Injuries to Professional and Amateur Kickboxing Contestants

A 15-Year Retrospective Cohort Study

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Background: Kickboxing is a group of full-contact combat sports that allows both kicking and punching from a standing position. Despite its popularity, there is a scarcity of published data elucidating the injury epidemiology in kickboxing.

Purpose: To determine the injury incidence, describe the injury pattern, and identify potential risk factors for injury in kickboxing.

Study Design: Descriptive epidemiology study.

Methods: Data describing fight outcomes and injuries sustained during professional and amateur kickboxing contests over a 15-year period were obtained from the official records of the Nevada Athletic Commission, United States. Injury incidence rates and rate ratios were calculated with 95% confidence intervals (95% CIs) per 1000 athlete-exposures (AEs) and per 1000 minutes of exposure. The injury pattern was described using frequencies and proportions of injuries by anatomic region and type of injury. In addition, Poisson mixed-effects generalized linear modeling was used to examine the multivariate relationships between injury incidence rates and potential risk factors.

Results: The sample consisted of 481 unique fighters competing across 57 events, 976 AEs, 9562 minutes of exposure, and 380 injuries. The mean ± SD age of the fighters was 29.0 ± 5.3 years (range, 15-48 years). The overall injury incidence rates were 390.1 injuries (95% CI, 351.9-431.4) per 1000 AEs and 39.7 injuries (95% CI, 35.8-43.9) per 1000 minutes of exposure. The most commonly injured anatomic regions were the head (57.8%) and lower extremity (26.1%), while the most common types of injury were laceration (70.6%) and fracture (20.6%). Professional fighters were 2.5 times more likely to get injured compared with amateurs (rate ratio, 2.51; 95% CI, 1.39-4.55), while defeated fighters were 3.5 times more likely to get injured compared with winners (rate ratio, 3.48; 95% CI, 2.73-4.44).

Conclusion: Injuries are frequent and often significant in kickboxing, and better injury surveillance is strongly recommended. The scarcity of good-quality epidemiological data in kickboxing, especially pertaining to the severity of injuries, underscores the urgent need for further research, whereupon evidence-informed sport safety and injury prevention policies can be developed.

Keywords: athletic injuries; kickboxing; martial arts; epidemiology; head injuries

Kickboxing, in the wider sense of the term, is a group of predominantly Japanese, Southeast Asian, and Western full-contact combat sports characterized by allowing both kicking and punching from a standing position. The rule sets may vary considerably among various kickboxing contests, however. For instance, some contests may allow clinch fighting, the use of knees or elbows, leg kicks, or leg sweeps and throws. The different rule sets mandate the use of different protective gear, which typically include mouth guards, hand-wraps, 10-ounce (283 g) boxing gloves, groin guards, and shin pads. In addition, padded kick-boots and protective head gear are often mandatory equipment for amateurs and athletes younger than 16 years.

Contests are usually scheduled for 3 to 5 rounds, each of which lasting 2 or 3 minutes with a 1-minute rest in between rounds. Some professional contests, however, may be scheduled for up to 12 rounds. The winner of a contest is determined by a (split or unanimous) decision by a panel of judges, or alternatively, contests may end prior to the

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expiration of the scheduled time by submission (ie, a contestant quits or a fighter's corner throws in the towel), knockout (KO), or technical knockout (TKO; ie, referee or medical stoppage). Weight classes vary across kickboxing styles and competitions but can range from minimum weight (47 kg) to super heavyweight (unlimited).

Despite the obvious potential for injury, there are limited data elucidating the injury epidemiology in kickboxing. The few studies that have been published to date nonetheless suggest that there is a considerable injury problem in full-contact kickboxing.[2-4,11] Zazryn and colleagues[11] reported an injury incidence rate of 109.7 injuries per 1000 athlete-exposures (AEs) in professional kickboxers competing in the state of Victoria, Australia. The remaining studies, however, involve only small to moderate sample sizes, and consequently, the conclusions that can be drawn from them are limited. To be sure, more data are needed to elucidate the injury problem in kickboxing. Thus, the purposes of this study were to determine the injury incidence rate, describe the injury pattern, and identify potential risk factors for injury in sanctioned kickboxing contests taking place over a 15-year period in the state of Nevada, United States.

METHODS

This retrospective cohort study adhered to guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement.[10]

Study Population

All fighters who participated in amateur and professional kickboxing contests sanctioned by the Nevada Athletic Commission between January 2000 and December 2014, inclusive, were included in this study.

Data Collection

Data were obtained from official event records that are in the public domain and freely accessible from the Nevada Athletic Commission website (http://boxing.nv.gov/). These event records contain information regarding the event (date, venue, and location), contestants (date of birth and weight), contest (number of scheduled rounds and whether it was a title fight), fight outcome (who won the contest, how the contest was decided, and, if applicable, the time of stoppage), and additional notes (basic description of the anatomic location and type of any injuries). All injuries were diagnosed and managed by attending ringside physicians. Because the recording of injuries was at the discretion of attending ringside physicians, no strict operational injury definition was imposed in this study. The injuries described in the official event records were coded by the author according to the Orchard Sports Injury Classification System (OSICS), version 10.[8]

Data Analysis

Injury incidence rates per 1000 AEs and per 1000 minutes of exposure were calculated with 95% confidence intervals (95% CIs) using standard methods for Poisson rates.[9] One AE was defined as 1 fighter participating in 1 contest, while 1 minute of exposure was defined as 1 athlete participating in a contest for a duration of 1 minute. Subgroups (sex or weight category) were compared by computing the rate ratio of the injury incidence rates of 2 subgroups. For the purposes of subgroup analyses in this study, competition weight classes were collated into 3 categories: light (<62.3 kg), middle (62.3-78.2 kg), and heavy (>78.2 kg). The 95% CIs were calculated for rate ratios using a standard formula for Poisson rates[9] and subsequently used to determine whether 2 rates were statistically different from one another (ie, whether the interval included the null value). In addition, Poisson mixed-effects generalized linear modeling was used to examine the multivariate relationships between injury incidence rates and potential risk factors (eg, age, sex, weight category, and fight outcome). The mixed-effects models used a random intercept for each athlete to account for the correlation induced by multiple observations of the same person. All statistical modeling was performed using R software, version 3.1.2 (The R Foundation for Statistical Computing).

RESULTS

Study Sample

The study sample consisted of 481 unique fighters (406 men, 75 women; 435 professionals, 59 amateurs) competing in 487 contests across 57 events. The mean ± SD age of the contestants was 29.0 ± 5.3 years (range, 15-48 years). The data set comprised a total of 974 AEs, 9562 minutes of exposure, and 380 injuries. The majority of contests were determined by judge's decision (57.5%), while the remaining contests were stopped prematurely, usually because of either TKO (29.6%) or KO (10.7%).

Injury Incidence

The overall injury incidence rates were 390.1 (95% CI, 351.9-431.4) injuries per 1000 AEs and 39.7 (95% CI, 35.8-43.9) injuries per 1000 minutes of exposure.

Injury Pattern

Table 1 provides an overview of the frequencies of injuries by anatomic region and type of injury. A large proportion of injuries did not specify the anatomic region (47.6%) or type of injury (64.2%). Of those injuries for which details were provided, the head (57.8%) and lower limb (26.1%) were the 2 most commonly reported anatomic regions to sustain injuries, while lacerations (70.6%) and fractures (20.6%) were the 2 most commonly reported types of injuries.

Risk Factors

Figure 1 shows the univariate rate ratio calculations of injury incidence rates per 1000 AEs. The analyses revealed that the risk of injury was significantly greater for male

TABLE 1
Injury Frequency by Anatomic Region and Type of Injury

Anatomic Region	n	Type of Injury	n
Head and neck	115	Dislocations	2
Head	115	Fractures	28
Upper limb	19	Hematoma	2
Shoulder	3	Joint sprain	1
Elbow	5	Laceration	96
Forearm	1	Nerve injury[a]	1
Wrist and hand	10	Organ injury	4
Trunk	13	Tendon injury	2
Chest	10	Injury unspecified	244
Abdomen	3		
Lower limb	52		
Hip and groin	3		
Thigh	2		
Knee	15		
Lower leg	17		
Ankle	4		
Foot	11		
Location unspecified	181		

[a]Includes concussion.

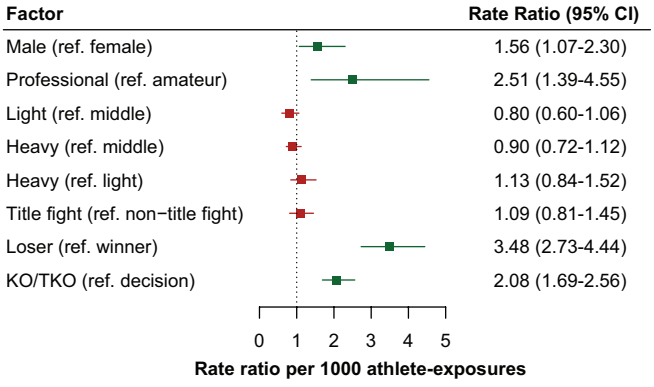

Figure 1. Univariate rate ratio calculations of injury incidence rates per 1000 athlete-exposures with 95% CIs. KO, knockout; ref, reference; TKO, technical knockout.

fighters (compared with females), professional fighters (compared with amateurs), those who lost (compared with those who won), and fighters in contests ending in KO or TKO (compared with fighters in contests ending from judge's decisions). Figure 2 shows that the results were similar when factoring in the actual exposure time (ie, calculating the rate ratios of injury incidence rates per 1000 minutes of exposure).

The results from the Poisson mixed-effects generalized linear modeling are shown in Table 2. The modeling revealed findings similar to the univariate rate ratio calculations, that is, the injury risk was significantly greater for those who lost (compared with those who won) and fighters in contests ending in KO or TKO (compared with fighters in contests ending from judge's decisions). There were no significant differences between males and females, however, and only the model not factoring in the exposure time

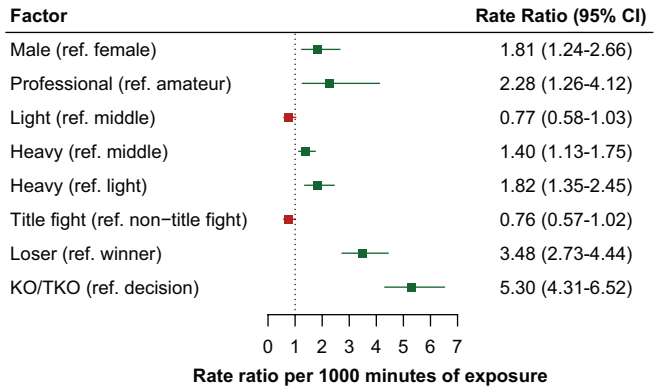

Figure 2. Univariate rate ratio calculations of injury incidence rates per 1000 minutes of exposure with 95% CIs. KO, knockout; ref, reference; TKO, technical knockout.

demonstrated that professional fighters had a greater risk of injury compared with amateur fighters.

DISCUSSION

This is the largest study of kickboxing injuries sustained during contests sanctioned in the United States to date. It highlights and elucidates that there is a substantial injury problem present in the sport of kickboxing.

The overall injury incidence rate in the present study (390.1 per 1000 AEs) is greater than the rates reported in previous studies on injuries in kickboxing[2-4,11] and other popular full-contact combat sports.[6] However, owing to differences in methodologies and operational injury definitions across these studies, it is possible that actual injury incidence rates differ significantly from the rates reported in these studies. Future studies are strongly encouraged to adhere to standard operational injury definitions.

Uncertainty notwithstanding, the reported differences in injury incidence rates across full-contact combat sports may potentially be explained by differences in competition rules (eg, permissible targets and techniques). For instance, kickboxing allows striking (ie, both kicking and punching, and in some cases, even elbow strikes) to the trunk and head regions, whereas boxing does not allow any kicking, and taekwondo does not allow punching to the head region. Mixed martial arts, on the other hand, not only allows striking similarly to kickboxing but also allows take downs, grappling, and joint locks to submit the opponent, thereby possibly reducing the amount of trauma that might have been inflicted if only striking were allowed. It is also worth noting that judo, which does not allow any striking, has the lowest injury incidence rate among full-contact combat sports.[6]

The distribution of injuries by anatomic region in the present study is similar to that described in previous reports.[2-4,11] With regard to the types of injuries, however, there appears to be a greater proportion of lacerations and fractures but a smaller proportion of contusions and concussions in the present study compared with previous

TABLE 2
Results From Multivariate Poisson Mixed-Effects Modeling Showing the Relative Risk of Injury per 1000 Athlete-Exposures and 1000 Minutes of Exposure[a]

Factor	Rate Ratio per 1000 Athlete-Exposures (95% CI)	*P* Value	Rate Ratio per 1000 Minutes of Exposure (95% CI)	*P* Value
Age, y	1.00 (0.98-1.02)	.912	1.00 (0.98-1.02)	.779
Male (ref. female)	1.36 (0.87-2.11)	.173	1.26 (0.76-2.09)	.364
Professional (ref. amateur)	2.01 (1.10-3.66)	.023	1.54 (0.74-3.19)	.244
Light (ref. heavy)	1.17 (0.83-1.64)	.371	0.72 (0.49-1.07)	.101
Middle (ref. heavy)	1.30 (1.05-1.61)	.018	0.99 (0.77-1.28)	.969
Title fight (ref. non–title fight)	1.13 (0.86-1.49)	.385	0.97 (0.71-1.34)	.875
Loser (ref. winner)	3.56 (2.83-4.48)	<.001	3.61 (2.77-4.71)	<.001
KO (ref. decision)	2.17 (1.63-2.90)	<.001	6.24 (4.45-8.74)	<.001
TKO (ref. decision)	2.05 (1.66-2.53)	<.001	4.83 (3.79-6.15)	<.001

[a]KO, knockout; ref, reference; TKO, technical knockout.

reports.[2-4,11] Moreover, the proportion of injuries by type in the present study is more similar to that reported in mixed martial arts and, to a slightly lesser degree, boxing.[6] The reason for this apparent dissimilarity with previous reports on kickboxing and similarity with other combat sports, such as mixed martial arts and boxing, may be due to differences in study methodology such as study populations, operational injury definitions, and data collection methods. For instance, both the present study and most of the available data from mixed martial arts are based on retrospective analysis of official event records where the reporting of injuries was at the discretion of the attending ringside physician, while some of the previous studies on kickboxing were prospective investigations with more inclusive operational injury definitions. In addition, because a large proportion of the reported injuries did not include diagnostic details such as anatomic region or type of injury, the injury pattern reported herein should be interpreted with caution. Future studies are therefore encouraged to report injury diagnoses using a standardized sports injury classification system such as the OSICS-10.[8]

There is good reason to believe that there is significant underreporting of concussion injuries in the official event records reviewed in the present study. A single case of concussion from a total of 380 injuries seems highly unlikely given that approximately 2 of 5 contests ended in either KO (10.7%) or TKO (29.6%). Hutchison and colleagues[5] found that the overwhelming majority (90%) of TKOs in mixed martial arts were a result of repetitive strikes rendering the contestant unable to intelligibly defend him- or herself. Thus, they argue that combining KOs and TKOs due to repetitive strikes (also referred to as *match-ending head trauma*) represents a reasonably good proxy for the actual incidence of concussion or mild traumatic brain injury in mixed martial arts. This argument could easily be extended to the present study to support the notion that concussion injuries are significantly underreported. Furthermore, this may also help explain the observed difference in proportions of types of injuries in the present study compared with previous studies on kickboxing. To be sure, the high proportion of head injuries in kickboxing is a cause for concern because increasing exposure to repeated head trauma is associated with decreased cognitive function and degeneration of brain structures such as the thalamus, hippocampus, and basal ganglia.[1]

Although this study has revealed a very high injury incidence rate, very little is known about the severity of these injuries. Alas, neither the present study nor any of the previous studies on kickboxing report on injury severity in objective terms. Future studies are strongly encouraged to determine the severity of injuries in kickboxing using objective severity measures such as actual, as opposed to estimated, time lost to participation in training or competition.

With regard to risk factors for injury in kickboxing, the strongest evidence from the present study pertains to level of play and outcome of contests. First, the injury risk for professional fighters was greater than that of amateur fighters. This finding is consistent with the only other study that has collected data from both amateur and professional kickboxers.[4] Second, the injury risk was, unsurprisingly, greater for defeated fighters (compared with winning fighters) and fighters in contests ending in KO or TKO (compared with fighters in contests ending with a judge's decision). Although none of the previous studies on kickboxing have reported specific injury incidence rates by contest outcome, similar findings have been reported in a recent meta-analysis of injuries in mixed martial arts.[7]

It is worth noting that none of the risk factors identified in this study are particularly modifiable. For instance, contests are bound to have a winner and loser (except in rare cases when the contest is a draw). However, it may be possible to envisage preventive interventions to reduce the number of KOs or TKOs due to repetitive strikes (eg, headgear), but whether such modifications will be acceptable to stakeholders such as sport governing bodies and athletes remains to be determined. Future studies are encouraged to increase efforts to identify potentially modifiable risk factors for injury in kickboxing, which in turn may inform the development, adoption, and implementation of injury prevention policies in the sport.

Limitations

This retrospective study included data from kickboxing contests sanctioned by the Nevada Athletic Commission, which may limit the generalizability of the findings reported herein. However, there are no obvious reasons why this cohort should be significantly different from those in other jurisdictions in the United States with similar legislation. For pragmatic reasons, this study did not adopt a strict operational injury definition. Because the recording of injuries was at the discretion of the attending ringside physicians, one can expect a number of injuries, presumably minor or less serious injuries, to go unreported. This may result in underestimating the actual risk of injury while potentially overestimating the relative proportion of more severe injuries, such as fractures. Injuries were diagnosed by qualified ring physicians; however, in the absence of advanced diagnostic technologies, there is a potential for misdiagnosis and misreporting. Moreover, a large proportion of injuries did not include diagnostic details such as anatomic region and type of injury. The findings reported herein should be interpreted in light of these limitations.

CONCLUSION

Injuries in kickboxing are frequent and often significant, and better injury surveillance is strongly recommended. The scarcity of high-quality epidemiological data in kickboxing, especially pertaining to the severity of injuries, underscores the urgent need for further research, whereupon evidence-informed sport safety and injury prevention policies can be developed.

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