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About the Cover

Artwork image courtesy of Plato Gallery; 202 Bowery, New York, NY 10012

The artwork on the cover of this issue; *Bow your head, close your eyes (2025), 18w x24h* Oil on linen; is by artist Jacob Rochester.

Jacob Rochester (b. 1995, Bloomfield, CT) is a multi-disciplinary artist passionate about exploring the evolution of culture at the turn of the 21st-century.

Jacob Rochester lives and works in Los Angeles, California. He earned a BFA in Graphic Design from the University of Connecticut in 2016. Rochester has collaborated as an illustrator with such companies and music artists as Apple, Aime Leon Dore, Citizen, Converse, Fear of God, Kendrick Lamar, NBA, Nike, New Balance, Playboy, Sabrina Carpenter, Spotify, Stone Island, Street Dreams, Supreme NY, and Tupac Estate, among many others.

For more information on purchasing this work or other works, please visit Plato Gallery at **platogallery.com**.

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Manuscripts are reviewed by peer reviewer ringside physicians from a broad array of specialties. Review is done in a systematic blinded process. We thank our peer reviewers from around the world for their expertise and time volunteered toward making this journal possible. If you would like to apply to be a possible peer reviewer, please e-mail the Editor-In-Chief at the e-mail address found by clicking on the submission guideline link above.

From the Editor's Desk

Dear Fight Sports Community,

Thank you for your contributions to our field and to athlete safety. Our work now in research and scholarship will continue to influence how regulators work, how doctors think, and what the standards will be for preventing and anticipating athlete injury.

We must continue to work on ways to better prepare doctors at ringside, both new doctors and seasoned doctors. We must hold ourselves accountable to continued learning and refinement of skills just as we do in our various medical specialties that we practice outside of ringside medicine. If we witness any efforts to push for shortcuts or lower standards in ringside physician preparation, we must guard against these efforts. There are no shortcuts or alternative pathways to patient safety. We must always maintain a high bar for our work.

This year the Association of Ringside Physicians is launching courses in Down Fighter Life Support (DFLS) and in Bare Knuckle Boxing Medicine, both of which will be taught at the ARP conference and at the Association of Boxing Commissions annual conference. I encourage everyone to consider these courses and share them with their commission. Additionally, if you have not attended the Association of Boxing Commissions annual conference, please consider registering and attending the courses and/or medical lectures: **abcboxing.com/conference-information**

Let us continue to work on our professional identity as ringside physicians. While most of our work goes unnoticed, let us be known as "the best docs" because of our preparation, attention to detail, continued learning, and our commitment to the sport communities we serve. Every one of us is an ambassador to the fight world for medicine and for ringside medicine.

George Velasco, M.D.
May 2026

RESEARCH ARTICLE

Epidemiology of Head Strikes Absorbed by Professional Boxing Fighters

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Keywords: Boxing, Head Trauma, Repetitive Head Impacts, Traumatic Brain Injury, Fighter Exposure

ABSTRACT

Background: Professional boxing is a combat sport in which repetitive head trauma is an inherent occupational exposure. Although prior literature has described neurological risk in boxers, there remains limited bout-level research examining how head strike absorption varies by weight class and method of victory in modern professional boxing.

Methods: This descriptive epidemiological study analyzed publicly available professional boxing data from 2023 through 2025. Bout-level variables included weight class, fight result, total fight time, and head strikes absorbed by winners and losers. Data were compared between winning and losing fighters by sex, weight class, and fight result (Knockout (KO), Technical Knockout (TKO), Unanimous Decision, or Split Decision). Descriptive statistics, mean differences, 95% confidence intervals, and p-values were calculated.

Results: Across 605 fights, winning fighters consistently absorbed fewer head strikes per minute than losing fighters. Among male fighters, this pattern was observed in nearly every weight class and across result categories, with the largest separation seen in KO/TKO bouts. Male winning fighters in heavier divisions absorbed fewer head strikes per minute compared with winners in lighter divisions, while no significant difference was observed between male losing fighters in the light group and heavy group. Among female fighters, winners also generally absorbed fewer head strikes than losers, although significance was only demonstrated in featherweight and lightweight divisions. In female bouts, KO/TKO and unanimous decision outcomes showed significant differences between winners and losers.

Conclusion: In professional boxing, fight outcome is strongly associated with head strike absorption, with losing fighters sustaining substantially greater head strike exposure than winners. These differences are especially pronounced in KO/TKO bouts. Weight class also influences exposure patterns. These findings support the use of head strike volume metrics as a practical method for characterizing exposure to repetitive head trauma and may help inform future athlete safety research and ringside decision-making.

INTRODUCTION

Boxing has long served as one of the clearest sport-based models for studying the neurological consequences of repetitive head trauma.[1,2,3] Concerns surrounding cumulative cranial trauma in boxers date back nearly a century, and modern literature continues to examine the relationship between repeated head impacts, neurocognitive decline, structural brain change, and chronic traumatic encephalopathy-like syndromes. [1,2,3]

More recently, prospective work from the Professional Fighters Brain Health Study has strengthened concern regarding cumulative exposure in combat sports, demonstrating associations between greater fight exposure and smaller regional brain volumes, as well as slower processing speed in active professional fighters.[2] Although that work includes both boxers and mixed martial artists, boxing remains uniquely relevant because the primary competitive objective is to land repeated strikes, many of which target the head.[4,5] Systematic review data have likewise suggested that boxing athletes sustain substantial acute and chronic neurologic burden, reinforcing the need for better ways to quantify exposure during competition.[6]

Prior epidemiological studies in boxing have largely focused on injury incidence, concussions, mortality, and long-term neurologic sequelae rather than bout-level head strike exposure.[7,8,9] These studies have shown that injured fighters are often the losing fighter and that knockout-based outcomes may carry particularly high risk.[7,8] However, fewer studies have examined a more granular exposure metric: the number of head strikes absorbed per unit of time during professional bouts.

Quantifying head strikes absorbed per minute may provide a practical and clinically relevant proxy for acute cranial impact burden. Such a metric allows comparison across bouts of varying duration and may better characterize exposure differences between fighters who win versus lose, between lighter and heavier divisions, and between different methods of victory. In turn, this may help identify contexts in which fighters are exposed to especially high rates of repetitive head trauma.

The purpose of this study was to evaluate head strikes absorbed per minute in professional boxing bouts and determine whether exposure differs by fight outcome, weight class, sex, and fight result. We hypothesized that losing fighters would absorb more head strikes per minute than winning fighters, and that stoppage bouts (Knockout (KO) or Technical Knockout (TKO)) would be associated with greater head strike exposure than decision bouts.

METHODS

This study is a descriptive epidemiological analysis using publicly available professional boxing bout data collected from 2023 through 2025. Publicly available bout records and punch statistics from BoxRec and CompuBox were used to identify fight characteristics including date, weight class, bout result, total bout time, and head punch volume. Because all data were obtained from publicly accessible sources and no protected health information was used, institutional review board approval was not required.

Data Collection: Bout-level data were compiled from publicly available professional boxing records and punch statistics databases. Variables included bout date, weight class, winning fighter, losing fighter, draw/no contest status, official result, total bout duration in seconds and minutes, and head punches landed by each fighter. For the purposes of this study, head strikes absorbed by one fighter were derived from the number of head punches landed by the opponent. Head strike absorption was normalized to bout duration and reported as head strikes absorbed per minute.

Weight Class Stratification: Male and female fights were analyzed separately. Weight classes were evaluated individually and also grouped into broader light and heavy divisions for comparison.

For male fighters, the light group included minimumweight, light flyweight, flyweight, super flyweight, bantamweight, super bantamweight, featherweight, and super featherweight. The heavy group included lightweight, super lightweight, welterweight, super welterweight, middleweight, super middleweight, light heavyweight, cruiserweight, and heavyweight.

For female fighters, the light group included strawweight/minimumweight through super featherweight, while the heavy group included lightweight and above (Table 1).

Table 1: Stratification of weight classes into Light Group and Heavy Group for male and female fighters with corresponding minimum fighter weights

	Weight Class	Limit (lb)
Light Group	Strawweight (Minimum)	< 105
	Light Flyweight	< 108
	Flyweight	< 112
	Super Flyweight	< 115
	Bantamweight	< 118
	Super Bantamweight	< 122
	Featherweight	< 126
	Super Featherweight	< 130
Heavy Group	Lightweight	< 135
	Super Lightweight (Jr Welter)	< 140
	Welterweight	< 147
	Super Welter (Jr Middle)	< 154
	Middleweight	< 160
	Super Middleweight	< 168
	Light Heavyweight	< 175
	Cruiserweight	< 200
	Heavyweight	> 200

Bout Result Stratification: Fight outcomes were categorized into KO/TKO, unanimous decision, and split decision. Bouts ending in draw, no contest, or disqualification were not included in result-specific subgroup analyses.

Statistical Analysis: Descriptive statistics were used to summarize bout characteristics and compare head strike absorption between winning and losing fighters. Mean head strikes absorbed per minute, mean differences, 95% confidence intervals, and p-values were calculated for each comparison. Analyses were performed separately for male and female fighters, by weight class, grouped weight class (light vs heavy), and fight result category. Statistical significance was defined as $p < 0.05$.

RESULTS

Male Fighters by Weight Class: Among male fighters, 546 bouts were included in the weight-class analysis. Winning fighters absorbed fewer head strikes per minute than losing fighters in 16 of 17 weight classes analyzed, with statistically significant differences in all male weight classes except light flyweight (Table 2) (Figure 1).

In male strawweight/minimumweight bouts ($n = 3$), losers absorbed a mean of 5.60 head strikes per minute compared with 1.06 among winners (95% CI: 2.47 to 6.60; $p = 0.011$). In light flyweight bouts ($n = 3$), losers absorbed 2.03 head strikes per minute compared with 3.40 among winners (95% CI: -7.45

to 4.72; p = 0.436). In flyweight bouts (n = 14), losers absorbed 5.05 head strikes per minute compared with 3.18 among winners (95% CI: 0.95 to 2.96; p = 0.001). In super flyweight bouts (n = 9), losers absorbed 5.20 head strikes per minute compared with 2.99 among winners (95% CI: 0.49 to 3.92; p = 0.018).

In bantamweight bouts (n = 19), losers absorbed 5.04 head strikes per minute compared with 2.12 among winners (95% CI: 1.59 to 4.26; p < 0.001). In super bantamweight bouts (n = 17), losers absorbed 4.09 head strikes per minute compared with 2.64 among winners (95% CI: 0.46 to 2.45; p = 0.007). In featherweight bouts (n = 38), losers absorbed 4.50 head strikes per minute compared with 2.72 among winners (95% CI: 1.11 to 2.46; p < 0.001). In super featherweight bouts (n = 39), losers absorbed 4.56 head strikes per minute compared with 2.57 among winners (95% CI: 1.29 to 2.70; p < 0.001).

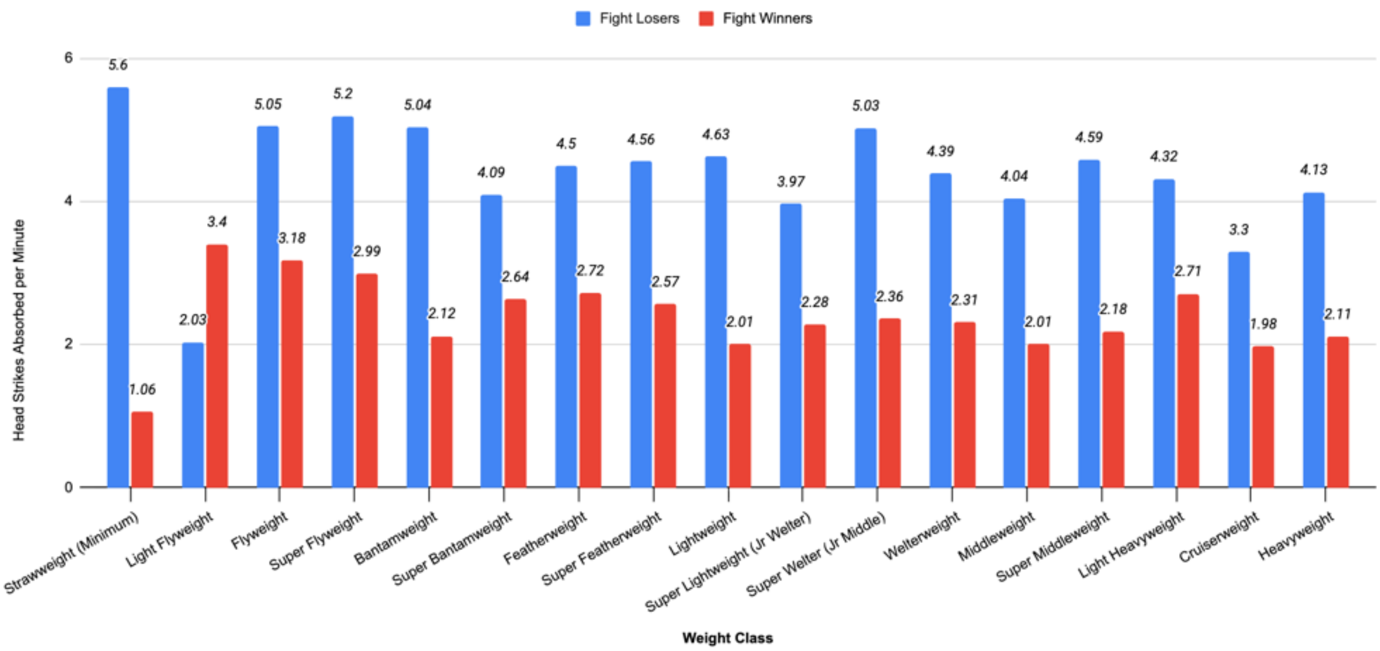
In lightweight bouts (n = 70), losers absorbed 4.63 head strikes per minute compared with 2.01 among winners (95% CI: 2.00 to 3.23; p < 0.001). In super lightweight/junior welterweight bouts (n = 62), losers absorbed 3.97 head strikes per minute compared with 2.28 among winners (95% CI: 1.19 to 2.18; p < 0.001). In welterweight bouts (n = 46), losers absorbed 4.39 head strikes per minute compared with 2.31 among winners (95% CI: 1.41 to 2.75; p < 0.001). In super welterweight/junior middleweight bouts (n = 51), losers absorbed 5.03 head strikes per minute compared with 2.36 among winners (95% CI: 2.01 to 3.34; p < 0.001).

In middleweight bouts (n = 36), losers absorbed 4.04 head strikes per minute compared with 2.01 among winners (95% CI: 1.19 to 2.86; p < 0.001). In super middleweight bouts (n = 43), losers absorbed 4.59 head strikes per minute compared with 2.18 among winners (95% CI: 1.60 to 3.23; p < 0.001). In light heavyweight bouts (n = 27), losers absorbed 4.32 head strikes per minute compared with 2.71 among winners (95% CI: 0.66 to 2.57; p = 0.002). In cruiserweight bouts (n = 23), losers absorbed 3.30 head strikes per minute compared with 1.98 among winners (95% CI: 0.60 to 2.05; p < 0.001). In heavyweight bouts (n = 46), losers absorbed 4.13 head strikes per minute compared with 2.11 among winners (95% CI: 1.34 to 2.71; p < 0.001) (Table 2) (Figure 1).

Table 2: Head strikes absorbed by winning and losing male fighters within weight classes

Weight Class	# of Fights	Loser Mean Head Strikes Absorbed/min	Winner Mean Head Strikes Absorbed/min	95% CI	P-value
Strawweight (Minimum)	3	5.6	1.06	2.47 - 6.60	**0.011**
Light Flyweight	3	2.03	3.4	−7.45 - 4.72	0.436
Flyweight	14	5.05	3.18	0.95 - 2.96	**0.001**
Super Flyweight	9	5.2	2.99	0.49 - 3.92	**0.018**
Bantamweight	19	5.04	2.12	1.59 - 4.26	**.0001**
Super Bantamweight	17	4.09	2.64	0.46 - 2.45	**0.007**
Featherweight	38	4.5	2.72	1.11 - 2.46	**.001**
Super Featherweight	39	4.56	2.57	1.29 - 2.70	**.0001**
Lightweight	70	4.63	2.01	2.00 - 3.23	**.001**
Super Lightweight (Jr Welter)	62	3.97	2.28	1.19 - 2.18	**.001**
Super Welter (Jr Middle)	51	5.03	2.36	2.01 - 3.34	**.001**
Welterweight	46	4.39	2.31	1.41 - 2.75	**.001**
Middleweight	36	4.04	2.01	1.19 - 2.86	**.001**
Super Middleweight	43	4.59	2.18	1.60 - 3.23	**.001**
Light Heavyweight	27	4.32	2.71	0.66 - 2.57	**0.002**
Cruiserweight	23	3.3	1.98	0.60 - 2.05	**.001**
Heavyweight	46	4.13	2.11	1.34 - 2.71	**.001**

Figure 1: Head strikes absorbed by winning and losing male fighters within weight classes



Female Fighters by Weight Class: Among female fighters, 59 bouts were included in the weight-class analysis. Winning fighters generally absorbed fewer head strikes per minute than losing fighters, although statistical significance was only demonstrated in featherweight and lightweight divisions (Table 3) (Figure 2).

In female strawweight bouts (n = 3), losers absorbed a mean of 3.73 head strikes per minute compared with 2.23 among winners (95% CI: -4.32 to 7.32; p = 0.384). In light flyweight bouts (n = 1), the losing fighter absorbed 5.35 head strikes per minute compared with 4.55 for the winning fighter; no statistical comparison was completed because only one bout was included. In flyweight bouts (n = 6), losers absorbed 6.39 head strikes per minute compared with 3.42 among winners (95% CI: -2.16 to 8.09; p = 0.197). In super flyweight bouts (n = 4), losers absorbed 6.31 head strikes per minute compared with 4.44 among winners (95% CI: -3.92 to 7.68; p = 0.379).

In bantamweight bouts (n = 5), losers absorbed 5.74 head strikes per minute compared with 2.72 among winners (95% CI: -0.55 to 6.59; p = 0.078). In super bantamweight bouts (n = 6), losers absorbed 5.11 head strikes per minute compared with 2.68 among winners (95% CI: -0.92 to 5.79; p = 0.121). In featherweight bouts (n = 7), losers absorbed 5.40 head strikes per minute compared with 2.08 among winners (95% CI: 1.23 to 5.41; p = 0.008). In super featherweight bouts (n = 1), the losing fighter absorbed 5.75 head strikes per minute compared with 3.70 for the winning fighter; no statistical comparison was completed because only one bout was included.

In lightweight bouts (n = 3), losers absorbed 4.42 head strikes per minute compared with 2.50 among winners (95% CI: 0.76 to 3.07; p = 0.019). In super lightweight/junior welterweight bouts (n = 5), losers absorbed 8.41 head strikes per minute compared with 5.60 among winners (95% CI: -5.51 to 11.14; p = 0.401). In welterweight bouts (n = 8), losers absorbed 5.12 head strikes per minute compared with 3.67 among winners (95% CI: -0.72 to 3.63; p = 0.159). In super welterweight/junior middleweight bouts (n = 5), losers absorbed 7.06 head strikes per minute compared with 2.85 among winners (95% CI: -1.00 to 9.43; p = 0.088).

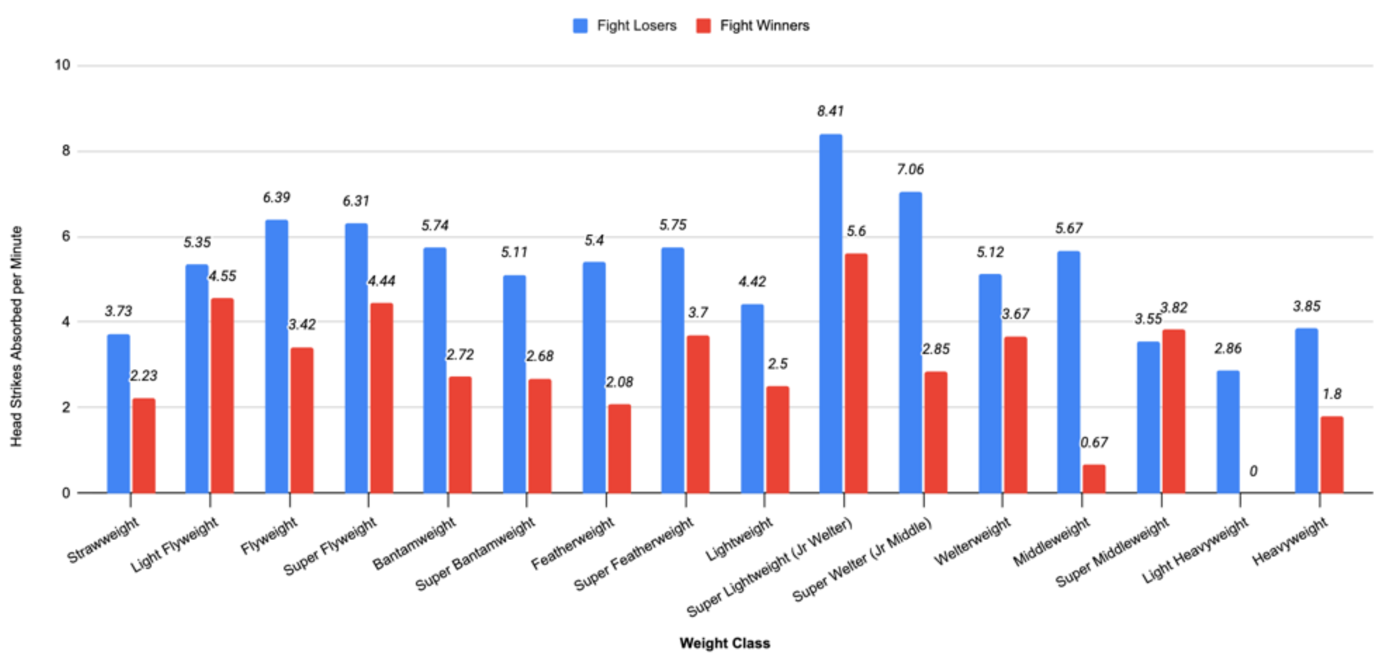
In middleweight bouts (n = 1), the losing fighter absorbed 5.67 head strikes per minute compared with 0.67 for the winning fighter; no statistical comparison was completed because only one bout was included. In super middleweight bouts (n = 2), losers absorbed 3.55 head strikes per minute compared with 3.82

among winners (95% CI: -1.86 to 1.31; p = 0.272). In light heavyweight bouts (n = 1), the losing fighter absorbed 2.86 head strikes per minute compared with 0 for the winning fighter; no statistical comparison was completed because only one bout was included. In heavyweight bouts (n = 1), the losing fighter absorbed 3.85 head strikes per minute compared with 1.80 for the winning fighter; no statistical comparison was completed because only one bout was included (Table 3) (Figure 2).

Table 3: Head strikes absorbed by winning and losing female fighters within weight classes

Weight Class	# of Fights	Loser Mean Head Strikes Absorbed/min	Winner Mean Head Strikes Absorbed/min	95% CI	P-value
Strawweight	3	3.73	2.23	−4.32 - 7.32	0.384
Light Flyweight	1	5.35	4.55	NA	NA
Flyweight	6	6.39	3.42	−2.16 - 8.09	0.197
Super Flyweight	4	6.31	4.44	−3.92 - 7.68	0.379
Bantamweight	5	5.74	2.72	−0.55 - 6.59	0.078
Super Bantamweight	6	5.11	2.68	−0.92 - 5.79	0.121
Featherweight	7	5.4	2.08	1.23 - 5.41	**0.008**
Super Featherweight	1	5.75	3.7	NA	NA
Lightweight	3	4.42	2.5	0.76 - 3.07	**0.019**
Super Lightweight (Jr Welter)	5	8.41	5.6	−5.51 - 11.14	0.401
Welterweight	8	5.12	3.67	−0.72 - 3.63	0.159
Super Welter (Jr Middle)	5	7.06	2.85	−1.00 - 9.43	0.088
Middleweight	1	5.67	0.67	NA	NA
Super Middleweight	2	3.55	3.82	−1.86 - 1.31	0.272
Light Heavyweight	1	2.86	0	NA	NA
Heavyweight	1	3.85	1.8	NA	NA

Figure 2: Head strikes absorbed by winning and losing female fighters within weight classes



Light Versus Heavy Weight Group Comparisons: Among male fighters, the light group included 142 fights and the heavy group included 404 fights. Within the light male group, losers absorbed a mean of 4.62 head strikes per minute compared with 2.63 among winners (95% CI: 1.62 to 2.36; $p < 0.001$). Within the heavy male group, losers absorbed 4.34 head strikes per minute compared with 2.20 among winners (95% CI: 1.91 to 2.37; $p < 0.001$).

When comparing winners across grouped male divisions, winners in heavy classes absorbed 2.20 head strikes per minute versus 2.63 in light classes, corresponding to a mean difference of -0.42 head strikes per minute (95% CI: -0.69 to -0.16; p = 0.002). When comparing losers across grouped male divisions, fighters in heavy classes absorbed 4.34 head strikes per minute versus 4.62 in light classes, corresponding to a mean difference of -0.28 head strikes per minute (95% CI: -0.65 to 0.10; p = 0.147).

Among female fighters, the light group included 33 fights and the heavy group included 26 fights. Within the light female group, losers absorbed a mean of 5.55 head strikes per minute compared with 2.95 among winners (95% CI: 1.51 to 3.68; $p < 0.001$). Within the heavy female group, losers absorbed 5.81 head strikes per minute compared with 3.43 among winners (95% CI: 0.88 to 3.88; p = 0.003).

When comparing winners across grouped female divisions, winners in heavy classes absorbed 3.43 head strikes per minute versus 2.95 in light classes, corresponding to a mean difference of 0.48 head strikes per minute (95% CI: -0.70 to 1.66; p = 0.416). When comparing losers across grouped female divisions, fighters in heavy classes absorbed 5.81 head strikes per minute versus 5.55 in light classes, corresponding to a mean difference of 0.26 head strikes per minute (95% CI: -1.37 to 1.90; p = 0.747).

Fight Result Analysis: Comparing head strikes absorbed by fight result demonstrated that stoppage bouts (KO/TKO) were associated with the greatest separation in head strike absorption between winners and losers.

Among male fighters, 268 KO/TKO bouts were analyzed. In these bouts, losers absorbed a mean of 5.01 head strikes per minute compared with 1.97 among winners (95% CI: 2.74 to 3.35; $p < 0.001$). Among 182 unanimous decision bouts, losers absorbed 4.07 head strikes per minute compared with 2.45 among winners (95% CI: 1.40 to 1.85; $p < 0.001$). Among 71 split decision bouts, losers absorbed 3.42 head strikes per minute compared with 3.07 among winners (95% CI: 0.01 to 0.68; p = 0.041) (Table 4).

Among female fighters, 12 KO/TKO bouts were analyzed. In these bouts, losers absorbed a mean of 7.43 head strikes per minute compared with 2.05 among winners (95% CI: 2.31 to 8.45; p = 0.003). Among 31 unanimous decision bouts, losers absorbed 5.21 head strikes per minute compared with 2.69 among winners (95% CI: 1.64 to 3.40; $p < 0.001$). Among 15 split decision bouts, losers absorbed 4.85 head strikes per minute compared with 4.33 among winners (95% CI: -0.26 to 1.31; p = 0.177) (Table 5).

Table 4: Head strikes absorbed by winning and losing male fighters for each fight result

Fight Decision	# of Fights	Loser Mean Head Strikes Absorbed/min	Winner Mean Head Strikes Absorbed/min	95% CI	P-value
KO/TKO	268	5.01	1.97	2.74 - 3.35	**.003**
Unanimous Decision	182	4.07	2.45	1.40 - 1.85	**.001**
Split Decision	71	3.42	3.07	0.01 - 0.68	**0.041**

Table 5: Head strikes absorbed by winning and losing female fighters for each fight result

Fight Decision	# of Fights	Loser Mean Head Strikes Absorbed/min	Winner Mean Head Strikes Absorbed/min	95% CI	P-value
KO/TKO	12	7.43	2.05	2.31 - 8.45	**0.003**
Unanimous Decision	31	5.21	2.69	1.64 - 3.40	**.001**
Split Decision	15	4.85	4.33	−0.26 - 1.31	0.177

DISCUSSION

This study provides a bout-level analysis of head strikes absorbed per minute in professional boxing and demonstrates a clear, consistent relationship between bout outcome and head strike exposure. Across nearly all analyses, losing fighters absorbed more head strikes per minute than winners. This pattern was especially pronounced in KO/TKO bouts, where the separation between winners and losers was greatest in both male and female fights.

These findings are directionally consistent with prior boxing injury literature showing that losing fighters and fighters stopped by knockout sustain disproportionately greater acute harm.[7,8] While earlier studies often focused on injury occurrence, concussion, or mortality, the present study extends that body of work by using head strike-volume data to characterize rate-based head strike exposure, which may serve as a practical proxy for acute repetitive head impact burden in competition.

The results also align with broader neurologic literature suggesting that cumulative exposure to repetitive head trauma is clinically meaningful in boxing and other professional fighting sports.[2,3,6] Prior work from the Professional Fighters Brain Health Study has demonstrated that increasing exposure is associated with smaller brain volumes and reduced processing speed.[10] Although our study does not assess imaging or neurocognitive outcomes directly, it contributes a competition-level exposure framework that may be useful for future longitudinal studies. Metrics such as head strikes absorbed per minute could potentially complement cumulative exposure models and help identify athletes at particularly high short-term or long-term risk.

One notable finding was that male winners in heavier divisions absorbed significantly fewer head strikes per minute than male winners in lighter divisions. This may reflect stylistic differences across boxing weight classes. Lighter divisions are often characterized by greater punch output and higher sustained tempo, whereas heavier divisions may involve lower overall volume with a greater premium on power and single-shot impact. Interestingly, this difference in the heavy group and light group was not significant among male losers, suggesting that once a fighter is consistently on the losing side of exchanges, the burden of head strike absorption likely remains high regardless of weight class.

Among female fighters, the same overall winner-loser pattern was present, but the number of statistically significant weight-class comparisons was limited. This is most likely explained by smaller sample sizes in many female divisions rather than the absence of a meaningful relationship. The point estimates in several female divisions still favored lower exposure among winners. As women's professional boxing continues to expand, larger future datasets may clarify whether weight class and fight result influence exposure similarly in men and women.

The fight-result analysis is particularly notable. In both sexes, KO/TKO bouts produced the greatest differences in head strike absorption between winners and losers. This is intuitive and clinically relevant. A stoppage often occurs after a fighter has sustained repeated unanswered strikes or a sequence of high-impact blows, meaning that the loser's head strike burden per minute may escalate rapidly before the bout is halted. These results may have implications for ringside monitoring and real-time injury surveillance. Quantitative punch-volume thresholds alone should not drive stoppage decisions, but they may eventually complement clinical judgment when assessing a fighter's cumulative exposure during a bout and throughout their career.

Limitations: This study has several limitations. First, it relies on publicly available punch statistics, which are subject to the inherent limitations of observational punch-counting systems. Second, head strikes absorbed per minute captures only one dimension of trauma exposure and does not account for strike force, rotational acceleration, knockdowns, defensive skill, prior fight history, sparring exposure, or cumulative lifetime exposure, which are areas of interest for future research. Third, this was a retrospective descriptive analysis and cannot establish causal relationships between head strike exposure and neurologic outcome. Finally, several female weight classes had small sample sizes, limiting statistical power. This dataset reflects professional boxing bouts over a defined study period and may not be broadly generalizable to amateur boxing, other combat sports, or other eras of professional boxing.

Despite these limitations, the present study offers a practical and interpretable framework for evaluating competition-based head trauma exposure in boxing. Head strike statistics provide an accessible way to quantify acute head strike burden and compare exposure across competitive contexts.

CONCLUSION

Professional boxing fighters who lose bouts absorb substantially more head strikes per minute than fighters who win, and this relationship is most pronounced in KO/TKO bouts. Male fighters demonstrated this pattern across nearly all weight classes, while female fighters showed a similar trend with more limited significance due to smaller subgroup sizes. Heavier male winning fighters absorbed fewer head strikes per minute than lighter male winning fighters, suggesting that weight class may influence exposure dynamics.

These findings support the use of head strikes absorbed per minute as a useful descriptive metric for characterizing bout-level repetitive head impact exposure in boxing. Future studies should link these exposure patterns to longitudinal neurologic, imaging, and cognitive outcomes in order to better inform fighter safety protocols, medical oversight, and potential exposure-monitoring strategies in combat sports.

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RESEARCH ARTICLE

Catch Wrestling Injuries at National and World Competition.

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Keywords: Catch Wrestling, epidemiology, injury incidence, grappling

ABSTRACT

Background: Catch Wrestling is a historic, internationally practised grappling sport for which there is limited epidemiological data. Prior research relied on retrospective self-reporting with low sample sizes, which may be subject to recall bias and limited medical accuracy, underscoring the need for prospective surveillance. The purpose of this study was to prospectively determine injury incidence, distribution of injury, and mechanisms of injury in Catch Wrestling competition using medically verified assessments.

Study Design: Prospective observational cohort study.

Methods: Injury surveillance was conducted across the 2025 Great Britain (GB) National and 2025 World Catch Wrestling Championships. A medical practitioner observed adult competitors who consented throughout the tournament. Injuries were documented during or immediately after bouts using standardised IOC surveillance procedures. Injury incidence rates (IRs) were calculated per 100 bout exposures (BE); body region, pathology, diagnosis, and mechanism were analysed using descriptive statistics and chi-square tests.

Results: A total of 123 wrestlers produced 326 bout exposures with 17 recorded injuries, yielding an overall IR of 5.21/100 BE (95% CI 2.7–7.7). The head was the most injured site (35.3%), followed by the shoulder, neck and elbow (each 11.8%). Muscle injuries were the leading pathology (29.4%), and the most common diagnoses were head and face contusion/hematoma and neck muscle strain (11.8% each). Defending takedowns accounted for 58.8% of injuries ($p < 0.01$), and 82.4% of all injuries occurred during bouts 1–2.

Conclusion: This study of Catch Wrestling demonstrates a low overall incidence of injury at 5.21/100 BE, comparable to Olympic wrestling and lower than that of striking combat sports. Injury risk is concentrated during early bouts and primarily involves head trauma during takedown defence.

INTRODUCTION

The sport of Catch-as-catch-can (Catch Wrestling) is an internationally practised combat sport that has influenced many modern grappling disciplines, such as freestyle wrestling, Brazilian jiu jitsu (BJJ), American collegiate wrestling and Japanese shoot wrestling [1]. It can be traced back to the Lancashire and West Yorkshire regions of the United Kingdom (UK), with mentions of the sport appearing in the 1330s, where it was referred to as Lancashire catch-as-catch-can[2]. Catch Wrestling was included in the Olympic Games from 1904, but was removed in 1936, as the rules were deemed too dangerous. Subsequently, submissions and holds were removed to create freestyle wrestling [3]. Despite this, Catch Wrestling is still practised, with a GB championship and a World Championship held annually.

The aim of Catch Wrestling is to either pin the opponent's shoulders to the mat or to cause them to submit, typically through the application of external force to a joint, which is commonly referred to as a hook [4]. Specifically, a hook is an indefinite move that stretches, retracts, twists, or compresses any joint or limb; two examples of this would be a "neck crank" or "leglock" [5]. Due to high-intensity, rapid, and forceful movements in the sport, and the inherent risks involved with full-contact grappling, injuries are anticipated. However, despite its long history, only one study has reported injury data. Bell et al. (2025) collected retrospective self-reported injury data from a mixed sample of grapplers in the UK, with 24 Catch wrestlers responding and reporting 28 injuries. The knee was identified as the leading body region (32%), with the leading mechanism of injury (MOI) reported as "being taken down by an opponent" at 29%, and the leading injury diagnosis was ligament sprains (26%). A competition injury rate (IR) was also calculated (35.09/1000 AE). However, due to the small sample size, the IR had a large confidence interval, with a 95% CI of 0.70 to 69.47 [6]. Additionally, the retrospective self-reported injury study design, whilst providing initial insights on the injury distribution in Catch Wrestling, may be impacted by underreporting, recall bias, and/or varying levels of medical knowledge among wrestlers [7].

Some common injury themes across grappling-based disciplines, such as folkstyle wrestling [8-12], BJJ, sambo and traditional jiu-jitsu have emerged. The knee has consistently been noted as the most frequently injured site, accounting for between 16.7% to 81.1.% of all injuries [8-22]. In Greco-Roman wrestling, Olympic wrestling and judo competitions, the head and neck are reported to be the leading injury sites [23-27]. Ligament sprains have been reported as the leading injury type in folkstyle wrestling and BJJ [20,28,29] and Judo [27]. It is unclear which grappling sports Catch Wrestling will resemble; however, by establishing injury patterns and trends, activity-specific injury reduction protocols can be developed.

As such, this study aims to establish the medically reported IR, distribution of Injuries, and MOI at the Catch Wrestling World and GB Championship using the protocols highlighted in the International Olympic Committee's (IOC) consensus statement [30].

MATERIALS AND METHODS

A prospective, medically reported observational cohort study design was used. All data was collected at the GB Catch Wrestling Championships on the 21st of June 2025, and the World Catch Wrestling Championships on 18th October 2025. All participants were over 18 years of age and were categorised by sex and competing weight. The study was approved by the School of Health Ethics Committee at Leeds Beckett University (ethics number 152721).

Prior to the competitions, all wrestlers were informed of the research project via email correspondence disseminated by the event organisers. At the pre-event medical examinations for both the GB Championship and the World Championship, wrestlers were given the option to consent to the use of their injury data in the study. The wrestlers were again provided with a participant information sheet and encouraged to ask the lead researcher any questions they may have. Each wrestler was asked to complete an informed consent form.

Injury Observation and Recording Procedures: Each bout was observed by the lead researcher alongside a registered doctor or paramedic. The registered doctor was qualified in MBBS (roughly equivalent to a MD degree) and registered with the General Medical Council, and the paramedic was registered with their UK governing body. Any injury sustained during a bout or subsequently assessed in the medical treatment room was recorded by the medical team. Diagnosis was made by the registered medical practitioner. The doctor had the authority to stop bouts when necessary to assess injuries and, if warranted, to declare a doctor's stoppage if the injury was judged too severe for the wrestler to continue. No safety equipment was mandatory; however, wrestlers were given the option to wear mouthguards and groin guards. All injuries that met the International Olympic Committee (IOC) [30] definition of injury were recorded, allowing multiple injuries to be documented per bout. Standardized injury documentation was used across both championships. These records were then transposed by the lead researcher onto a Microsoft Excel spreadsheet, which included information on each athlete's age, gender, weight/experience category, injured body region, pathology type and mechanism of injury.

Definitions and Categorization: Injury was defined as "tissue damage or other derangements of normal physical function due to participation in sports resulting from rapid or repetitive transfer of kinetic energy", as per "injury" in the IOC injury surveillance guidelines [30]. IR was calculated using injuries per bout exposures (BE); one exposure was defined as "one athlete participating in a competition during which they are exposed to a possibility of athletic injury" [31].

Injuries were recorded in any instance where medical assessment or treatment was required, either during or after a bout. A qualified medical practitioner conducted all assessments. The IOC consensus statement [30] categories were used to classify body areas according to the Orchard Sports Injury Classification System 15 (OSICS) [32], which defines pathology types and specific injury types. MOI subcategories from previous grappling studies were merged to create MOIs suitable for Catch Wrestling [8,13]. The OSICS has a reported Kappa statistic of K=0.568 [33].

Statistical Analysis: The Statistical Package for the Social Sciences (SPSS) version 31 was used for all descriptive and inferential statistics, with statistical significance set at $p \leq 0.05$. Descriptive statistics were presented as tally counts and percentages, with 95% confidence intervals (CIs) for the binomial distribution. One-variable chi-squared tests (χ^2) were used to assess whether observed values differed significantly from expected values, calculated as percentages based on the number of options in each category. For example, if a group has four categories, the expected value would be 25%. The following variables were tested: body region, pathology type, diagnosis and mechanism of injury. Effect sizes were calculated using Cramér's V to assess the magnitude of distribution differences, and were interpreted using conventional thresholds (0.10 small, 0.30 medium, 0.50 large) [34]. Holm–Bonferroni correction was applied across the five chi-square tests to control the familywise error rate. A Spearman's rank-order correlation was conducted to assess the relationship between bout number and injury frequency. Bout number was treated as an ordinal variable, and injury counts were aggregated per bout. This non-parametric test was selected due to the small sample size and non-normal distribution of injury frequencies. Statistical significance was set at $p \leq 0.05$.

The injury incidence rate is calculated per 100 bout exposures (BE) with 95% confidence intervals (95% CI) [35,36]. Overall Injury incident rate = Total number of injuries/Competition bout exposure hours x 100. Fisher F and chi-square functions were used to calculate lower and upper binomial confidence intervals[37]. The injury IR confidence intervals were calculated using the equations, Upper Limit = (1000 / total exposures) (total number of injuries + (1.96 x square root of total number of injuries)) and Lower Limit = (100 / total exposures) (total number of injuries - (1.96 x square root of total number of injuries)).

To examine whether specific mechanisms of injury were disproportionately associated with anatomical injury sites, a cross-tabulation of MOI and body area contingency table was constructed. Expected cell frequencies were computed under the assumption of independence, and standardised Pearson residuals were calculated to identify cells in which observed frequencies exceeded or fell below expected values. Residuals greater than +2 were interpreted as over-represented injury patterns, whereas residuals less than −2 indicated under-represented patterns. These residuals were visualised using a standardised residual heatmap, allowing identification of phase-specific injury risk patterns beyond frequency counts alone

RESULTS

The combined sample from the two competitions comprised 123 fighters (Males = 104, Females = 19). All competing athletes consented to the collection of their data. This resulted in 326 bout exposures. During these exposures, 17 injuries were sustained. The overall injury incidence was 5.21/100 BE (95% CI 2.7 to 7.7). The IR for the GB National championship was 4.05/100 BE (95% CI 1.4 to 6.7), the IR for the World championship was 7.69/100 BE (95% CI 2.4 to 13), equating to a Rate Ratio (RR) between the two championships of 1.90 (95% CI 0.73 to 4.98).

Body Area: The head was the most frequently injured site, accounting for 35.3% (6/17, 95% CI 1% to 62%), followed by the shoulder, neck, and elbow, each at 11.8% (2/17, 95% CI 1% to 36%). All remaining injuries were to the knee, hand, foot and chest (5.9%, 1/17, 95% CI 0% to 29%). Head injuries included lacerations, contusions, and concussions. A one-variable chi-squared test found a significant difference between expected and observed values in anatomical sites ($\chi^2(23) = 59.0$, $p < 0.001$, Holm–Bonferroni $p = 0.000$) with a very large effect size (Cramér's V = 1.86). Table 1 presents the frequencies for each body area.

Table 1: Distribution of injuries by body region

Injury Site	Frequency %
Head	35.3% (6/17)
Neck	5.9% (1/17)
Shoulder	11.8% (2/17)
Upper arm	0% (0/17)
Elbow	11.8% (2/17)
Forearm	0% (0/17)
Wrist	0% (0/17)
Hand	5.9% (1/17)
Trunk	0% (0/17)
Chest	5.9% (1/17)
Thoracic spine	0% (0/17)
Lumbosacral	0% (0/17)
Abdomen	11.8% (2/17)
Lower limb	0% (0/17)
Adductors	0% (0/17)
Hip/Groin	0% (0/17)
Thigh	0% (0/17)
Adductors	0% (0/17)
Knee	5.9% (1/17)
Lower leg	0% (0/17)
Ankle	5.9% (1/17)
Foot	5.9% (1/17)
Unspecified Region	0% (0/17)
Multiple regions	0% (0/17)

Pathology Type and Specific Diagnosis: Muscle injuries were the leading pathology type (29.4%, 5/17, 95% CI 13% to 56%), followed by joint sprain (23.5%, 4/17, 95% CI 7% to 50%), with contusion/vascular (17.7%, 3/17, 95% CI 4% to 43%) as the third most common pathology type. A one-variable chi-squared test demonstrated no statistically significant difference between expected and observed values for pathology type ($\chi^2(6) = 6.47$, p = 0.37; Holm–Bonferroni $p = 0.74$). The effect size was large (Cramer's V = 0.62), suggesting that a greater proportion of injuries were muscle injuries and joint sprains.

Head and facial contusion/hematoma and neck muscle strain were the most common specific injury diagnoses (11.8%, 2/17, 95% CI 1% to 36%), with all other diagnoses accounting for 5.9% (1/17, 95% CI 0% to 29%). One injury, a dislocated radial head, was diagnosed via x-ray prior to the tournament. The full list is shown in Table 2. A one-variable chi-square test demonstrated no statistically significant difference between observed and expected frequencies of specific injury diagnoses ($\chi^2(14) = 1.53$, $p = 0.999$, Holm–Bonferroni $p = 0.999$). The effect size was small to moderate (Cramér's V = 0.30), indicating that specific diagnoses were evenly distributed within the sample.

Table 2: Distribution of injuries by pathology type and diagnosis

Pathology Type and Diagnosis	Frequency %
Muscle Injury	**29.4% (5/17)**
Deltoid Muscle Injury	5.9% (1/17)
Anterior Compartment Muscle Injury	5.9% (1/17)
Neck Muscle Strain	11.8% (2/17)
Foot Muscle Strain/Spasm/Trigger Points	5.9% (1/17)
Cartilage	5.9% (1/17)
Costal Cartilage/Costochondral Joint Injury	5.9% (1/17)
Joint Sprain	**23.5% (4/17)**
Patellar Subluxation	5.9% (1/17)
Grade 1 A/C Joint Sprain	5.9% (1/17)
DIP Joint Dislocation of the Middle Finger	5.9% (1/17)
Dislocated Radial Head	5.9% (1/17)
Brain/Spinal Cord Injury	**5.9% (1/17)**
Concussion/mTBI	5.9% (1/17)
Contusion/Vascular	**17.7% (3/17)**
Epistaxis (Nosebleed)	5.9% (1/17)
Head and Face Contusion/Hematoma	11.8% (2/17)
Laceration	**11.8% (2/17)**
Lip Laceration	5.9% (1/17)
Eyebrow Laceration Not Requiring Suturing	5.9% (1/17)
Fracture	**5.9% (1/17)**
Fractured Olecranon	5.9% (1/17)

Mechanism of injury: A Takedown (defence) was the leading mechanism of injury (58.8%, 10/17, 95% CI 33% to 82%), followed by Escaping (a pin or an unwanted position) (17.7%, 3/17, 95% CI 4% to 43%), and a Submission (defence) (11.8%, 2/17, 95% CI 1% to 36%) in third. A one-variable chi-squared test demonstrated a statistically significant difference in injury frequency across mechanisms of injury ($\chi^2(4) = 16.82$, $p = 0.002$, Holm–Bonferroni $p = 0.008$), with a very large effect size (Cramér's V = 0.99), indicating that injuries were disproportionately associated with defending takedowns. The standardised residual heatmap (Figure 1) demonstrated distinct mechanism-specific injury patterns. Head injuries were disproportionately associated with takedown defence, elbow injuries with submission defence, shoulder injuries with reversal movements, and ankle and chest injuries with escape attempts. Hand injuries were associated with hand-fighting exchanges.

Table 3: Distribution of injuries by mechanism

Mechanism of Injury	Frequency %
Takedown (Defence)	58.8% (10/17)
Submission (Defence)	11.8% (2/17)
Escaping (A Pin or an Unwanted Position)	17.7% (3/17)
Hand Fighting	5.9% (1/17)
Reversal	5.9% (1/17)

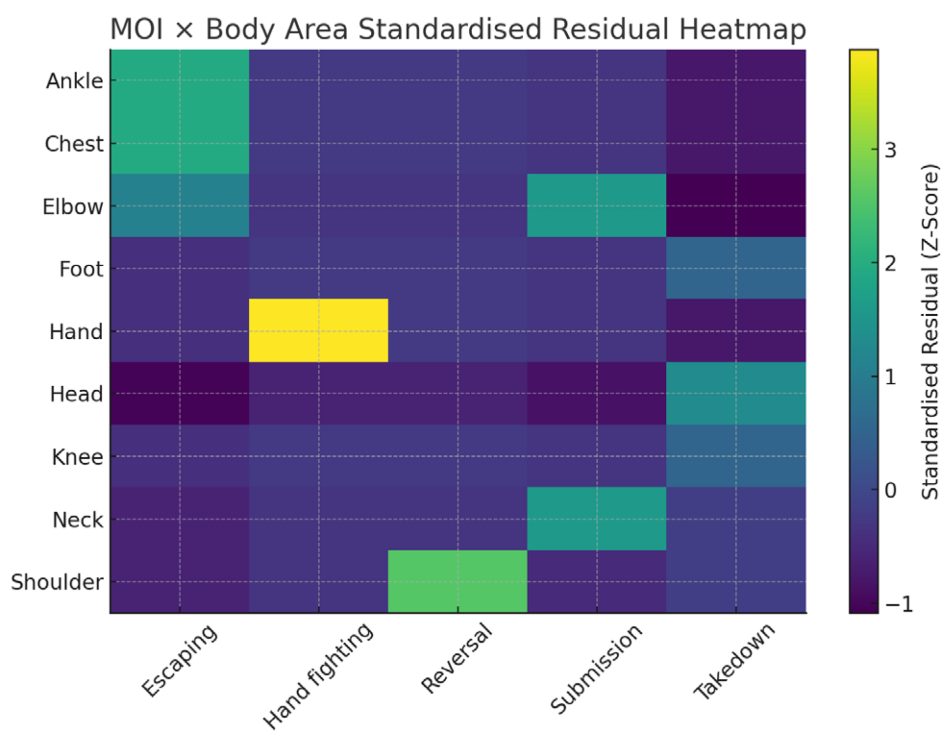
Bout number: The maximum number of bouts some wrestlers had per tournament reached 5. Bout 1 had the most injuries recorded (47.1%, 8/17, 95% CI 23% to 72%), followed by bout 2 (35.3%, 6/17, 95% CI 14% to 62%), and bout 4 (11.8%, 2/17, 95% CI 1% to 36%).. A one-variable chi-squared test indicated a statistically significant difference in injury frequency across bout numbers ($\chi^2(4) = 13.88$, $p = 0.0077$, Holm–Bonferroni $p = 0.023$), with a very large effect size (Cramér's V = 0.90), showing a greater proportion of injuries occurring during bouts 1 and 2. A Spearman's rank-order correlation was performed to examine the association between bout number and injury frequency. Results demonstrated a strong, statistically significant negative correlation between the two variables ($\rho = -0.90$, $p = 0.037$), indicating that injuries decreased substantially with increasing bout number.

Table 4: Distribution of injuries by bout number

Bout Number	Frequency %
1	47.1% (8/17)
2	35.3% (6/17)
3	5.9% (1/17)
4	11.8% (2/17)
5	0% (0/17)

The standardized residual heatmap demonstrated distinct mechanism-specific injury patterns Figure 1. Head injuries were disproportionately associated with takedown defence, elbow injuries with submission defence, shoulder injuries with reversal movements, and ankle and chest injuries with scramble and escape phases. Hand injuries were associated with hand-fighting exchanges. These associations exceeded expected distributions, indicating that injury risk is highly dependent on the technical phase of grappling rather than being evenly distributed across body sites.

Figure 1: Standardised residual heatmap illustrating associations between the mechanism of injury and the anatomical injury site



DISCUSSION

This study is the first to prospectively medically reported injury incidence and mechanism in Catch Wrestling competition. The overall injury incidence rate was 5.2/100 bout exposures, with a higher rate observed at the World Championships (7.69/100 BE) compared with the GB Championships (4.05/100 BE). However, the rate ratio indicated that this difference was not statistically significant (Rate Ratio = 1.90, 95% CI 0.73 to 4.98). The head was the most frequently injured site, comprising 35.3% of all injuries. The leading type of pathology was muscle injuries, accounting for 29.4% of all injuries. The most common specific injury diagnoses were the head and face contusion/hematoma and neck muscle strain, both at 11.8%. 58.8% of injuries occurred while defending a takedown, with the highest rate in match 1 (47.1%) of the two championships. There were no emergent transfers to the hospital required, but several fighters were advised to attend the hospital for further investigation (X-rays).

The injury IRs for both championships are lower than those reported in striking combat sports, with IRs ranging from 22.9 to 55/100 AE[38,39] and 55/100 BE [40] for Muay Thai [40], and from 17.1 to 24/100 BE [41,42] for boxing. It is also lower than the IRs in Shotokan Karate, which ranges from 9 to 30/100 BE [43,44], and taekwondo, with reported rates reaching 139.5/1000 AE (95% CI 94.0 to 185.1) [45]. Many studies, such as the taekwondo study, have reported IR using an injury rate per 1000 hours of athletic exposure (AE).

The IRs for both championships are also similar to those reported in Olympic wrestling styles, with IR from the 2016 Rio Olympic Games reported as 6.1/100 BE and 9.8/100 BE from Tokyo 2020 [46]. Rates are also comparable to other grappling-based sports, such as Judo, as shown in Mooren's (2022) systematic review of injuries in Judo competitions, which reported IRs ranging from 32.2 to 115/1000 AE for competitions using the current ruleset that allows Judokas to attack their opponents' legs. Injuries in BJJ competition have been reported to range from 38.9 to 55.9/1000 AE [15,47], which is slightly lower than those in Judo, Catch, and Olympic wrestling. Overall, these comparisons indicate that while Catch Wrestling demonstrates a lower IR than striking-based combat sports, its IR is consistent with those of other grappling disciplines.

Although similarities were found across grappling sports with respect to IR, differences in the distribution of specific injuries were observed among sports. This study found the head to be the most common body area injured at 35.3%. However, multiple studies in BJJ have found the knee to be the most frequently injured body area, with values between 20.8% to 81.1% of all injuries [13-20]. In collegiate wrestling, often referred to as folkstyle wrestling, the knee has been reported as the most frequent injury in competition and practice (16.7% to 30.4%) [8-12]. Olympic wrestling and Judo show consistency with Catch Wrestling, with studies showing the head to be the most commonly injured site in Olympic wrestling competitions, ranging from 29.1% to 71.4% of injuries [46,48] Mooren et al. (2023) conducted a systematic review of 25 Judo studies and found that the head and neck were the most common sites of injury in competition; however, no rates were stated. The similarities in rates of injury to various body regions among Catch Wrestling, Olympic wrestling, and Judo likely stem from their shared technical and tactical characteristics. All three disciplines emphasise high intensity standing exchanges, where takedowns and defensive scrambles are primary means of scoring or achieving victory. These dynamic movements often involve rapid changes in momentum and upper-body control, resulting in head collisions with the opponent or the ground, increasing the ratio of head impacts. In contrast, Brazilian Jiu-Jitsu (BJJ) is predominantly ground-based and submission-oriented, with a slower tempo and fewer high-amplitude throws [49-51].

Muscle injuries were the leading pathology type in both Catch Wrestling tournaments, accounting for 29.4%. However, there was no statistically significant difference between expected and observed values, as joint sprains (23.5%) and contusions/vascular injuries (17.7%) also showed high percentiles. Studies that reported pathology were significantly fewer than those reporting body area. However, comparisons can be seen in freestyle and collegiate wrestling that reported strains/sprains as the most common pathology [8,52,53]. The injury reporting method deployed in the present study allows specific diagnoses to be reported, with results showing a wide range of injuries; Head and face contusion/hematoma and neck muscle strains are the most frequent diagnoses at 11.8%, with a small to moderate effect size (Cramér's V = 0.30). There is currently a paucity of research that reports specific diagnoses, which makes it challenging to draw comparisons. However, it provides vital information that medical professionals can use when planning future Catch Wrestling events.

The results show that Takedown (defence) was the leading MOI in Catch Wrestling at 58.8%, with a very large effect size (Cramér's V = 0.99). This aligns with previous research on freestyle and folkstyle wrestling, which is unanimous in stating that takedowns are the leading MOI, accounting for 39% to 54.3% of all reported injuries [1,8,9,11,12,54]. There is a paucity of studies reporting medically documented competition-based injury surveillance in BJJ. Scoggin et al. (2014) study reported the Armbar, a specific submission type, was the leading MOI in 5022 competition exposures, although no percentage was provided. In Judo (34.9%) and Greco-Roman wrestling (54%), the leading MOI has been stated as "the direct impact of the head or shoulder on the mat" [24,55]. A systematic review of Judo injuries reported that 50% to 85.2% of injuries occurred during Tachi-waza (standing techniques), with certain studies elaborating further and stating that the most prevalent MOI in standing techniques is being thrown [56-58]. Overall, these findings suggest that Catch Wrestling aligns closely with other wrestling-based disciplines, where takedown-related mechanisms account for most injuries, rather than with submission-oriented grappling arts such as BJJ.

This study's results showed injuries decreased substantially with increasing bout number, with 82.4% of all injuries sustained during the first two bouts. However, this finding reflects absolute injury counts rather than exposure-adjusted risk, as a greater number of athletes competed in the initial rounds. However, several contextual factors may also contribute to this pattern, such as inadequate warm-up intensity, mismatches and insufficient physiological readiness for early matches, which may lead to increased nervous system tension during initial competition phases [59]. In the stress injury model, injury is associated with visual field restriction and attentional distraction [60]. In athletes, this is defined as the "capacity to selectively direct attention toward a specific source of information, shift focus between multiple sources as needed and simultaneously monitor several stimuli" [61]. This can denote an athlete's capacity to attend to relevant sensory information efficiently [62]. In Catch Wrestling, this could refer to a wrestler's ability to concentrate on key sensory cues from their opponent, rapidly shift focus between offensive and defensive actions, and simultaneously track multiple movements and positional changes during a bout [63]. Similar trends have been reported in freestyle wrestling, where most injuries occur in the initial matches of a tournament [48], and Judo tournaments, where the majority of injuries happen in the earlier rounds or elimination matches [57]. The study suggested that the rapid exposure to maximal competitive intensity and cold muscle states during initial contests may be aggravators of injury likelihood [57]. Finally, due to the tournament structure, wrestlers were not matched by rankings, which could lead to mismatches in experience, technical ability, or physical capacity, potentially increasing the likelihood of injury in early bouts. However, the effect of mismatched athletes on injury risk is unclear. Fuller et al. (2010) reported in a study of teams competing at the 2007 Rugby Union World Cup that overall weight and match performance did not increase the risk of injury for the lighter or less successful teams. Showing that more research is needed in the area before an assumption can be made. This highlights the importance of comprehensive warm-up protocols, between-bout rewarm-ups, psychological readiness, and early-bout pacing strategies to reduce the risk of acute injury, as well as future research consisting of in-depth bout analysis that incorporates injury incidence and types in a larger sample of Catch wrestlers.

Practical applications: In the present study, most injuries occurred during the first bout. Therefore, it is advisable that coaches educate their wrestlers on the importance of an effective warm-up protocol that replicates the biomechanical and physiological demands of competitive exchanges. This could include dynamic balance perturbations, reactive footwork, and progressive-intensity wrestling drills that stimulate both the vestibular and proprioceptive systems [63].

The high frequency of head and shoulder impact injuries during takedown defence movements highlights the importance of breakfall (Ukemi) training. Research has shown that Ukemi breakfall drills can dramatically reduce peak resultant translational acceleration (PRTA) and peak angular momentum of neck extension (PAMNE) from Judo-based throws [64-66].

Landing drills are commonly used in sports to improve an athlete's ability to attenuate ground reaction forces (GRF) through biomechanical adjustments that distribute the force and increase impact time [67]. The Ericksen, Gribble, Pfile and Pietrosimone [68] systematic review concluded that expert-provided and self-analysis of landing techniques can successfully lower GRF. Therefore, it is plausible to suggest that catch wrestlers should adopt a similar approach by incorporating periodized breakfall technique training, with frequent coach and wrestler analysis, emphasising head-tucking, angular momentum control, and energy dissipation through sequential limb contact.

The monitoring of athlete readiness and attentional focus during pre-competition may further reduce the likelihood of injury [69]. This could be achieved by integrating cognitive-motor drills into a warm-up to enhance selective attention and situational awareness, including reaction time and decision-making [70]. Additionally, dynamic and isometric neck weakness has been demonstrated to be a modifiable intrinsic risk factor for concussion [71]. Research evaluating injury reduction strategies in rugby union and MMA shows that neck strengthening exercises should be used to reduce both the number and severity of cervical muscle injuries and sports-based concussions [72,73]. Therefore, it is recommended that Catch wrestlers incorporate structured cognitive-motor preparation alongside targeted neck strengthening protocols into their pre-competition warmups and strength and conditioning programs.

LIMITATIONS

Although this study provides the first prospective, medically reported injury surveillance data for Catch Wrestling, several limitations must be acknowledged. First, the sample size was relatively small, with 123 athletes and 17 recorded injuries across two competitions. While this aligns with event participation numbers in similar niche combat sports, it limits the generalisability of the findings. Consequently, confidence intervals were wide for several variables, and some subgroup analyses may have lacked sufficient sensitivity to detect more minor effect differences. Therefore, studies documenting injury patterns in future Catch Wrestling competitions are needed to confirm the accuracy of these results.

A common limitation of tournament-based injury studies is the inability to calculate injury burden, as no follow-up data on days lost or time to return to training is collected. Without these metrics, the clinical impact of each injury cannot be quantified. Additionally, contextual and psychosocial factors—such as warm-up quality, fatigue, and psychological readiness—were not measured, despite their potential influence on the higher injury rates observed in early bouts. Incorporating post-event monitoring and assessing these contextual variables in future research would allow for more precise interpretation of injury patterns and more targeted prevention strategies.

CONCLUSION

The overall injury incidence in Catch Wrestling of 5.21/100 BE is comparable to that of other grappling sports and substantially lower than that of striking-based disciplines. Head injuries were most common, with muscle injuries as the leading pathology type. Head/face contusion/hematoma and neck muscle strains were the most common specific injury diagnoses. While defending takedowns accounted for the majority of injuries, most occurred during the first bouts.

To mitigate injury risk, coaches should emphasise comprehensive warm-ups that incorporate wrestling-specific movements, cognitive-motor tasks, and neuromuscular activation. Structured breakfall and takedown-defence training should also be integrated into warm-ups and technical sessions, and neck strength training should be incorporated into strength and conditioning sessions. Future research should explore the contribution of psychological and contextual factors to refine reduction strategies.

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REVIEW ARTICLE

Physiological Dangers of Dehydration in Youth Athletes (Ages 10–17)

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ABSTRACT

Background: Rapid weight-cutting through dehydration is commonly practiced in weight-class sports, but in youth athletes (ages 10–17), it poses heightened physiological risks.

Objective: This position paper summarizes the pathophysiological risks associated with dehydration in adolescent athletes, with emphasis on the clinical impact of mild, moderate, and severe fluid deficits. It also provides evidence-based recommendations to enhance safety in youth combat sports.

Methods: A review of peer-reviewed literature and official sports medicine guidelines was conducted to describe the effects of dehydration on cardiovascular, renal, thermoregulatory, cognitive, and neurological systems in adolescents.

Results: Mild dehydration (3-5%) impairs endurance, neuromuscular coordination, and cognitive performance. Moderate dehydration (6-9%) further compromises thermoregulation and decision-making. Severe dehydration (≥10%) significantly reduces work capacity by up to 30% and increases the risk of heat stroke, cardiac arrhythmias, rhabdomyolysis, and acute kidney injury. Full physiological recovery, including restoration of intracellular and plasma volume, requires more than 48 hours, indicating that rapid weight regain after weigh-in does not restore function.

Recommendations: To safeguard youth athletes, we recommend strict hydration monitoring protocols and educational interventions. Specifically, we advocate for a single official weigh-in approximately 60 minutes before competition, paired with clinical hydration assessment, to identify and prevent unsafe weight-cutting. Continuous education for athletes, families, and coaches is critical to promote long-term, performance-oriented hydration practices.

INTRODUCTION

Competitive youth athletes in combat sports like wrestling, martial arts, and boxing often engage in rapid "weight-cutting" via dehydration to qualify for lower weight classes.[1] However, losing body water is not a benign tactic in growing athletes – it carries significant physiological danger. This underscores that weight-cutting by fluid loss can be lethal, especially in younger bodies still developing.

Dehydration is commonly classified by the percentage of total body mass lost as fluid. In youth athletes, even mild dehydration (3–5% body mass loss) significantly degrades both aerobic and anaerobic performance and impairs cognitive functions such as concentration, memory, and decision-making.[2,3] Moderate dehydration (6–9%) further compromises physiological resilience, while severe dehydration (≥10%) can overwhelm thermoregulatory and cardiovascular mechanisms, leading to potentially life-threatening heat illness.[4] Children and adolescents are especially vulnerable due to immature thermoregulatory systems, lower sweating capacity, and a higher surface area-to-mass ratio, which together reduce heat dissipation under physical stress.

Research shows that in dehydrated children, core temperature may rise by over 0.2°C for each 1% of body mass lost—faster than in adults. A fluid deficit of just 3% could raise core temperature by more than 0.6°C, increasing the risk of heat exhaustion or heat stroke under exertional or hot environmental conditions.[3,4] Furthermore, recent evidence in elite wrestlers with average age of 19 demonstrates that rapid weight loss induces significant biochemical alterations (higher creatinine, BUN, and cortisol; lower albumin and testosterone) and heightened anxiety, confirming the dual physiological and psychological burden of these practices.[5]

In a study conducted in Mexico with 160 youth athletes from wrestling and taekwondo, 96% reported using rapid weight loss strategies, and more than half lost over 5% of their body mass. The most common practices included training with plastic suits, fluid restriction, and sauna use. Moreover, greater weight loss was associated with physiological symptoms (such as rapid breathing and blood pressure alterations) and mood disturbances (fatigue, sadness, confusion), with coaches, parents, and nutritionists identified as the main influencers of these behaviors.[6]

In summary, mounting evidence confirms that even mild dehydration—often underestimated in competitive contexts—can immediately impair safety and performance in youth athletes, while more severe fluid deficits constitute acute medical emergencies.[2,7] This review details the pathophysiological effects of dehydration on major body systems in youth athletes, highlighting differences between moderate and severe dehydration.[2,7]

We emphasize that restoring hydration is a slow physiological process – often taking well over 48 hours – so rapid weight regain after weigh-in does **not** mean the athlete has recovered normal function. Finally, we present recommendations to mitigate these risks, including policy changes (a same-day pre-competition weigh-in with hydration checks) and educational initiatives for athletes, parents, and coaches. The goal is to ensure that no child's health is jeopardized for the sake of making weight.

Pathophysiology of Dehydration in Youth Athletes: Dehydration affects virtually every organ system, and its impacts rise with increasing amounts of fluid loss. **Table 1** summarizes how physiology is impaired as dehydration worsens. Crucially, the cascade of physiological changes triggered by fluid loss is more pronounced in youth due to their developing bodies and lower compensatory reserves. Key pathophysiological effects include:

- **Cardiovascular Strain:** Dehydration reduces plasma volume, which in turn lowers venous return and stroke volume. The heart must beat faster to maintain output; heart rate rises about 3–5 beats per minute for each 1% of body mass lost.[3] Systemic vasoconstriction also increases to compensate for falling blood pressure. At moderate dehydration (~6%), these adjustments lead to higher perceived exertion and reduced exercise tolerance.[8] At severe levels (≥10%), the ability to maintain blood pressure and cardiac output can fail, precipitating hypotension, dizziness, or syncope. Electrolyte disturbances from dehydration (such as hypernatremia or potassium shifts) may provoke cardiac arrhythmias or cardiac muscle cramps, compounding the cardiac risk
- **Thermoregulatory Impairment:** Sweating and skin blood flow are the body's primary cooling mechanisms during exercise. Dehydration undermines both. Even >2% body water loss is known to decrease sweat rate and delay sweating onset.[3] This means a dehydrated athlete stores heat more rapidly. Core temperature rises linearly with fluid deficit – roughly 0.15–0.20°C per 1% of body mass lost in adults.[3] Children experience an even steeper climb in core temperature for a given water loss, as they have fewer sweat glands per area and produce less sweat.[4,9] The combined effect is that a moderately dehydrated youth (2–3%) can overheat quickly, and a severely dehydrated youth (>5%) is at extreme risk of heat exhaustion or heat stroke. Notably, dehydration also negates the usual advantages of fitness and heat-acclimatization – even well-trained, heat-adapted athletes will see their core temperatures soar if they are hypohydrated.[9] Once core temperature approaches ~39.5°C, central fatigue and collapse can occur rapidly.

- **Renal and Metabolic Stress:** The kidneys suffer from reduced renal blood flow and glomerular filtration during dehydration. Acute kidney injury can result, especially when high-intensity exercise is layered on existing hypovolemia. Biomarkers of renal stress (blood urea nitrogen, creatinine) rise significantly after rapid weight-cutting, indicating renal impairment .[1] In a review of combat-sport athletes losing ~5% body mass in <1 week, most showed acute kidney damage due to dehydration. Electrolyte imbalances (such as high sodium or low potassium) from sweating and water loss can cause muscle cramps and, in severe cases, dangerous heart rhythm disturbances.[3] Dehydration also elevates circulating stress hormones (catecholamines), accelerating muscle glycogen breakdown and contributing to earlier fatigue. Furthermore, when combined with intense exertion, severe dehydration can lead to rhabdomyolysis, a breakdown of muscle tissue. Heat and dehydration together create a "perfect storm" for rhabdomyolysis: muscle fibers overheat and die, and the dehydrated kidneys cannot adequately flush the resulting toxins. This can cause potentially life-threatening kidney failure if not promptly treated.[10]
- **Neurological and Cognitive Effects:** The brain is exquisitely sensitive to hydration status. Even mild dehydration (~1–2%) can impair cognitive performance, particularly tasks requiring attention, coordination, and short-term memory.[2] Adolescents may notice increased difficulty concentrating or making decisions during games when underhydrated. Mood and subjective symptoms also worsen – dehydrated young athletes report greater fatigue, irritability, and headaches.[9] Of particular concern is the interaction between dehydration and concussion. Studies have found that moderate dehydration (~2.5% loss) significantly increases self-reported symptoms that mirror concussion, such as confusion and dizziness.[7] Dehydration can reduce the cushioning effect of cerebrospinal fluid and exacerbate postural instability. Although dehydration itself does not cause concussion, a dehydrated athlete who sustains a head impact may experience more severe effects, or conversely, dehydration symptoms might be mistaken for concussion. Thus, keeping athletes euhydrated is important for neurological safety. In extreme cases, central nervous system complications of dehydration include delirium, seizures, or coma, especially if heat stroke ensues or if electrolyte derangements (like severe hypernatremia) develop.

CLINICAL IMPLICATIONS

Dehydration in youth is not a trivial side-effect of training – it directly impairs performance and endangers health. The physiological disruptions above translate into very real clinical risks on the field. Even at 3% dehydration, young athletes run slower, think slower, and fatigue faster, while beyond 9% dehydration their bodies are in a state of medical crisis. No child or adolescent should ever commence competition in a significantly dehydrated state. Coaches, trainers, and medical staff should be alert to the signs of dehydration and its potential consequences in young athletes. Table 2 summarizes the clinical complications from acute dehydration.

- **Heat Illness and Collapse:** Dehydration is a major predisposing factor for exertional heat illness in youth. When an adolescent athlete is even moderately dehydrated, their core temperature can reach dangerous levels much more quickly during intense exercise. [4,9] Cases of heat exhaustion or heat stroke in youth sports often involve inadequate hydration. A dehydrated child may suddenly collapse during practice or competition due to a combination of overheating and circulatory collapse (heat syncope).[11] Such an event is life-threatening and requires immediate cooling and rehydration. Tragically, as noted, even well-trained young athletes have died from hyperthermia when severe dehydration and heavy exercise were combined. This is entirely preventable with proper hydration and monitoring.[11]
- **Injuries and Cognitive Errors:** As dehydration degrades motor coordination and mental sharpness, the risk of sport injuries rises. An athlete who is dizzy or has slowed reaction times is more likely to suffer a direct trauma (e.g. a fall or blow) or make tactical mistakes leading to injury. For example, a dehydrated wrestler or boxer may have impaired ability to defend themselves or may exhibit slowed reflexes, increasing the chance of concussive impacts.[7] Furthermore, dehydration-related

cramping or muscle weakness can lead to musculoskeletal injuries (strains, etc.) during competition.[2] From a safety and performance standpoint, a well-hydrated athlete will simply fight smarter and more safely than a dehydrated one.
- **Acute Kidney Injury:** As detailed, the combination of intense exercise and dehydration can acutely impair kidney function. There are documented instances of acute kidney injury (AKI) in adolescent athletes following rapid weight loss.[1] Signs of AKI can include dark (concentrated) urine, low urine output, and in severe cases flank pain or systemic symptoms. If an athlete is dehydrated enough to have significantly elevated BUN or creatinine levels post-competition, this indicates kidney stress that can have lasting effects. Repeated episodes of dehydration may cumulatively damage the kidneys over time.[1] Thus, from a clinical perspective, preventing dehydration may also prevent kidney damage in young athletes.
- **Arrhythmias and Cardiovascular Events:** While rare in the young, serious cardiac events can be precipitated by extreme dehydration. There have been reports of dehydration-linked cardiac arrhythmias in athletes, likely due to electrolyte imbalances (especially hyperkalemia or hypokalemia) and reduced coronary perfusion.[8] A heart under strain from high heart rate and low blood volume is more susceptible to malfunction. In most cases, the heart issues manifest as fainting (vasovagal or orthostatic syncope) rather than sudden cardiac arrest. However, any collapse on the field must be treated as a medical emergency. Clinicians should consider dehydration as a possible contributing factor in any unexplained collapse of a young athlete,[8] and emergency personnel should be prepared to rapidly assess hydration status and begin intravenous rehydration if needed.
- **Prolonged Recovery Period:** An often overlooked implication is that rehydration takes time. After a youth athlete has dehydrated to "make weight," even if they consume fluids and seem to regain weight in the hours following, their intracellular spaces and electrolytes may not normalize for 1–2 days.[3] The athlete may still be physiologically compromised during their event, with reduced blood volume and altered muscle function, despite outwardly regaining the pounds. Coaches or parents might assume that if the child's weigh-in weight is back to normal by game time, all is well – but internally, that athlete could be on the edge of heat illness or fainting. This false sense of security is dangerous. In practical terms, this means a dehydrated athlete cannot be "fixed" in an hour or two by chugging water or sports drinks. Full rehydration of a 5% deficit (especially reloading glycogen and electrolytes in muscle cells and restoring plasma volume) will typically require more than 48 hours of consistent fluid and electrolyte intake and rest.[3] Clinicians should emphasize this point: weight regained does not equate to recovery achieved. Many physiological parameters (e.g., heart rate, core temp responses) remain abnormal long after the weight is regained.

In summary, the clinical picture is clear: dehydration in young athletes can lead to a spectrum of adverse outcomes, from subpar performance and increased injury risk to catastrophic collapse or organ damage. It is far easier to prevent these outcomes with proactive strategies than to treat them after the fact. Fortunately, sports medicine organizations have developed guidelines to monitor and safeguard hydration in youth sports, which leads to the recommendations of this paper.

RECOMMENDATIONS

1. Implement a Pre-Competition Weigh-In ~1 Hour Before the Event, with Hydration Status Checks: Current practices in many youth combat sports involve an official weigh-in many hours (or even a day) before competition. This delay allows (and inadvertently encourages) athletes to dehydrate to make weight, then rapidly rehydrate before competing. To close this loophole, we recommend a single weigh-in on contest day, approximately 60 minutes before the bout, under medical supervision. At this time, two assessments occur: (a) confirm body weight is still at or below the class limit (ensuring the athlete did not "cut" and then regain significantly), and (b) assess hydration status clinically.

Urine-based hydration assessments, including urine specific gravity and osmolarity testing, have limited reliability in the setting of acute or intentional dehydration. In addition, practical constraints and delays in sample collection further reduce their clinical usefulness in the weigh-in and pre-competition context. For these reasons, hydration status should be primarily determined through direct clinical evaluation of the athlete and interpretation within the overall physiological and competitive context.

One of the most effective strategies to mitigate the health risks associated with rapid weight loss (RWL) is to reconsider the timing of official weigh-ins. As highlighted in the *Association of Ringside Physicians' Manual of Combat Sports Medicine*,[13] the single greatest determinant of how much weight loss an athlete can tolerate without jeopardizing health and performance is the length of time between the official weigh-in and the start of competition. When weigh-ins are scheduled 24 hours before the event, athletes often engage in extreme dehydration practices, which may result in serious medical consequences. In contrast, same-day weigh-ins—such as those conducted one hour prior to competition—significantly limit the magnitude of weight cutting by restricting the time available for rehydration and glycogen replenishment.[13]

Post–weigh-in priorities are fundamentally determined by the duration of the recovery window available prior to competition. When sufficient time is provided, athletes may attempt to restore physiological homeostasis before transitioning toward performance preparation; however, this objective is frequently not fully achieved unless the magnitude of fluid and electrolyte loss has been minimal. In contrast, when weigh-ins occur in close temporal proximity to competition, the opportunity for meaningful recovery is markedly constrained, rendering aggressive dehydration strategies ineffective and maladaptive. Under such conditions, athletes are compelled to compete closer to their habitual body mass, thereby reducing the incentive for extreme rapid weight loss. This temporal compression functions not only as a deterrent to unsafe weight-cutting practices but also as an inherent safeguard for athlete safety, particularly in youth and amateur populations. From a preventive and regulatory standpoint, minimizing the interval between weigh-in and competition represents a structural harm-reduction strategy that discourages extreme dehydration practices without reliance on punitive enforcement or athlete compliance alone. This strategy is currently being used by the Brazilian Sports MMA Confederation.

2. Prohibit and Penalize Intentional Dehydration for Weight Cutting: Sport governing bodies should establish clear rules forbidding dehydration as a weight-control method for minors. Just as performance-enhancing drugs are banned for health reasons, severe weight cutting should be viewed as a form of endangerment. Coaches and athletes should be educated that "drying out" to shed pounds is unacceptable in youth sports. If a young athlete cannot make a weight class without dehydration, they must compete at a higher weight class. The American College of Sports Medicine (ACSM) and other authorities have long condemned RWL by dehydration in youth.[14,15,16] We echo these positions. A culture shift is needed so that drastic weight cutting is seen as cheating the system and risking lives, not as a badge of honor. Young athletes must be taught that the "lightest weight possible" is not worth dying for, and that true competitive advantage comes from training and nutrition, not from dehydrating their bodies.[1,12,17]

3. Prioritize Education on Healthy Hydration for Athletes, Parents, and Coaches: Proper hydration practices should be a pillar of youth sports training, starting at the community and school level. We recommend regular workshops or briefings, perhaps at the start of each season, to review hydration guidelines and the dangers of dehydration. Key points should include daily fluid intake needs, recognizing early signs of dehydration, the performance costs of even mild dehydration, and safe methods to achieve weight goals (focusing on nutrition and gradual changes, not fluid restriction).[2,9] Parents and coaches should understand that children may not instinctively drink enough; they need scheduled hydration breaks and encouragement, especially in hot weather. The American Academy of Pediatrics (AAP) advises that young athletes be weighed *before and after* strenuous activity to gauge individual fluid losses and guide rehydration. In practice, a child who is, for example, 1.5 kg lighter after a training session should be instructed to drink enough to fully replace that (~1.5 liters fluid per kg lost), and coaches should adjust practice intensity or breaks if large losses are seen.[3] Educating stakeholders also means debunking myths: for example, the misconception that water will cause bloating or slow an athlete down – in reality, dehydration does far more harm to speed and strength. We also advocate distributing simple tools like urine color charts and "hydration report cards" for kids. If every youth athlete knows that clear to light lemonade-colored urine means good hydration and anything darker means drink up, that alone can prevent many issues.[18] "Hydration literacy" should become as fundamental as knowing how to warm up or put on protective gear. Moreover, coaches need to create an environment where kids feel safe reporting if they feel unwell or overly thirsty, rather than fearing punishment or reduced fight time.[17]

4. Ensure Access to Fluids and Cooling Strategies During Activity: While this might seem obvious, many cases of dehydration in sports are exacerbated by inadequate opportunities to drink or cool off. Youth sports leagues must mandate and facilitate frequent hydration breaks, especially in hot conditions. Water (and electrolyte drinks for sessions over 1 hour) should be readily available *and* athletes should be reminded to use them.[8] Implement "water coaches" or assign team captains to prompt hydration. During summer training camps or heat waves, consider weighing athletes at practice start and end as recommended, and be prepared to modify or cancel activities if weight loss exceeds safe levels (e.g., >2% in a single session).[3] Cooling measures like shade tents, misting fans, and ice towels should be on hand at competitions. These measures, while not directly stopping dehydration, mitigate its thermal effects and can be lifesaving if an athlete becomes overheated.[9] It is notable that after the high-profile dehydration deaths, many state high school athletic associations instituted mandatory hydration education and put limits on practice in extreme heat. These steps should be continually evaluated and enforced.[11,17]

5. Promote Research and Data Collection on Youth Dehydration: Sports science research on dehydration has historically focused on adults. More data on youth athletes – how quickly they dehydrate, how effective various rehydration strategies are, and what thresholds are truly unsafe – will help fine-tune guidelines.[2,9] We encourage youth sports organizations to partner with researchers (many are willing to do field studies at little cost) to monitor hydration in their athletes and publish findings. Even simple record-keeping, like tracking any instances of heat illness or hospitalizations related to dehydration in a season, can identify risk patterns (e.g., problematic training routines) that can be addressed.[11,17] Over time, evidence-based policies specific to youth will emerge .[4,6] For example, if research shows that 11–13-year-olds can only safely lose <3% body mass in water, whereas older adolescents tolerate slightly more, rules can be adjusted for age. The ultimate aim is that guidelines are continually updated with the best available science to protect our young athletes.[12]

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Table 1: Physiological effects of various levels of dehydration in youth

DEHYDRATION LEVEL	PHYSIOLOGICAL EFFECTS AND RISKS
Mild (3-5% body mass)	Thirst and mild fatigue begin. Core temperature may rise slightly (by ~0.2–0.3°C). Cognitive changes can appear, to include reduced alertness and short-term memory loss. Athletic performance starts to decline (e.g. ~5% drop in VO_2max at 3% loss). However, serious systemic effects are usually not yet present.
Moderate (6-9%)	**Cardio:** Noticeable increase in heart rate (3–5 bpm per 1% lost) and reduced endurance. Blood pressure maintenance is strained; risk of dizziness or fainting under exertion. **Thermoregulation:** Sweating decreases; core temperature rises ~0.2°C per 1% lost, risking heat exhaustion at ~3% loss, especially in warm climates. **Cognitive/Neurologic:** Marked impairment in concentration, decision making, and coordination. Athletes may report headaches, confusion, or nausea. **Renal/Muscular:** Reduced urine output; elevated BUN/creatinine indicating renal stress. Early muscle cramping may occur as electrolytes become imbalanced.
Severe (≥10%)	**Cardio:** Danger of hypovolemic shock – drastic drop in blood pressure and cardiac output. Arrhythmias are possible due to electrolyte disturbances. Collapse or unconsciousness can occur. **Thermoregulation:** Extremely high core temperatures (>39°C) likely; inability to cool raises risk of heat stroke and organ failure. Sweating may cease (hot, dry skin in heat stroke). **Neurologic:** Confusion, delirium, or seizures possible. Loss of consciousness is an acute emergency. **Renal/Muscular:** Acute kidney injury likely – dehydration severe enough to cause rhabdomyolysis (muscle breakdown) with brown urine and risk of kidney failure. Liver damage is possible from thermal injury. Without prompt medical intervention (aggressive cooling and rehydration), severe dehydration can be fatal.

Table 2: Clinical complications from dehydration-induced rapid weight loss (RWL) in youth combat sports.

CLINICAL COMPLICATIONS	FINDINGS	REFERENCES
Heat illness & collapse	57% reported excessive rise in body temperature; 72.9% experienced muscle cramps	Lakicevic et al. 2022; Armstrong et al. 2012
Acute kidney injury (AKI)	Elevated creatinine, BUN, and uric acid in adolescent wrestlers; significant increases ($p<0.01$) indicating transient AKI.	Lakicevic et al. 2021; Trivić et al. 2023
Arrhythmias & cardiovascular strain	48% reported palpitations during RWL; dehydration	McDermott et al. 2017; Lakicevic et al. 2021
Other physiological sequelae	High prevalence of cramps (~73%), dyspnea (61%), fatigue; symptoms such as headache, dizziness, nosebleeds; hormonal alterations (↑ cortisol, ↓ testosterone).	Adan 2012; Armstrong et al. 2012; Lakicevic et al. 2021; Castor-Praga et al. 2021

CASE REPORT

Platelet Rich Plasma Injection in the Treatment of Recurrent Auricular Hematoma: A Case Report

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Keywords: Auricular hematoma, Cauliflower ear, Platelet-rich plasma (PRP), Regenerative medicine, Tissue healing

ABSTRACT

Auricular hematoma is a common sports-related injury that can cause athletes to miss training and may lead to the development of "cauliflower ear". Although treatment guidelines remain undefined, management typically involves drainage and application of a compression dressing to restore normal anatomy and revascularize the underlying auricular cartilage. This case outlines the treatment of a recurrent auricular hematoma in a Jiu-jitsu athlete managed with drainage followed by platelet-rich plasma (PRP) injection. No compression dressing was applied, and the auricular hematoma resolved after the single PRP treatment. PRP contains a high concentration of growth factors involved in tissue healing and should be considered as an adjunctive treatment for recurrent auricular hematomas. Further refinement of the PRP injection technique and protocol for this indication may reduce the need for compression dressings, facilitate hematoma resolution, and promote revascularization.

INTRODUCTION

Auricular hematoma occurs when trauma to the ear results in a small-vessel hemorrhage into the subperichondrial space.[1] Combat sports such as Jiu-jitsu, mixed martial arts, wrestling, boxing, and rugby are the most common causes of auricular hematoma; however, the condition can also arise secondary to assault, falls, postoperative complications, and ear piercings.[2] Spontaneous auricular hematomas have been reported, with anticoagulation therapy likely serving as a contributing factor in their development.[3] The use of headgear in contact sports has been shown to reduce the incidence of auricular hematoma.[4]

Once an auricular hematoma forms, coagulation begins within 6 hours. The resulting serosanguinous pocket of fluid is infiltrated by chondroblasts over the next 2 weeks, and new cartilage typically develops within 4 weeks.[5] Without prompt treatment, deposition of neocartilage results in a cosmetic deformity colloquially known as "cauliflower ear."[5]

Treatment traditionally involves drainage of the hematoma via needle aspiration or incision and drainage followed by application of a compression dressing-with or without drain placement – to prevent re-accumulation of blood.[6] Challenges in treatment include the need for specialty consultation, unwieldy dressings, and the requirement for close serial follow-up for wound care. Complications include recurrence, infection, compression-associated-necrosis, and cosmetic deformity.[6]

Platelet-rich plasma (PRP) injections are an effective treatment for various orthopedic, gynecological/urological, and cosmetic medical conditions.[7] Platelets contain growth factors that assist in tissue healing and vascularization as well as adhesive molecules that assist in wound closure.[8] For this reason, PRP has potential as an adjunctive treatment for the management of auricular hematoma.

CASE

A previously healthy 31-year-old female presented to the Neuromusculoskeletal Medicine office with one month of swelling and pain in her right ear. Her pain started after a Jiu-jitsu training session during which her ear was repeatedly struck against her training partner's head. Following her injury, persistent pain was accompanied by palpable fluid accumulation in the area. Seven fluid aspirations were attempted by an unlicensed practitioner, but each was followed by rapid reaccumulation. On exam, the right ear was slightly erythematous and edematous with fluctuant fluid noted in the inferior crux of the anti-helix and cymba concha.

Given the patient's history and exam findings, treatment options were discussed, including the standard of care and projected long-term outcomes for auricular hematoma (ICD-10-CM: M95.11), also known as "cauliflower ear" A trial of PRP injection was also discussed, with acknowledgement of the limited data regarding its use in acute ear injuries. Detailed risks, benefits, and alternatives were discussed. Given the patient's recurrent accumulation of fluid and pain, as well as the low risk associated with PRP, the patient opted to pursue a trial of a single PRP injection procedure.

During the procedure, a 60 mL centrifuge cylinder was prepared with 6 mL of sodium citrate as an anticoagulant, and 54 mL of blood was drawn from the right antecubital vein and placed in the Emcyte Pure PRP System centrifuge for two cycles. This process yielded 7 mL of PRP, to which no activating agent was added. Laboratory analysis of platelet or leukocyte concentration was not performed prior to the procedure. After cleansing and preparing the ear with alcohol pads, a 20-gauge needle was used to aspirate 2.5 mL of fluid from the anti-helix of the ear. Subsequently, using a clean 27-gauge needle, 0.5 mL of PRP was injected into the potential space. The patient tolerated the procedure well and experienced only pruritus for approximately 4 days post-procedure. By day 5, she was symptom-free and returned to full contact jiu-jitsu training 1 week after the procedure. She remained asymptomatic without reaccumulation of fluid or pain at 1-month, 6-month, and 12-month follow up visits.

DISCUSSION

Platelets are anucleate cells that release granules when activated.[9] These granules contain numerous bioactive molecules, including peptide growth factors (GF), which enhance tissue repair mechanisms such as angiogenesis and extracellular matrix remodeling, and stimulate stem cell recruitment, proliferation, differentiation and chemotaxis.[8] Platelets deliver GF to injured tissue by activating in response to molecules associated with epithelial injury, such as von Willebrand Factor (vWF), collagen, fibronectin, and laminin.[10]

PRP is a blood-derived product containing a supra-physiological concentration of platelets that can be injected or applied topically for therapeutic purposes. PRP is most commonly used intra-articular for orthopedic injuries, where it exerts its regenerative effects on articular cartilage and ligamentous structures.[11] Multiple case series have demonstrated the effective use of PRP to treat auricular hematoma in canine models; however, no published cases describe its use for auricular hematoma in humans.[12,13] In humans, PRP injections into the pinna have shown success as part of the treatment of auricular keloids.[14] The potential benefits of PRP for auricular hematoma are multifactorial – assisting with tissue layer adhesion, revascularization of cartilage, and overall tissue healing.

Fibronectin and vitronectin, adhesive proteins contained within platelets, bind to cell surface integrins and influence cell adhesion, growth, migration, and differentiation.[8] PRP may facilitate the adhesion of chondral and perichondral layers of the pinna that are separated by trauma, thereby eliminating this potential space and preventing hematoma recurrence.

In this case, no reaccumulation of blood occurred following aspiration and a single PRP injection, unlike the 7 prior aspirations without PRP administration. No dressing was applied after treatment, suggesting that PRP facilitated closure of the subperichondrial space. In the case of a larger hematoma, PRP may reduce – but not necessarily eliminate – the need for post-procedural dressing.

Post-procedural dressings aim to prevent hematoma recurrence and restore normal ear anatomy. These include tie-through/bolster dressings, pressure wraps, silicone splints, clips, magnets, and sutures. Reducing the need for compression dressing benefits both physicians and patients, as such dressings are inconvenient to maintain, aesthetically unappealing, require close follow-up, and can lead to complications. Notably, commercially available dressings marketed for auricular hematoma management have been associated with avascular necrosis.[15]

Avascular necrosis is caused by a disruption of the vascular supply to tissue. Therefore, restoration of normal blood flow to the underlying cartilage remains a primary treatment goal in auricular hematoma. Traditionally, this is achieved by draining the hematoma and applying a secure but non-restrictive dressing. PRP, however, could reasonably be expected to support cartilage revascularization by promoting collateral vessel formation and nourishing the existing vasculature of the ear. Platelet granules contain vascular endothelial growth factor A, B, and C (VEGFA, VEGFB, and VEGFC respectively) which stimulate angiogenesis, recruit vascular nutrients to peripheral tissues, and regulate blood vessel physiology.[8]

The rationale to use PRP in the treatment of auricular hematoma can be conceptualized using the World Health Organization's six-step guide to good prescribing.[16] Once the problem is identified, treatment goals should be defined in partnership by the physician and patient. In this case, goals included closure of separated tissue layers, revascularization of the underlying cartilage, and achievement of a favorable cosmetic outcome – all accomplished in a minimally invasive way with convenient follow-up. Given the characteristics of PRP and the limitations of traditional therapies, needle aspiration followed by PRP injection without compression dressing was selected. Following the procedure, the patient was instructed to report any concerning signs or symptoms and was monitored for one year, during which she remained symptom-free.

The injection technique for PRP use in auricular hematoma requires further refinement. Injecting a large volume of PRP to the subperichondrial space could theoretically inhibit tissue layer closure and worsen cosmetic outcomes; therefore, PRP should be used judiciously. In future applications, technique modifications could improve precision and reduce volume burden. For instance, after aspiration, the syringe containing the aspirate could be exchanged for the syringe containing PRP without removing the needle from the subperichondrial space, allowing for PRP delivery directly into the intended tissue plane. This would ensure accurate placement without relying solely on visual signs of tissue induration. Furthermore, standardization of PRP preparation protocols is needed. PRP formulations vary widely depending on technique, preparation system used, and practitioner, and this variability has unknown implications on clinical outcome.

More research is needed, not only to define the role of PRP in the treatment of auricular hematoma, but to establish any evidence-based treatment for auricular hematoma.[17] Currently, there is a paucity of high-quality studies comparing needle aspiration versus incision techniques, and the efficacy of different dressings. Developing standardized management protocols will require controlled, high-quality evidence. While this paper is limited by its single-patient design and lack of control data, it highlights the potential value of investigating PRP effects on tissue layer adhesion, cosmetic outcomes, and complications such as infection or necrosis.

CONCLUSION

This case describes a recurrent auricular hematoma that was completely resolved after a single treatment with PRP. The theoretical basis for PRP use in auricular hematoma is that peptide growth factors may facilitate the primary treatment goals – tissue layer closure and revascularization. To date, there are no evidence-based standard treatments for auricular hematoma. The use of PRP may help reduce the need for pressure dressings, which are inconvenient and may lead to complications. Therefore, PRP should be considered a potential treatment option for both acute and recurrent auricular hematomas.

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SPECIAL FEATURE

Three questions with the ARP President Dr. Lou Durkin

By George Velasco, M.D.

In this special feature we ask the ARP president three questions on useful and exciting topics.

George Velasco: What do you carry in your bag on fight night?

Lou Durkin: I have 3 different bags depending on the event and timing. My pre-fight physical bag has a stethoscope, automatic blood pressure cuff, and a manual cuff with 3 different size cuffs. It is especially important to have the extra-large cuff for the big guys. An undersized cuff will give a falsely high reading. And the automatic cuffs will often overestimate the diastolic, which can be better assessed with the manual cuff. I also have hand sanitizer, O2 Sat probe, and a thermometer. I don't carry a specific eye chart. My second bag is a suture set-up. In addition to the typical suture kits, I carry a ring light for dark venues, chux to absorb blood and saline, Dermabond, Steri-Strips, and benzoin ampules for strip adhesion. I try to make sure the suturing is as close to how I would do it in the ER as possible. The fighters deserve it. My third bag is for ring-side/cage-side. I have 4x4 gauze and plenty of gloves. I always glove up before the fight starts. I have Goggles (any safety-glasses type of eyewear to protect against potential splash with blood or sweat), snacks, gum, water, and a good pair of Lister bandage scissors. I have used every type of scissors and trauma shears available. The very high-end Lister scissors work the best so far. I like to cut off the wraps post-fight. It gives me a little more time with the fighter and you can assess the hands much better without the wraps in place. I like the 8-inch scissors with the large ring for the most leverage.

George Velasco: You cover many bare-knuckle events and are in the bare-knuckle fighting hall of fame. What are some clinical pearls or advice for doctors who are covering bare-knuckle events, both for those who are new to bare-knuckle or for those who have already covered some events in the past?

Lou Durkin: Watch a lot of past events to get a better idea of the types and number of lacerations. Especially watch any fights worked by Dr. Donato Muzzi. He is the best ever to work bare knuckle and can give you a very good idea of when a bout needs to be stopped or can continue. Also, get a good idea of the "No-Go" areas like the eyelid and lacrimal duct. About a third of all bare-knuckle fighters will need sutures. Make sure there is a dedicated suture doctor for the event. And make sure they are good at it. Before your next bare-knuckle event, take the new 2-hour ARP course on Bare Knuckle Fighting. It will be offered live at the Orlando conference in May and will be available on-line afterwards.

George Velasco: What are some exciting new things for the ARP in 2026?

Lou Durkin: This is going to be a big year for the ARP! We are developing a number of inter-disciplinary trainings designed to help everyone work as a team. We are re-vamping our Ringside Basics Course so we can teach it live with updated materials and position statements. We plan on traveling to other countries with this course to help expand and standardize the specialty of Combat Sports Medicine. This is really exciting. We will also be launching 3 new trainings at our 2026 annual conference in Orlando May 28-31st. The pre-conference day on the 28th will feature "Downed Fighter Life Support". This 4-hour course is designed to standardize the approach to the seriously injured fighter. Its target audience is the entire fight team-- doctors, referees, deputies, paramedics. It covers the basic medicine of severe trauma and medical emergencies and how to treat them as a team. The conference will also feature additional training on Bare Knuckle Fighting and Slap Fighting. As these are two rapidly expanding sports, and it is important to have specific training before covering an event for the first time. These will also be available online.

Information and Submission Instructions for Authors

General and Formatting Guidelines

All manuscripts must be in written in English, using UK or American English spellings. All materials must be submitted electronically to Kevin deWeber, Editor-in-Chief, at **kdeweber@peacehealth.org**.

Submissions must:

- Be submitted in Microsoft Word format (.doc or .docx);
- Be double-spaced with 1" margins;
- Be typed in a commonly-used font (Times Roman, Helvetica, Arial, or similar), no smaller than 11 points;
- Include page numbers.

Abbreviations and Acronyms
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Print Journal (1-6 authors)

Nathan JP, Grossman S. Professional reading habits of pharmacists attending 2 educational seminars in New York City. *J Pharm Practice.* 2012;25(6):600-605.

Print Journal (more than six authors)

Geller AC, Venna S, Prout M, et al. Should the skin cancer examination be taught in medical school? *Arch Dermatol.* 2002;138(9):1201-1203.

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Centers for Disease Control and Prevention (CDC). Licensure of a meningococcal conjugate vaccine (Menveo) and guidance for use--Advisory Committee on Immunization Practices (ACIP), 2010. *MMWR Morb Mortal Wkly Rep.* 2010;59(9):273.

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Rantucci MJ. Pharmacists Talking With Patients: A Guide to Patient Counseling. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2007.

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