A Survey of Combat Athletes' Rapid Weight Loss Practices and Evaluation of the Relationship With Concussion Symptom Recall

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Abstract

Objective: There is a high incidence of concussion and frequent utilization of rapid weight loss (RWL) methods among combat sport athletes, yet the apparent similarity in symptoms experienced as a result of a concussion or RWL has not been investigated. This study surveyed combat sports athletes to investigate the differences in symptom onset and recovery between combat sports and evaluated the relationships between concussion and RWL symptoms. **Design:** Cross-sectional study. **Setting:** Data were collected through an online survey. **Participants:** One hundred thirty-two (115 male athletes and 17 female athletes) combat sport athletes. **Interventions:** Modified Sport Concussion Assessment Tool (SCAT) symptom checklist and weight-cutting questionnaire. **Main Outcome Measures:** Survey items included combat sport discipline, weight loss, medical history, weight-cutting questionnaire, and concussion and weight-cutting symptom checklists. **Results:** Strong associations ($r_s = 0.6–0.7$, $P < 0.05$) were observed between concussion and RWL symptoms. The most frequently reported symptom resolution times were 24 to 48 hours for a weight cut (WC; 59%) and 3 to 5 days for a concussion (43%), with 60% to 70% of athletes reporting a deterioration and lengthening of concussion symptoms when undergoing a WC. Most of the athletes (65%) also reported at least one WC in their career to "*not go according to plan*," resulting in a lack of energy (83%) and strength/power (70%). **Conclusions:** Rapid weight loss and concussion symptoms are strongly associated, with most of the athletes reporting a deterioration of concussion symptoms during a WC. The results indicate that concussion symptoms should be monitored alongside hydration status to avoid any compound effects of prior RWL on the interpretation of concussion assessments and to avoid potential misdiagnoses among combat athletes.

Key Words: traumatic brain injury, martial arts, boxing, wrestling, dehydration

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INTRODUCTION

Concussions are mild traumatic brain injuries, generally experienced in sport from direct or indirect contact to the head, leading to linear and rotational acceleration of the brain.[1] Concussions occur commonly in combat sports, such as mixed martial arts (MMA), boxing, and kickboxing/Muay Thai (KB/MT), due to head impacts in training and competition.[2] Within boxing and MMA, concussion rates range between 16 and 25 per 100 athletic exposures,[2–4] but this may be underestimated due to the absence of medical personnel in a large proportion of training time. With evidence of both short-term and long-term health consequences as a result of repetitive head trauma,[5–7] there is an emerging concern for the welfare of combat sport athletes. Therefore, determining the factors that contribute to concussion risk has become a priority.

Combat sports are categorized by weight divisions to ensure fair bouts between opponents and reducing potential injuries that might occur as a result of major weight differences.[8] Typically, athletes aim to lose body mass (through water) in the shortest time possible, using rapid weight loss (RWL) methods to obtain a perceived advantage of competing against a lighter or weaker opponent.[9] Common forms of RWL are fluid restriction, dehydration by sweating, diuretics, laxatives, and "water-loading"—a method by which large volumes of fluid are consumed to manipulate renal hormones (eg, aldosterone) and urine output, resulting in further weight loss.[10,11] These strategies can lead to hypohydration and, subsequently, alterations to renal function,[12] immunoendocrine status,[13] brain ventricular volume, and metabolic activity.[14]

Both cellular dehydration, induced by hypohydration or "water-cutting," and concussive events have been reported to impair central nervous system function.[1,14] Although the mechanistic basis of these effects is currently uncertain and meaningful links are unestablished, disruption of fluid or ion homeostasis has been commonly reported among hypohydrated subjects and those experiencing concussions.[14,15] Hypohydration

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is also reported to lead to cognitive and neuromuscular deficits,[16,17] which could theoretically lead to reduced performance and a heightened risk of concussion. Patel et al[18] investigated the symptomology of hypohydrated, nonconcussed subjects and found an increase in concussion-related symptoms, indicating that hypohydration and concussion may elicit similar effects. Indeed, any synergistic effects caused by hypohydration or concussive events could exacerbate the reported symptoms. Whether such physiological and physical alterations lead to combat athletes competing or training with a higher risk (or perceived risk) of brain trauma is unknown, although this has been anecdotally reported by mainstream media outlets.[19] It is also unclear whether certain combat sports place athletes at greater risk, particularly among striking-dominant disciplines or those with stringent weight classifications. Similarly, the clear overlap in the symptoms associated with hypohydration and concussion is problematic because diagnostic criteria for both conditions, and apparent severity thereof, are heavily dependent on subjective scoring processes. This increases the risk of concussion misdiagnosis around competition and could jeopardize athlete welfare.

Studies investigating concussion symptoms, in isolation, have frequently reported neck pain, fatigue or low energy, trouble falling asleep, and headaches,[20] with 60% of MMA athletes returning to sparring within 2 days or less of their first symptom.[21] Symptoms pertaining to heat stress and hypohydration are also reported to include headaches, dizziness, and increased perception of fatigue.[18,22] Despite the incidence of concussions and abundant use of RWL among combat athletes,[10,23] to date, there has been no study of both self-reported concussion and RWL symptoms in combat athletes or evaluation of their interrelationships. Therefore, the aims of this survey were to (1) investigate the differences in RWL and concussion symptom onset and recovery between combat sports and (2) evaluate the relationships between concussion and RWL symptoms among combat athletes who have previously suffered from a concussion and undergone RWL before competition.

METHODS

Participants

After institutional ethical approval, participants were recruited through web sites and social media, with informed consent obtained in accordance with the Declaration of Helsinki (2013). Participants were required to be 18 years or older, competed (at least once) in a combat sport, and had "cut weight" before a competition. A "weight cut" (WC) was defined as any method leading to the loss of water, including but not limited to sauna, fluid restriction, diuretics, sweating gels, hot water baths, laxatives, fat burners, vomiting, and "water-loading". A total sample size of 132 (115 male athletes and 17 female athletes) combat athletes (age: 29 ± 8 years, body mass: 77.0 ± 12.9 kg, training experience: 13 ± 6 years) completed the survey. Sporting modalities reported were MMA (31%), KB/MT (20%), boxing (22%), wrestling (5%), Brazilian jiu-jitsu (BJJ; 10%), judo (8%), and "others' (6%). Of the total sample, 70% of athletes were actively competitive, with 50% of male athletes and 29% of female athletes competing professionally.

The Survey

The survey combined 2 validated questionnaires: the Mixed Martial Arts Weight-Cutting Questionnaire (MAWC-Q[24]) and the Sport Concussion Assessment Tool 5 (SCAT-5[25]). Participants were asked preliminary questions regarding demographic, sporting, and medical history, after which the questionnaire was split into 3 sections, which aimed to address (1) WC practices, (2) WC symptoms, and (3) concussion history and symptoms.

The survey was piloted through completion by 15 combat athletes, a wrestling coach, and 2 experts (current researcher in the field of nutrition and a ringside medic). Written feedback was provided on the suitability and clarity of questions and amendments were made before the finalized version was released online (Joint Information Systems Committee Online surveys).

Martial Arts Weight-Cutting Questionnaire

The MAWC-Q consisted of 26 questions, aiming to establish the prevalence and magnitude of RWL methods, specifically among MMA athletes. Modifications were made to the MAWC-Q were as follows: (1) rephrasing of questions to ensure appropriateness to all combat athletes; (2) omission of questions regarding age of first WC, specific method of weight loss, and symptoms; (3) addition of questions related to cumulative number of WCs and time in between a WC; and (4) the addition of a question, asking if a WC had "*not gone according to plan*" and a series of resultant scenarios. This was to establish the frequency and experiences of worst-case scenarios in weight-cutting practices.

Sport Concussion Assessment Tool 5

Symptom profiles for concussion and WCs were assessed using a 22-point symptom checklist from the SCAT-5. Each symptom was assessed using a Likert scale of severity, ranging from 0 (none) to 6 (severe +); however, modifications were made to the checklist through the addition of 2 physical symptoms "*physically weak*" and "*unable to train*." This resulted in a "symptom score" of 24 (sum of each selected symptom) and a "symptom severity" of 144 (sum of all Likert scale selections). Thereafter, participants answered 6 additional "yes or no" questions (Table 2 and Figure 4) related to the relationship between symptom recovery, fluid consumption, and head impacts. The sum of the symptom score and 6 additional questions led to a third measure: an "adjusted symptom score" of 57.

Statistical Analysis

Statistical analyses were completed using SPSS (v22, IBM Corp, Armonk, NY). Data were presented as means ± standard deviations (SD), frequency of responses to each item (n), range (where appropriate), or median and interquartile range (IQR) if nonnormally distributed. Assumptions of normality and equality of variance were assessed using Shapiro–Wilk and Levene tests, respectively. For parametric (WC symptom variables) data, a one-way analysis of variance was used to assess the difference between each sport (MMA, boxing, KB/MT, judo, wrestling, and BJJ). For nonparametric data, a Kruskal–Wallis test was used to establish differences in concussion symptom variables between each sport. Where

there was a significant main effect, pairwise comparisons were examined by a Tukey (parametric) or Dunn–Bonferroni *post hoc* (nonparametric) to account for the homogeneity of variance. A Spearman Rho correlation was used to assess the relationship between concussion and WC symptom variables (symptom severity, symptom score, and adjusted symptom score). An alpha level of ≤ 0.05 was set for all analyses.

RESULTS

Modified Martial Arts Weight-Cutting Questionnaire

Most of the athletes (83%) reported using a fight preparation camp, with the highest reported WCs being 10 kg (10 days), 8.6 kg (7 days), 7 kg (3 days), and 5 kg (24 hours). Median WC was 6.6% of body mass (Table 1A). Most athletes (65%) reported a WC to "*not going according to plan*," with the most frequent consequences being a lack of energy (83%), lack of strength/power (70%), and suboptimal coordination and reaction time (55%) (Table 1B). Responses included in the "other" section were "*collapsed*" and "*cramping*" (n = 2) and "*coughing blood and unable to function*", "*projectile vomiting*," "*was asked to keep weight off for an extra 36 hours*," "*felt cold and lips became blue during fight*," "*menopause*," "*fluid ascites*," and "*process was more grueling due to period making me retain more water*" (n = 1).

Weight Cut and Concussion Symptom Profiles

There was a significant relationship between WC and concussion symptom severity (r_s = 0.68, 95% CI [0.54, 0.74], $P < 0.001$), symptom scores (r_s = 0.60, 95% CI [0.44, 0.72], $P < 0.001$), and adjusted symptom scores (r_s = 0.72, 95% CI [0.59, 0.81], $P < 0.001$) (Figure 1).

Mean scores for WC symptom severity, symptom score, and adjusted score were 49 ± 30 of 144, 15 ± 7 of 24, and 19 ± 9 of 57, respectively. A significant main effect was observed in WC symptom severity ($F_{(5, 118)} = 5.464$, $P < 0.001$), with differences between MMA and KB/MT (59.2 vs 36.5, $P = 0.01$), MMA and boxing (59.2 vs 38.0, $P = 0.02$), judo and KB/MT (67.5 vs 36.5, $P = 0.02$), judo and boxing (67.5 vs 38.0, $P = 0.03$), and judo and BJJ (67.5 vs 31.9, $P = 0.04$). A significant main effect was also observed in adjusted symptom scores ($F_{(5, 118)} = 3.213$, $P = 0.009$), with a difference between MMA and KB/MT (22.0 vs 15.6, $P = 0.03$) (Figure 2A and B).

Median (IQR) scores for concussion symptom severity, symptom score, and adjusted score were 48 (57) of 144, 18 (14) of 24, and 26 (19) of 57, respectively. A significant main effect was observed in concussion symptom severity ($\chi^2_{(5)} = 14.142$, $P = 0.015$), with a difference between MMA and boxing (56.0 vs 31.9, $P = 0.023$). A main effect was also observed in adjusted symptom scores ($\chi^2_{(5)} = 13.348$, $P = 0.02$), with pairwise comparisons showing a significant difference between MMA and boxing (55.5 vs 32.8, $P = 0.04$) (Figure 2C and D).

Of the 132 combat athletes who completed the survey, approximately two-thirds (64%) reported sustaining at least one concussion during their professional career, but only 45% were hospitalized or underwent imaging and 34% were medically diagnosed. The median (IQR) reported time before returning to training after a concussion was 7 (12) days.

Most of the athletes (70%) reported deterioration of concussion symptoms during and after a fight or sparring session, while 37% reported deterioration of WC symptoms. A summary of symptom recovery responses can be found in Table 2.

DISCUSSION

This study surveyed combat sport athletes to investigate the differences in symptom onset and recovery between combat sports and evaluated the relationships between concussion and RWL symptoms. There were strong associations between concussion and RWL symptom profiles, particularly for feelings of dizziness, headaches, physical weakness, and fatigue. Most of the athletes (60%-70%) reported a deterioration and lengthening of concussion symptoms when undergoing a WC, suggesting that prior RWL might affect concussion symptoms.

This is the first study to assess the relationship between reported symptoms experienced as a result of previous RWL events and concussions among combat athletes. Our findings indicate a positive relationship between symptoms associated with RWL (through dehydration and leading to hypohydration) and concussions, based on both reported total number and severity of symptoms (Figure 1). Analysis of individual symptoms revealed that the most common WC symptoms were physical weakness, fatigue, dizziness, not feeling "right," difficulties in concentration, and irritability. The most frequently selected concussion symptoms comprised the same responses as WC, in addition to headaches, head pressure, and neck pain (Figure 3). These findings are in accordance with the previous literature,[18,26–28] indicating that RWL through dehydration increases concussion-related symptoms. The possible reasons for feelings of weakness and fatigue could relate to perturbations in ionic balance to restore osmotic equilibrium[29] and subsequent alterations to cell excitability and excitation–contraction coupling capabilities.[30,31] Hypohydration also leads to a reduction in total blood volume (hypovolemia), leading to light-headedness and dizziness, while dizziness postconcussion may also be related to vestibular system damage, further increasing headaches, feelings of confusion, and concentration difficulty.[32] This may explain why the most frequently reported symptom (for both concussed and RWL athletes) after a WC or sparring session was headaches[18] (Figure 3 and 4). Therefore, the implications of less discernible concussion-related symptoms (eg, dizziness and headaches) in athletes undergoing RWL, might mask or exacerbate the effects of cumulative subconcussive impacts received throughout the bout. This challenges the accuracy of concussion identification tools, particularly if baseline protocols do not account for hydration status. The extreme practices of WC are likely to introduce a source of external noise to the assessment of concussion symptoms, meaning that knowledge of hydration status is necessary during all protocols to avoid erroneous results. Given that the risks associated with extreme WC could endanger athlete welfare in pursuit of a competitive advantage, further consideration of sporting governing bodies to set limits on weight-cutting is warranted.[33]

To the best of our knowledge, our study is the first to report the various experiences of combat athletes who believed their WC did not go according to plan, with 70% to 80% of

TABLE 1. Participant Preparation Camp and WC Characteristics (Average) (A) and WC Characteristics (Frequency) (B)

A	Mean ± SD/Median (IQR)	Range
Average camp length (wk)	7 ± 3	4-12
Shortest camp length (wk)	3 ± 2	1-5
General "walking" weight (kg)	76.3 ± 13.0	47-105
Usual weight cut (kg)	5 (5)	0-22
Usual weight regain (kg)	3 (3.5)	0-10
Shortest weight cut timing (d)	3 (6)	0-15
Weight lost (kg)	5 (4)	0-13
Weight loss in 24 h before weigh-in (kg)	2 (2)	0-5
Total no. of weight cuts in career	15 (20)	0-147
B	**n**	**%**
Time between weigh-in and bout (h)		
24-36	75	56.8
12-23	14	10.6
6-12	10	7.6
2-5	20	15.2
<2	6	4.5
Time between each weight cut (mo)		
<1	76	57.6
1–2	31	23.5
3–4	18	13.6
≥ 5	7	5.3
Weight cut not according to plan (Y/N)	Y = 86	65.1
Felt a lack of energy	71	82.6
Felt a lack of strength/power	60	69.8
Coordination and reaction time felt suboptimal	47	54.7
Felt dehydrated during the fight	41	47.7
Felt easier to get 'rocked' during the fight	33	38.4
Initially failed to make weight	30	34.9
Fell ill in the lead up to the fight	27	31.4
Felt too bloated going into the fight	20	23.3
Other	11	12.8

athletes reporting a lack of energy, strength, and power, as well as 40% to 50% reporting a reduction in coordination and feeling more susceptible to concussion (Table 1B). It was also found that 60% to 70% of athletes reported their concussion symptoms to deteriorate and lengthen during a camp where they were weight-cutting and in a fight in which they were

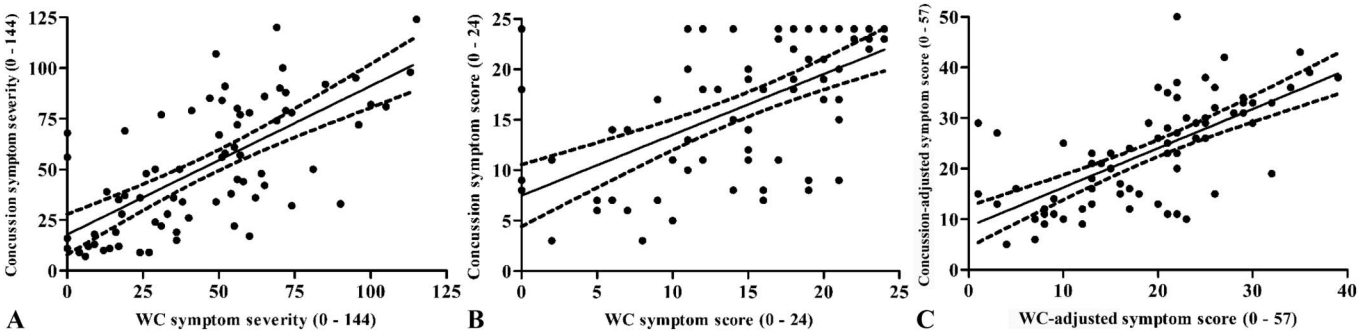

Figure 1. Significant correlations between concussion and WC with 95% confidence intervals. A, Symptom severity (r_s = 0.68), (B) symptom scores (r_s = 0.60), and (C) adjusted symptom scores, (r_s = 0.72). (N = 80).

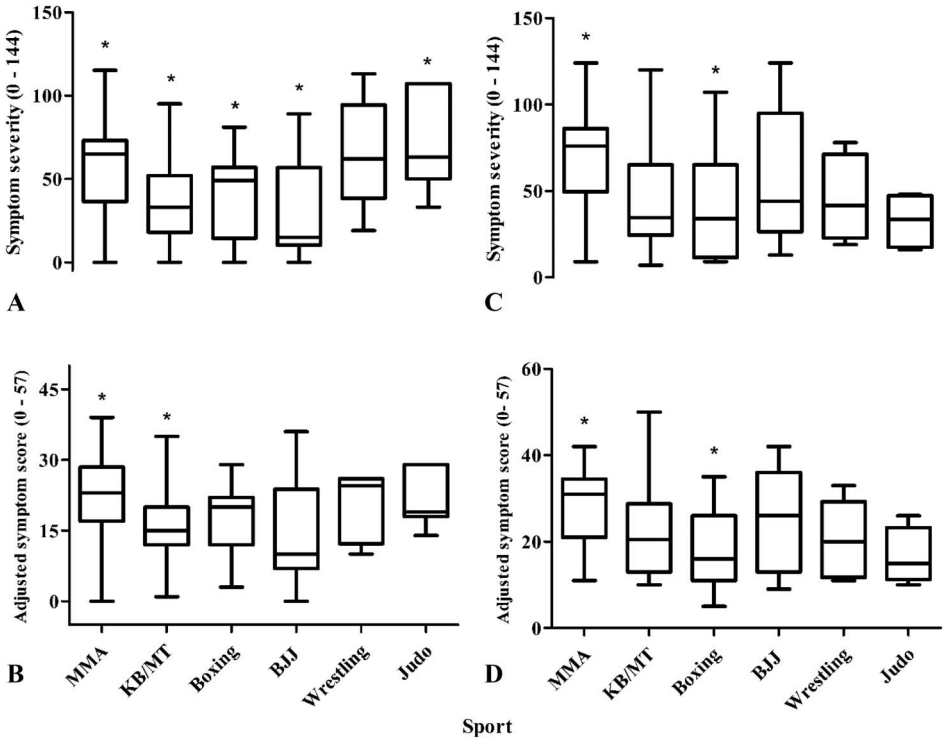

Figure 2. Average WC symptom severity (A), adjusted symptom score (B), concussion symptom severity (C), and adjusted symptom score (D) for each combat sport.

dehydrated (Table 2). Furthermore, ~ 50% of athletes reported increased feelings of being "slowed down," experiencing fatigue, irritability, and physical weakness after fighting in a hypohydrated state or cutting weight in camp (Figure 4). These reports could indicate mechanisms by which hypohydration exacerbates the physiological responses to a concussion. Indeed, concussions are known to lead to hyperglycolysis, coupled with relative depletion of energy reserves, to restore ionic imbalances.[15] The combination of hyperglycolysis, alongside additional physiological stressors (in a bout) and hypohydration, may induce a competing substrate demand, which could be further

TABLE 2. Symptom Recovery Profile, Y = Yes

	WC		Concussion	
Symptom Recovery–Related Questions	**% (n)**	**Total n**	**% (n)**	**Total n**
Do you feel that these symptoms became worse during/after the fight (or sparring session) within which you were dehydrated? (Y)			70 (56)	80
Do you feel that these symptoms improved when you were able to consume fluids again? (Y)	94 (124)	132	30 (17)	56
Do you feel that these symptoms lasted longer in comparison with a camp/session when you were not cutting weight? (Y)	61 (81)	132	60 (48)	80
Do you feel that you experienced less of these symptoms in a camp/session when you were not cutting weight? (Y)	89 (117)	132	70 (56)	80
Do you feel that these symptoms became worse during/after the fight (or sparring session)? (Y)	37 (49)	132		
How long did these symptoms tend to last for?		49		56
Less than 24 h	22 (11)		15 (12)	
24-48 h	59 (29)		28 (23)	
3-5 d	10 (5)		43 (34)	
6-13 d	2 (1)		8 (6)	
14-28 d	6 (3)		4 (3)	
Over 28 d	0		3 (2)	

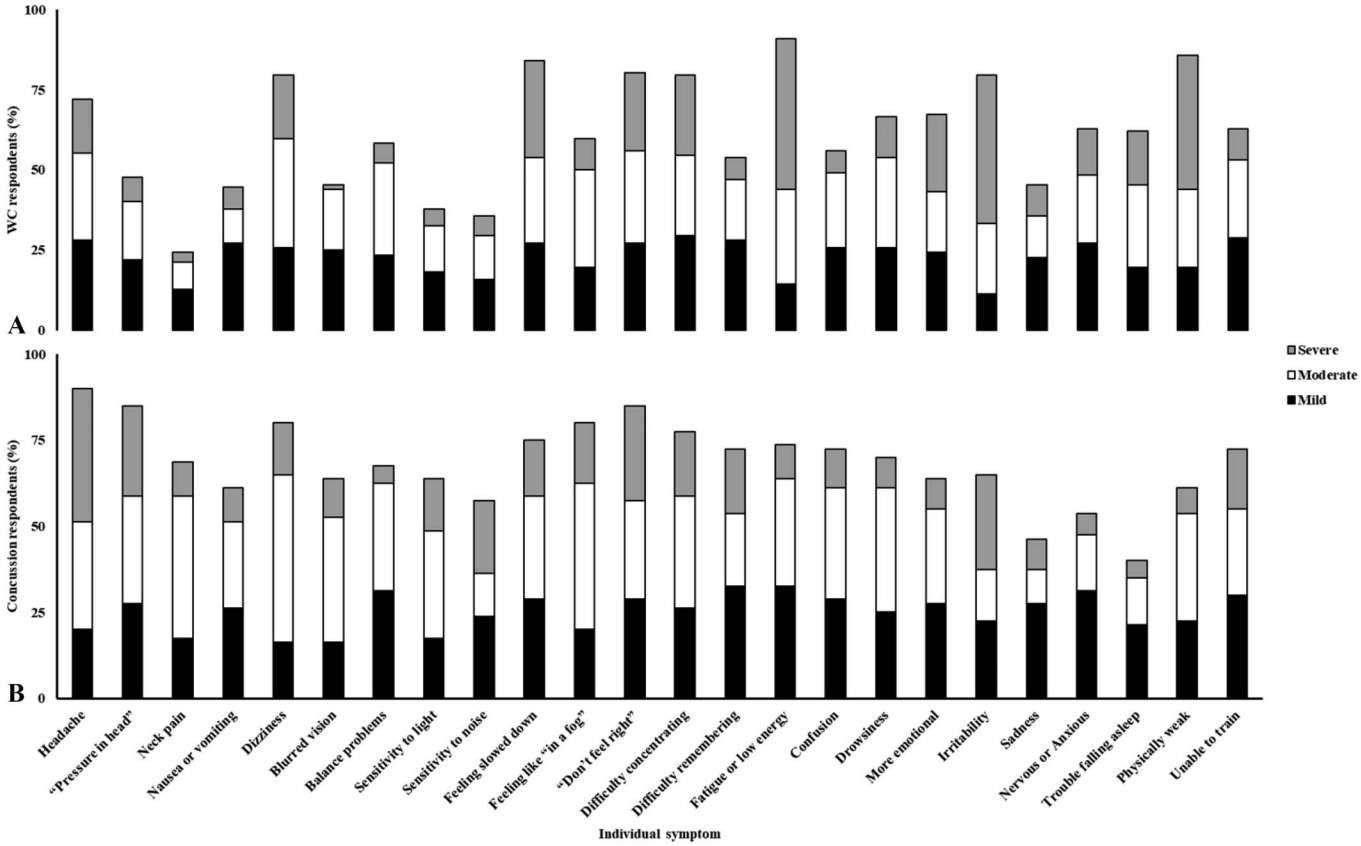

Figure 3. Percentage of athletes who selected each symptom severity for WC (A) and concussions (B).

exacerbated by reduced overall blood volume. In addition, it is possible that damage to neurons (eg, diffuse axonal or shear injuries) is enhanced secondary to hypohydration because of altered membrane stability,[31] tissue elasticity,[34] and cerebrospinal fluid production,[35] leaving the brain more vulnerable to cortical damage from trauma. This could, subsequently, lead to prolonged recovery or further exposure to head trauma, which in chronic cases has been associated with later development of neurodegenerative diseases, for example, dementia pugilistica, chronic traumatic encephalopathy, and Alzheimer disease.[36–38]

The individual reports of mishaps during WC practices, while anecdotal and possibly related to factors unknown in this study, expose a plethora of additional negative outcomes associated with RWL. In addition, most of the athletes (65%) stated at least one incident of RWL to "*not go according to plan*", indicating the perceived competitive advantage may often not be achieved by combat athletes.[39] It is crucial these reports do not go ignored and athletes seek medical/professional advice regarding RWL strategies because many poor outcomes in individual athletes have been documented.[40] In addition, MMA athletes presented higher

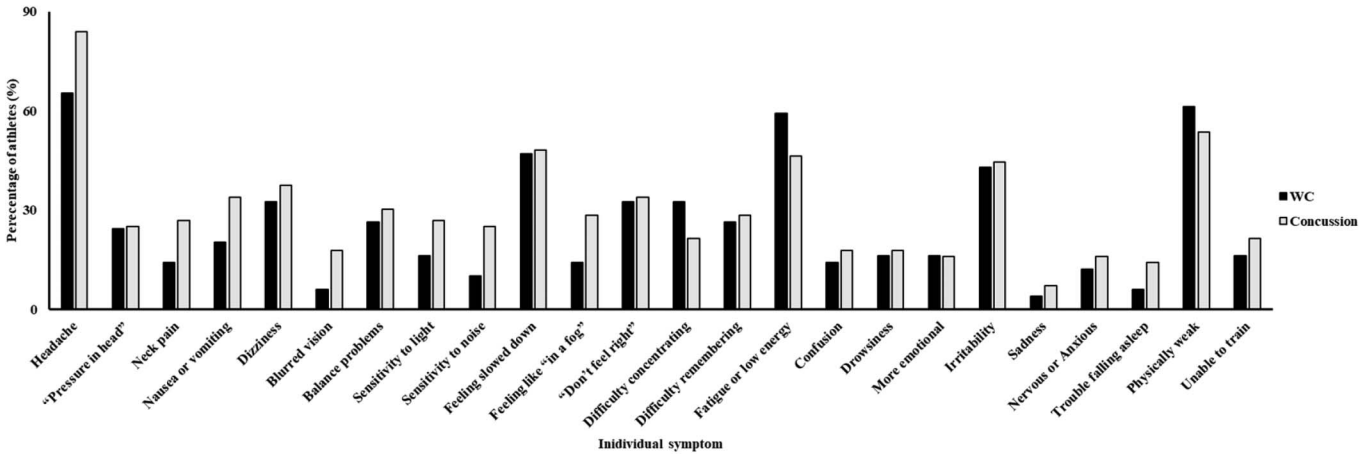

Figure 4. Percentage of athletes who reported symptoms to deteriorate after hypohydration or head impact, WC (n = 49) and concussion (n = 56).

symptom severity and adjusted scores for both concussion and RWL (Figure 2), indicating RWL and concussion symptoms to be more severe in MMA. Symptom severity of RWL in MMA was similar to wrestling, which is also associated with larger and more aggressive RWL magnitudes and methods.[23] Interestingly, concussion symptom severity and adjusted scores were not different between sports, except between MMA and boxing. This may be explained by the higher range of weight classes and lack of indirect head impacts (eg, takedowns) experienced by boxing athletes in comparison with MMA. Given the differences in symptom severity across various combat sports, we recommend that combat sport organizations aim to incorporate baseline concussion and continual hydration testing protocols to verify the effects of hypohydration and concussions independently.

To date, this is the first study to report on the resolution of combined RWL and concussion symptoms. Almost all athletes (94%) reported their WC symptoms to improve with fluid replenishment; however, the most frequently reported recovery time (for those with increased symptom scores after a fight) was 24 to 48 hours (Table 2). This indicates that, despite fluid replenishment, more than a day was required for said symptoms to resolve. An explanation for this could, in part, be due to (1) the method of hydration, that is, bolus vs tapered drinking strategies[41]; (2) electrolyte and carbohydrate-deficient fluids insufficiently restoring blood osmolality, volume, and glucose[42]; or (3) concussive/subconcussive impacts further adding to alterations in cell integrity and ionic imbalances.[43,44] Coaches, athletes and clinicians, should consider the implications of RWL and all aspects of training load (particularly different modes, such as sparring) because this could heavily affect recovery and preparation for a bout.[13]

One of the main limitations of our study was that we did not account for the additional weight loss methods used during fight preparation (eg, food restriction). Furthermore, it is possible that symptoms were misreported due to surpassed time, which could mean that the effects of RWL on concussion-related symptoms have been overestimated or underestimated in this study.

CONCLUSIONS

Overall, our findings suggest that RWL symptoms are strongly associated with concussion symptoms, and although these varied between sports, MMA athletes present with the most severe symptoms associated with RWL and concussions. Based on our findings, it is possible that prior WC practices could exacerbate the deleterious effects of a concussion. Indeed, given that WC practices occur before most concussive events and that athletes are unlikely to have recovered from the effects of hypohydration by this time, it is possible that WC increases the risk of misdiagnosis. If hydration status is unmonitored during any neurocognitive assessment, such as that performed during baseline concussion assessment protocols or precompetition, the results are likely to be affected. Where an athlete is safe and able, we recommend that clinicians should monitor hydration status (eg, point-of-care urine or blood analysis and gross body mass), when performing baseline and postrecovery neurocognitive tests, such as those used to screen for concussion symptoms. More generally, the findings of this survey suggest that RWL through WC methods should be avoided near to combat training or competition because it is possible that this could interfere with the decision-making of medical professionals' diagnosis of concussion.

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