and without (open and team categories) weight limits, the incidence in weight categories in males was 0.166 (or 1 injury in every 6 matches) and in

**Table 16.1** Injury classification system used by the World Karate Federation Medical Commission since 1990

| |
|---|
| Severe injuries |
| – Grade III concussions (involving loss of consciousness) |
| – Fractures excluding clavicular, nasal, digital, metacarpal, and metatarsal fractures, but including any fracture involving a joint surface or requiring open reduction or internal fixation |
| – Third-degree sprains, or any joint injury likely requiring surgery or expected to result in permanent disabling sequelae |
| – Dislocated joint requiring manipulative reduction |
| – Damage to viscera (pneumothorax, acute abdomen, etc.) |
| – Major facial laceration with cosmetic or functional sequelae |
| – Facial bone fracture excluding nasal fractures |
| – Eye injury likely to cause residual visual loss (globe laceration, hyphema, retinal detachment, etc.) or injuries causing damage to lid function or lacrimal apparatus |
| – Any injury requiring hospitalization or surgery, or expected to result in significant functional or cosmetic sequelae |
| Moderate injuries |
| – Grade II concussions (involving retrograde and/or antegrade memory loss) |
| – Clavicular, nasal, digital, metacarpal, and metatarsal fractures, but not involving a joint surface or requiring open reduction or internal fixation |
| – Dental injury with tooth loss or requiring restorative procedures |
| – Corneal abrasions acutely affecting vision |
| – Laceration requiring stitches |
| – Joint dislocation that self-reduces at the ring |
| – Contusion, sprain, or hematoma preventing use of the limb on the day of competition |
| Minor injuries |
| – Grade I concussion (the athlete is briefly stunned and confused, regaining full faculty within a few minutes) |
| – Contusion of solar plexus |
| – Epistaxis without a fracture |
| – All other injuries not listed above and generally not requiring removal from the match or further medical care |

females it was 0.117 (or 1 injury in every 8.56 matches), while in categories without weight limits, the incidence was 0.178 in males (1 injury in every 5.6 matches), and 0.128 in females (1 injury in every 7.8 matches). For calculations, moderate and severe injuries were grouped, with a total of 34 injuries. When analyzing the incidence of such injuries in matches with weight limits, there were 0.0151 important injuries per fight in male categories (1 injury in every 66 matches) and 0.0146 important injuries per fight in female categories (1 injury in every 68.5 matches); in matches without weight category, there were 0.026 important injuries per fight in male categories (1 in every 38 matches), and 0.018 injuries per fight in female categories (1 in every 56 matches). With regard to the mechanism of injury, punches (203, or 72.5%) caused more injuries than kicks (38, or 13.6%) and sweeping and falls caused 28 injuries (10%), while in 11 cases (3.9%) the injury mechanism was not recorded. Most injuries were located in the face (198, or 70.71%). Among the important injuries, 44.11% were located in the head (seven grade 2 or 3 concussions) or face (six nose fractures and two mandible fractures). Although the injury classification used was different, results seem to be the same as was found in a similar study done at a national competition level [9]. Only 23.6% (66 out of 280) of the total number of injuries were caused by sweeping/projections and kicks, but 44.1% (15 out of 34) of the moderate and severe injuries were caused by them. The percentage is even higher if only the more severe injuries are considered: 11 out of 17 severe injuries, or 64.7% were caused by sweeping/projection and kicks. Although explanations remain speculative, it is possible that the added scoring offered to kicking and sweeping techniques by the new rules has caused competitors to use them more frequently. These techniques could be more prone to produce more severe injuries, due to the greater impact energy of the body segments involved (lower limb versus upper limb).

Logically, the prevention of injuries during karate training and competition relies not only on the use of protective equipment, but also in the strict adherence to the fighting rules and the development of control and defensive skills of the contestants. During competition, a very important part of the ability to reduce the number of injuries depends on the referee's attitude and willingness to stop any kind of potentially dangerous situations by the strict application of the rules. For kids, the no-contact rule is mandatory, so training and competition seem to be very safe., The injury level in under 18-year-old players is extremely low [8].

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# Chapter 17
# Wushu (Chinese Martial Arts)

**Santos F. Martinez**

*The goal is not to demonstrate strength, power, or violence. The goal is to attain serenity, tranquility, and the discovery of oneself. It is truly an exercise of the spirit*
*Comments from Master Tung Kai Ying, Third-generation Yang Taijijuan Practitioner*

## Learning Objectives

- To understand the rich heritage and evolvement of Chinese martial arts
- To understand the contrasts between internal and external Chinese martial arts styles
- To present an elemental exposure to competition formats and regulations
- To review common medical conditions and guidance to provide a safe competition venue

## 17.1 History and Current Practices

The term Wushu literally translates into "martial art techniques" and represents a wide variety of pugilistic Chinese martial art systems with a very rich heritage. These disciplines are, at times, inaccurately referred to as kung fu, a term that may actually reflect many nonmartial "disciplines completed with refined skill." Although many associate Chinese martial arts with the most visibly publicized forms of the 5th and 6th centuries such as the Shaolin Temple systems, the origin of Chinese martial arts spans several thousand years. The primary emphasis would have been directed to functional survival, such as self-defense, protection for villages, and use of weapons for hunting. The evolution during countless dynasties reflected the needs of the individuals and their society. During some periods of Chinese history, martial arts development was encouraged to insure a core strength for society, while at other times they were discouraged among lay individuals in order to control the population by limiting discord and rebellion. In such latter times, training was outlawed and martial art practitioners were forced to go underground for clandestine training.[1]

The development of several hundred systems of martial arts followed patterns of military, provincial, and philosophical (e.g., Daoism, Buddhist, and Muslim) influences. The nomenclature reflects those developmental roots, as well as a more

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**Table 17.1** Traditional styles of Wushu[a]

| External (hard, physical) styles |
|---|
| Northern |
| • Northern Shaolin |
| • Chang Chuan (Long Fist) |
| • Praying Mantis |
| • Eagle Claw |
| • Monkey |
| • Drunken-style |
| • Drunken Eight Fairies |
| • Ba-ji |
| Southern |
| • Southern Shaolin (Ermei Shaolin, Wudang Shaolin) |
| • Hung Gar |
| • Choy Li Fut |
| • Wing Chun |
| • Five Animal System (Dragon, Snake, Tiger, Leopard, Crane) |
| • White Eyebrow |
| • White Crane |
| • Lo Han |
| Internal (soft, mental/spiritual) styles |
| • Taijiquan |
| • Baguazhang |
| • Xingyiquan |

[a] There are other, less common styles, but space constraints preclude an all-inclusive listing

contemporary orientation towards sports or health preservation. Other frequently used categories focused on apparent energy outlay, generally classifying the Chinese martial arts into external or hard styles and internal or soft styles. Regional influences also are apparent in technique variations such as northern and southern styles. Some styles evolved from combative techniques observed in the animal kingdom.[2] Currently under consideration is distinguishing between martial arts of a more traditional nature and those of a contemporary variety. A partial listing of traditional external and internal styles is provided in Table 17.1.

The technological advancement and effectiveness of military firearms progressively replaced much of the dependence on traditional martial arts training. In a number of months, a recruit could be trained to use a weapon that could maim or kill a master who may have dedicated his life to refining his martial art. Political and practical factors resulted in less visibility and popularity of the traditional martial artist. Subsequently, the threat of losing these time-honored arts was recognized, and a concerted effort was begun to preserve these disciplines. It was obvious that the years required for the traditional teaching necessary to master these arts were not very practical for widespread dissemination. Masters, with government encouragement, reviewed, codified, and modified training routines and forms, and opened the first formal Wushu university department in Nanjing, China, in the late 1920s.

In the 1950s, concerted government efforts resulted in Wushu taking on its more contemporary presentation of a formal sport with organized competitions.[1,2]

## 17.2 Training Considerations

The training modalities used for Chinese martial arts vary depending on the outcome objectives. The orientation of traditionalists with primary concerns of self-defense and internal development may be very different than those who have the goal of medal placement in tournaments for form or contact "point" sparring. Traditionally, students were encouraged to dedicate their training efforts to one discipline in order to master it and reach a very deep and profound level of training. The more recent formal university-trained Chinese Wushu system leans more towards quantity, as students are exposed to a large number of styles. Some train for neither self-defense nor sport, but have an interest in theatrical capabilities (e.g., Jackie Chan) or health preservation. Chinese martial arts offer something for everyone ranging from children to senior citizens. Some styles are even tailored for specific body types.

Popular culture, such as the television series "Kung Fu," has contributed to the mystique surrounding the Chinese martial arts, which were presented as unattainable because of a perceived inaccessibility to competent masters and training facilities. Martial artists frequently are opinionated as to where their particular allegiance lies. These differences in objectives unfortunately can lead to a division in organizational efforts and less-effective promotional endeavors. The most visible promoter of contemporary Wushu is the International Wushu Federation (IWUF) with more than 90 member nations conducting tournaments worldwide.[3] Much interest has been expressed in making contemporary Wushu an Olympic sport. There are various organizations that hold competitions restricted to more traditional systems.

## 17.3 External "Hard" Styles

The external styles generally emphasize rapid ballistic movements, using visible power in the upper and lower extremities.[4] These are the styles that have captured the public's attention in cinema depictions of individuals who seem to defy physical limitations (Bruce Lee, Jet Li). The training is very vigorous and includes body-conditioning modalities and martial art-specific activities. Training regimens for the purely physical requirements generally include flexibility, resistance training, plyometrics, development of rapid eye–hand coordination with and without weapons, lower extremity strengthening and endurance training, standing postures, body desensitization, breaking techniques, and exercises to facilitate jumping for airborne techniques. Sports-specific techniques also promote visual spatial skills, patterned choreography, and open-hand or weapon techniques and forms, which may be solo, paired, or multiple-assailant routines. The amount of mental training and meditation varies according to style. Different color sashes are used in some systems to signify a ranking system. Modern anthropometric screening devices may be used to select prospective team candidates in countries where "elementary farm leagues" are cultivated, particularly in Asia.

## 17.4 Internal "Soft" Styles

Internal martial arts theoretically refer to a category of disciplines that depend less on brawn and muscle development and more on less visible power-generating talents that are acquired over a span of years.[4] These individuals are not nearly as lean as the external stylists. Although these arts can be introduced at a relatively young age, they are associated with health preservation, particularly Taijijuan, in the elderly. Ample western research literature supports considerable health benefits, particularly from Taijijuan, in those with arthritis, hypertension, and balance disorders. Internal martial art movements are characteristically slower, more fluid, and contemplative. Some refer to these as "meditation in motion" (Fig. 17.1).

Emphasis is on energy conservation, using the opponent's power and intentions against him. When an aggressive action is received from the opponent, the energy is followed and transferred away or as an instrument for stored energy to be transferred back to the opponent. With offensive motions, the energy is transferred from the ground in an ascending manner from the lower extremities through the trunk and eventually expressed through the extremity providing the technique or maneuver. Much time is devoted to forming the optimal body structure and posture refinement, including exercises to develop a greater awareness and control of fascial and anatomical tensegrity models. Similar to the external martial arts, there are open-hand and weapon forms. Traditional forms have been modified by consensus with input from traditional masters and contemporary Chinese Wushu professors for varying objectives. For competition, sparring is limited to a modality referred to as "push hands," which allows contact sensitivity and more interaction between practitioners and emphasizes the use of basic internal skills to move or overcome the opponent. An integral paradigm

**Fig. 17.1** Graceful traditional Yang style with double-edged straight sword (Jian) performed by Master Tung Kai Ying

includes Daoist philosophy and consideration of yin/yang interplay with each potential self-defense scenario and responsive strategy. The three main categories of internal martial arts are XingYi, Taijiquan, and Bagua.[1,2,4] Each has its own characteristics, with Bagua emphasizing circuitous movements, XingYi more direct and linear/angular responses, and Taijiquan a combination of circular and linear features. These systems were traditionally passed down through generations, frequently through family styles, and guarded closely. Although often associated with health preservation, there are definitive traditional martial applications and forms that focus on slow and more rapid responses. Contemporary Wushu competition routines now mandate maneuvers that require more acrobatic skills and, thus, begin to resemble the external styles.[3] The internal styles do not characteristically have a ranking system to identify participants' maturity or effort in the style.

### *17.4.1 Training Observances*

From the moment a martial artist enters the training center, there is a change in protocol depending on the school orientation. Various observances are expected of the student regarding respect for the teacher, fellow students, the art, and the training site. These time-honored disciplines and etiquette promote an effective approach for ensuring an orderly training environment and a predictable outcome. These worthwhile attributes cross over into the participants' personal lives and help make them more useful in their occupations and in society at large. The instructor's training pedigree and experience are major determinants in directing training strategy. Some modern teachers consider themselves coaches, while more traditional instructors see their function as a master mentor with students as disciples. Traditional teachers expect very stringent ethical standards from their students. In earlier times, teachers reserved higher-level training for those identified to carry on the art, sometimes referred to as "indoor students."

### *17.4.2 Dress*

Uniform requirements range from basic physical education workout clothes to more formal silk uniforms. Contemporary competition uniforms can be very colorful and elaborate. Clothing for contact competition is more practical.

### *17.4.3 Weapons*

Although more than 200 weapons have been identified in China, fewer than 20 are commonly recognized as standardized for competition.[1–4] Many weapons have their roots as utilitarian tools with progressive refinements incorporating offensive and defensive maneuvers. A basic example is the staff, which typically is made of a flexible wood and can deliver power, but its length would ideally keep an opponent at some distance. The staff was a commonly available tool used as a walking aid and lever for carrying food stuffs (baskets, water pails). A natural extension of the staff is the spear. Within each category of weapon, there are countless variations in length, size, and weight depending on the martial art style and intention. Weapons usually are introduced in an orderly sequence during training. Students are expected to master basic open-hand forms and a fairly large compendium of curriculum before embarking on weapons forms. Solo and multi-individual sparring forms are available for weapons training in most styles. Sometimes scarves or tassels are attached to the weapon, which originally served to distract the opponent, signify the maturity of the practitioner, or serve some other practical function. A listing of some weapons is provided in Table 17.2. Weapons for contemporary competition have been modified to be light, thus facilitating more brisk motions and an added flair not possible with the traditional heavier weapons.

### *17.4.4 Medical Training*

The traditional training curriculum included basic instruction in the care of injuries and various illnesses. Students were taught bone setting, which included treatment of strains and sprains, joint subluxations and dislocations, and some fractures. Tuina and other manual medicine techniques (similar to osteopathy) were reviewed along with some herbal medicine. Acupuncture was a well-respected, time-honored discipline included as part of the trained martial artist's resources. They also were well-versed in Qigong, which was either a stationary or dynamic discipline to promote health and vitality to the meridian system and functioned prophylactically to prevent disease.[5,6]

## 17.5 Contact Sparring

The status of a martial art frequently is judged by its effectiveness under combat simulation. The risk of injury from such competitions has resulted in the gradual development of defined rules to allow contact fighting while observing certain precautions and using protective equipment. Although some might consider any restrictions on combative techniques or equipment to violate and diminish the original purpose of the martial art, it is neither practical nor safe to promote a martial art (either as a sport or self-defense) unless some accord can be reached to provide a safe environment for competition. Although there are some traditional contact-point sparring tournaments still being conducted, the main contemporary contact fighting technique presently recognized for international competition by the IWUF is Sanshou. It is in this form of competition that the most serious and life-threatening injuries occur.

**Table 17.2** Weapons used in Wushu

| Nonstandard | Pounding/bludgeoning | Sharp-edged | Flexible | Throwing |
|---|---|---|---|---|
| Sash | Crutch | Arhat coin | 7–12 section whip | Bow and arrow |
| Bench | Cane | Axes | Bull whip | Crossbow |
| Chopsticks | Dragon head stick | Brush | Rope | Back cross bow |
| Iron comb | Eight-corner hammer | Claw | Weighted rope | Fly whisk |
| Flute | Golden melon hammers | Comb | Kriss sword breaker | Flying dart |
| Iron ring | Buddha hand | Crescent rake | Double-headed comet star hammer | Flying fork |
| Iron smoking pipe | Cymbals | Daggers | Double-headed flying maul | Flying locust stone |
| Iron toad | Hammer | Fork (various) | Iron chain linking club | Flying knife |
| Mandarin duck spade | Hook | Halberd (various) | Three-section staff | Flying weight |
| Monk cudgel | Lashing staff | Hoe | Soft hammer stick | Meteor hammer |
| Monk spake | Mace | Hooks | Soft whip | Dart knife |
| Whip chain | Mother and son hammer | Knives (butterfly, deer antler) | Four-section “tang” rope | Rope javelin |
| Rake | Shield | Lance | Dart | Rope sling shot |
| Ring wheel | Three-section staff | Rake | Comet star hammer | Sling shot |
| Scholar’s brush | Flail | Shovel | Dragon head whip club | Mother–son cross darts |
| Pen | Two-section staff | Spades | Dragon or plum flower claw | Sleeve arrow blow dart |
| Sickle | Water-parting shield | Spear (standard, hooked, throwing) | Flying claw/hook | Flying sting |
| Tiger fork | Wolf teeth club | Sword (single/double-handed) | Leather soft whip | Brass chopsticks |
| Four-section sickle | Wolf teeth hammer | Broad sword | | Iron mandarin duck |
| Steel fan | | | | Plum flower needles |
| Hoe | | | | |
| Dragon whisker fork | | | | |
| Ox horn fork | | | | |
| Two point fork | | | | |

Modified from www.atlantamartialarts.com

## 17.6 Sanshou

Sanshou (free-hand sparring) is a synthesized, practical-oriented fighting system that combines components from various martial arts.[1–4] For competition purposes, safeguards have been added to limit serious injuries. To the observer, Sanshou appears similar to kickboxing. The event takes place on an elevated platform (Lei Tai) with no guard rails or ropes to restrict the fighters from falling off the ring to the floor. The platform and surrounding surfaces are covered with padding and canvas (Fig. 17.2). Traditional or contemporary full-contact competitions have varying regulations depending on the level of competition (amateur, semi-pro, professional). Some of the amateur regulations are shown in Table 17.3.

**Fig. 17.2** Pan-American Sanshou competition (amateur), Venezuela

**Table 17.3** International Wushu Federation (IWUF) Sanshou requirements (Modified from www.iwuf.org)

| |
|---|
| **Protective equipment** |
| • Head/chest protector |
| • Gum/mouth protector |
| • Groin cup protector |
| • Boxing gloves (230 g for weight <48 kg, 280 g for weight >70 kg) |
| **Medical requirement** |
| • Completed physical exam form and health certificate |
| • EEG/ECG |
| • The above completed within 20 days of the event |

(countinued)

**Table 17.3** (countinued)

| |
|---|
| **Weight/age requirements** |
| • Eleven weight categories from <48 to >90 kg with divisions at intervals between 4 and 5 kg |
| • Adult division (18–35 years of age), Junior division (15–18 years of age) |
| **Rounds** |
| • Three 2-min rounds with 1 min in between |
| **Target sights** |
| • Accepted |
| - Use of hands and feet as weapons allowed |
| - Head, trunk, and thighs may be struck |
| - The fighter may perform throws, sweeps, takedowns |
| • Not accepted |
| - Use of head, elbows, or knees as striking weapons |
| - Chokes and arm locks are prohibited as are strikes to the posterior cranium and groin |
| - The fighter cannot strike the opponent's head when he or she is down |
| **Fighting ring/platform specifications** |
| • 80 cm high, 800 cm long, 800 cm wide |
| • No ropes are provided to keep fighters in ring |
| • The ring floor is covered with a soft mat and covered with canvas; protective mats are placed on the floor surrounding the platform |

## 17.7 Taolu

Choreographed forms (Taolu) traditionally have been an integral part of most martial arts.[1–4] Forms develop stamina, promote flexibility and tolerance, and assist with mastering movements and techniques. The emphasis of form competition in tournaments has in recent years gradually departed from the more traditional presentations. The contemporary designated forms appear to be hybrids between ballet, gymnastics, and martial arts, which makes this "visual art" exciting to watch. Obviously, athletes have to train differently for this type of event, and this can result in a wide variety of injuries that may have not been common under the more traditional training. There are timed sequences containing mandatory movements in both external and internal forms. Taijijuan, which has roots as an internal style, now has incorporated moves that require greater flexibility and jumping skills. These modern internal and external Taolu forms have become so subspecialized that some team members train for only one-open-hand or weapons forms. They have to spend much time fine-tuning acrobatic and gymnastics skills in order to be competitive and to achieve the ultimate goal of medal placement (see Fig. 17.3). Traditionally, the martial artist would have been using such time for further internal and martial arts skill development. There continue to be some limited traditional tournaments. It is rare that a forms competitor also competes in Sanshou in the contemporary Wushu "sport." There is some concern that such acrobatic requirements may discourage amateur athletes from pursuing these arts and may serve unintentionally as a deterrent rather than promoting wider Chinese martial art dissemination.

The IWUF competition forms are as follows[3]:

**Fig. 17.3** Contemporary Wushu demonstrating butterfly with three-section staff, performed by a member of the Beijing Wushu team

1. Changquan (long fist)
2. Nanquan (southern fist)
3. Taijijuan (shadow boxing)
4. Daoshu (broadsword)
5. Jianshu (sword)
6. Nandao (southern broadsword)
7. Taijijian (Taiji sword)
8. Qiangshu (spear)
9. Gunshu (cudgel)
10. Nanqun (southern style cudgel)
11. Duilion (dual events)
12. Jiti (group events)

There is both enthusiasm and some skepticism in those observing the course of contemporary Wushu. There is no doubt that the excitement and beauty of contemporary Wushu is unparalleled among martial art demonstration forms. Enthusiasm for new discoveries of the body's acrobatic capabilities, however, must be tempered by a training format that honors and promotes long-term health maintenance, limits injury, and provides a functional self-defense capability.

### *17.7.1 Medical Pearls*

The medical objective is to provide a safe environment for the athletes within parameters that will contribute to a successful event. The physician should not be perceived as an obstacle but an asset for the event. The physician should be prepared

**Table 17.4** Medical recommendations for competition organizers

| |
|---|
| 1. Medical coverage |
| (a) Sanshou: doctor and/or EMT presence with oxygen and spine-board precaution capability; preferably the physician covering is licensed in the state or country of the events |
| (b) Contact sparring: minimum – registered nurse, physician assistant, or licensed athletic trainer |
| (c) Taolu (forms competition): suggested but not mandatory – nurse, physician assistant, or certified athletic trainer |
| 2. Evacuation plans in case of emergency injury |
| 3. Designated hospital for the event in case of injury |
| 4. Sanshou athletes must have their medical clearance form completed within the designated time frame (20 days preceding event for IWUF events). Ideally, a physician examines Sanshou athletes before and after the competition. Sparring and Taolu athletes with written/signed medical clearance within 1 year of the event. |
| 5. Medical supply kit |
| 6. The tournament organizers should have the medical requirements listed on the Web page advertising the event |

**Table 17.5** Team physician checklist

| |
|---|
| • Obtain a complete list of team members (athletes, coaches) and their addresses and telephone numbers |
| • Obtain copies of completed medical forms |
| • Be aware of tournament-specific requirements (e.g., EKG, EEG) |
| • Ensure that no contact fighters have medical conditions transmittable by blood (see Chapter 7) |
| • Confirm required vaccinations (required by some countries) |
| • Check contents of medical travel kit (e.g., extra batteries for ophthalmoscope, cell phone). |
| • Be aware of athletes' medical/health insurance coverage in case of injury |
| • Have contact name and telephone number of tournament physician |
| • Ideally, make sure that waiver covers medical personnel |
| • Know the name and location of the referral hospital in case of injury |
| • Make sure athletes have team doctors' contact telephone numbers and hotel room numbers |
| • Visit tournament site before the competition to assess safety and medical support availability |

for the unexpected and should carry some limited medical supplies rather than depending completely on the sponsors of the tournament to provide basic first-aid supplies. More significant equipment and personnel definitely should be supplied by the organizers. There is a wide disparity in adequate medical planning between local and international tournament organizers (see Tables 17.4 and 17.5). There have been times when I was traveling as team physician for a country only to arrive and have to serve as the tournament physician.

Ideally, competitors will have undergone pre-competition medical screening to identify high-risk individuals. In most competitive sports, the minimal standard of practice is to have at least one physical examination each year.[7,8] Full-contact competitors should be examined more frequently and within 6 weeks of the competition (IWUF events, 20 days). A better approach for full-contact martial artists would include examinations before and after competition. If full contact is included in the event, a review of available medical personnel is paramount, with a designated physician, emergency medicine technicians with oxygen, transport, spine precaution capabilities, and an identified hospital for necessary care. Waiver forms used for the event should protect not only the event organizers from liability but also medical personnel. [9] Frequently, the medical personnel are volunteers with potential liability exposure. Exclusion criterion must be identified for prospective athletes. Termination parameters for the contact competitions should be discussed with officials before the event. National and international competitions should allow for appropriate drug doping monitoring.

Although there are no hard data delineating the injury demographics of modern Chinese martial arts, it is apparent that more serious injuries occur with contact competition in the external "hard" styles and include head and neck injuries, fractures, severe joint and soft-tissue contusions, lacerations, and sprains.[10–12] A wide variety of factors may come into play as injury contributors: age, experience, general health, conditioning level of the athlete, mismatch between competitors, precautions in weight loss observance, and a history of head injury or concussion. This brief manuscript is not intended to cover all medical aspects of Wushu but to provide the reader with a glimpse of some of the more common areas of concern. Less frequently encountered visceral (e.g., abdominal, pelvic, and thoracic) injuries are not discussed.

## 17.8 Head and Spine Injuries

Very few situations cause more anxiety to the treating physician than a fighter with a change in mental status or the possibility of a spinal cord injury. Significant precautions and adequate medical support are necessary to insure the safety of the martial artist. The physician should have limited evaluation equipment: ophthalmoscope and otoscope, reflex hammer, portable airway or oral barrier for CPR use, stethoscope, and possibly a pocket Snelling chart to assess vision. The fighting venue should have a back board, cervical collar, and cardiopulmonary equipment on hand. Given the dire consequences of these injuries, a short synopsis on this topic is provided below. The reader is referred to Chapter 6 for a more in-depth review on head injury in combat sports.

### *17.8.1 Head Injury: Concussion*

Concussions are most common in contact competition[10–12]; they are rare but possible with Taolu. The alteration in mental status caused by a concussion frequently resolves relatively spontaneously and usually represents a functional change; less frequently, there is a demonstrable structural lesion. Sustaining a concussion makes the athlete more susceptible to a future concussion, and the injury may carry long-term sequelae (decreased verbal learning, decreased attention span, decreased processing speed, reduction in neuropsychology scoring). Complications include second impact syndrome, post-concussion syndrome, posttraumatic seizure, chronic traumatic brain injury (dementia pugilistica), subdural hematoma, epidural hematoma, parenchymal hemorrhage, diffuse axonal injury, and rarely death. An athlete with a concussion should be treated with spinal precautions until mental status allows more thorough evaluation.

### *17.8.2 Physical Examination During Competition*

- Usually the official requests a physician evaluation.
- The physician may approach the official if concerns arise during or between rounds. The physician at the ringside must be very observant of the rhythm of the competition and the fighters' ability to respond to their opponents.
- Telltale signs may be an athlete's inability to protect himself/herself and instability in gait or movement.
- If the athlete, his corner, or the physician notes persistent headache, instability in gait, subjective motor or sensory alterations, or a change in vision, the fight should be discontinued for medical reasons.
- Examination includes: cognition, visual fields, pupillary responses, motor and sensory testing, balance and cerebellar testing, and reflex and functional testing. Palpation and range-of-motion testing are important to delineate spinal injury.
- If loss of consciousness occurs, the athlete should not be removed from the ring. Spinal precautions must take place along with basic airway care.
- If athlete regains consciousness within 2 min and has no significant spinal pain, he may gradually be advanced to sitting and standing as the examination allows. Loss of consciousness for longer than 2 min or worsening of the athlete's condition, with or without spinal symptoms, warrants transportation with spine-board precautions to a medical facility for further evaluation and monitoring.

### *17.8.3 Diagnostic Studies*

- CT scan, MRI, and EEG are reserved for more severe injuries.
- Neuropsychology testing is more sensitive.
- PET and functional MRI may reflect metabolic uptake abnormalities.

### *17.8.4 Return to Fight*

- No established protocols by the Wushu organizations regarding returning to fight after concussions currently exist.
- Suggested guidelines indicate that documented concussion should require a minimum of a 30-day suspension, and as much as a 180-day suspension, from contact fighting depending on the duration of symptomatology.

### 17.8.5 Cervical Spine Injuries with Neurologic Deficit

These injuries rarely occur in Wushu competitions, although they can be caused by blows to the head or neck, falls, sweeps, throws, and takedowns. Cervical spine injuries may cause transient symptoms (e.g., cervical cord neuropraxia with transient quadriplegia) or more definitive and permanent deficits.[13] The athlete should be examined for unilateral or bilateral symptoms or signs. Unilateral upper extremity symptoms may represent a brachial plexopathy or nerve root traction injury. Pathology may include vertebral fracture with cord or nerve root injury, cord compromise on a congenitally or developmentally smaller vertebral canal, disc herniation, or nerve root injury. Physical examination is similar to that for an athlete with a concussion, with a low threshold for transport to a medical facility with spinal precautions. Imaging studies include basic radiographs (anteroposterior, lateral, open mouth, flexion/extension); if possible, the Torg spinal canal to vertebral body ratio should be determined. MRI and/or CT scanning are mandatory. Treatment is dictated by the clinical presentation and imaging studies.

### 17.8.6 Other Spinal Injuries

*Spondylolysis* is a stress fracture of the pars interarticularis caused predominantly by hyperextension movements (e.g., butterfly maneuver in Wushu). Other sports with a predisposition for spondylolysis include gymnastics, dancing, and figure skating. The L4–5 level is most frequently affected, and fractures may be unilateral or bilateral. Spondylolysis usually causes pain in the back, buttocks, and thigh that is aggravated by lumbar extension and prone lower extremity extension; focal paraspinal pain and spasm and tight hamstrings are frequent; neurologic symptoms or signs are rare. Imaging studies should include basic radiographs (anteroposterior, lateral, oblique, flexion/extension) and, occasionally, MRI and single photon emission computerized tomography (SPECT) (Fig. 17.4); CT scanning allows evaluation of spinal morphology and assessment of healing.

Treatment consists of the use of a flexion bias brace (e.g., Boston brace) for 2–8 months depending on symptoms and healing. A limited flexion bias rehabilitation program is initiated early with limited strengthening and conditioning program. A back stabilization program is begun with no axial pounding exercises allowed. Gradual progression of activity is allowed as clinical and imaging findings indicate, with extension activities prohibited for several months. Surgery rarely is required.

*Spondylolisthesis* indicates translation of one vertebra over adjacent segment, and usually is preceded by bilateral spondylolysis. Its severity is classified according to the amount of slippage: grade 1, 0–25%; grade 2, 25–50%; grade 3, 50–75%; and grade 4, 75–100%. The presentation is similar to that of spondylolysis, but neurologic

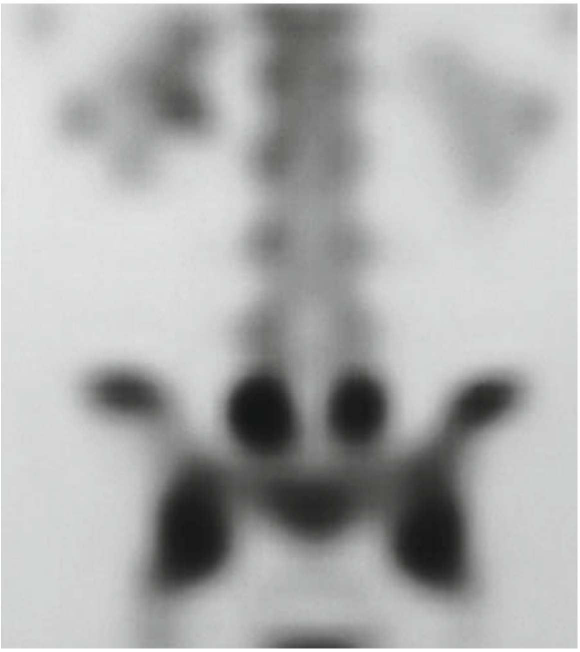

**Fig. 17.4** Bone scan showing pars injury

symptoms or findings may be present. Conservative treatment is similar to that for spondylolysis. Surgery may be required for grades 3 and 4 slippage or persistent symptoms.

*Herniated nucleus pulposus* is rare in younger athletes. The levels most frequently involved are L4–5 and L5–S1. Herniation usually develops with aggressive trunk flexion combined with rotatory movements. The athlete presents with paraspinal pain or extremity sensory or motor symptoms, which may increase with trunk flexion or Valsalva maneuvers. Examination findings may include paraspinal pain, spasm, motor, and/or sensory findings localized to specific dermatomes/myotomes, altered reflexes, positive neural tension signs, and rarely alteration in bladder/bowel control. Imaging studies should include radiographs and MRI or CT scan; occasionally electromyography is indicated. If no neurologic sequelae develop, most patients can be treated conservatively with analgesics and anti-inflammatory agents (nonsteroidal anti-inflammatory agents, corticosteroids, acupuncture, or homeopathic remedies) and, at times, fluoroscopic-guided interventional injections (e.g., translaminar, transforaminal epidural blocks). Manual techniques and exercise rehabilitation with an extension bias orientation are included along with a back stabilization program. Surgery is done only as a last resort.

## 17.9 Lacerations

Facial lacerations occur less frequently with use of head gear and occur more frequently with contact competition than with Taolu weapons or two-person forms.[10–12] Tournament regulations vary with respect to termination of the contest depending on skill level (amateur or professional).[3] Protective rubber gloves should be worn when evaluating cuts. Cuts overlying the facial vicinity of the following regions require close observation or possible discontinuation of a bout: supraorbital or infraorbital nerve regions, nasal lacrimal duct region (should be sutured only by subspecialist), tarsal plate region of the upper eyelid, and nasal base adjacent to a nasal fracture. Suturing or adhesive material can be used for wound closure; I prefer suturing, especially in contact fighters. Although facial sutures are removed after several days, the skin may take 6–12 months to reach full strength. Athletes usually return to fighting soon after the stitches are removed regardless of recommendations.

## 17.10 Shoulder Conditions

*Laxity of the glenohumeral joint* frequently is considered advantageous by coaches because both the open hands and weapons forms have ballistic maximal range-of-motion demands. However, if the flexibility is not balanced by good shoulder stabilizers, injury may result. Once laxity causes symptoms, then a more practical concern is the progression from laxity to clinical instability, which can be multidirectional or single-plane. Instability can be caused by an acute injury or chronic overuse. Anterior instability is more common than posterior instability in young athletes and has a high rate of recurrence. Instability may lead to impingement, recurrent subluxation, and rarely dislocation. The most frequent complaints are anterior shoulder pain and arm fatigue with training.

Occasionally, the athlete reports feeling a "shift" occur at the glenohumeral joint. Apprehension and relocation test usually are positive. Shoulder cuff weakness may be present, along with dysynchrony in scapulothoracic muscle activation. Palpatory tenderness frequently is noted along the glenohumeral joint line. Anterior dislocation causes an obvious alteration in shoulder contour with the arm slightly abducted and externally rotated. Posterior palpation reveals an abnormal absence of the humeral head in its glenoid receptacle. Posterior dislocations are less frequent and usually are caused by a forceful axial load. They may be difficult to appreciate on standard radiographs. Radiographs should include anteroposterior, lateral, and outlet Y views and should be evaluated for normal glenohumeral orientation.

Treatment of symptomatic laxity and instability is initially conservative rehabilitation: rest (sling or shoulder immobilization) for 2–6 weeks depending on symptoms and condition, limited range-of-motion exercises, shoulder stabilization exercises, and limited pharmacologic support. Refinement of athletic movement mechanics upon return to Wushu is imperative. Anterior shoulder dislocations usually can be reduced by one of several traction methods with or without intra-articular or intravenous sedation. Recurrent dislocations or symptomatic instability may require a surgical glenohumeral stabilization procedure. Years of repetitive ballistic movements on an unstable or suboptimally conditioned shoulder may lead to attritional degenerative changes of the shoulder.

*Labral injury* can be caused by trauma or by hypermobility and overuse. The presenting symptoms are similar to those in patients with hypermobility. Pain is reported with acceleration and deceleration phases of movement requirements. The "clunk" and O'Brien tests may be positive.

The labral injury may be accompanied by tendonopathies of the shoulder or a posterior ganglion or cyst that compromises the infraspinatus branch of the suprascapular nerve (Fig. 17.5). Superior labral tears often are called superior labrum anterior–posterior (SLAP) lesions and four types have been identified. Type I (fraying and degeneration of the superior labrum) is the most common and often is associated with tears of the rotator cuff or cuff tendonopathy. Type II SLAP lesions involve detachment of the superior labrum and biceps insertion from the supraglenoid tubercle; these often are associated with participation in overhead sports in younger patients and are the most common type in martial arts participants. Types III and IV are bucket-handle tears. In addition to routine radiographs, MRI with contrast should be obtained. Treatment initially is conservative over 2–6 weeks, after which arthroscopic evaluation should be considered if symptoms persist. Cysts may be aspirated and injected (CT guided) (Fig. 17.6).

**Fig. 17.5** After labral injury with spinoglenoid cyst causing neural compromise to the infraspinatus branch of the suprascapular nerve resulting in infraspinatus atrophy


**Fig. 17.6** MRI shows spinoglenoid cyst accompanying labral injury

*Clavicular injuries* that can occur in Wushu, especially in contact fighting, include clavicular fractures and acromioclavicular and sternoclavicular dislocations. Posterior displacement of the medial clavicle with a sternoclavicular dislocation can cause life-threatening neurovascular compromise that requires immediate reduction of the dislocation.

Other less-frequent shoulder injuries include brachial plexopathy or mononeuropathies, and fractures of the forearm or humerus.

## 17.11 Elbow and Wrist Injuries

Elbow and wrist injuries can occur in both forms of Wushu. Dynamic injuries include tendonopathies of the extensor and flexor tendons, radial and ulnar collateral ligament sprains and avulsions injuries, and osteochondritis dissecans of the capitellum. Contact fighting is more likely to produce radial or ulnar nerve injuries, elbow dislocations, and radial or ulnar fractures.

In the wrist, injuries also are likely to involve the ligaments (radioulnar, radiocarpal, intercarpal, and carpometacarpal), tendons, and nerves (compression or traction neuropathies of the medial, radial, and ulnar nerves). Contact fighting can produce fractures of the distal radius and ulna and of the carpal bones. Carpal fractures usually are the result of a significant axial injury or a fall on an outstretched upper extremity with the wrist dorsiflexed. Bone scan or CT scan may be needed to diagnose or delineate the fracture if it is not seen on radiographs. The most frequent significant fractures that cause residual problems are fractures of the scaphoid, lunate, and hamate. A vascular insult may affect bony healing or cause avascular changes (Kienbock disease of the lunate). Surgery may be required depending on the location of the fracture and the orientation of the vascular supply.

Treatment of metacarpal fractures depends on the location and amount of angulation and rotation of the fracture and whether there is extension into the joint. Some fractures can be treated with casting after reduction while others require surgery. Splinting is recommended until further assessment by a hand surgeon.

## 17.12 Hip and Thigh Conditions

A wide variety of hip injuries and conditions are present in Wushu participants, where the demands of the sport frequently outpace the tolerance of the joint and its supporting structures. Some athletes have an anatomic predisposition to hip joint laxity, such as a dysplastic development of the hip, which allows great mobility but tends to make the hip joint unstable. Hip and thigh injuries in Wushu athletes are much like those encountered in dancers and gymnasts.

An athlete with *snapping hip syndrome* feels a popping sensation, clicking, or possibly a shifting in the joint, which may be palpable or audible and may or may not be painful. Often this click can be reproduced volitionally. Most frequently snapping of the hip is caused by the iliopsoas passing over the iliopectinal eminence or the iliotibial or gluteus maximus tendon passing over the greater trochanter, but acetabular labrum tears also can be a cause. The diagnosis is clinical and imaging studies seldom are necessary, although this phenomenon has been documented with ultrasound.

*Femoral-acetabular impingement syndrome* causes anterior hip and inguinal pain that is exacerbated by hip flexion, adduction, and internal rotation. Excessive stress on the hip joint or abnormal contact between the femur and the acetabulum causes inflammation of the anterior capsule and labral complex. The impingement test (pain elicited by 90 degrees of flexion, adduction, and rotation of the hip) is almost always diagnostic. Athletes with hypermobile hips and an anatomic mismatch between the femoral head and the acetabulum may be predisposed to this condition, and it is believed to contribute to the development of labral tears and osteoarthritis.

*Labral injuries* can be caused by an acute injury or progressive attritional changes; they may represent a continuum, with impingement leading to progressive joint narrowing and degenerative arthritis. Symptoms overlap those of snapping hip syndrome and impingement. Athletes with hip dysplasia, altered femoral head contour, or abnormal femoral head–neck configuration are predisposed to labral tears. Although standard radiographs can identify bony abnormalities, MRI/arthrogram with contrast is the "gold standard" for identifying labral tears.

Initial treatment for all of these hip conditions is nonoperative: oral anti-inflammatory medications, physical therapy, local modalities, activity modification (occasionally partial- or non-weightbearing) and rarely injection therapy. Muscle imbalances, suboptimal technique, and moderation in training regimen must be included with treatment. Arthroscopic or open labral repair may be required for documented labral tears.

*Stress fractures* in the hip and thigh region can occur in the acetabulum, pelvis, or proximal femur and generally cause pain in the groin, hip, buttock, or thigh. These fractures may be found in athletes with an imbalance in bone metabolic homeostasis, especially female athletes with menstrual irregularities and disordered eating habits, which can lead to osteoporosis ("female athlete triad"). Bone density should be checked in female athletes in whom this triad is suspected. Stress fractures can be documented by imaging studies and often are visible on bone or CT scans or MRI before they can be seen on standard radiographs. Stress fractures of the femoral neck in athletes tend to be compression fractures, which often heal with limitation of weightbearing; tension-oriented (distraction) fractures heal less readily and may require surgery.

*Osteoarthritis* of the hip joint is rare in Wushu athletes but can be devastating (Fig. 17.7). Development of osteoarthritis can be precipitated by trauma or repetitive extreme motions combined with jumping; it may be preceded by the impingement-labral attritional cycle. Nonoperative treatment includes nonsteroidal anti-inflammatory medications, fluoroscopic-guided intra-articular injections (steroid, hyaluronidase),

**Fig. 17.7** Osteoarthritis of hips in a Wushu instructor and previous forms competitor

altered weightbearing, and physical therapy. Persistent symptoms may require osteotomy or arthroplasty. Even with current minimally invasive total hip arthroplasty (THA) techniques, most athletes are not able to return to high competitive jumping levels after THA.

*Osteonecrosis of the femoral head* may be a primary or secondary diagnosis. A large percentage of patients have an idiopathic etiology. Posttraumatic osteonecrosis has been reported in athletes. Other contributing factors include chronic alcohol intake, corticosteroid use, sickle cell anemia, kidney disease, osteodystrophy, and gout. Imaging studies (radiographs, MRI, bone scan) can identify the severity of the osteonecrosis. Treatment depends on the level of involvement of the femoral head (graded from 1 to 4). If symptomatic treatment is unsuccessful, core decompression, vascularized bone grafting, osteotomy, or arthroplasty may be necessary.

Other hip and thigh conditions include greater trochanteric bursitis, tendonopathies (hip flexor, hamstring, quadriceps, adductor), contusions with hematomas (especially in the thigh), and injury to the lateral femoral cutaneous nerve.

## 17.13 Knee Injuries

As in other sports that require twisting, pivoting, jumping, and sudden deceleration, *knee ligament injuries* are frequent in Wushu athletes. With a tear of the *anterior cruciate ligament* the athlete feels a "pop" in the knee, with immediate pain and instability. Frequently effusion follows, with a sense of insecurity (buckling) with weightbearing. Initial treatment includes bracing, crutches for non-weightbearing, physical modalities to reduce swelling, and range-of-motion exercises. This nonoperative regimen may be appropriate for individuals who are willing to modify their lifestyles; however, they are unlikely to be able to return to activities requiring pivoting, turning, and jumping. Reconstruction of the ligament with a graft (such as patellar or hamstring tendons) generally is required for athletes who wish to return to Wushu competition. Rehabilitation after reconstruction may require 8–12 months of dedicated physical therapy.

Injury of the *medial collateral ligament* is less common and most often is caused by a direct blow to the lateral knee (usually a kick) that causes an abrupt valgus moment; the MCL can be injured by noncontact mechanisms that place excessive valgus and external rotation forces on the knee. As for ACL injuries, initial treatment is bracing, limited range of motion, and control of pain and swelling, which is successful for most MCL injuries.

Lateral collateral and posterior cruciate ligament injuries are uncommon and usually occur in combined ligament injury patterns.

*Meniscal injuries* may occur as isolated injuries or with ACL injuries and can cause localized pain, effusion, clicking, and locking of the knee. The medial meniscus is more frequently injured than the lateral meniscus. Provocation testing (McMurray, Apley) usually is positive and the diagnosis can be confirmed by MRI. Persistent mechanical symptoms may require arthroscopic or open repair, or excision (partial or complete meniscectomy) of the damaged meniscus. Meniscal repair requires a longer period of guarded weightbearing than does meniscal excision. Rehabilitation after complete meniscectomy requires a gradual resumption of weightbearing activities over a 4–6-week period; partial meniscectomy allows a more aggressive rehabilitation approach.

Other, less-frequent knee injuries include sprains, strains, or tears of the extensor mechanism, Osgood-Schlatter disease, chondromalacia patellae, and fractures of the patella, tibia, or femur.

## 17.14 Lower-Leg Injuries

*Tibial stress fractures* (anterior cortical tension fractures) are relatively common in Wushu, as they are in other running and jumping activities such as basketball, ballet, and jogging. Fractures along the posterior tibial cortex have a more predictable healing course, while those along the anterior cortex (distraction configuration) are less predictable. Once the "dreaded black line" is visible along the anterior tibial cortex on radiographs, healing can take 1–2 years with nonoperative treatment that may include alterations in weightbearing, physical therapy (often aqua therapy), pneumatic compression bracing, and electrical bone stimulation. Surgery usually is reserved for fractures that do not heal within 6 months, but may be indicated earlier for high-level athletes. Surgery may include intramedullary rod fixation, debridement of the fracture, and bone grafting.

Other lower-leg injuries include fibular fracture caused by direct contact (such as a kick), peroneal nerve injury, ankle sprains, contusions and fractures of the metatarsal, tarsal, and phalangeal, and heel areas.[14]

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# Chapter 18
# Mixed Martial Arts

**Gregory H. Bledsoe**

## Learning Objectives

- To provide a brief history of mixed martial arts
- To explain the rules and scoring of mixed martial arts
- To review the medical literature pertaining to mixed martial arts

## 18.1 Introduction

The sport of mixed martial arts (MMA) is a relatively new phenomenon in most countries. Although MMA can be traced back to the Vale Tudo matches occurring in Brazil since the 1920s and 1930s, some have argued that the true origins are more likely the ancient Greek games and the sport of pancrase. In any event, MMA has a long history and its popularity has grown exponentially in the USA and other western countries in the past 10–15 years. Though cloaked in controversy, it appears MMA is here to stay. Those involved in combat sports need to understand the history and rules of MMA in order to understand the sport and help prevent injury.

## 18.2 Background

Although pancrase – a sport in the ancient Greek games that combined wrestling and boxing – appears similar to MMA, the recent history of the sport is traced back to the country of Brazil and in particular the Gracie family. The story of the beginning of MMA in the USA – a beginning that spread to other countries like Japan, Canada, and many in Western Europe – is a story of the beginning of a new martial art called Brazilian, or Gracie, Jiu Jitsu. The name Brazilian Jiu Jitsu (BJJ) was given to this art to differentiate it from the traditional art of Japanese Jiu Jitsu from which it sprang.

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Brazilian Jiu Jitsu (BJJ) began with the immigration of a highly skilled jiu jitsu (judo) fighter named Count Komo (Mitsuo Maeda) from Japan. At the beginning of the 1900s Japan was attempting to form a colony in the country of Brazil and Count Komo immigrated in order to further the work of the Japanese in that country. Komo was a skilled jiu jitsu fighter who had trained under the tutelage of the famous Jigoro Kano, the founder of modern judo.

During Komo's time in Brazil the Japanese colony was aided by a Brazilian politician of Scottish descent named Gaston Gracie. As a means of thanking Gracie for helping the colony, Komo began mentoring Gracie's sons in the art of jiu jitsu even though teaching the art to non-Japanese was forbidden at that time. Komo continued teaching Gracie's sons for a few years and then moved back to Japan, leaving them to modify the art.

Of the Gracie's sons, the most notable were Carlos, the athletic older brother, and young Helio, a frail and small child. Carlos began modifying the art to make it as practical as possible for the rough streets of Brazil. In the beginning, Helio Gracie had difficulty with the techniques due to his small stature. To compensate for his small size he practiced different leverage points to maximize the efficiency of a technique allowing even a very small person to accomplish it and defeat a much stronger opponent. Through Helio's creativity and constant practice, BJJ became a very practical and efficient art that truly allowed a smaller opponent to defeat a larger one.

As Helio Gracie entered his athletic prime he and Carlos attempted to promote their art by offering a challenge that any man of any size could request a fight. These matches were called *Vale Tudo*, which means "anything goes" in Portugese, the native language of Brazil. Helio fought many times in these first "no holds barred" fights and his fame began to spread across the country.

Helio Gracie fought any and all comers for years in Brazil, even challenging the great US heavyweight boxer Joe Louis to a fight (Louis declined). Over the next half century, the name Gracie and the art of jiu jitsu that the family developed was respected throughout the country of Brazil.

In the early 1990s, Rorian Gracie, one of the sons of Helio Gracie, helped create a new enterprise called the Ultimate Fighting Championship (UFC). The UFC was Rorian Gracie's way of showcasing in the USA the effectiveness of the art that his father had developed. In 1993, the first UFC was held in Denver, Colorado. It was promoted as a no-holds-barred bloodsport with no weight classes, no time limits, and few rules. This first UFC was fought in tournament format in which the winner would continue competing until he won the bracket – three fights in one night. Rorian and the Gracie family selected younger brother Royce Gracie to represent the clan in this first UFC.

Although Royce Gracie only weighed around 175 lb (80 kg), he defeated all his opponents by tap out (the opponent signaling their desire to end the match by tapping the mat) even though he was outweighed in every fight, sometimes by as much as 60 lb (27 kg). This first event caused three major happenings in the world of martial arts. First, it catapulted the Gracie name into the fight business in the USA and introduced their art, Brazilian Jiu Jitsu, to American fight enthusiasts. Second, it demonstrated the effectiveness of grappling techniques and the importance for a fighter to know how to fight on the ground – until this time most fighters focused solely on striking and the striking arts such as boxing, karate, and taekwondo. Third, it coined a new term “ultimate fighting” that eventually developed into the current sport of mixed martial arts.

Over the next decade the UFC and the sport of MMA went through difficult times as they faced mounting criticisms from combat sports regulators and the mainstream media. Senator John McCain lead the charge to ban the new sport, calling it “human cock fighting” [1] and when no legitimate sport authority sanctioned the events, the sport was forced to survive underground due to a lack of funding and pressure from the government.

In 2001, a company named Zuffa bought the rights to the UFC and began working with both the New Jersey State Athletic Control Board and the Nevada State Athletic Commission to develop a set body of rules so that the sport could become a sanctioned event in those states. Currently, the sport of MMA is sanctioned in approximately 30 states in the USA and its pay-per-view ratings top even well-promoted boxing matches. In the USA, the sport of MMA is riding a wave of popularity behind the creation of a cable television show and a marketing blitz by Zuffa and its partners. The sport of MMA is now the fastest growing combat sport in the world.

## 18.3 Rules

The rules of MMA have changed dramatically from the first days of the UFC. While the original events were marketed as no-holds-barred blood-fests, the current organizers have moved towards regulations with an emphasis on fighter safety and longevity of the sport.

The New Jersey State Athletic Control Board was the first to provide an acceptable measure of regulations and rules. These rules were in turn adopted by Zuffa and accepted by the Nevada Boxing Commission (Table 18.1). By 2001, MMA was an officially sanctioned sport in Nevada and New Jersey, bringing MMA back onto pay-per-view and beginning its metamorphosis into a mainstream sporting activity.

Originally, MMA was vilified for having no meaningful rules. Contestants entered an octagon and fought without time limits, without weight classes, and in a tournament format that saw fighters fighting sometimes three or four matches during a single event. Under the current sanctioning regulations, MMA fighters must meet the same requirements for all other combat sports participants. They are required to fight within a weight class (Table 18.2) and they receive prefight medical screening that tests for infectious disease and structural brain anomalies that would preclude them from fighting (Table 18.3).

MMA matches are typically three rounds of 5 min each. Championship bouts last five rounds. An MMA match is decided by one of five possible outcomes: decision, knockout (KO), technical knockout (TKO), tap out (TO), or choke. In a decision,

**Table 18.1** Acts Constituting Fouls for MMA Matches (Nevada State Athletic Commission, http://www.leg.state.nv.us/NAC/NAC-467.html)

1. Butting with the head
2. Eye gouging of any kind
3. Biting
4. Hair pulling
5. Fishhooking
6. Groin attacks of any kind
7. Putting a finger into any orifice or into any cut or laceration on an opponent
8. Small joint manipulation
9. Striking to the spine or the back of the head
10. Striking downward using the point of the elbow
11. Throat strikes of any kind, including, without limitation, grabbing the trachea
12. Clawing, pinching, or twisting the flesh
13. Grabbing the clavicle
14. Kicking the head of a grounded opponent
15. Kneeing the head of a grounded opponent
16. Stomping a grounded opponent
17. Kicking to the kidney with the heel
18. Spiking an opponent to the canvas on his head or neck
19. Throwing an opponent out of the ring or fenced area
20. Holding the shorts or gloves of an opponent
21. Spitting at an opponent
22. Engaging in any unsportsmanlike conduct that causes an injury to an opponent
23. Holding the ropes or the fence
24. Using abusive language in the ring or fenced area
25. Attacking an opponent on or during the break
26. Attacking an opponent who is under the care of the referee
27. Attacking an opponent after the bell has sounded the end of the period of unarmed combat
28. Flagrantly disregarding the instructions of the referee
29. Timidity, including without limitation, avoiding contact with an opponent, intentionally or consistently dropping the mouthpiece or faking an injury
30. Interference by the corner
31. Throwing in the towel during competition

**Table 18.2** Weight classes for MMA events in Nevada (http://www.leg.state.nv.us/NAC/NAC-467.html)

| | |
|---|---|
| Flyweight | up to 125 lb |
| Bantamweight | over 125–135 lb |
| Featherweight | over 135–145 lb |
| Lightweight | over 145–155 lb |
| Welterweight | over 155–170 lb |
| Middleweight | over 170–185 lb |
| Light heavyweight | over 185–205 lb |
| Heavyweight | over 205–265 lb |
| Super heavyweight | all over 265 lb |

**Table 18.3** MMA prefight screening tests

| |
|---|
| EKG |
| Urinalysis |
| CBC |
| Electrolytes |
| RPR |
| HIV |
| MRI/MRA of brain |
| Eye exam by an ophthalmologist |
| Hepatitis B |
| Hepatitis C |

fighters fight the entire bout without a decisive victory. Judges award a fighter the "decision" based on his apparent advantage throughout the fight. A knockout is defined as the spontaneous loss of consciousness, usually immediately following a strike to the head. A technical knockout (TKO) is ruled when the fighter has taken significant punishment from his opponent, but has not been knocked out. A tap out is unique to MMA. Fighters signal a tap out by tapping the mat or their opponents when caught in an armlock or other "submission hold" from which they cannot free themselves. Fighters are allowed to tap out from strikes when they are taking significant blows and cannot intelligently defend themselves. A "choke" occurs when a fighter passes out from a constricting choke hold prior to tapping out.

## 18.4 Equipment

MMA participants are required to use a mouthpiece, a cup for groin protection, and 4–6 oz "grappling gloves" with the fingers and thumb exposed so the participant can grasp his opponent. Participants are not allowed to wear any other garb, including but not limited to, masks, traditional martial arts gis, and shoes.

## 18.5 Training

Fighters who train for MMA bouts receive instruction in a variety of martial art specialties. Most competitors have an area of expertise from which they arrived in MMA – wrestling, Brazilian Jiu Jitsu, Judo, boxing, kickboxing, and Muay Thai kickboxing – but all crosstrain in multiple disciplines. Since bouts start on the feet, but can continue on the ground, contestants must be proficient in many different techniques and be able to defend against many different styles.

Participants are well conditioned and schedule regular intervals of both cardiovascular and strength training with weights. It is not unusual for MMA contestants to have fought at very elite levels in other sports, and more than one professional fighter has been drawn from the Olympic ranks, particularly in the grappling arts like wrestling. A survey published by Amtmann [2] in 2004 indicated that most MMA fighters participate in a variety of strength exercises and regularly supplement their training with a number of conditioning regimens.

## 18.6 Injuries

Although much has been written about MMA in the lay press, very little research has been done on the injuries in MMA. Only three articles in the medical literature focus on MMA injuries.

The first article was an attempt to determine if certain techniques used during MMA put the spine – particularly the cervical spine – at risk. Kochhar et al. used kinematics and biomechanical models to “assess qualitatively and quantitatively the potential risk for participants to sustain cervical spine and associated soft tissue injuries” [3]. From their models the authors determined that MMA participants were using techniques that placed the cervical spine at significant risk. It should be noted that all four techniques studied – the *O goshi* judo hip throw, the suplex wrestling/jiu jitsu takedown, the souplesse (a throw similar to the suplex), and the guillotine drop (a jiu jitsu choke hold) – are all legal techniques in Olympic grappling sports such as Judo and wrestling. While the models seemed to indicate that MMA participants were at increased risk of cervical spine injuries, no data or studies were available at that time to put the theory to the test.

The first medical article to actually report injuries in the medical literature was published in the *British Journal of Sports Medicine*. In this article, the author reviewed video footage of 642 MMA matches between 1993 and 2003 to determine the reasons for match stoppage [4]. The findings suggested that blunt trauma to the head was a common reason for match stoppage and fighters in MMA are at risk of head injury.

The only other article to look at MMA injuries was published in 2006 in *The Journal of Sports Science and Medicine*. The authors of this article reviewed the comments made by the ringside physicians and the outcomes of 171 fights in the state of Nevada [5]. The results were compared to a prior study using the same methods that looked at boxing injuries in that state [6].

The findings of this study demonstrated an injury rate of 28.6 per 100 fight participations, comparable to the prior reported boxing rate of 17.1 per 100 fight participations. The most common means of ending a fight in MMA was shown to be technical knockout (TKO) followed by tap out (TO). When the proportion of knockouts (KO) in MMA was compared to boxing, MMA had 6.4% of matches ending in KO while boxing had 11.3%.

The findings of all three of these MMA studies demonstrate the need for further research on this important topic. No longitudinal studies have been done on MMA athletes, so much remains to be determined about the true long-term consequences of these matches.

Although there is a lack of data, this has not stopped both critics and proponents of MMA from weighing-in on the relative safety of the sport. Critics of MMA have likened MMA to "a bar-room brawl." They mention the use of elbows and knees as striking instruments as potential problems (in the USA and most MMA matches, knees to an opponent while he is on the ground are forbidden; elbow strikes, however, are allowed).

Proponents point to the fewer rounds – most MMA matches are three rounds with championship matches lasting five rounds – and the lack of a "standing eight count" (like the rule in boxing that allows a fighter to continue with the match after he is concussed) as two measures that help ensure the safety of MMA. Also, through use of the "tap out," MMA provides an honorable means for fighters to end the match if they are caught in a submission hold or are taking too much damage. The "tap out" is the second most common ending to most MMA matches [5]. It should be noted that although there have been numerous deaths in other combat sports, there has never been an MMA death in a sanctioned MMA event. The only MMA death of note is one of an American fighter who fought in an unsanctioned event in the Ukraine in 1998 [7].

## Summary

MMA is a growing combat sport and involves well-conditioned athletes from a variety of backgrounds. More research is necessary to elucidate the true risk of MMA, but initial studies seem to indicate that it is at least as safe as other combat sports involving striking.

## Further Reading


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# Chapter 19
# Kickboxing

**George J. Buse**

## Learning Objectives

- To understand the physiologic demands of competitive kickboxing
- To outline a training regimen that will improve a kickboxer's anaerobic and aerobic capacities
- To identify the most common injuries sustained in kickboxing and suggest preventive measures
- To outline the provision of medical coverage for kickboxing matches

## 19.1 History

Although the genesis of modern kickboxing remains elusive and debatable, several sources have traced its origin to the sixteenth century.[1–3] During this time, soldiers in Indochina trained to use each segment of each limb for offensive and defensive purposes. Such training prompted military members to test their skills against each other in competitive kickboxing matches. In Thailand especially, these matches were embraced by royalty and the general populace alike.[1–3]

The matches involved two competitors directing full-force strikes with the hands, elbows, knees, shins, and feet at each other. Matches were stopped after expiration of a given time limit or once a competitor could no longer continue. Rules became standardized in the twentieth century and the kickboxing matches were formally recognized as *muay Thai* (Fig. 19.1), which translates to *Thai boxing*.[1–3]

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**Fig. 19.1** Professional muay Thai kickboxers (Photo courtesy of Mick Lowe)

Although other styles such as Japanese kickboxing may have direct lineage to Thai kickboxing, the styles of Chinese san shou, French savate, Indian adithada, and American- or European-rules kickboxing seem to have developed asynchronously and independently of their Thai counterpart. The following is not inclusive of all kickboxing styles, but highlights the most common and influential styles observed internationally.

Japanese kickboxing, also known as international rules kickboxing, gained popularity in the 1960s and its development in Japan was likely influenced directly by Thai kickboxing.[2] Japanese kickboxing is similar to Thai kickboxing, except the former does not consistently allow for strikes with the elbows and knees. In addition, Japanese kickboxing does not incorporate the ritualistic aspects of its Thai predecessor.

San shou is historically and etymologically related to *san da*, which translates to *free fighting*. Derived from the hand-to-hand combat training of the Chinese military and a ramification of modern wushu, san shou became recognized as an official sport by the Chinese government in the twentieth century.[4]

Savate, which may be translated from French as *old shoe* and first referenced in eighteenth-century literature, was likely derived from the fighting styles of sailors and hoodlums.[5] By the 1800s, a savate training center was established in Paris, the style became popular throughout France, and Napoleon III mandated that his soldiers be proficient in its application. This style is unique in that competitors wear shoes during competition. Technically, a scoring blow may be recognized if any portion of the shoe contacts one's opponent. Savate was recognized internationally as an official sport in the 1900s.

Adithada is a style that appears to have developed in southern India and is similar to Thai kickboxing. However, the former adds pressure point techniques to the competitor's armamentarium. Adithada potentially antedated and influenced the development of other kickboxing styles in Indochina.[6]

American- or European-rules kickboxing appeared in the late 1960s as a full-contact variant of sport karate; hence, this style is also referred to as full-contact karate.[7] With the exception of foot sweeps, this style's rules mandate that all strikes be delivered above the waist.

## 19.2 Current Practice

Certain regions may promote one style of kickboxing over others due to spectator-based, cultural, or ritualistic interests. However, some event organizers promote several different kickboxing styles on one fight card, and may even showcase other combat sports such as mixed martial arts (MMA) and boxing. Some individuals participate in point or semi-contact kickboxing matches, in which full-force techniques are not allowed or are strictly limited.[8]

## 19.3 Facilities and Equipment

Training facilities generally have a variety of heavy bags, handheld pads, speed bags, protective body pads, jump ropes, medicine balls, headgear, boxing gloves, shin guards, and areas for calisthenics and sparring. Actual competitions are typically held in a boxing ring. However, some venues hold matches on an unenclosed platform or in a cage as used for MMA.

Protective equipment for competition varies depending on the kickboxer's sex, experience level, and the rules specific to a given style of kickboxing. Amateur kickboxing match rules, in general, mandate that competitors wear boxing gloves, mouth guards, protective headgear, groin protectors for males, and shin guards (Fig. 19.2). For those amateur matches in which competitors are not allowed to kick below the waist, protective foot covers are also usually required (Fig. 19.3).

Amateur matches in Thai kickboxing may include the addition of elbow and thoracoabdominal padding (Fig. 19.4).

**Fig. 19.2** Amateur kickboxers (Photo courtesy of Connie Szeto. Note the protective equipment typically worn by amateurs)

**Fig. 19.3** Amateur kickboxers, American or European rules (Photo courtesy of IAKSA ("IAKSA" stands for International Amateur Kickbox Sport Association). Note the addition of protective foot covers per these rules)

Professional kickboxing match rules, in general, mandate that competitors wear boxing gloves, mouth guards, and groin protectors for males (Fig. 19.1). For professional matches in which competitors are not allowed to kick below the waist, shin guards and protective foot covers are also usually required.

Photo courtesy of Andrew C. Villasis. Note the addition
of padding for the elbows and thoracoabdominal region per these rules.

**Fig. 19.4** Amateur kickboxers, Thai rules (Photo courtesy of Andrew C. Villasis. Note the addition of padding for the elbows and thoracoabdominal region per these rules)

## 19.4 Rules Related to Sports Medicine

A kickboxing match is typically divided into rounds of 2–4 min each with a rest of 1–2 min between each round. A Thai kickboxing match often consists of 3–5 rounds, while other styles of kickboxing may have more than 12 rounds per match. A competitor seeks victory by (1) disabling his or her opponent via any permutation of techniques, or (2) outscoring an opponent by landing blows more frequently and decisively (Table 19.1).

## 19.5 Training and Physiology

Bioenergetics underlies physiology and should be considered when designing a kickboxing training regimen. Adenosine triphosphate (ATP) serves as an immediate source of energy for muscle contraction and its replenishment is core to sustained performance.[9] ATP is replenished through anaerobic and aerobic metabolism. Anaerobic metabolism includes the phosphocreatine-based phosphagen system and the lactic acid-producing anaerobic glycolysis system. The phosphagen system is most active through the first 10–15 s of maximal-intensity exercise, whereas anaerobic glycolysis predominates if the effort lasts greater than 10–15 s. For efforts

**Table 19.1** Legal techniques and scoring areas in kickboxing[1–8]

| Kickboxing style | Legal techniques | Legal scoring areas[a] |
|---|---|---|
| Thai (Muay Thai) | Punches, clinching, takedowns, elbow strikes,[b] knee strikes,[c] kicks | Head, neck, torso, upper and lower extremities |
| Japanese (International Rules) | Punches, clinching,[b] elbow strikes,[b] knee strikes,[c] kicks | Similar to Thai style |
| Chinese (San Shou) | Punches, clinching, takedowns, body throws, knee strikes,[b,c] kicks | Similar to Thai style |
| French (Savate) | Punches, kicks | Similar to Thai style |
| Indian (Adithada) | Similar to Thai style; includes pressure point techniques | Similar to Thai style |
| American/European (Full-Contact Karate) | Punches, foot sweeps, kicks | Except for foot sweeps, all blows are above the waist |

[a] The posterior head, spine, and groin are not usually legal scoring areas
[b] Allowed variably in some organizations
[c] Head is a legal target variably with this technique

**Table 19.2** Percent contribution of anaerobic and aerobic metabolism to ATP replenishment during maximal-intensity exercise (Adapted from Powers and Howley[9])

| Duration of maximal-intensity exercise (s) | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 | 30 | 60 | 120 | 240 | 600 | 1,800 |
| Anaerobic (%) | 90 | 80 | 70 | 60 | 35 | 15 | 5 |
| Aerobic (%) | 10 | 20 | 30 | 40 | 65 | 85 | 95 |

Shaded portion represents typical time range of a round in kickboxing

lasting greater than 2 min, pyruvic acid-producing aerobic glycolysis, the Krebs cycle, and oxidative phosphorylation pathway work in tandem to provide the majority of ATP replenishment. To clarify, aerobic metabolism still occurs during short-duration, maximal-intensity exercise; however, the majority of ATP is provided via anaerobic pathways in such instances (Table 19.2).[9]

As with karate, the repetitive delivery of high-power techniques makes kickboxing an anaerobically demanding sport.[10] Anaerobic replenishment of ATP is key to maximal power output, which is the maximum amount of work done in the least amount of time.[9] However, since rounds last between 2 and 4 min, a match may have up to 12 rounds, and recovery is facilitated by aerobic metabolism, a kickboxer could conceivably derive more than 50% of ATP from aerobic metabolism (Table 19.2).[9,11]

Since kickboxing taxes both the anaerobic and aerobic systems, the kickboxer should focus on optimizing each. Poor anaerobic or aerobic capacity is of concern, for the unconditioned, inexperienced competitor may be at increased risk for injury.[12] In addition to adequate rest, nutrition, cultivation of kickboxing skills, and psychological preparedness, a critical determinant of a fighter's success is the degree to which he/she trains the metabolic pathways and skeletal muscles.[13]

Zabukovec and Tiidus examined physiologic variables among four elite professional kickboxers.[14] Mean anaerobic capacity was comparatively higher than that of elite amateur wrestlers, while mean aerobic capacity exceeded that of elite karate competitors and boxers. Although the sample size was small, limited to males weighing 68–76 kg, and focused on American- or European-rules kickboxing, the researchers found that elite professional kickboxers developed relatively high anaerobic and aerobic capacities.

Anaerobic capacity may be improved through high-intensity interval training, other forms of power training, and strength training.[11,13] Aerobic capacity may be improved through interval training and endurance training.[9,11,15] Since interval training can improve anaerobic and aerobic systems concomitantly, it should be a mainstay of the fighter's training regimen.[13,15]

Interval training for the kickboxer should involve intense sprint-type exercises. Examples include hill sprints and rapid, forceful barrages of punch-kick combinations into a target. To train the phosphagen system, the kickboxer should perform maximal-intensity sprints that last less than 15 s. A 1:5 work to rest ratio is appropriate (e.g., after 10 s of work, rest 50 s) with about five sets done per session.[13] To train the anaerobic glycolysis system and improve tolerance to lactic acid accumulation, the kickboxer should perform sprints that last roughly 15 s–2 min. A 1:2 work to rest ratio is appropriate with several sets done per session.[13] Of note, the less one rests between sets or the longer one sustains a sprint, the greater the utilization of one's aerobic metabolism.[9,11] Due to the high demands of interval training, sessions should be limited to several sessions per week with roughly 48 h between sessions.

In addition to interval training for anaerobic improvement, other power-training methods may be incorporated into the kickboxer's training regimen. Examples include explosive weightlifting techniques, plyometrics, and agility drills. Explosive weightlifting techniques include the hang clean and power snatch. Plyometrics, which help decrease the transition period between eccentric and concentric muscle contractions,[16] include single-leg hops, box jumps, and medicine ball catch-throws. Agility, defined as the ability to change direction rapidly and then accelerate,[17] may be improved through speed-intensive footwork drills in the ring.

Each repetition performed during power training should involve a high degree of mental concentration, be performed with maximal force generation in the least amount of time, and rest periods between sets should be adequate enough to ensure that the kickboxer sufficiently recovers for the next set. From a neuromuscular standpoint, speed and power cannot be maximized if power training is conducted in a fatigued state.[11]

For explosive weightlifting, the kickboxer should consider performing less than six repetitions at 75–90% of his/her one-repetition maximum for that lift. A 2–5 min rest is appropriate between each set, several sets may be performed per session, and no more than 2–3 sessions should be done per week.[18]

Plyometrics may include about 100 contacts (e.g., 100 single-leg hops) per session. A session could be divided into 10 sets, with 10 maximal-intensity contacts performed per set. An appropriate work to rest ratio may be as much as 1:10, 48–72 h should elapse between sessions, and no more than several sessions should be conducted per week.[16] For additional background in power training and examples of programs that may be useful for the kickboxer, the reader is referred to Chu[16] and Fleck and Kraemer.[18]

Strength training can increase the force of maximal contraction and the velocity of submaximal contraction, both of which are key to power development.[9] Strength training may also provide a base for power training[18] and prevent injury by fortifying the musculotendinous structures that support joints.[19] Strength refers to the time-independent production of force by muscle,[9] and is especially important for isometric-type challenges (e.g., clinching in Thai kickboxing). However, power and endurance remain quintessential to the kickboxer's success.[14] Therefore, interval training and kickboxing-specific drills should take precedence over strength training alone.

Strength training for fighters should include multi-joint lifts that mimic motions used in competition (e.g., bench press motion is similar to that of a straight punch).[13] To improve strength, the kickboxer should perform several sets of an exercise at a weight that allows no more than 12 repetitions per set. Strength gains are diminished when greater than 15 repetitions are performed per set; likewise, no additional gains are seen with higher training volumes (e.g., six sets per exercise).[9,18] A rest of 2–5 min is appropriate between sets and at least 48 h should elapse before a body part is strength-trained again. Of note, shorter interset rest periods and higher repetition schemes promote muscular endurance over strength gains.[9,18] For additional background in strength training and examples of programs that may be useful for the kickboxer, the reader is referred to the monograph of Fleck and Kraemer.[18]

To improve maximal aerobic capacity (i.e., maximal rate of oxygen consumption, or $VO_{2max}$), the kickboxer should consider incorporating interval and endurance training into his/her regimen. Interval training as discussed above can further tax aerobic metabolism if one increases the duration of a sprint activity or decreases the rest period between sets.[9,11] Aerobic capacity may also be optimized through judicious endurance training. Examples include running, sparring, and heavy bag drills. Endurance training should be done at 60–80% of one's $VO_{2max}$, last 20–30 min per session, and should not exceed four sessions per week in light of other training demands.[9,13] To estimate percent $VO_{2max}$ and therefore training intensity, the kickboxer may use his/her resting heart rate (HR) and heart rate reserve (HRR).[20] Conveniently, 60–80% of HRR approximates 60–80% of $VO_{2max}$.[9] Table 19.3 illus-

**Table 19.3** Estimating target exercise intensity via heart rate reserve.[20]

| Formula steps | Example |
|---|---|
| 1. Maximal HR = 220 – Age in years | 220 – 20 = 200 bpm |
| 2. HRR = Maximal HR – Resting HR | 200 – 60 = 140 bpm |
| 3. 60% HRR = 0.60 × HRR | 0.60 × 140 = 84 bpm |
| 4. 80% HRR = 0.80 × HRR | 0.80 × 140 = 112 bpm |
| 5. Add 60% and 80% HRR values to resting HR to obtain target HR range | 84 + 60 = 144 bpm 112 + 60 = 172 bpm |
| The target HR range for this kickboxer would therefore be 144–172 bpm, which corresponds to the desired aerobic exercise intensity of 60–80% of $VO_{2max}$. | |

Example: 20-year-old with resting heart rate of 60 beats per min
HR: heart rate; bpm: beats per min; HRR: heart rate reserve

trates the means by which HRR, target HR, and therefore sustained exercise intensity may be estimated.

For a kickboxer with an already high relative $VO_{2max}$ (e.g., 75 ml/kg/min), he/she would have to train greater than 85% of $VO_{2max}$ to derive additional, albeit likely negligible, improvements in aerobic capacity.[9] Contrary to the misconception that abundant endurance training (e.g., jogging 60 min daily) builds an “aerobic base” for anaerobic training, prolonged endurance training can actually impair power and strength development.[9,11,13,21] For additional background in aerobic training that may be useful for the kickboxer, the reader is referred to Potteiger.[22]

The aforementioned methods are used to improve anaerobic and aerobic capacities without the same risk of injury and overtraining that a kickboxer may face by solely engaging in maximal-intensity sparring. However, sport-specific training fosters reciprocal improvements between neuromuscular memory (e.g., efficient and instinctive application of fighting techniques) and exercise metabolism.[9,11,13] Therefore, controlled sparring and related drills should be an integral part of the kickboxer’s training regimen.

Techniques are often delivered through a relatively full range of motion (e.g., kicks directed at the head of a standing opponent). Therefore, the kickboxer should consider the usefulness of routine flexibility training. This may include progressive static and technique-based dynamic stretches. If feasible, the kickboxer may implement proprioceptive neuromuscular facilitation stretches, which have been shown to be superior to other methods for improving range of motion.[23] The reader is referred to Holcomb[24] for flexibility training that may be useful for kickboxers.

Overtraining, which is stagnation in performance due to exerting oneself too intensely for too long, may be averted by varying one’s training routine, tapering training intensity and volume several days to weeks prior to competition, applying periodization strategies such that one peaks for competition, and ensuring nutrition as well as rest are commensurate to training demands.[9,11] For proper nutrition and psychological optimization, the reader is referred to Chapters 1 and 3, respectively.

## 19.6 Acute and Chronic Injuries

Since the main intent of the kickboxing encounter is to land blows more frequently and decisively than one’s opponent,[8] both acute and chronic injuries may be expected. Data are limited with regard to the type and severity of chronic injuries among kickboxers. However, acute injury trends have been elucidated in several studies and case reports.

Focused on injuries among professional kickboxers, Zazryn et al. reviewed all match injuries from 1985 to 2001 that were recorded in an Australian combat sports database.[25] Of 3,481 fight participations, a total of 382 injuries were observed. Fight participation could be defined as one kickboxer’s exposure to one match.

Injury to the head, face, and neck area was most common in this study. Nearly 52% of all injuries involved this anatomic region, which translated to about 57 such injuries per 1,000 fight participations. The second most common region of injury was the lower extremity, which accounted for nearly 40% of all injuries or about 44 such injuries per 1,000 fight participations.

Although the head, face, and neck areas were the most commonly injured regions, the specific body part that was most commonly injured was the lower leg. Nearly 26 lower-leg injuries were observed per 1,000 fight participations. The second most common site was the face, with approximately 21 facial injuries per 1,000 fight participations. Approximately half the fight participations that resulted in injury involved a knockout or required stoppage of the match by the referee. Of the fight participations that involved injury, only 30% resulted in a win for those kickboxers that were injured.

In terms of type and rate of injuries sustained, superficial wounds (e.g., abrasions) were most common. About 40% of all injuries involved superficial wounding, which translated to 43 such injuries per 1,000 fight participations. Open wounds (e.g., lacerations) were the second most common, with nearly 25% of all injuries or about 27 such injuries per 1,000 fight participations. Intracranial injuries, which included concussions, were next at 18% of all injuries or about 19 such injuries per 1,000 fight participations. Fractures and internal organ injuries were least common. These findings highlighted the nature of kickboxing: the lower extremity is often used to both deliver and absorb forceful blows, while the head region is a common target.[8,25–27]

Focusing on injuries sustained among amateur kickboxers, Gartland et al. assessed prospectively the type and rate of injuries associated with competition.[26] Among 92 Thai-style kickboxers that compiled nearly 590 min of competition time, 15 injuries were observed: epistaxis (six incidents), concussive head trauma (six incidents), head laceration (two incidents), and leg contusion (one incident). The researchers reasoned that the scoring system in Thai kickboxing may have been contributory to the preponderance of head trauma. Since head strikes were scored higher and could end the match early via knockout, competitors may have been compelled to target the head aggressively. Diametric to their professional counterparts,[25] amateurs in this study had relatively few injuries to the lower extremity region. This may have been related to the mandatory wear of shin guards among the amateurs. Of the 12 females in the study, none sustained an observable injury. This was postulated to be due to differences in force generation, technique execution, and aggressiveness as compared to the males.

Another prospective study of 148 amateurs in Thai kickboxing addressed the type and number of injuries that caused match stoppage.[8] Twenty-three of the 74 total matches (31%) were stopped due to injury. Fifteen (65%) of all the match-ending injuries were due to concussion, four (17%) were due to lower extremity injury, three (13%) were due to blunt trauma to the thoracoabdominal region, and one injury involved ocular trauma from a punch. The proportion of matches stopped due to concussion was significantly higher than that of all other causes combined. As in Gartland et al.,[26] this finding was attributed to the fact that head kicks were scored higher and victory was attained most readily via knockout. However, in contrast to Gartland et al.,[26] female kickboxers in this study sustained injuries. Furthermore, there was no significant difference in the proportion of matches stopped due to concussion between males and females.

With regard to lower extremity injuries that required match stoppage, half involved powerful kicks impacting the receiving kickboxer's lateral knee. Post-match evaluations were highly suspicious for internal derangement of the knee. The remaining lower extremity injuries involved debilitating thigh contusions. All matches stopped because of thoracoabdominal trauma were caused by knee strikes. Although blunt force to this area may increase one's risk for pneumothorax, myocardial injury, damage to intra-abdominal structures, and potential fetal injury among pregnant competitors, such injuries occur relatively infrequently in sports.[12,28] Likewise, no such injuries were observed among the kickboxers in this study.

Another study was conducted in which 152 Thai-style kickboxers were interviewed throughout the UK and Holland.[27] The kickboxers, who had at least 1 year of training were stratified based on competitive background: beginner (i.e., no contact allowed), amateur (i.e., full contact allowed but headgear, mouth guards, elbow pads, boxing gloves, body padding, groin protectors for males, and shin guards were required), and professional (i.e., full contact allowed with only mouth guards, groin protectors for males, and boxing gloves used for protection). The number of injuries reported was directly proportional to experience, wherein beginners had the least and professionals the most. Across all experience levels in this study, lower extremity injury was reported most frequently. It corresponded to three fourths of the injuries sustained among beginners, nearly two thirds of the injuries among amateurs, and about half the injuries among professionals. In terms of types of lower extremity injuries sustained, there were reportedly 780 incidents of shin contusion, 298 incidents of thigh contusion, and nearly 100 incidents of foot contusion. Among professionals, fractures were expectedly more common because less protective equipment was required, training may have been more intense, and impact forces were likely greater than that among less-experienced kickboxers.

Head trauma accounted for approximately 2%, 31%, and 43% of all injuries sustained among beginners, amateurs, and professionals, respectively. The low percentage among beginners was attributed to the noncontact nature of their participation. However, head trauma was the second most common injury among amateurs and professionals. In terms of the types of head injuries sustained, there were reportedly 545 incidents of head and neck contusion, 158 incidents of head and neck laceration, 40 incidents of epistaxis, and 22 incidents of nasal fracture. Similar to the aforementioned studies,[8,25,26] head and lower extremity trauma were again the two most commonly reported acute injury types.

In an attempt to ascertain the effects of Thai kickboxing on renal and hepatic function, Saengsirisuwan and colleagues obtained serum and urine samples from 10 sedentary adolescent males and compared the results to those of 10 adolescent male Thai kickboxers.[29] Although mean age was less than 16 years, those in the kickboxing group were recognized as professional competitors. The kickboxing group exhibited significantly higher concentrations of serum creatine kinase as well as aspartate aminotransferase after training and competition as compared to the sedentary controls. These findings suggested that muscle cell damage occurred during training and competition. However, there was no conclusive evidence that training or competition resulted in compromised renal or hepatic function.

Several case reports about kickboxing-related injuries have been published in the medical literature. During a world championship match, a kickboxer received multiple blows to his left thigh.[30] Six hours after the match, he presented with progressively worsening thigh pain. Based on his pain, a palpably tense anterior thigh, and an elevated intracompartmental pressure measurement, he was diagnosed with acute compartment syndrome. The middle portion of his left vastus lateralis was found to be ruptured and 300 ml of blood was evacuated from the thigh during fasciotomy. He was discharged from the hospital 9 days later and resumed his kickboxing career within 1 year.

Malek et al. reported the case of a kickboxer that suffered traumatic dissection of his left vertebral artery.[31] While sparring with full protective gear, the kickboxer received a kick to his left jaw. He subsequently developed stroke-like symptoms to include dysarthric speech, a sluggish pupillary response to light, left sixth cranial nerve palsy, and a left facial droop. Computed tomography of the head revealed diffuse subarachnoid hemorrhage and blood in the fourth ventricle. Cerebral angiography exposed an intracranial fusiform pseudoaneurysm of the left vertebral artery. The pseudoaneurysm was treated endovascularly, the kickboxer underwent rehabilitation, and his deficits resolved within 3 months of the injury. Echaniz-Laguna et al. reported another case of dissection due to a kick, although this episode involved the internal carotid artery.[32]

One case report discussed an isolated first rib fracture sustained by an individual during a kickboxing match.[33] The kickboxer presented with stabbing pain in the right shoulder area, which began during his match. Despite normal initial radiographs, pain persisted beyond 4 weeks. Four weeks after the match, follow-up imaging studies confirmed the above diagnosis. Although his symptoms finally resolved after 6 months, the authors noted that serious sequelae of this condition include pneumothorax, aortic arch aneurysm, tracheoesophageal fistula, brachial plexopathy, subclavian artery rupture, and periclavicular abscess formation.[33]

In another case report, a kickboxer ruptured his left extensor pollicis longus (EPL) tendon.[34] He incurred the injury by performing reverse press-ups as a part of his kickboxing training regimen. This exercise stressed the dorsum of the hands and involved wrist hyperflexion. The ruptured EPL was irreparable, but an extensor indicis proprius transfer resulted in full restoration of finger motion by 8 weeks postoperation.

Davis and colleagues surveyed participants in kickboxing exercise classes.[35] Of 572 surveys reviewed, the researchers discovered that instructors had a slightly higher rate of injury as compared to students. A significant relationship existed between the occurrence of injury and number of days of participation. The most common sites injured, in descending order, were the back, knees, hips, and shoulders. About half the injured participants sought medical care. Nearly two thirds of the injured participants had to change their daily activity routines as a result of injury. Although this study did not specifically address competitive kickboxing injuries, it did generalize injury trends for those engaged in the fundamentals of kickboxing training (e.g., shadow boxing, calisthenics). As such, these results may be most applicable to novices that are beginning training. Likewise, the results reinforced the need for individuals to warm up before participating, increase exercise intensity gradually, and recover sufficiently between sessions to decrease their risk for injury and overtraining.[11]

## 19.7 Mechanism of Injuries and Risk Factors

Injuries in competitive kickboxing are caused primarily by blunt trauma, although mechanical overload of the musculoskeletal system also warrants discussion. Blunt, concussive trauma to the head region can cause injury ranging from temporary neuropsychological deficits to life-threatening intracranial bleeding.[36,37] If blunt trauma to the head is repetitive and chronic, permanent and irreversible encephalopathy may occur. Chronic traumatic encephalopathy may drastically affect well-being and social function, as it often manifests as dementia, cerebellar dysfunction, personality change, parkinsonism, and pyramidal tract dysfunction.[37,38] The risk of serious, permanent damage to the central nervous system has not yet been quantified among kickboxers. However, Schwartz and colleagues found that punches and kicks delivered to a viscoelastic dummy head resulted in similar accelerometer measurements.[39] The G-forces that were generated ranged from 90 to 120, which were deemed violent enough to engender encephalopathy among kickboxers.

Blunt trauma and mechanical overload of the musculoskeletal system are common sources of morbidity among kickboxers.[8,25,27] Associated injuries include contusions and hematoma formation, sprains, strains, and fractures. The lower extremities are at particular risk for injury, as they are used extensively in most kickboxing styles to both defend against and deliver full-force attacks. In terms of chronic sequelae following joint trauma, the degree of articular incongruity and surface stress, amount of residual joint instability, ongoing regenerative and degenerative alterations in joint contact geometry, and increased age are associated with the development of posttraumatic osteoarthritis.[40,41] No long-term studies have been conducted to quantify the risk of chronic musculoskeletal problems among kickboxers.

Although not specific to kickboxing, Birrer conducted an 18-year international survey of martial artists.[12] Based on the length of the study, the relatively large sample size, and stratification of data, some of his findings reasonably translate to kickboxing. Birrer confirmed that injury incidence and severity were greatest for free fighting and least for controlled sparring scenarios. In addition, the head, face, and neck were injured at a significantly higher frequency during free fighting than other martial arts activities. Injury incidence was inversely proportional to amount of protective equipment worn. Of the severe injuries reported, nearly two thirds were associated with cerebral concussion. Reinjury was directly correlated to contact sparring, lack of protective equipment, limited medical support, incomplete rehabilitation, poor supervision, and participation in competition.

## 19.8 Prevention, Treatment, and Functional Rehabilitation

A number of preventive measures may thwart undue morbidity and mortality in kickboxing. Based on the risks identified in the aforementioned studies,[8,12,25–27] general recommendations for injury prevention may be considered (Table 19.4).

Kickboxing-specific insights were provided by a professional world champion kickboxer (Cung Le, oral communication, 21 November 2006). Attuned to the inherently risky nature of kickboxing, Le advocated that trainers and trainees focus on longevity – both in terms of the trainee's kickboxing career and long-term health. Paralleling Birrer's recommendations,[12] Le proposed that training injuries may be prevented via proper warm-up, thorough stretching, and liberal use of protective equipment. Specifically, headgear, mouth guards, boxing gloves, body padding, and protection for the extremities should be used routinely during sparring sessions.

To ensure that a novice participant is sufficiently prepared for the psychological, physiologic, and skill-based demands of his/her first competitive match, Le recommended gradual immersion in the sport. This is done by exposing novices to progressively higher levels of stress via *smoker matches*. Smoker matches provide participants with maximal protective equipment, rules are strictly enforced, the threshold for continuing an overmatch is low, spectators in attendance bolster a competitive ambiance, and coaches critique each participant constructively in an effort to promote improvement. After a novice has completed several smoker matches and is deemed sufficiently capable, only then will Le endorse that novice's entrance into official amateur competition. When an amateur subsequently enters the professional ranks, the focus on safety should continue: preserve one's longevity in kickboxing and long-term health by employing maximal safety measures.

Le echoed the medical community's concerns about head trauma in sports and acknowledged that competitors tend to understand its potentially serious sequelae. Le highlighted that grave risks are associated with every sports activity. However, he noted that risks may be mitigated via comprehensive pre-competition training, ringside medical support, and meticulous officiating with strict adherence to rules.

Likewise, rule changes may also serve a preventive role. An international karate organization instituted rules that resulted in more stringent officiating and penalties for excessive contact. Comparing injury trends before and after the rule changes,

**Table 19.4** Recommendations for decreasing the incidence and severity of injuries[8,12,25–27]

- Limit contact and mandate the use of protective equipment, especially with regard to the head region
- Establish skill and conditioning prerequisites for those about to enter competition
- Standardize and enforce rules across organizations
- Mandate pre-participation and post-match physical evaluations for each competitor
- Track injuries through a standardized registry to (1) enforce return to competition guidelines, and (2) to use such data for future research
- Establish certifiable medical standards (e.g., cardiopulmonary resuscitation) for coaches, trainers, and officials
- Adhere to protocols established for the medical coverage of events

Macan et al. discovered that the relative risk of head injury decreased significantly after the changes were instituted.[42] Modification of kickboxing rules could conceivably decrease the risk of certain injuries as well.

In terms of medical support during matches, Le indicated that competitors prefer having a physician and ambulance crew present at ringside, rather than either one alone. The physician may provide a definitive medical disposition on a competitor's injury, whereas an ambulance crew can provide expeditious transport to a medical facility for more serious conditions. However, as discussed below, the presence of competent ambulance support may prove to be of greatest utility.

Following injury, functional rehabilitation should be started as soon as reasonably possible and tailored to the individual. Rehabilitation is intended to return the kickboxer as close to his/her pre-injury activity level as possible.[43] This should be accomplished via therapeutic modalities (e.g., ultrasound, iontophoresis), activities that improve range of motion about the injured site (e.g., stretching exercises), techniques that restore or improve the integrity of surrounding musculotendinous structures (e.g., isometric and closed-chain exercises), exercises that improve proprioception (e.g., balance training), and activities that minimize total body deconditioning (e.g., aquatic aerobics, cycling).[19]

Psychological sequelae may arise from physical injury and highlight the need for a multidisciplinary rehabilitation effort. Any cognitive-behavioral issues that the kickboxer may be facing should be addressed promptly. In some instances, this may warrant the consultation of a mental health professional.

Once function is restored, the kickboxer may gradually return to training. Once moderate- to high-intensity training can be accomplished without incident, the kickboxer may gradually return to contact sparring and eventually competition. In addition, the uninjured kickboxer may consider applying the preceding rehabilitation concepts for the sake of prehabilitation, which is the attempt to prevent injuries by correcting weaknesses and preparing the body for the demands of an activity.[44] The reader is referred to Frontera et al.[19] for additional insights regarding the sports medicine-based approach to rehabilitation.

## 19.9 Match Coverage

Ringside medical coverage should be provided at all events.[12] However, medical coverage at combat sports events has reportedly been variable and even absent at some venues.[45] Medical support at an event is important for (1) identifying medical conditions that may not be compatible with competition, (2) counseling participants and guardians of the risks of competition, and (3) providing ringside medical assessment and initial management of competitors' conditions. The preceding concepts have been developed into a checklist (Fig. 19.5).

Medical personnel should integrate themselves as soon in the event planning process as possible; they are consultants to the promoter and will be the competitors' on-scene care providers. One should not assume that the promoter will address the details of medical support. Just as one may document medical care provided to a

- ☐ Obtain means by which event promoter may be contacted readily.
- ☐ Discuss with promoter the details of the event.
  - – Date, location, number of matches, match rules, and use of protective equipment.
  - – Arrange private location for pre-participation evaluations, have medical personnel at ringside for each match, and ensure adequate time between matches for post-match assessment of participants.
- ☐ Discuss with promoter the details of legal waiver documentation that will be given to participants.
  - – Ensure verbiage explicitly waives medical personnel from adverse outcomes that may occur during or after the event.
- ☐ Obtain and save copy of legal waiver documentation.
- ☐ Advise promoter to have at least one ambulance crew available for emergency transfers.
  - – If a transfer must be made, advise promoter that the next match should not start until medical personnel are ready at ringside and another ambulance is readily available.
- ☐ Discuss with ambulance crew(s) the closest, most capable facility to which transfers will be made.
  - – Plan for emergencies specific to head and orthopedic trauma.
  - – Plan for contingencies (e.g., ability to transport to alternate facilities via alternate means).
- ☐ Bring medical questionnaires, physical evaluation forms, and requisite equipment to pre-participation evaluations. Recommended items include stethoscope, otoscope, and ophthalmoscope.
- ☐ Recommended items while serving at ringside include non-latex gloves, sterile gauze, and penlight.
- ☐ Along with post-match examination of participant, advise that medical care be sought immediately in the event of progressively worsening or new symptoms; advise follow up with primary medical caretaker for less urgent conditions.

**Fig. 19.5** Checklist for match coverage

patient, logistical advice or insights shared with the promoter should also be documented for medicolegal purposes. Details about the rules and protective equipment to be used are important in planning for types of injuries expected. For instance, one may expect a higher risk of lower leg trauma at events that do not mandate the use of shin guards.

Documentation of injury or illness that arises during competition should be thorough. It should be completed in the context that it may be used for follow-up medical care, potential legal proceedings, or possibly as data for future research. Likewise, consider having an informed consent statement that each competitor acknowledges and signs. The statement may address the risks of participation and limitations of ringside medical care, as well as the possibility that data collected could be used for future research. Contact information on competitors may also prove beneficial should follow up be necessary.

Considering the most common injuries in kickboxing (i.e., head and lower extremity trauma), medical providers at an event should have such items as airway management supplies, cervical spine collars, backboards, splints, and sterile dressings readily available. If a serious injury or illness arises, medical personnel should respond expeditiously. If the individual has suspected or actual compromise of airway, breathing, or circulation, emergent transport to the closest capable medical facility should be done while that individual is managed supportively en route. This likewise applies to suspected or obvious ocular, neurologic, maxillofacial, thoraco-abdominal, and orthopedic emergencies. In general, transfer to a higher echelon of medical care should take precedence over managing a condition at the event.[46] As such, having an ambulance crew available at an event could be more beneficial than having solely a physician or other medical provider in attendance. Whether medical personnel must contend with a minor injury or life-threatening condition, the next match should not begin until they are again ready at ringside to address any subsequent medical issue.

Contingency plans should also be developed. For instance, consider the feasibility of aeromedical transport should ground-based ambulance transfer be hindered.[47] Also consider planning for larger contingencies, such as the means by which ringside medical personnel should respond to a mass casualty situation.[48] In essence, planning for routine and contingency situations should be done in advance of the kickboxing event to minimize the possibility of medically related shortfalls.

## Summary

Kickboxing, which has flourished internationally, touts a varied and elusive history. Since techniques may be delivered powerfully and repetitively over the course of a match, kickboxing taxes both anaerobic and aerobic metabolism. Likewise, the delivery of and defense from such techniques presents a particular risk for head and lower extremity trauma. Through comprehensive preparation for competition and adherence to safety guidelines, morbidity and mortality may be mitigated. Rehabilitation should be multidisciplinary and focus on returning the kickboxer to his/her pre-injury level of function. If providing medical coverage at an event, planning is preferably done in advance and should delineate the means by which pre-participation evaluations, ringside medical care, emergency transportation, and contingencies will be addressed.

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## Web sites

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## Disclaimer

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*In loving memory of my mother, Donna Mae Mazar-Buse (1942-2006)*

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