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Acute weight cycling and hydration status in elite kickboxers: a repeated-measures field study

Bayram Ceylan^{1*}, Hasan Basri Taşkın¹, Uğur Sarıkaya², Hacı Ahmet Pekel³ and Türkan Nihan Sabırlı⁴

Abstract

Objective This study aimed to monitor acute changes in body weight and hydration status—measured via urine-specific gravity (USG) and urine color (UC)—in elite-level kickboxers during a real-world competitive environment. The research sought to provide critical insights into current weight-management practices and the prevalence of hypohydration during the pre-competition period.

Methods Using a cohort repeated-measures design, ten elite male kickboxers (age: 20.5 ± 2.8 years) were monitored at four distinct time points: one week before the competition (T1), one day before the official weigh-in (T2), at the official weigh-in (T3), and on the competition day (T4). Body weight was measured using a calibrated scale, and body composition was assessed via bioelectrical impedance. Hydration status was evaluated through midstream urine samples analyzed for USG and UC. Hypohydration was defined as a USG ≥ 1.020 .

Results Athletes underwent significant rapid weight loss (RWL), losing an average of 3.1 ± 1.7 kg (4.2%) in the week leading up to the weigh-in. This was followed by a rapid weight regain (RWG) of 3.3 ± 1.4 kg (4.8%) between the weigh-in and the start of the competition. Hydration markers worsened significantly as weight decreased, with USG and UC values peaking at the official weigh-in (1.030 ± 0.006 and 7.3 ± 1.3 , respectively), indicating peak hypohydration. Notably, while 50% of athletes were hypohydrated at T1, all remained hypohydrated on competition day (T4) despite the substantial weight regain.

Conclusion The results indicate that elite kickboxers engage in significant RWL followed by RWG that returned athletes to their starting body weight. However, this weight gain does not equate to recovery of a euhydrated state, as the vast majority of athletes remain hypohydrated at the start of competition. Coaches and athletes should implement personalized, professional rehydration plans rather than relying on acute weight gain as a proxy for hydration recovery.

Keywords Combat sports, Dehydration, Weight loss, RWG, Rehydration

*Correspondence:

Bayram Ceylan
bceylan@kastamonu.edu.tr

¹Department of Coaching Education, Faculty of Sport Sciences,
Kastamonu University, Kastamonu 37150, Türkiye

²Department of Physical Education and Sport, Mehmet Arabacı School of
Physical Education and Sport, Harran University, Şanlıurfa, Türkiye

³Department of Coaching Education, Faculty of Sport Sciences, Gazi
University, Ankara, Türkiye

⁴Department of Recreation, Faculty of Sport Sciences, Eskişehir Technical
University, Eskişehir, Türkiye



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Introduction

Combat sports include disciplines in which athletes compete one-on-one within the framework of specific rules involving physical contact. These sports may include striking techniques, such as punches and kicks, grappling maneuvers, such as choking and joint-locking, or a combination of both [1]. Combat sports are generally classified into grappling, striking, and mixed disciplines. Federations categorize athletes according to their body weight to ensure that they compete under physically equitable conditions and reduce the probability of injury [2]. Nevertheless, combat athletes often resort to rapid weight loss (RWL) to compete in a lower weight class in the days and weeks preceding the official weigh-ins. Athletes aim to gain a competitive advantage and match lighter and weaker opponents [1, 3]. This practice is common in virtually all combat sports. Between 60% and 80% of athletes in competitive combat sports, such as Brazilian jiu-jitsu (BJJ), taekwondo, boxing, judo, kickboxing, and wrestling, typically undergo RWL [1, 4, 5].

During the RWL process, athletes utilize various weight-loss methods, such as limiting energy intake through gradual dieting and fasting, reducing total body fluid by restricting fluid intake and increasing sweating via exercising in a heated environment, plastic suits, saunas, and spitting, and employing medical practices involving excessive use or abuse, such as laxatives, diet pills, diuretics, and “sports bulimia” or induced vomiting [3, 6, 7].

Acute fluid deficit, otherwise known as “dehydration,” is one of the most common methods and is frequently observed in combat athletes prior to competition due to RWL [6, 8–12]. Dehydration negatively affects health and athletic performance of athletes. It is generally associated with decreased plasma volume and harmful effects on cardiovascular function [13]. Furthermore, Cheuvront and Kenefick [14] determined that dehydration exceeding 2% decreases endurance, strength, and muscle power. Jones et al. [15] also stated that a dehydration level of approximately 2.9% of body weight reduces the anaerobic power generation capacity of the upper and lower bodies. Even mild dehydration (1–2% of body weight) adversely affects athletic performance [16]. Moreover, a disrupted body water balance can lead to a decline in cognitive functions, such as slowed decision-making time [17], lower attention levels, poor psychomotor performance [18], and negative mood states [19]. As weight-class athletes frequently lose 5–13% of their body weight for competition [3, 20, 21], it is thought that dehydration may detrimentally affect performance following RWL.

Kickboxing is a combat sport in which athletes deliver full-force strikes using their hands, elbows, knees, calves, and feet [22]. It involves various striking techniques that utilize the upper and lower body, making it a full-body

exercise that requires high levels of physical fitness and technical skills. Kickboxing matches are characterized by high-intensity interval activity characteristics; athletes rapidly combine explosive kicks, punches, and defensive movements with low-intensity movements throughout the rounds [23]. This activity model leads to significant metabolic heat production and consequently increased fluid loss through sweating [6]. Therefore, optimal hydration status is a fundamental determinant for kickboxers, not only for health but also for strength, power, speed, accuracy, and high-tempo performance sustained until the end of the match [24, 25]. However, widespread weight-cutting practices are also present among kickboxers due to their weight-class nature [1, 26, 27].

Numerous studies have examined pre- and post-competition hydration statuses in other weight-class sports, such as judo, taekwondo, and wrestling [10, 28–30]. Despite extensive research on other combat sports, studies specifically examining the RWL and hydration status of kickboxing athletes before an official competition are notably absent. Although the physiological demands and weight-loss culture of kickboxing show similarities with other sports [4, 5, 31], its unique technical movement patterns, round structure, and competition strategies necessitate a specific evaluation of hydration status. Therefore, this study aimed to determine the extent of body weight changes and hydration status (via urine-specific gravity (USG) and urine color (UC)) in elite-level kickboxers during the pre-competition period, providing critical insights into current practices and potential risks in this specific combat sport. The hypothesis of this study was that athletes would experience both high weight loss and exhibit high levels of hypohydration during the pre-weigh-in period.

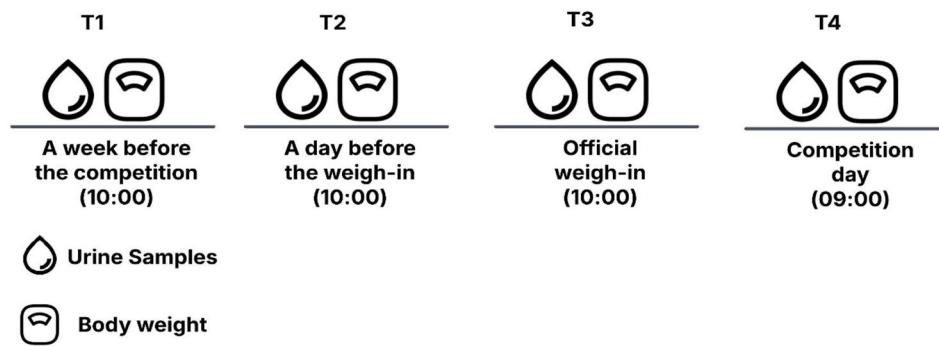
Materials and methods

Study design

This cohort repeated-measures design study aimed to monitor the acute changes in body weight and hydration status via USG and UC a week before (T1), a day before the official weigh-in (T2), at the official weigh-in (T3), and on the competition day (T4) in elite kickboxers during a real competitive environment. The study design is shown in Fig. 1.

Participants

Ten elite male kickboxing athletes voluntarily participated in this study. The descriptive data for the mean baseline participant characteristics are presented in Table 1. The eligibility criteria for participation included at least 5 years of kickboxing experience, having a medal at least one international competition during the last year, and cutting weight for the upcoming competition at the time of the study. Written informed consent was

**Fig. 1** Study design**Table 1** Descriptive data of the participants' characteristics ($n = 10$)

Variable	Mean $\pm$ SD	95% CI
Age (years)	20.5 $\pm$ 2.8	18–24
Height (cm)	1.75 $\pm$ 0.05	1.66–1.83
Body weight (kg)	70.7 $\pm$ 11.1	54.0–90.3
Body fat percentage (%)	9.7 $\pm$ 4.5	5.0–18.7
Muscle mass (kg)	58.3 $\pm$ 6.6	46.6–68.4

obtained from each athlete before all measurements, and the study was conducted in accordance with the Declaration of Helsinki. The study was approved by the Kastamonu University Non-Interventional Clinical Trials Ethical Committee (2025-47).

Measurements

Acute weight changes

The participants' actual body weight was obtained using a calibrated digital scale in the morning, one week before (T1) and one day before (T2) the official weigh-in, at the official weigh-in, and on the competition day. The official weigh-in was held between 09:00 and 17:00, almost 24 h before the start of the event, and the participating athletes were weighed in the morning on the weigh-in day. All procedures were performed using the same weighing scale. Acute weight loss (AWL)/acute weight gain (AWG) and weight loss/gain percentages were calculated as follows [32]:

AWL = (body weight a week pre weigh-in) – (body weight at official weigh-in).

AWG = (body weight on the competition day) – (Body weight at official weigh-in)

$$\% \text{Weight loss} = \left(\frac{\text{Acute weight loss}}{\text{A week pre weight}} \right) \times 100$$

$$\rightarrow \% \text{Weight gain} = \left(\frac{\text{Acute weight gain}}{\text{official weight}} \right) \times 100$$

Body composition assessment

Body composition was assessed using a bioelectrical impedance (BIA) device (TANITA BC-545, Japan). Before the measurement, to ensure the reliability of segmental body composition data, athletes were instructed to abstain from engaging in any vigorous physical activity or exposure to heat (e.g., saunas, hot showers) for a minimum of 12 h prior to the assessment [33]. Participants were required to arrive at the laboratory in a post-absorptive state, having fasted for at least 4 h, and were instructed to void their bladders immediately before the measurement. Additionally, to account for orthostatic fluid redistribution, athletes were directed to remain in a standing position for 5 min prior to the test to ensure that the results were not influenced by transient changes in segmental impedance [34, 35]. All measurements were conducted with bare feet and hands, ensuring that electrode contact points were clean and devoid of excessive moisture or topical creams. The information about sex, height, and age was entered into the BIA device, and athlete mode was selected. BIA is an appropriate device for determining the body composition of people with different physical activity levels [34] and young adult participants [36]. The body fat percentage and muscle mass were recorded for each athlete.

Hydration status evaluation

A midstream urine sample was collected from each athlete immediately prior to any body weight measurements. To ensure accurate hydration assessments and minimize confounding variables, athletes were instructed to avoid consuming vitamin B-complex supplements, ergogenic aids with artificial colorants, and pigment-rich foods (e.g., beets, blackberries) for 24 h before testing. Additionally, participants were prohibited from consuming alcohol or caffeine-containing beverages during this period, as these substances have diuretic effects that could artificially alter USG readings. To prevent the effects of acute hyperhydration on urine transparency, athletes were also restricted from 'bolus' fluid intake in the 60 min immediately preceding the assessment, ensuring that urine was

not affected by transient fluctuations in renal output. The samples were placed in plastic cups, and USG was determined using a digital refractometer (ATAGO PAL-10 S, Japan), while urine color was classified according to a urine color chart for athletes, which has been shown to be a valid method to monitor hydration status [37]. The urine samples were immediately analyzed for USG and UC and then immediately disposed of. USG was classified as hypohydrated ($USG \geq 1.020$) according to recommendations from the ACSM position stand [38].

Statistical analysis

Data were analyzed using JASP software (Version 0.19.3.0). Normality was assessed by examining the Shapiro–Wilk test results and evaluating skewness and kurtosis values, with thresholds of ± 2 being considered acceptable. Descriptive statistics were presented as means, standard deviations, and 95% confidence intervals. A one-way analysis of variance with repeated measurements was used to determine the differences in body weight, USG, and urine color at different measurement times. A Holm post-hoc test was used when a significant effect was found in the analysis of variance. In case of violation of sphericity the correction of Greenhouse-Geisser was used. Eta square (η^2) was calculated to determine the effect size (ES), using 0.0099, 0.0588, and 0.1379 as small, medium, and large effect sizes, respectively [39]. Cohen's d was calculated to determine ES for pairwise

comparisons and classified as small (0.2), medium (0.5) and large (≥ 0.8). Statistical significance was set at $p < 0.05$.

Results

One-way repeated-measures ANOVA showed a significant main effect of time on body weight ($F(1.55,13.91)=24.22$, $p<0.001$, $\eta^2=0.73$, ES=Large). Athletes significantly lost weight from one week before the competition to one day before the official weigh-in ($p=0.020$, Cohen's $d=0.21$, ES= Small), and from one week before the competition to official weigh-in day ($p=0.001$, Cohen's $d=0.29$, ES=Small). They also significantly gained weight from the official weight to before the start of the competitions ($p<0.001$, Cohen's $d=-0.31$, ES=Small). Figure 2 shows the changes in athletes' body weight. Athletes lost 2.2 ± 2.0 kg from a week before the competition to one day before the official weigh-in and 3.1 ± 1.7 kg from a week before the competition to the official weigh-in. Athletes lost 3.1 ± 1.7 kg (4.2%) in the week before the competition and gained 3.3 ± 1.4 kg (4.8%) from the official weigh-in to the start of the competition.

Athletes' UC values differed significantly at different measurement points ($F(3,27)=10.86$, $p<0.001$, $\eta^2=0.55$, ES=Large). Athletes' UC values increased significantly from one week before the competition to official weigh-in day ($p=0.003$, Cohen's $d=-2.19$, ES=Large), from one

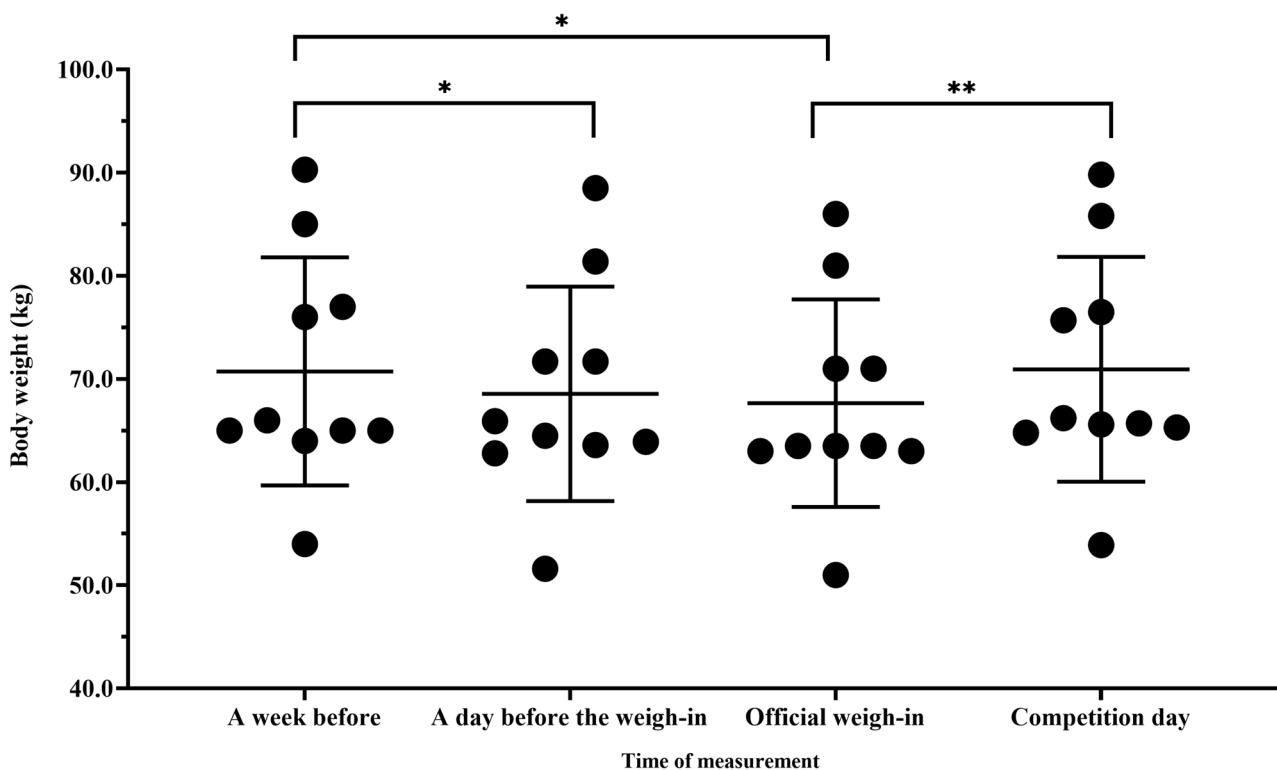


Fig. 2 Body weight change of the athletes across measurement times; * $p < 0.05$, ** $p < 0.001$

Table 2 Athletes UC and USG changes across different measurement points ($N=10$)

Variables	Mean $\pm$ SD	95% CI
UC _{T1}	4.1 $\pm$ 1.7	2.9–5.3
UC _{T2}	5.7 $\pm$ 1.6	1.6–6.8
UC _{T3}	7.3 $\pm$ 1.3 ^{a, b, c}	6.4–8.2
UC _{T4}	5.8 $\pm$ 1.3	4.9–6.7
USG _{T1}	1.021 $\pm$ 0.005	1.018–1.024
USG _{T2}	1.026 $\pm$ 0.006	1.021–1.030
USG _{T3}	1.030 $\pm$ 0.006 ^{a, c}	1.025–1.034
USG _{T4}	1.026 $\pm$ 0.004	1.023–1.029

^aDenotes a significant difference from T1 (one week before competition) ($p < 0.05$); ^b denotes a significant difference from T2 (one day before official weigh-in) ($p < 0.05$); ^cdenotes a significant difference from T4 (before the start of competitions) ($p < 0.05$)

day before the official weigh-in to the official weigh-in ($p = 0.008$, Cohen's $d = -1.10$, $ES = \text{Large}$) and significantly decreased from the official weigh-in to before the start of the competitions ($p = 0.004$, Cohen's $d = 1.03$, $ES = \text{Large}$). The athletes' UC values are presented in Table 2.

There was a significant main effect of time on the USG values ($F(3,27) = 9.64$, $p < 0.001$, $\eta^2 = 0.52$, $ES = \text{Large}$). Athletes' USG values increased significantly from one week before the competition to official weigh-in day ($p = 0.012$, Cohen's $d = -1.61$, $ES = \text{Large}$), and decreased significantly from the official weigh-in day to the start of the competition ($p = 0.012$, Cohen's $d = 0.71$, $ES = \text{Medium}$). The changes in the USG values are presented in Table 2.

Half of the athletes were classified as hydrated, while the rest were classified as hypohydrated one week before the competition. Seven athletes were classified as hypohydrated one day before the official weigh-in, while nine were hypohydrated at the official weigh-in. Moreover, all athletes were classified hypohydrated on the competition day.

Discussion

This study aimed to monitor the acute changes in body weight and hydration status of elite kickboxers during a real competitive environment. The main findings of the study were as follows: (a) Athletes underwent a significant weight reduction phase, losing an average of 3.1 ± 1.7 kg (4.2%) from one week prior to the official weigh-in. This was followed by a rapid weight regain of 3.3 ± 1.4 kg (4.8%) between the weigh-in and the start of the competition; (b) concomitant with weight loss, hydration markers significantly worsened; USG and UC values peaked at the official weigh-in (T3), indicating peak dehydration levels; and (c) A critical finding is the high prevalence of hypohydration throughout the study. While 50% of athletes were hypohydrated a week before the event, this figure escalated to 90% by the official weigh-in. Notably, despite the substantial weight regain (4.8%) prior to the start of the competition, 90% of the athletes remained

hypohydrated on competition day. This suggests that the recovery period was characterized by weight gain rather than true rehydration.

Previous research indicates that 68–100% of kickboxing athletes practice RWL prior to competitions [40, 41]. It has been reported that RWL typically begins 7–15 days before the competition, and athletes lose 2–8% of their body weight [40]. Furthermore, weight loss usually intensifies during the final days of RWL [42]. When the literature is examined, a study on amateur boxers reported that when athletes were asked to be at their competition weight in a week, they lost 5.16% of their weight [43]. In the current study, it was determined that elite kickboxers lost 2.2 ± 2.0 kg from 1 week before the competition until 1 day before the official weigh-in, and 3.1 ± 1.7 kg (4.2%) by the day of the official weigh-in. Additionally, in a survey study of elite kickboxers, the athletes reported losing $3.5 \text{ kg} \pm 1.5$ (~ 4.9%) before the competition [40]. These results are consistent with the 2–5% body weight loss data specified in the literature, stating kickboxing and boxing athletes are thought to have similar RWL habits before competitions.

Combat athletes aim to approach their actual weight by replacing fluid and energy deficits through rapid weight gain (RWG) following pre-competition RWL [21, 44]. Matthews and Nicholas [45] suggested that adult MMA athletes lost 5.6 ± 1.4 kg (~ 8%) in one week before the competition. They also gained 7.4 ± 2.8 kg (~ 11.7%) from the official weigh-in until the match. This exceptional finding may be related to the wide recovery interval of 24–36 h (32 h in the mentioned study) available to MMA athletes between the official weigh-in and the competition.

In a study where hydration status and RWG were compared between judo athletes and wrestlers, Ceylan et al. [10] reported that judo athletes regained 2.3 ± 1.3 kg (~ 3.3%), while wrestlers regained 0.5 ± 0.7 kg (~ 0.7%) in the process from the official weigh-in to the competition (15 h for judo athletes and 2 h for wrestlers). Reale et al. [46] stated that judo athletes regained 1.7 ± 1.3 kg (~ 2.6%) during a 15–20 h recovery phase before competition. In another study, it was reported that within a 24-hour period, young female wrestlers underwent 2.7 ± 1.4 kg (~ 6.3%) RWG, and male wrestlers gained 1.5 ± 0.9 kg (~ 3.1%) [47]. Young male and female taekwondo athletes achieved 1 kg (~ 1.6%) and 1.2 kg (~ 2.2%) RWG during a 16–20 h recovery period [48]. In a different study on wrestlers, it was determined that wrestling athletes regained a weight of 1.6 ± 1.6 kg (~ 2.3%) within 16 h [49]. Based on these studies, it can be inferred that RWG magnitude tends to increase with longer recovery periods; however, this phenomenon may vary by sports and age group. In the current study, the findings showed higher RWG values (3.3 ± 1.4 kg (~ 4.8%)) than those

with similar recovery times in the studies that mentioned above. These data indicate that kickboxing athletes can reach their habitual body weight during the recovery period. Conversely, when urine parameters (USG and UC) in the current study were examined, they showed that RWG did not provide rehydration. This increase likely stemmed from an increase in gastrointestinal content and replenishment of glycogen deficits, rather than just rehydration [50, 51]. Therefore, AWG during recovery may not indicate rehydration. Furthermore, at the commencement of the study, half of the athletes were already experiencing hypohydration. This suggests a habitual state of hypohydration among athletes, which warrants further investigation in future studies, particularly when athletes are not subject to weight loss requirements.

Combat athletes resort to methods that restrict fluid intake or trigger fluid loss during RWL [6, 20, 21, 40]. This process triggers pre-competition hypohydration [6, 9, 28]. In line with the values of USG and UC (Table 2), which are reliable and practical methods for pre-competition hydration assessment [52], the hydration level of our participants worsened severely during the week preceding the competition. The literature indicates that combat athletes are usually in a state of hypohydration before competitions [8, 11, 12]. Furthermore, it has been suggested that hypohydration is prevalent among athletes regardless of the official weigh-in time (morning of the competition or one day before) [10, 29].

Despite the tendency of combat athletes to replace the body weight loss through RWG [21, 44], it has been observed that they generally fail to achieve rehydration before the competition [6, 9, 29, 53]. In the current study, kickboxing athletes replaced their habitual body weight during recovery after the official weigh-in (RWL rate: 4.2% vs. RWG: 4.8%), but the athletes were unable to achieve rehydration. Additionally, almost all participants were in a state of hypohydration before the official weigh-in and competition. In a study conducted on MMA athletes, it was determined that after a recovery period of approximately 22 h, the number of athletes who could achieve sufficient rehydration before the competition was quite limited, despite a 4.4% RWG [12]. Ceylan et al. [6] reported that judo athletes underwent 6.8% RWL within the week before the competition, and 3 out of 8 athletes were still in a state of hypohydration 24 h after the official weigh-in despite 4.2% RWG. In another study on judokas, it was suggested that male and female athletes gained 1.8% and 3.0% during the recovery following the official weigh-in, but all athletes were still in a state of hypohydration [9]. In a study on Brazilian jiu-jitsu athletes, it was stated that although the athletes regained weight a day after the competition compared to 10 days before the competition, 88.2% of the athletes were in a

state of hypohydration [53]. *Ad libitum* fluid consumption was stated to be insufficient for rehydration during the recovery period before competition [6, 9, 29]. In line with these results, it is understood that simply replacing the body weight deficit through RWG does not mean that rehydration has occurred in combat athletes.

During the official weigh-in (T3), athletes exhibited critical levels of hypohydration, with a mean USG of 1.030 ± 0.006 . This peak values represent a significant increase from baseline levels recorded one week prior (1.021 ± 0.005 ; $p = 0.012$). Notably, the mean value of 1.030 indicates that a substantial portion of the cohort exceeded the clinical threshold for severe hypohydration [54], a condition that poses serious risks to athlete safety, including impaired thermoregulation [55], increased cardiovascular strain [13], and potential acute kidney injury [56]. These physiological stressors are further evidenced by the simultaneous peak in UC at T3 (7.3 ± 1.3), which showed a significant elevation compared to both one week (4.1 ± 1.7) and one day (5.7 ± 1.6) before the weigh-in. Although USG values significantly decreased by the start of the competition (T4) to 1.026 ± 0.004 ($p = 0.012$), athletes remained in a state of significant fluid deficit. Entering high-intensity combat without achieving euhydration (USG < 1.020) could limit the protective capacity of cerebrospinal fluid and increases the risk of heat-related illness [57], suggesting that current weight management practices may compromise the long-term health of the participants.

This study has some limitations. One of our limitations is that the weight loss methods athletes used during RWL were not followed via a survey or observation. Additionally, the nutritional attitudes of athletes during RWL and RWG were not monitored. Due to competition conditions, the amount of food or fluid consumed by the athletes during the weight loss and weight gain periods could not be recorded; therefore, the absence of dietary and fluid intake tracking limits our ability to determine why athletes failed to rehydrate despite weight regain. Another limitation is that the sample size consisted of a small number of participants. However, following hydration and weight changes at four different times during the competition is important for providing direct data regarding the weight management of kickboxing athletes before the competition given that the participants were elite athletes. Therefore, findings may not be generalized to female kickboxers or lower competitive levels, and the findings of the current study should be validated with larger samples and female athletes in different weight categories. Invasive measurement methods could not be used due to the pre-competition process. However, non-invasive measurement methods, such as USG and UC, are considered reliable for pre-competition hydration assessment [52]. The most accurate result for hydration

assessment using USG is the first morning urine sample [54]. However, in our current study, the fact that all four measurements were made at approximately the same hour is thought to provide consistent and accurate results for comparison.

Conclusion

The results of this study showed that kickboxing athletes were exposed to a significant level of RWL in the last week before the competition and increased their body weight above the starting level during the recovery process. However, rehydration could not be achieved. In this regard, it should be known by athletes and their coaches that replacing the weight deficit during the recovery period does not mean that rehydration is complete. It is recommended that a good, especially personalized, rehydration plan be implemented for athletes during the recovery process after the official weigh-in. Additionally, long-term and controlled weight management should be prioritized, and recovery period should be based on real-world solutions supported by professionals to help athletes rehydrate and get enough nutrition before competitions. Future studies should monitor the nutrition and fluid consumption habits of kickboxers before the competition and during the recovery process, investigate the individualized fluid amounts that provide rehydration during recovery, and include larger samples from different weight categories.

Authors' contributions

BC contributed to the conception and design of the work; BC and HBT collected the data; BC, HBT, US, HAP and TNS contributed to the acquisition, analysis, and interpretation of data; BC, HBT and US prepared the manuscript; BC, HBT, US, HAP and TNS substantively revised the manuscript.

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Data availability

The data will be provided upon request by the corresponding author.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Kastamonu University Non-Interventional Clinical Trials Ethical Committee (2025-47) and written informed consent was obtained from each participant before the commencement of the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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