

[Primary Care]

Injuries Sustained by the Mixed Martial Arts Athlete

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Context: Mixed martial arts (MMA) is rapidly growing in popularity in the United States and abroad. This combat sport joins athletes from a wide variety of martial art disciplines, each with characteristic and distinguishing injury profiles, together in competition. Because of increasing participation by professionals and amateurs alike, injuries sustained by MMA athletes have been on the rise.

Evidence Acquisition: A review of relevant publications using the search term *mixed martial arts* and each of its component combat sports (eg, *Muay Thai*, *Brazilian jiu-jitsu*) from 1980 through 2015 was completed using PubMed and Google Scholar.

Study Design: Clinical review.

Level of Evidence: Level 5.

Results: The majority of studies on MMA injuries evaluate those sustained during competition, which range in incidence from 22.9 to 28.6 per 100 fight-participations. Striking-predominant disciplines such as boxing, karate, and Muay Thai have high rates of head and facial injuries, whereas submission-predominant disciplines such as Brazilian jiu-jitsu, judo, and wrestling have high rates of joint injuries.

Conclusion: Numerous studies have evaluated injuries in athletes who participate in MMA and its component disciplines during competition but much remains to be discovered about injuries sustained during training and in specific patient populations such as adolescents and women.

Keywords: MMA; combat sport; training injury; clinical review

WHAT IS MIXED MARTIAL ARTS?

The term “martial art” refers to fighting techniques that traditionally were used by combatants in warfare.⁵ Many martial art disciplines are practiced in combat sports, such as boxing, Muay Thai, Brazilian jiu-jitsu, judo, karate, wrestling, and others. Each martial art has evolved over generations and is unique in its relative distribution of fighting techniques, such as striking, grappling, and takedowns. Boxing, for example, utilizes only upper extremity strikes (eg, punches), whereas Brazilian jiu-jitsu employs submission holds and joint locks.⁵

Mixed martial arts (MMA) is a combat sport that brings athletes from these martial art disciplines together in competition. Mixed-style martial art competitions date as far back as 648 BC with Greek Pankration, but modern-day

mixed-style events did not become commonplace until the early 20th century, when sports such as Vale Tudo in Brazil began garnering fame.⁵ MMA first took root in the United States on November 12, 1993, when the MMA league known as the Ultimate Fighting Championship (UFC) held its inaugural event, called UFC 1, in Denver, Colorado.⁵ This event included 8 athletes from various martial art backgrounds participating in a 1-loss elimination tournament. Because of its perceived brutality, however, the sport was initially met with societal and political resistance, which limited its widespread appeal.⁵

In 2001, UFC was purchased by 2 business partners who realized the importance of fighter safety not only for the health of their athletes but also for the viability of commercial MMA.⁵ Shortly thereafter, the Unified Rules of Mixed Martial Arts was created, establishing weight classes, illegal moves, and other

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regulations aimed at improving athlete welfare. This new focus led to the widespread acceptance of MMA by state athletic boards and, subsequently, mainstream sports fans.⁵

Over the past 15 years, the sports world has accepted MMA, and it has become one of the fastest growing sports in the United States.⁵ Professional fight events are held with increasing frequency, and MMA-specific gyms have begun opening across the nation where beginners, amateurs, and professionals alike train. Most MMA athletes have 1 primary martial art discipline but typically incorporate aspects from other styles. Adolescent athletes have become increasingly involved with MMA as the sport's popularity has grown as well.⁴⁰ ESPN reports that 5.5 million teenagers and 3.2 million children younger than 13 years participate in MMA in the United States alone, numbers that are comparable to the levels of participation in youth tackle football and baseball.³⁸

As a result of this rising MMA participation, health care providers are tasked with treating injuries in this growing population despite scarce evidence and awareness of injuries particular to the MMA athlete.

COMPETITION INJURIES

Aided by the fact that MMA events require a ringside health care provider to document and treat all injuries sustained during competition, multiple studies have evaluated the type and frequency of injuries sustained by MMA athletes during professional competitions.^{6,27,29,33} A review of 171 MMA matches in Nevada from 2001 to 2004 demonstrated that MMA athletes had an injury rate of 28.6 per 100 fight-participations: 47.9% were facial lacerations, 13.5% hand injuries, 10.4% nasal injuries, and 8.3% ocular injuries.⁶ A separate group subsequently evaluated 635 MMA matches, again in Nevada, from 2002 to 2007 and found that the injury rate had actually decreased during this time period to 23.6 per 100 fight-participants.²⁹ Facial lacerations and upper extremity injuries were the most common in this MMA athlete population.²⁹

A 7-year retrospective study of 116 matches found an incidence of 23.7 injuries per 100 fight-participations, and lacerations were the most common injury type (51%).³³ A 2014 systematic review of injuries sustained by MMA athletes summarized that the composite injury rate during MMA competition was 22.9 per 100 athlete-exposures.²⁵ The most frequently injured regions were the head/face (66.8%-78.0%) followed by the wrist/hand (6.0%-12.0%).²⁵ Skin lacerations were the most frequent injury type at 36.7% to 59.4%, while fractures accounted for 7.4% to 43.4% and concussions for 3.8% to 20.4% of competition injuries.²⁵

A study of 711 MMA events in Missouri and Kansas from 2008 to 2012 found a significantly lower competition injury rate of 8.5 per 100 fight-participations.²⁷ This lower rate may have resulted from the widespread adoption of the Unified Rules of Mixed Martial Arts.²⁷

The anatomic region and frequency of injuries in MMA athletes appears to vary according to the martial art style primarily employed by the MMA athlete and his or her opponent. For example, in a 4-year prospective study of military

personnel who participated in various combat sports, those who participated primarily in wrestling had high rates of joint injuries while those who participated primarily in boxing had high rates of facial and head injuries such as concussions and facial fractures.¹ Injury types and frequencies appear to be a function of the fighting techniques, which include upper and lower extremity strikes, takedowns, and submission holds utilized within each discipline (Figure 1).⁵

Striking-Predominant Disciplines

Striking-predominant disciplines, including boxing,^{7,20,36} karate,⁴¹ Muay Thai,^{11,12} and taekwondo,^{22,23} have relatively high rates of head and facial injuries (Table 1, Figure 1a and 1b). Head and facial injuries comprise between 57.8% and 70% of competition injuries in these athletes.^{7,21,41} The most frequent types of injuries in these striking-predominant disciplines are facial abrasions, facial fractures (eg, nose), periorbital injuries, and concussions.^{7,21,41}

Striking-predominant disciplines vary in how frequently upper versus lower extremity strikes are used, and their characteristic injury types and anatomic regions reflect this distribution. Studies of both professional boxing and kickboxing in Nevada, for instance, have found that while head and facial injuries comprise the majority of competition injuries in both sports, kickboxing has higher rates of lower extremity injuries (26.1%)²¹ while boxing has higher rates of upper extremity injuries (17%).⁷ Similarly, participants in Muay Thai, a sport that relies heavily on lower extremity striking, have been found to have significant rates of acute and chronic lower extremity injuries.³⁹ Interestingly, lower extremity injuries were common in Muay Thai athletes during training,¹² but these injuries were rare during competition,¹¹ underscoring the need to differentiate between these 2 types of injury settings.

Submission-Predominant Disciplines

While striking-predominant disciplines result in frequent head and facial injuries, submission-predominant disciplines have high rates of joint injuries during competition (Table 1, Figure 1c).^{16,17,31,33} A prospective study of 950 Brazilian jiu-jitsu athletes found that joint injuries, particularly of the knee and elbow, were the most common injuries during competition (64.5%).¹⁷ A study of Brazilian jiu-jitsu competitions (2005-2011) found that 78% of injuries were orthopaedic in nature, with the elbow being the most frequently injured joint.³³

Other submission-predominant disciplines have high rates of joint injuries as well, though the injury location distribution varies by discipline. For instance, in judo, a discipline that relies on throws and takedowns (Figure 1d) as well as submissions, the shoulder, elbow, and knee joints are the most frequently injured joints.^{16,31} Conversely, a prospective study of 458 high school wrestlers found that the shoulder was the most commonly injured joint (24%) followed by the knee (17%).³⁰

TRAINING INJURIES

The majority of an athlete's time and energy in MMA is spent in training, and studies have repeatedly confirmed that the majority



Figure 1. Examples of maneuvers performed by mixed martial arts (MMA) athletes. (a) Upper extremity strike (elbow), which often results in head and facial injuries. (b) Lower extremity strike (kick) to the torso. (c) Elbow joint lock, used in submission-predominant disciplines. Notice the hyperextension at the elbow joint. (d) Takedown throw, typical of martial art disciplines such as taekwondo.

of combat sport athletes' injuries occur during training (Table 2). A retrospective study of 620 karate athletes in Iran found that 90% of injuries were sustained in training.⁴¹ Similarly, a study of 152 Australian taekwondo athletes found that 81.5% of their injuries occurred during training; 60% required attention from a health care professional.²³ Because the burden of training injuries exceeds that of competition injuries, taekwondo governing bodies and stakeholders are encouraged to devote more efforts toward the identification of risk factors for and prevention of training injuries.²³

Few studies have evaluated the type and frequency of injuries sustained during training in MMA athletes. In the most comprehensive study of MMA training injuries, 77.9% of injuries had been sustained during training as opposed to 22.1% during competition in 55 athletes over the preceding year.³² The most commonly injured region was the head/neck region (38.2%) followed by the lower (30.4%) and upper (22.7%) extremity.³² Thirty-two percent of injuries were recurrent, and 1 in 5 required medical attention.³²

Training injuries outnumber competition injuries 4 to 1.^{23,32,41} This ratio will only increase as more recreational athletes join MMA gyms without the intent of fighting competitively.

Understanding and preventing training injuries is important for professional MMA athletes and the UFC as well. Match cancellations due to training injuries cause a professional burden to both the injured athlete and his or her opponent, as well as being an unfortunate disservice to the UFC and its fans.

NONORTHOPAEDIC INJURIES AND CONDITIONS

In a 10-year review of professional MMA matches, head trauma was found to be the single most common reason for match stoppage (28.3%), ahead of musculoskeletal stress (16.5%) and neck choke (14.1%).⁹ A retrospective review of 844 UFC fights from 2006 to 2012 found that head trauma was the immediate cause of every knockout that occurred and that athletes sustained an average of 2.6 additional strikes before the match

Table 1. Partial list of martial art disciplines and their associated injuries

	Martial Art Discipline	Techniques	Injury Locations
Striking-predominant disciplines	Boxing	Striking (UE only)	Head, face
	Karate	Striking	Head, face
	Muay Thai	Striking	Head, face, foot/ankle
	Sanshou/sanda	Striking, grappling	Head, face
	Taekwondo	Striking	Head, face, foot/ankle
Submission-predominant disciplines	Brazilian jiu-jitsu	Submission holds, joint locks	Joints (elbow > knee)
	Judo	Takedowns, throws	Joints (shoulder > elbow, knee)
	Wrestling	Grappling, takedowns, submission holds	Joints (shoulder > knee)

UE, upper extremity (eg, punches, elbows).

Table 2. Distribution of training versus competition injuries in martial art studies

Study	Discipline (Country)	Training Injuries, %	Competition Injuries, %
Loosemore et al ²⁰	Boxing (UK)	70.0	30.0
Lystad et al ²⁴	Taekwondo (Australia)	81.5	18.5
Pasque and Hewett ³⁰	Wrestling (USA)	63.0	37.0
Rainey ³²	Mixed martial arts (USA)	77.9	22.1
Kujala et al ¹⁸	Karate and judo (Finland)	70.0	30.0

was called.¹⁴ In a retrospective survey study, 15% of the 115 MMA athletes surveyed reported a history of at least 1 knockout.¹³

Striking-predominant disciplines have higher rates of head trauma than submission-predominant disciplines (see Table 1). Sixty-one percent of injuries sustained during karate competition, a striking-predominant sport, occurred in the head/neck area,⁴¹ while 42.5% of injuries in professional Muay Thai events occurred at the head.¹¹ Conversely, a 4-year prospective study of South Korean judo, a submission-predominant sport, found that head and neck injuries accounted for only 5.6% of those sustained in training and competition.¹⁶

The long-term ramifications of these neurologic injuries are concerning. Prospective radiographic studies have found that there is more cortical thinning in MMA athletes than in age-matched noncombat sport athletes.²⁶ Additionally, studies have found decreases in thalamus and caudate lobe size in MMA athletes, and these decreases correlate with increased MMA training intensity.^{4,34} These structural radiographic changes appear to lead to functional changes as well; there was an

average of a 0.19% decrease in brain processing speed on serial cognitive testing for every MMA fight in which an athlete participated.⁴

In addition to concussions and traumatic brain injury, MMA athletes are also at risk for a number of facial and neck injuries.^{8,37} Facial lacerations are common, particularly in the periorbital region, because of the prominence of facial bones and relative local hypervascularity.³ These lacerations are especially troublesome during competitions, as bleeding leads to visual impairment and may even cause fight cancellation.³ Muay Thai athletes in particular have a high incidence of facial lacerations.³⁵ Facial fractures are also common in MMA athletes, particularly in Muay Thai and kickboxing athletes.³⁵

MMA fighters are frequently in close skin-to-skin contact and often develop skin lacerations and dermatologic infections.^{2,19,28} These infections may be bacterial, viral, or fungal.^{2,19,28}


MMA athletes are often under extreme competitive pressure to both gain muscle mass and lose significant amounts of weight in short periods of time at various points during their training.¹⁰ Because of weight class restrictions, fighters often engage in

potentially dangerous weight loss behaviors immediately before fights to “weigh in.”¹⁰ Athletes may employ dehydration to lose water weight, and this can lead to biochemical and hormonal alterations.¹⁰ Measuring markers of dehydration in athletes immediately before a competition has shown 39% had urine-specific gravity levels indicative of severe dehydration.¹⁵

CONCLUSION

To date, the majority of studies on injuries in the MMA athlete have focused on those sustained during competition, while the majority of injuries are sustained while training. These studies

have found that the injury rate for MMA athletes in competition ranges from 22.9 to 28.6 per 100 fight-participations.^{6,25} These injuries most frequently occur in the head and facial region followed by the extremities. Skin lacerations are the most common injury type followed by fractures. Studies on specific martial art disciplines reveal that striking-predominant disciplines such as boxing, karate, Muay Thai, and taekwondo have high rates of head and facial injuries whereas submission-predominant disciplines such as Brazilian jiu-jitsu, judo, and wrestling have high rates of joint injuries. Research on pediatric and female MMA athletes is currently lacking as well.



Clinical Recommendations

SORT: Strength of Recommendation Taxonomy

A: consistent, good-quality patient-oriented evidence
B: inconsistent or limited-quality patient-oriented evidence
C: consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
Striking-predominant martial arts disciplines have high rates of head and facial injuries, including concussions. ^{11,20,24}	A
Submission-predominant martial arts disciplines have high rates of joint injuries. ^{16,28,33}	A
Nonorthopaedic injuries, such as skin infections, are also common in MMA athletes. ^{2,19,30}	C

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