

Injury Profile of Mixed Martial Arts Competitors

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INTRODUCTION

Mixed martial arts (MMA) have a long history beginning in ancient Greece.^{1,2} Today, the sport is regulated under the Association of Boxing Commissions' "Unified Rules of Mixed Martial Arts."³ According to these rules, professional and amateur MMA bouts are to consist of 3 (non-title) or 5 rounds (title) with the length of each round ranging from 3 to 5 minutes. Winners are declared by knockout (KO), technical knockout (TKO), submission, judge's decision, referee stoppage, physician stoppage, or disqualifications. Fighters are paired based on weight class and previous win/loss record. During an event, each fighter must wear protective gear (4 oz or 6 oz gloves, groin protection, and a mouth guard) and compete barefooted as shoes are restricted (in events that do not follow the unified rules, wrestling shoes can be worn, but this is uncommon). Numerous strikes, chokes, joint locks, and other moves are permissible and there are few restrictions on how (eg, brief contact as with strikes or extended torque ala locks) and where (eg, legs, face) these moves can be applied.³

The safety of athletes at the professional and amateur levels in many sports is of growing concern. For instance, in 2012, the National Football League made an unprecedented 30 million dollar donation to the National Institutes of Health to establish a funding mechanism supporting research on sports injuries especially those to the brain.⁴ Given the nature of MMAs, fighters seem to be more susceptible to injuries than in other sports. In fact, some perceive the sport to be extremely dangerous and attempts have been made to make MMA illegal.⁵ Previous reports place the rate of injury at between 23% and 29% of fight participations (number of fights \times 2).^{6,7} These rates are comparable with those reported by some for boxing (~25%)^{8,9} but higher than those for kickboxing (~11%).¹⁰ Data pertaining to head injuries are of particular importance considering recent attention on traumatic brain injury and chronic traumatic encephalopathy, which are highly prevalent among athletes in extreme contact sports.¹¹ For MMA, it has previously been reported that between 38% and 48% of all injuries occur to the head/neck/face region^{6,12} and approximately 6.5% of bouts end in a KO (compared with 11.3% for boxing).⁶ Studies using video footage analysis suggest that 28.3% of MMA bouts were stopped because of head impact and between 3% and 5% result in a concussion (compared with 2% for kickboxing) with some being severe.^{7,13} Scoggin et al¹⁴ found that 20% of injuries sustained during MMA bouts were concussions resulting in brief (<15 s) loss of consciousness and/or retrograde amnesia.

Although previous studies on MMA injuries are informative, they often rely on small sample sizes, exclude

Objective: To provide an updated comprehensive profile of mixed martial arts (MMAs) injuries.

Design: Correlational and multivariate analyses were conducted on cross-sectional data to examine injuries sustained during 711 MMA bouts. One physician diagnosed any injuries occurring during the bouts.

Setting: Various sports venues in Kansas and Missouri holding MMA competitions.

Participants: Male and female and amateur and professional MMA competitors contributing to 1422 fight participations (fight participations = 711 bouts \times 2 fighters/bout).

Independent Variables: State, level (amateur or professional), gender, number of rounds, and bout outcome (knockout/technical knockout [KO/TKO] vs. other outcomes [eg, decision]).

Main Outcome Measures: Injuries/fight participations, injury sustained (yes vs. no), and fighter referred to emergency room (ER; yes vs. no).

Results: The overall injury rate was 8.5% of fight participations (121 injuries/1422 fight participations) or 5.6% of rounds (121/2178 rounds). Injury rates were similar between men and women, but a greater percentage of the injuries caused an altered mental state in men. The risk of being injured was significantly greater for bouts held in Kansas, at the professional level, lasting more rounds, and ending in a KO/TKO. Fighters also were more likely to be referred to the ER if they participated in longer bouts ending in a KO/TKO.

Conclusions: The observed injury rate was lower than previously reported suggesting recent regulatory changes have made MMA a safer sport. Increased clinical awareness and additional research should be extended to head-related injuries in MMAs especially those associated with KOs/TKOs.

Key Words: sports, health, medicine, gender

(*Clin J Sport Med* 2014;0:1–5)

Submitted for publication May 29, 2013; accepted December 9, 2013.

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The authors report no conflicts of interest.

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female fighters, and use injury data from surveys of fighters not physician assessments.^{6,7,12-14} In addition, most were conducted before the adoption of the Unified Rules of Mixed Martial Arts in 2009 which addresses referee training, gloves, moves, amateur and female fighters, and a host of other elements that could affect injury rates and/or injury types. Given these issues, up-to-date studies using better methodological approaches are needed to help maximize the safety of MMA by informing fighters, trainers, promoters, physicians, and sanctioning/governing bodies. The objectives of the current study were to provide a contemporary detailed description of physician-diagnosed injuries incurred during male and female and professional and amateur MMA competitions and examine predictors of injuries during MMA competitions.

METHODS

This study used a cross-sectional design, with injury, bout, and demographic data obtained by 1 physician immediately after a bout. The bouts occurred between 2008 and 2012 in either Kansas (KS) or Missouri (MO). On a given competition day, the physician and assistants reported to the venue approximately 1 hour before the first bout to familiarize themselves with the environment and fighters. Records were reviewed and in some instances, a fighter was interviewed. No fighter was designated ineligible by the physician before a bout. During the competition, the physician and assistants sat at ringside and were available to assist with any physical issues occurring during a bout. Immediately after a bout, the fighters were led to the dressing room where they were examined. The examination included standard heart and lung auscultation, pertinent cranial nerve examination, blood pressure reading, and assessment of the fighter's orientation to person, place. Further examination included assessments of the fighter's head, neck, face and hands for fractures, hematomas, lacerations, and/or abrasions. A focused examination of specific injuries and/or complaints also took place at this time.

Participants were professionals and amateurs, men and women, and from all weight categories. None of the participants displayed any physical disabilities that would have restricted their ability to engage in MMA competitions. All participants read and signed an informed consent form approved by the university's institutional review board for protection of human subjects before participation. None of the fighters approached and asked to be in the study refused to participate.

The physician labeled injuries as lacerations and abrasions, altered mental state, fractures, and others. Altered mental state was defined as the fighter's inability to orient themselves to person place or time. The "other" category consisted of dislocations, edemas, oral issues, and severe fatigue. All other variables (eg, how fight ended) were based on records from each event.

Statistical Analysis

All bouts were MMA style and lasted between 1 and 3 rounds. The number of rounds of exposure to competition were compared between men and women, levels (amateurs

and professionals), and states (KS and MO) using Student *t* tests. The χ^2 procedures were used to contrast prevalence rates of injury and injury types (eg, lacerations) relative to the number of rounds of exposure to competition when comparing genders, levels, and states and relative to the number of bouts when comparing bout outcomes (KO/TKO vs. other). Logistic regression analysis was employed to determine if bout and competitor characteristics were associated with injury occurrence (yes or no) and being referred to the ER (yes or no). The level of significance was set a priori at $P < 0.05$ and the SPSS package was used to run all analyses (version 20.0; SPSS, Chicago, IL).

RESULTS

Descriptive

A total of 711 MMA bouts provided 2178 rounds of exposure to fight action for amateurs (556 bouts and 1626 rounds) and professionals (155 bouts and 552 rounds). In addition, bouts were held in the states of MO (497 bouts and 1399 rounds) and KS (214 bouts and 779 rounds). Although amateur and professional bouts were held at similar rates in KS (48.1% were amateur bouts), almost all the bouts in MO were at the amateur level (91.1%). The average number of rounds/bout differed between states and levels. In KS, bouts were 1.83 ± 0.90 rounds and in MO, they were 1.40 ± 0.70 rounds ($P < 0.001$). Amateurs participated in 1.46 ± 0.75 rounds versus professionals whose bouts lasted 1.79 ± 0.88 rounds ($P < 0.001$). The sample included a relatively large number of female fighters who were more likely to be classified as professionals than their male counterparts (72.2% vs. 17.7%; $\chi^2 = 87.2$; $P < 0.001$). Most female bouts (77.8%) were held in KS, whereas most male bouts (73.8%) occurred in MO. Men competed in a total of 1966 rounds (657 bouts), whereas women fought in 212 rounds (54 bouts). The mean difference was significant ($P < 0.001$) with men participating in 1.50 ± 0.77 rounds per bout and women 1.96 ± 0.86 rounds per bout.

Overall, submissions were the main reason for terminating a bout followed by KO/TKOs (Table 1). Few bouts were ended by the referee. This pattern was consistent for men, women, amateurs, and professionals and for bouts held in MO and KS. However, there were some small differences such as the higher rate of KO/TKO ended bouts in women (35.2% vs. 29.1% overall) and the very different rates of bouts going to a decision between MO (8.2%) and KS (30.4%), which also varied substantially from the overall average rate of decisions (14.9%).

Injury

Given in Table 2 are injury rates for the subgroups examined in this study. Overall, 121 injuries occurred in 115 or 16.2% of the 711 bouts. In 6 bouts, both fighters were injured. The overall injury rate relative to rounds of exposure was 5.6% (121 injuries/2178 rounds) or 8.5% of fight participations (121 injuries/1422 fight participations). The most common types of injuries were lacerations and abrasions (38.0%) followed by altered mental state (21.5%) and

TABLE 1. Reasons for Ending Bouts by Gender, Level, and State

	KO/TKO	Submission	Decision	Referee Stopped
Overall (711 bouts)	29.1% (n = 207 bouts)	55.3 (393)	14.9 (106)	0.7 (5)
Men (n = 657 bouts)	28.6 (188)	56.6 (372)	14.0 (92)	0.8 (5)
Women (54 bouts)	35.2 (19)	38.9 (21)	25.9 (14)	0
Amateur (556)	29.5 (164)	58.1 (323)	12.1 (67)	0.4 (2)
Professional (155)	27.7 (43)	45.2 (70)	25.2 (39)	11.9 (3)
KS (214 bouts)	26.2 (56)	42.5 (91)	30.4 (65)	1.0 (22)
MO (497 bouts)	30.4 (151)	60.8 (302)	8.2 (41)	0.6 (3)

fractures (16.5%). The remaining types of injuries termed other comprised 24.0% of all injuries. The injury rate was similar between men (110 injuries/1966 rounds or 5.6%) and women (11 injuries/212 rounds or 5.2%; $\chi^2 = 0.06$; $P > 0.05$), as were the injury types ($\chi^2 = 2.5$; $P > 0.05$). The most common types of injuries were lacerations and abrasions in men (39.1% of injuries to men) and lacerations/abrasions and fractures in women (each comprising 27.3% of injuries to women). Although the rate of injuries classified as “altered mental state” was higher in men (22.7%) than women (9.1%), the difference was not statistically significant.

Injuries were more likely among professionals (42 injuries/552 rounds or 7.6%) than amateur (79 injuries/1626 rounds or 4.9%; $\chi^2 = 5.9$; $P < 0.05$). Professionals were approximately twice as likely to sustain lacerations/abrasions, fractures, and other types of injuries than amateurs ($\chi^2 = 14.6$; $P < 0.01$). For bouts held in KS, the injury rate (56 injuries/779 rounds or 7.2%) was significantly higher than the rate seen in MO (65 injuries/1399 rounds or 4.6%; $\chi^2 = 6.1$; $P < 0.05$). Lacerations and abrasions, fractures, and altered mental states occurred at higher rates in KS than MO ($\chi^2 = 11.4$; $P < 0.05$).

A total of 30 referrals to the emergency room (ER) were made for the 121 injuries (24.8%). The chance of being sent to the ER did not vary significantly by gender (1.5% or 29 referred males/1966 rounds vs. 1.4% or 1 referred female/212 rounds), professional versus amateur (1.2% or 20 referrals/1626 rounds vs. 1.8% or 10 referrals/552 rounds), or state (1.3% in MO and 1.5% in KS). No significant group differences emerged when the rate of referral to the ER was expressed relative to the number of injuries rather than rounds of exposure.

Injuries were less likely if the bout ended in a submission, decision, or disqualification (61 injuries/1626 rounds or 3.8%) versus a KO/TKO (60 injuries/552 rounds or 10.9%; $\chi^2 = 39.8$; $P < 0.001$). The rate of injury in bouts ending in strikes was 9.1% (60 injuries/656 rounds), which was significantly higher than the rate observed in bouts ended by decision, choke, or lock (4.0% or 61 injuries/1522 rounds; $\chi^2 =$

23.1; $P < 0.001$). The diagnosis of an altered mental state was made at a much lower rate in bouts ended by submission, decision, or disqualification (0.2% or 3 altered mental state injuries/1626 rounds) than bouts ended by a KO/TKO (4.2% or 23 altered mental state injuries/552 rounds; $\chi^2 = 45.2$; $P < 0.001$). Similarly, the diagnosis of an altered mental state was made at a much lower rate in bouts ended by decision, choke, or lock (0.2% or 3 altered mental state injuries/1522 rounds) than by strikes (3.5% or 23 altered mental state injuries/656 rounds; $\chi^2 = 42.6$; $P < 0.001$).

Provided in Table 3 is a summary of the logistic regression analysis for variables predicting the probability of an injury during a bout and/or being referred to the ER. The risk of being injured was significantly greater for bouts that were held in the state of KS versus MO, at the professional versus amateur level, lasted more rounds, and were ended by a KO/TKO versus another method (3-fold higher). Fighters were more likely to be referred to the ER if they participated in longer bouts and/or were in a bout ended by a KO/TKO (2.5 times more likely).

DISCUSSION

Our study provides the most comprehensive analysis of ringside physician collected data on amateur and professional MMA fighters and female fighters. Most importantly, our results are derived from contemporary data collected after the adoption of the Unified Rules of Mixed Martial Arts. The rules target several aspects of competition to promote fairness and, above all, fighter safety.

Overall injury rates were relatively low and we identified factors that increase the likelihood of injuries and their severity. The overall injury rate was 8.5% (relative to fight participations), which is considerably lower than previously reported MMA injury rates that ranged between 23.6% and 28.6%.^{6,7,14} This disparity is also evident when examining injury rates as a function of rounds of exposure (5.6% vs. 12.5%).⁶ Furthermore, the injury rates described herein can be viewed with much more favor today than previously when compared with other high contact sports such as boxing,^{9,10,15} kickboxing,¹⁰ karate (~26%),^{16–18} and even many traditional collegiate sports (eg, football at 3.6% of participations).¹⁹

The rate of injury was approximately 2-fold higher in professionals than amateurs. Although this disparity is similar to what has been observed in boxing,⁹ it is less robust than the 3-fold higher injury rates for professional MMA fighters reported by Rainey et al.¹² Our data suggest that the higher injury rate among professionals can be partially attributed to their bouts lasting longer than amateur bouts (1.79 ± 0.88 rounds; 1.46 ± 0.75 rounds, respectively; $P < 0.001$) in concordance with injury rates increasing the more rounds a bout lasts. Longer bouts mean greater exposure to injury-producing situations, and thus, more injuries. Fight strategies based on skill levels could contribute to longer bouts whereby professional strategies involve more tactical components that require more time. Alternatively, professional bouts may be extended in length because professionals are less willing to succumb to submissions (ie, tap out) when placed in a submission hold. The reasons for this are not known but may

TABLE 2. Injury Rates and Types of Injuries by Gender, Level, and State

	Injury Rates	Types of Injuries							
		Lacerations and Abrasions		Fractures		Altered Mental State		Other*	
		Per Rounds	Per Rounds	Per Injuries	Per Rounds	Per Injuries	Per rounds	Per Injuries	Per Rounds
Overall (2178 rounds)	5.6% (n = 121 injuries)	2.2% (46)	38.0	1.0 (20)	16.5	1.2 (26)	21.5	1.4 (29)	24.0
Men (1966 rounds)	5.6 (110)	2.3 (43)	39.1	1.0 (17)	15.5	1.3 (25)	22.7	1.4 (25)	22.7
Women (212 rounds)	5.2 (11)	1.4 (3)	27.3	1.4 (3)	27.3	0.5 (1)	9.1	1.9 (4)	36.4
Amateur (1626 rounds)	4.9 (79)	1.8 (28)	35.4	0.8 (13)	16.5	1.3 (21)	26.6	1.1 (17)	21.5
Professional (552 rounds)	7.6 (42)	3.6 (18)	42.9	1.6 (8)	19.0	0.9 (5)	11.9	2.4 (11)	26.2
KS (779 rounds)	7.2 (56)	3.2 (24)	42.9	1.5 (11)	19.6	1.5 (12)	21.4	1.3 (9)	16.1
MO (1399 rounds)	4.6 (65)	1.6 (22)	33.8	0.6 (9)	13.8	1.0 (14)	21.5	1.4 (20)	30.8

*Includes dislocations, edemas, oral issues, and severe fatigue.

involve professionals having more to lose (especially financially) than amateurs or a relatively stronger belief (based on experience) of professionals in their abilities to escape holds. The notion of submission is unique to MMA and may be vital to the safety of its fighters. Therefore, training and regulatory processes should address its importance at all levels of skill, but particularly among professional MMA fighters.

Our study is the first to specifically analyze injury rates in women MMA fighters. Unlike professional male boxers who are 3 times more likely to be injured than female boxers,¹⁵ our analysis did not show sex differences in overall MMA injuries or injury type. This was the case even though a higher percentage of women fought professionally and had fights lasting more rounds than men. Although not to a statistically significant degree, injuries classified as causing an “altered mental state” accounted for fewer of the total injuries in women (9.1%) than in men (22.7%). Taken in aggregate, these findings are encouraging because they may suggest that there are risk factors for injuries that may be modifiable. These risk factors could be addressed in male MMA fighters

to achieve lower injury rates and drastic reductions in dangerous head-related injuries.

Bouts were almost 3 times more likely to be ended by KO/TKOs than submissions, decisions, or disqualifications. This is what would be expected based on earlier findings for MMA (3.3%–6.4%)^{6,7,13} and well below the 11.3% KO rate reported for boxing.¹⁵ Bouts that were ended by KO/TKOs were far more likely to produce injuries resulting in altered mental states than bouts ended in another fashion (4.2% vs. 0.2%, respectively). Although this fits with the perception of MMA as a violent sport,⁵ the occurrence of severe head injuries (eg, concussions) has been found to be much lower than boxing.^{7,13,20} Nevertheless, even nonconcussive altered mental status can lead to brain trauma as measured via specific biochemical markers.²¹ Therefore, the results of this study and others clearly indicate that concussions, and to a greater extent, altered mental states, are prevalent in MMA (and boxing) and ringside MMA physicians should be particularly attentive to neurological examinations for fights ending by KO/TKO.

TABLE 3. Summary of Logistic Regression Analysis for Predictors of Injury and ER Referral

Predictor	Injury (n = 121)			Referred to ER (n = 30)		
	β	SE β	e ^β	β	SE β	e ^β
State (MO = 1; KS = 2)	0.55*	0.26	1.74	0.20	0.45	1.22
Level (amateur = 1; pro = 2)	0.57*	0.27	1.77	0.61	0.46	1.85
Gender (female = 1; male = 2)	-0.60	0.41	0.55	-1.74	1.07	0.18
Round (1–3)	0.53§	0.14	1.70	0.65†	0.24	1.92
Outcome (other = 1; KO/TKO = 2)	1.43§	0.23	4.17	1.26‡	0.40	3.52
Constant	-5.29§	0.63	0.01			
χ ²		64.77			19.26	
df		5			5	

*P < 0.05.
 †P < 0.01.
 ‡P < 0.005.
 §P < 0.001.
 β, beta; SE, standard error; e^β, exponentiated β; df, degrees of freedom.

Level, sex, and state were not significantly associated with being referred to the ER. In addition, the low ER referral rates for both men (1.5% of injuries referred) and women (1.4%) are similar to those noted in boxing (1.3%)²² providing evidence that MMA injuries are not usually severe and more brutal than other contact sports. Although referrals were limited in number, the data does suggest that while professional MMA fighters and MMA fighters in KS have higher rates of injury, they are not referred to the ER more frequently than their comparative others. One reason may be that professionals and KS fighters are better protected. Professionals have acquired aversion skills that are sometimes more difficult to master than attack skills that help them limit the impact of their opponents blows. In KS, slight deviations in how fights are run could reduce severe injuries.

Though we recorded “altered mental status” type injuries, these were based on ringside physician evaluation rather than standardized mental status markers. Future studies could incorporate a standardized prefight mental status measure and reanalyze it postfight. In addition, the same physician made all the fighter evaluations and diagnosis. Although this eliminated intraobserver variability, it detracted from a more universal application of the results. Our data also were limited because we did not have the actual times bouts ended (eg, 2:43 of the second round), but rather only the round it ended. A more “fine-grained” analysis may reveal additional insights. Finally, this study lacked long-term follow-up on fighters, as ringside coverage lasted only until the end of the event.

CONCLUSIONS

In this most current examination of MMA injury, a positive shift in the overall safety of the sport was noted. The rate of injuries during MMA competitions is consistent with what would be expected for a contact sport. However, the findings suggest that there are certain aspects that require attention from clinicians, sanctioning bodies, and researchers. For instance, preventative or follow-up measures could be employed to lower rates of head injuries. Future studies could examine extended medical follow-up (eg, 1-week postcompetition) and employ methods to track long-term cognitive function.

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