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Research article

INCIDENCE OF INJURY IN PROFESSIONAL MIXED MARTIAL ARTS COMPETITIONS

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ABSTRACT
Mixed Martial Arts (MMA) competitions were introduced in the United States with the first Ultimate Fighting Championship (UFC) in 1993. In 2001, Nevada and New Jersey sanctioned MMA events after requiring a series of rule changes. The purpose of this study was to determine the incidence of injury in professional MMA fighters. Data from all professional MMA events that took place between September 2001 and December 2004 in the state of Nevada were obtained from the Nevada Athletic Commission. Medical and outcome data from events were analyzed based on a pair-matched case-control design. Both conditional and unconditional logistic regression models were used to assess risk factors for injury. A total of 171 MMA matches involving 220 different fighters occurred during the study period. There were a total of 96 injuries to 78 fighters. Of the 171 matches fought, 69 (40.3%) ended with at least one injured fighter. The overall injury rate was 28.6 injuries per 100 fight participations or 12.5 injuries per 100 competitor rounds. Facial laceration was the most common injury accounting for 47.9% of all injuries, followed by hand injury (13.5%), nose injury (10.4%), and eye injury (8.3%). With adjustment for weight and match outcome, older age was associated with significantly increased risk of injury. The most common conclusion to a MMA fight was a technical knockout (TKO) followed by a tap out. The injury rate in MMA competitions is compatible with other combat sports involving striking. The lower knockout rates in MMA compared to boxing may help prevent brain injury in MMA events.

KEY WORDS: Brain injury, ultimate, boxing, jiu jitsu.

INTRODUCTION

Mixed Martial Arts (MMA) competitions were introduced in the United States with the first Ultimate Fighting Championship (UFC) in 1993 (Krauss and Aita, 2002). Styled after the popular *Vale Tudo* (Portugese for "anything goes") matches in Brazil (Peligro, 2003), these first UFC matches were marketed as brutal, no-holds-barred tournaments with no time limits, no weight classes, and few rules (Hamilton, 1995).

Politicians such as Senator John McCain of Arizona led the charge to ban these competitions from cable television, describing the events as "human cock fighting" (Krauss, 2004). When their cable contracts were terminated in 1997, MMA events survived underground through internet and word of mouth promotions until their organizers agreed to a change of rules that allowed the Nevada State Athletic Commission and the New Jersey State Athletic Control Board to sanction the competitions

Table1. Frequencies and rates of mixed martial arts injuries to professional competitors, September 2001 through December 2004, Nevada.*

Injury site	Number	(%)	Injury Rate per 100 Competitors
Facial Laceration	46	(47.9)	13.45
Eye	8	(8.3)	2.34
Ear	1	(1.0)	.29
Nose	10	(10.4)	2.92
Mouth	0	(0.0)	.00
Jaw	1	(1.0)	.29
Neck	1	(1.0)	.29
Shoulder	5	(5.2)	1.46
Arm	1	(1.0)	.29
Elbow	2	(2.1)	.58
Hand	13	(13.5)	3.80
Chest	0	(0.0)	.00
Abdomen	0	(0.0)	.00
Back	2	(2.1)	.58
Knee	3	(3.1)	.88
Ankle	2	(2.1)	.58
Foot	1	(1.0)	.29

*Up to four injuries recorded per competitor per match.

in 2001 (Krauss, 2004).

This study is the first report of the incidence of injury in MMA competitions. No study has previously documented injuries in MMA events either before or after the tightening of regulations. Fight results and injury incidence from professional MMA bouts since their sanctioning in 2001 in Nevada are compared to boxing data from the same state. A discussion of MMA events and combat sports injuries is also included.

METHODS

Mixed Martial Art (MMA) data from all professional MMA matches in the state of Nevada from September 2001 until December 2004 (n = 171 matches) was obtained from the Nevada State Athletic Commission. All professional MMA matches occurring in the state during the study period were included. Data obtained included gender, date of the match, date of birth, weight, rounds scheduled, rounds fought, whether the fighter won or lost, how the match ended (knockout, technical knockout, decision, draw, disqualification, no decision, tap out, or choke) and the injuries that occurred in the match and the type of injuries sustained. Up to four injuries per fighter were recorded per competition. These data are in the public domain and accessible on the website of the Nevada State Athletic Commission (http://boxing.nv.gov, last accessed January 2005).

Medical and outcome data for all professional MMA matches were analyzed based on a pair-matched case-control design. Cases were fighters who sustained an injury during the matches. Fighters who were not injured served as controls. Matches in which both competitors were injured or both were uninjured were excluded from the conditional logistic regression. Both conditional and unconditional logistic regression models were used to assess risk factors for injury.

Injuries were recorded based on the clinical report of the physician at ringside. No follow-up study was done to confirm the accuracy of the reported injury based on radiography or other diagnostic testing. Injuries were divided into seventeen broad classifications: eye injuries, facial lacerations, ear injuries, nose injuries, mouth injuries, jaw injuries, hand injuries, shoulder injuries, elbow injuries, ankle injuries, foot injuries, chest injuries, abdominal injuries, knee injuries, back injuries, neck injuries, and arm injuries. Lacerations to the eyelid and nose were counted as facial lacerations. Only those injuries documented other than lacerations—such as possible orbit fractures or a nose deformity—were listed as eye or nose injuries respectively.

The Johns Hopkins University School of Medicine's Institutional Review Board approved the study protocol via exemption.

RESULTS

A total of 171 MMA matches involving 220 different fighters occurred during the study period. All participants were male with an average age of 28.5 years (SD = 4.7, range from 19 to 44 years old). The average weight was 87.6 kg (SD= 16.3 kg, range from 60.4 to 166.4 kg). A total of 1,130 rounds were scheduled, of which 624 (55%) were actually fought. These rounds were each 5 minutes for a total of 3120 minutes of fighting. A total of 67 fighters fought in more than one fight during the study period. The average number of competitions for these 67 repeat fighters was 2.8 (SD = 1) with a range of 2 to 6 fights each.

There were a total of 96 injuries to 78 fighters. Of the 171 matches fought, 69 (40.3%) ended with at least one injured fighter. The overall injury rate was 28.6 injuries per 100 fight participations, 12.5 injuries per 100 competitor rounds, or 3.08 injuries per 100 fight minutes. The majority of recorded injuries were injuries to the facial region with facial lacerations being the most common. Hand injuries were the second most common injury, accounting for 13.5% of all injuries, followed by injuries to the nose (10.4%) and eye (8.3%, Table 1).

Older fighters were at greater risk of injury as were those who lost a match by knockout or technical knockout (Tables 2 and 3). Those who lost their match under any circumstance—whether knockout, technical knockout, decision, tap out, choke, or disqualification—were significantly more likely to suffer an injury during the course of the competition than those who won ($p < 0.001$). Also, the incidence of injury increased with the length of the fight with matches lasting 4 or 5 rounds being more likely to include a fighter who suffered an injury (Tables 2 and 3). The most common conclusion to a MMA fight was a technical knockout (TKO) followed by a tap out (Table 4). The proportion of fighters suffering a knockout during the competition was 6.4% (n = 11).

Table 2. Incidence rates of injury in mixed martial arts matches by competition characteristics, September 2001 through December 2004, Nevada.

	Competitors #(%)	Injured Competitors #(%)	Injury Rate per 100 Competitors	Rounds fought #(%)	Injury Rate per 100 Fought Rounds
Age Groups (years)*					
<25	76 (22.3)	13 (16.9)	17.1	132 (21.2)	9.8
25-29	144 (41.5)	29 (37.7)	20.6	260 (41.8)	11.2
30+	124 (36.4)	35 (45.5)	28.2	230 (37.0)	15.2
			χ^2=3.9, p=0.14		χ^2=2.2, p=0.33
Weight Class					
Fly, bantam, feather, or light	32 (9.4)	5 (6.4)	15.23	53 (8.5)	9.4
Welter or Middle	150 (43.8)	35 (44.9)	23.33	300 (48.1)	11.7
Light heavy, heavy, or super heavy	160 (46.8)	38 (48.7)	23.75	271 (43.4)	14.0
			χ^2=1.04, p=0.59		χ^2=0.95, p=0.62
Match Outcome					
Win	169 (49.4)	27 (34.6)	16.0	306 (49.0)	8.8
Loss	169 (49.4)	51 (65.4)	30.2	306 (49.0)	16.7
Draw	4 (1.2)	0 (0)	0.0	12 (1.9)	0.0
			χ^2=9.6, p<0.001		χ^2=8.2, p=0.02 †
Type of Outcome					
TKO or KO	158 (46.2)	42 (54.0)	26.6	240 (38.5)	17.5
Other	184 (53.8)	36 (46.2)	19.6	384 (61.5)	9.4
			χ^2=2.38, p=0.12		χ^2=6.8, p=0.009
Rounds fought					
1	176 (51.5)	32 (41.0)	18.2	176 (28.2)	18.2
2	76 (22.2)	19 (24.4)	25.0	152 (24.4)	12.5
3 - 5	90 (26.3)	27 (34.7)	30.0	296 (47.4)	9.12
			χ^2=5, p=0.08		χ^2=6.3, p=0.04

Table 3. Odds Ratios (OR) and 95% Confidence Intervals (CIs) of injury in mixed martial arts matches from multivariate logistic regression models, September 2001 through December 2004, Nevada.

Model	Variables	OR	95%CI
Unconditional logistic regression			
	Age *†	1.29	0.73-2.26
	Weight *†	1.03	0.95-1.11
	Lost match	2.32	1.36-3.98
	KO or TKO	1.71	0.97-3.01
	Rounds fought †	1.44	1.11-1.87
1:1 matched conditional logistic regression			
	Age *†	3.11	1.11-8.59
	Weight difference *†	1.10	0.90-1.34
	Lost match	2.69	1.44-5.0

*Odds Ratio for a ten-unit change in age and weight.
† A continuous variable.

DISCUSSION

Though initially promoted as brutal, no-holds-barred contests, Mixed Martial Arts competitions in the United States have changed dramatically and now have improved regulations to minimize injury. A total of 13 states now sanction MMA events, the first two being Nevada and New Jersey in 2001. Since the sanctioning, MMA competitions have followed much stricter regulations. Fighters are now forbidden to headbutt, stomp or knee an opponent on the ground, strike the throat, spine or back of the head, must fight within a predetermined weight class, and are allowed only one fight per night—all important changes that were implemented with sanctioning.

Table 4. Results of Mixed Martial Arts Competitions in Nevada, September 2001 through December 2004.

Result	Number (%)
Technical Knockout	68 (39.8)
Tap Out	52 (30.4)
Decision	31 (18.1)
Knockout	11 (6.4)
Choke	4 (2.3)
Disqualification	3 (1.8)
Draw	2 (1.2)
Total	**171**

The mandatory "grappling" gloves now used in MMA events weigh between 4 to 8 ounces, thinner than the 8 to 10 ounce gloves worn by professional boxers, and are designed with the fingers exposed so a fighter can grasp his opponent. Fighters must pass the same physical exam used to screen professional boxers including a cerebral MRI, before being licensed. Referees and ringside physicians are required to be present and have the authority to stop the match at any time.

Fighters train in both the striking and grappling arts (Amtmann, 2004) and become proficient in a number of means of "submitting" or defeating their opponents (Figures 1 and 2). Fights can be ended not only by the traditional knock out, technical knock out, and decision of boxing, but also by "tap out"—where an opponent either taps the mat or his opponent to signal his desire to stop the match or verbally indicates to the referee his desire to stop—and "choke"—where an opponent refuses to tap even though caught in a choke hold and passes out.

Figure 1. Fighter A (in blue) applies a traditional jiu jitsu choke to Fighter B (in white).

MMA events should be differentiated from the infamous "Toughman" competitions held around the country. Toughman competitions feature amateur fighters who often have little or no training

experience, wear "one-size-fits-all" protective gear, do not need a thorough physical exam to compete, and often feature inexperienced referees and ringside physicians (Branch, 2003). While there have been no deaths in the United States in MMA competitions, at least 12 participants have died during Toughman events—two of whom were being supervised by ringside physicians who were chiropractors (Branch, 2003). Incidentally, both Nevada and New Jersey—the first two states to sanction MMA competitions—are "among 10 states that have banned or attempted to ban [Toughman] events." (Branch, 2003).

Figure 2. Fighter A (in blue) applies a traditional jiu jitsu armbar to Fighter B (in white).

The relatively high incidence of injuries in combat sports has been well documented. The giving and receiving of high velocity blows seems to be the best correlation of whether a sport will have an increased risk of injury.Styles that include striking—such as boxing (Bledsoe et al., 2005; Zazryn et al., 2003a), kickboxing (Gartland et al., 2001; Zazryn et al., 2003b), karate (Zetaruk et al., 2005), and taekwondo (Kazemi and Pieter, 2004)—have been shown to have a higher incidence of injury than styles that involve grappling alone, such as collegiate wrestling (Jarret et al., 1998). Strikes from elite athletes, particularly professional boxers, can generate a significant amount of force (Walilko et al., 2005)—equivalent to "a padded wooden mallet with a mass of 6 kg (13 lbs) if swung at 20 mph" (Atha et al., 1985) according to one study. This seems to explain why many injuries in the striking arts are prevalent not only in the target areas of the face and torso, but also the extremities used for striking such as the hands for boxing and the upper and lower extremities in kickboxing and karate.

While no prior articles document the incidence of injury in MMA, injury rates from boxing have been reported. In 2003, Zazryn and colleagues (2003a) reported an overall injury rate to professional boxers in Victoria, Australia of 25 injuries per 100 fight participations. A recent look at the injury rates of professional boxers in Nevada showed 17.1 injuries per 100 fight participations (Bledsoe et al., 2005). With an overall injury rate of 28.6 injuries per 100 fight participations, MMA competitions demonstrate a high rate of overall injury, but a rate in keeping with other combat sports involving striking. By contrast, sports involving grappling have demonstrated much lower rates of injury. For example, collegiate wrestling has been documented to have rates as low as 1 injury per 100 participations when analyzed for participants in both practice and competition (Jarret et al., 1998).

As opposed to professional boxing, MMA competitions have a mechanism that enables the participant to stop the competition at any time. The "tap out" is the second most common means of ending a MMA competition (Table 4) This unique characteristic, combined with more options of attack when competing, is thought to help explain a knockout proportion in MMA competitions that is almost half of the reported 11.3% of professional boxing matches in Nevada (Bledsoe et al., 2005). With the growing concern over repetitive head injuries and the risk of *dementia pugilistica* among career boxers, decreasing the number of head blows a fighter receives during a match has been promoted as an important intervention (Mendez, 1995; Unterharnscheidt, 1995). With MMA competitions, the opportunity to attack the extremities with arm bars and leg locks and the possibility of extended periods of grappling could serve to lessen the risk of traumatic brain injury. When TKOs are compared, proportions between professional boxing (38%)and MMA are similar (Bledsoe et al., 2005).

There are several limitations to this study. First, the injuries reported were based on the physical exams performed at ringside by the ringside physician. No labs or radiologic studies were ordered and no diagnoses were confirmed. The incidence of injury in these fighters may have been higher than reported. Second, although the study included all MMA fights throughout a 40 month period, the total number of matches was relatively small. Third, the fights included in this study were all held in Nevada, the premiere site for MMA events. How injury rates would change for events held under different conditions with less supervision is a matter of concern. Finally, for the purpose of discussion, knockouts and technical knockouts were not defined as injuries although many would argue that these represent the most serious of all boxing injuries. Due to the sometimes subtle nature of traumatic brain injury—and since there was no radiographic imaging available to verify whether an injury had occurred—KOs and TKOs were discussed as separate entities and not included in the

overall injury data. Further research is needed to determine the true nature of these injuries and their cumulative effects upon the individual fighters.

CONCLUSION

Mixed Martial Arts competitions have changed dramatically since the first Ultimate Fighting Championship in 1993. The overall injury rate in MMA competitions is now similar to other combat sports, including boxing. Knockout rates are lower in MMA competitions than in boxing. This suggests a reduced risk of TBI in MMA competitions when compared to other events involving striking.

MMA events must continue to be properly supervised by trained referees and ringside physicians, and the rules implemented by state sanctioning—including weight classes, limited rounds per match, proper safety gear, and banning of the most devastating attacks– must be strictly enforced. Further research is necessary to continue to improve safety in this developing new sport.

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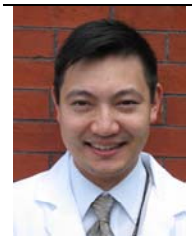

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KEY POINTS

- Mixed martial arts (MMA) has changed since the first MMA matches in the United States and now has increased safety regulations and sanctioning.
- MMA competitions have an overall high rate of injury.
- There have been no MMA deaths in the United States.
- The knockout (KO) rate in MMA appears to be lower than the KO rate of boxing matches.
- MMA must continue to be supervised by properly trained medical professionals and referees to ensure fighter safety in the future.

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