

# Head Trauma Exposure in Mixed Martial Arts Varies According to Sex and Weight Class

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**Background:** Brain injury arising from head trauma is a major concern in mixed martial arts (MMA) because knockout (KO) and technical knockout (TKO) are frequent fight outcomes. Previous studies have shown a high incidence of matches ending due to strikes to the head but did not consider weight categories and female fights. This study aimed at analyzing match stoppages in MMA and the exposure to head trauma distinguished by sex and weight categories.

**Hypothesis:** The heavier the weight class, the greater the risk and incidence of head trauma will be, regardless of sex.

**Study Design:** Descriptive epidemiology study.

**Level of Evidence:** Level 3.

**Methods:** Publicly available data of 167 MMA events from 1903 fights between 2014 and 2017 were assessed, comprising 8 male and 2 female weight categories.

**Results:** The combined KO/TKO rates per 100 athlete-exposures in the middleweight (19.53), light heavyweight (20.8), and heavyweight (26.09) divisions were greater than previously reported for MMA. While stoppage via KO/TKO occurred in 7.9% of combats in the female strawweight division, it occurred in 52.1% of the male heavyweight fights. The male middleweight ( $P = 0.001$ ), light heavyweight ( $P < 0.001$ ), and heavyweight divisions ( $P < 0.001$ ) had an increased risk of KO/TKO due to strikes to the head by 80%, 100%, and 206%, respectively. The risk in the flyweight division decreased 62% ( $P = 0.001$ ). All categories were compared with the lightweight division. The female bantamweight category presented a 221% increased risk in matches ending due to KO/TKO compared with the strawweight division ( $P = 0.012$ ). Punches to the head were the major technique used to end a combat via KO/TKO, regardless of sex and weight class.

**Conclusion:** Head injury risk and incidence varies considerably according to sex and weight category in MMA.

**Clinical Relevance:** The analysis of head trauma exposure in MMA athletes should be distinguished according to sex and weight category.

**Keywords:** combat sports; head injuries; brain concussion; traumatic brain injury; chronic traumatic encephalopathy

“Mixed martial arts” (MMA) is an umbrella term for a combat sport that encompasses athletes with backgrounds in several fighting disciplines that mainly involve standing strikes, grappling, and locking techniques.<sup>9,11</sup> Despite the increasing popularity of MMA worldwide, numerous medical associations around the globe have called for the banishment of the sport,

mainly based on presumed risk of brain injury.<sup>7,11,12</sup> In response, a cooperative work at different levels has been developing to diagnose, recognize, and provide reliable recommendations to make the sport safer.<sup>21</sup>

Because blows directly to the head are an effective way to achieve a win, MMA could report even higher rates of traumatic

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brain injury than those assessed in American-style football and ice hockey.<sup>7</sup> Both knockout (KO) (ie, when a competitor is unconscious or disoriented) and technical knockout (TKO) (ie, when an athlete is judged to be unable to competently defend himself) are frequent fight outcomes.<sup>4,7,11</sup> Both outcomes could easily entail concussive events, as sports-related concussion is, among various aspects, a subset of mild traumatic brain injury induced by biomechanical forces that may or may not involve loss of consciousness.<sup>15,21</sup>

Recently, inappropriate representation of the long-term risks of repeated head trauma and concussions in popular culture has gained attention.<sup>27</sup> The previous studies reporting traumatic brain injury risk in MMA did not consider that there are significant differences between weight categories in several aspects of the fight, including strikes landed in the distance, clinch, and on the ground.<sup>18,20</sup> Moreover, female fights were neither included nor analyzed, which is of utmost importance since there likely exist differences between males and females toward recovery and concussion rates.<sup>8,16,24</sup>

Therefore, the aim of the present study was a comprehensive investigation evaluating match stoppages and head trauma risk in MMA fights according to sex and weight class. This analysis includes the percentage of each fight outcome including the incidence of KO and TKO in MMA, the source that resulted in match-ending head traumas, and the identification of sex and weight categories that were more susceptible to match-ending due to head trauma.

## METHODS

### Data Collection

All data collected for the present investigation were obtained from publicly available sources. All Ultimate Fighting Championship (UFC) matches from 2014 up to 2017 were assessed, comprising a total of 167 events and 1903 fights. Every event within these 4 years was analyzed. This includes the following: *UFC 169 to 219*, *UFC Fight Night 34 to 123*, *UFC on Fox from 10 to 26*, *The Ultimate Fighter Finale from 19 to 26*, *The Ultimate Fighter Finale China*, *The Ultimate Fighter Finale Nations*, and *The Ultimate Fighter Finale Brazil 3* (see Appendix 1, available in the online version of this article).

Each fight outcome and the source of stoppage was obtained from a specialized and publicly available website ([www.sherdog.com](http://www.sherdog.com)), while the official UFC website ([www.ufc.com](http://www.ufc.com)) was used to confirm the weight category for each bout analyzed. Similar data collection procedures were used previously to verify MMA fight outcomes and athlete records.<sup>3,7</sup> When further information was needed, video analysis of the specific bout was performed. The possible fight outcomes in the present study were classified as decision, submission, KO, TKO, disqualification, medical stoppage, and no contest. In addition, both KO and TKO resulting from blows to the head were investigated to identify the source (eg, punches, elbows, knee, kick, and some combinations) that determined the stoppage.

### Weight Categories

The UFC male weight categories assessed in the present study were flyweight (52.1-56.7 kg), bantamweight (56.7-61.2 kg), featherweight (61.2-65.8 kg), lightweight (65.8-70.3 kg), welterweight (70.3-77.1 kg), middleweight (77.1-83.9 kg), light heavyweight (83.9-93.0 kg), and heavyweight (93.0-120.2 kg). For female weight classes, the strawweight (<52.1 kg) and the bantamweight (56.7-61.2 kg) divisions were analyzed, since these were the 2 categories with a considerable amount of data during the evaluated period. Fights in a catchweight occur when athletes agree to fight in an unofficial weight class and were considered to match the exclusion criteria for the present study. These data were not analyzed regardless of sex, since these fights could have occurred at any weight, and results and conclusions would be affected.

### Statistical Analysis

All statistical analyses were performed using SPSS (v 17.0; SPSS Inc). Descriptive absolute and relative data are presented for each weight class as well as the total male and female cases. We applied a previous definition for an athlete-exposure (AE),<sup>7</sup> that is, participation in any competition in which one was exposed to the possibility of an athletic injury (ie, 1 fight with 2 competitors yields 2 AEs). Binary logistic regression analyses were performed to verify and compare the odds ratios of a KO/TKO stoppage due to strikes to the head among weight categories for each sex. A significance level of  $\leq 5\%$  was set, with 95% CIs.

## RESULTS

### Fight Outcomes and KO/TKO sources

A total of 1728 male combats were analyzed. This includes 126 flyweight, 179 bantamweight, 218 featherweight, 350 lightweight, 347 welterweight, 233 middleweight, 137 light heavyweight, and, 138 heavyweight combats. For females, a total of 175 fights were analyzed: 101 in the strawweight and 74 in the bantamweight division. The proportions of the main fight outcomes for each weight class are represented in Figure 1. Disqualification, no contest, medical stoppage, and TKOs not directly related to blows to the head (eg, body kick) were considered as "other."

Fighters employed different technique combinations to achieve a referee stoppage during the bouts. Despite the use of the elbow, knee, shin, and foot, the hands/fists were the most used parts of the body to obtain a KO/TKO with traumatic blows to the opponent's head. Thus, punches were widely used to end combat, either singly or in combination with other parts of the body, regardless of sex and weight category (Figure 2).

### AE and Odds Ratios for Head Trauma

The TKO result is commonly associated with blows to the head; however, musculoskeletal injuries, lacerations, and corner or

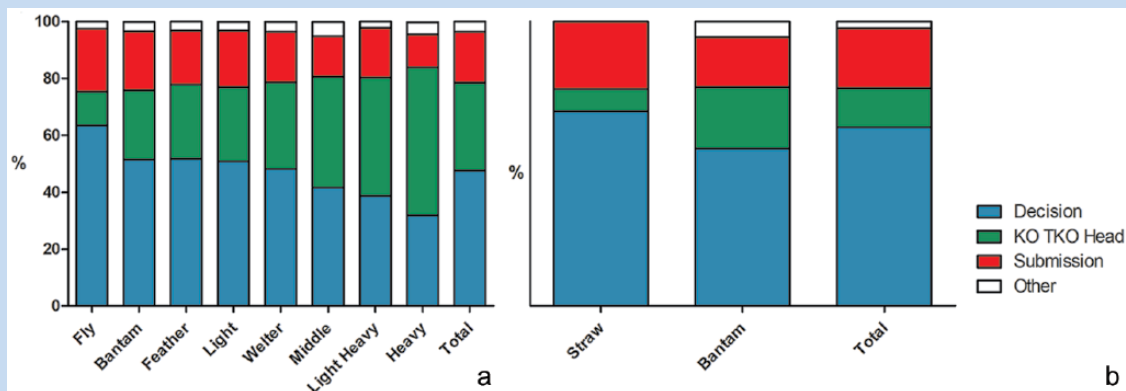


Figure 1. Percentage of fight outcomes according to (a) 8 male and (b) 2 female categories. KO, knockout; TKO, technical knockout.

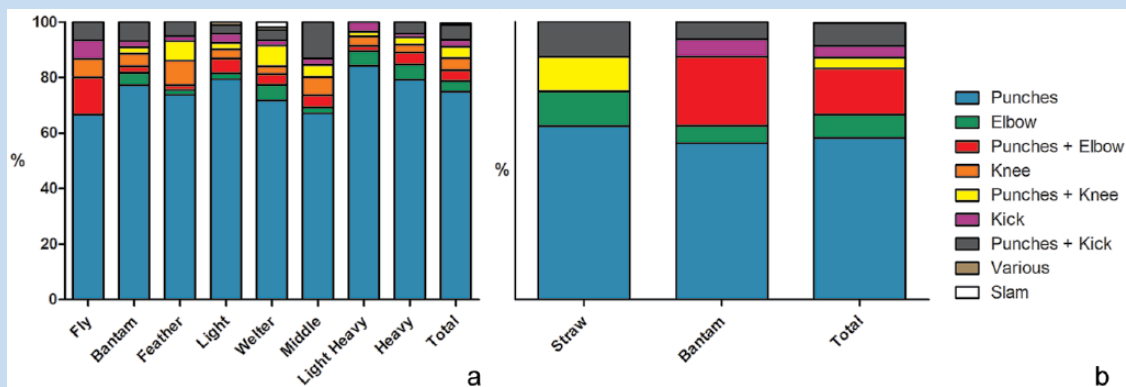


Figure 2. Proportion of the source of impact that resulted in knockout (KO) and/or technical knockout (TKO) to the head in each (a) male and (b) female weight category.

medical stoppages can also lead to TKOs. The vast majority of TKOs assessed in the present study were due to blows to the head (Table 1). Every combat analyzed comprised 2 AEs, which generated a total of 3456 and 350 AEs for males and females, respectively. Table 1 demonstrates the proportion of TKO stoppages due to head impact in each weight class, as well as the frequency of KO and combined KO/TKO episodes for every 100 AEs.

The lightweight division was chosen as the reference for the binary logistic regression analysis of the male categories according to previous literature<sup>7</sup> (Table 2). Flyweight was the only category that presented significantly diminished risk (-62%) of a KO/TKO due to strikes to the head. In contrast, the middleweight, light heavyweight, and heavyweight categories increased the risk of sustaining a KO/TKO outcome caused by strikes to the head by 80%, 100%, and 206%, respectively. The strawweight division was the reference for the female analysis. Fights of the bantamweight category presented a 221% increased risk of a KO/TKO resulting from strikes to the head.

## DISCUSSION

### Relevance of Sex and Weight Class on Head Trauma Risk in MMA

Prior investigations reported a general KO incidence of 4.8 and 6.4 per 100 AEs in MMA matches.<sup>4,7</sup> These results are slightly lower than our overall result regardless of the body mass category (6.68). However, our results show that the occurrence of KO and combined KO/TKO varies considerably according to sex and weight category. Both female categories and the male flyweight division presented lower values, whereas the results from male bantam, feather, light, and welterweights were in between those previously assessed and widely disseminated. The odds ratios analysis performed using the lightweight category as a reference revealed that the middleweight, light heavyweight, and heavyweight divisions presented, respectively, 80%, 100%, and 206% increased risk of a match stoppage due to head trauma. Moreover, these 3 heavier weight classes have achieved values near the upper limit or even higher (see Figure 1)

Table 1. Percentage of technical knockout (TKO) stoppages caused by blows to the head and the incidence of knockout (KO) and KO/TKO per 100 athletes-exposures (AEs)

	% TKOs to the Head	100 AEs KO	100 AEs KO/TKO to the Head
M Flyweight	70	3.17	5.95
M Bantamweight	93.1	4.75	12.29
M Featherweight	94.1	5.73	13.07
M Lightweight	92.9	5.57	13.14
M Welterweight	93.7	6.63	15.27
M Middleweight	90	7.94	19.53
M Light heavyweight	100	9.85	20.8
M Heavyweight	95.2	11.59	26.09
M Total	92.9	6.68	15.45
F Strawweight	100	0.99	3.96
F Bantamweight	78.5	3.38	10.81
F Total	85	2	6.85

F, female; M, male.

Table 2. Odds ratios (OR) for knockout (KO) and technical knockout (TKO) outcomes caused by strikes to the head according to the weight division

	KO/TKO to the Head	
	OR (95% CI)	P
M Flyweight	0.38 (0.21-0.68)	0.001
M Bantamweight	0.91 (0.60-1.38)	0.671
M Featherweight	0.99 (0.68-1.46)	0.971
M Lightweight <sup>a</sup>	1.00	—
M Welterweight	1.23 (0.89-1.72)	0.213
M Middleweight	1.80 (1.26-2.56)	0.001
M Light heavyweight	2.00 (1.32-3.03)	<0.001
M Heavyweight	3.06 (2.03-4.61)	<0.001
F Strawweight <sup>b</sup>	1.00	—
F Bantamweight	3.21 (1.29-7.97)	0.012

F, female; M, male.

<sup>a</sup>Male lightweight division as reference.

<sup>b</sup>Female strawweight division as reference.

than the range of KO and TKO prevalence (28.3%–46.2% of all matches) previously reported in MMA.<sup>11</sup> Since the present study indicates that heavier categories encompass larger risks and incidences of KO and TKO, it is reasonable to consider whether these athletes had increased chances of suffering from more severe traumatic brain injuries.

Conversely, the scorecard decision was the fight outcome for the vast majority of the male fly- (63.4%), bantam- (51.4%), feather- (51.8%), light- (50.8%), and welterweight (48.1%), as well as for the female straw- (68.3%) and bantamweight (55.4%) divisions (see Figure 1). Combats that went to decision presented elevated numbers of total strikes attempted to the head during standing combat,<sup>19</sup> hence athletes may develop symptoms of chronic exposure to repetitive trauma to the head<sup>3,27</sup> and/or subconcussive impacts (ie, a cranial impact not diagnosed as a concussion).<sup>13,25</sup> Although without perceptible acute symptoms after the bout, repeated evaluations are necessary to diagnose delayed signs and symptoms of concussion.<sup>21</sup> Furthermore, specific recommendations to athletes who underwent an entire combat should be considered, since repetitive traumas to the head have been associated with decreased cognitive performance,<sup>1,3</sup> lower brain volume,<sup>3</sup> cerebral perfusion,<sup>1</sup> and risk of chronic traumatic encephalopathy.<sup>14,15</sup>

Female fight outcomes presented the same trend as males. The bantamweight showed a 221% higher chance of stoppages by KO/TKO than in the strawweight division. A special concern in female fighters should be addressed, since females presented greater peak angular acceleration and displacement in the head-neck segment than males.<sup>26</sup> Moreover, females also reported several symptoms<sup>16</sup> and presented greater long-term alterations in executive function<sup>24</sup> and a more persistent autonomic nervous system disruption (eg, reduced heart rate variability) after concussion compared with males.<sup>8</sup>

### Preferred Technique May Not Change, but the Sport Does

Punches were the most frequently used technique to end an MMA combat via KO and TKO.<sup>4,7</sup> During standing combat, clinch, or groundwork, strikes attempted and landed to the head are the most frequent compared with those addressed to the body or legs in male<sup>17</sup> and female<sup>19</sup> MMA fights. Our results confirm that punches accounted for the majority (male, 75%; female, 58.3%) of blows struck to end a combat by KO and TKO regardless of sex and body mass division (see Figure 2).

This clear preference for head strikes allows several comparisons between MMA and boxing concerning head trauma risks. While both modalities have the head and wrist/hand as the major injured body sites,<sup>9,10,12</sup> boxers receive more strikes to the head,<sup>6</sup> are more likely to experience loss of consciousness,<sup>10</sup> and present lower brain volumes than MMA athletes.<sup>3</sup>

Some features imported from boxing have been suggested as alternatives to make MMA a safer sport, like mandatory protective head gear, bigger gloves, and the introduction of the 10s rule every time a competitor is knocked down.<sup>7,10</sup> Considering the abovementioned harsher symptoms presented

by boxers compared with MMA fighters, these do not seem to contribute effectively to making the sport safer. However, as in boxing, MMA rules could consider calling the end of a fight (by TKO) if a combatant is knocked down 3 times in the same round.<sup>21</sup> Alternatively, the ban on strikes to the head immediately after a knockdown episode, allowing only the submission techniques during a determined period of time, might be considered. Above all, fair play and respect for opponents are ethical values that should be encouraged.<sup>15</sup> MMA companies could award the fair play of the night instead of, or in addition to, other bonuses (eg, performance of the night and fight of the night), especially due to the extra strikes and impacts that a fighter experiences unnecessarily after the loss of consciousness in MMA.<sup>7</sup>

### Education, Behavior Changes, and Specificity to Evolve

The periods of suspension imposed by commissions after an official fight have no effect on an athlete's training routine,<sup>21</sup> which reinforces the need to educate those directly involved with the fighter's training. To date, there is no study showing whether MMA athletes and coaches actually possess any level of knowledge of aspects related to head trauma, brain injury, or concussion, which could potentially affect the long-term health status of these athletes. Athletes are an essential part of this education program since the minority reported symptoms of concussion to their coaches to keep the training routines.<sup>16</sup> Therefore, not only an educational program but also the urgency for a behavioral change is needed.

The training routine of MMA athletes is likely to include KO and TKO episodes.<sup>6</sup> Sixty percent of MMA athletes who declared experiencing a concussive event during training returned to competition within a few days, while only 13% sought medical attention.<sup>6</sup> Moreover, each previous concussion seems to be associated with an increased risk of a future similar event.<sup>7,22,27</sup> Rigorous supervision during training should be recommended, since subconcussive injuries are likely to occur countless times in the 2.5 to 12 weekly sparring sessions reported by MMA athletes.<sup>2,6</sup>

A structured and detailed sport-related concussion record is highly recommended and should include specific information as to previous symptoms of a concussion and length of recovery, as well as information about all previous head, face, or cervical spine injuries.<sup>15</sup> It should also consider the potential differences in concussion rates and recovery between males and females<sup>16</sup> and the imminent influence of the weight category on the head trauma risk and severity, as shown in the present study. Finally, the King-Devick test,<sup>5</sup> the Fight Exposure Score,<sup>3</sup> and computerized neuropsychological testing<sup>21</sup> are practical alternatives to diagnose and follow-up after concussive events in MMA, even though brain injury can be present without measurable cognitive impairment.<sup>23</sup>

The MMA continues to experience public growth and attracts the attention of medical associations concerned about the safety of the sport.<sup>7,11,12,21</sup> However, the majority of the conclusions concerning brain injury and concussion are still made based on



studies with American-style football male players,<sup>13,14</sup> in which the rates of impacts to the head are already known for differing according to the position on the field.<sup>25</sup> Similarly, sex and weight category must be taken into account for future investigations and recommendations with regard to head trauma analysis in MMA. Ultimately, it is crucial that MMA athletes, coaches, and staff be educated and follow the guidelines for concussion management and return to sport specifically designed for combat sports.<sup>21</sup>

## Limitations

There are many significant limitations to this study. Most important, the severity of any injury was not determined. Even though the referee stoppage due to head strikes is a relevant indicator of potentially applied brain injury mechanism, it was not possible to assess the acute and chronic symptoms of sport-related concussion. In addition, the fighters' age and previous KO history were not included in the analysis, which would incorporate relevant elements in the investigation.

## CONCLUSION

There is a need to consider both sex and weight class when analyzing the incidence of exposure to head trauma in MMA and its severity. The lightest categories were those in which athletes were potentially more susceptible to receive repetitive subconcussive blows to the head. The male middleweight, light heavyweight, and heavyweight categories presented increased incidence and risk of a match ending with an athlete either unconscious or unable to defend himself. Females presented the same pattern, albeit further evaluation is recommended with regard to specific symptoms, protocols, and recommendations after head trauma in female MMA athletes.

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