ORIGINAL ARTICLE

Reactance as a possible predictor of better rehydration strategy of combat sport athletes

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ABSTRACT

Rapid weight loss is a widespread practice in combat sports, intended to meet weight-class requirements while preserving an anatomical advantage. These strategies primarily reduce extracellular and intracellular fluid volumes by manipulating carbohydrate, sodium, and water intake, followed by rapid weight gain after the official weigh-in. This study analysed the association between raw bioelectrical impedance variables measured immediately after weigh-in and competitive outcome in amateur combat athletes. A cross-sectional analytical design was conducted with 54 athletes from boxing, Mixed Martial Arts, and Muay Thai. Measurements of resistance (R), reactance (Xc), and phase angle (PhA) were obtained under standardized conditions using a tetrapolar device. Descriptive statistics characterized the sample, and logistic regression evaluated predictors of winning or losing. Mean values for R/H (height), Xc/H, PhA/H, and Z/H reflected a dehydrated profile consistent with recent weight cutting. Only Xc/H met the regression model's entry criteria. Higher Xc/H values were associated with lower odds of winning (OR = 0.857), suggesting that athletes with lower post-weigh-in reactance/height — potentially reflecting more effective rehydration and extracellular volume restoration — were more likely to achieve victory. These findings highlight the physiological relevance of bioelectrical markers for assessing recovery and their promise as indicators of competitive readiness in combat sports.
Keywords: Sport medicine, Bioelectrical impedance analysis, Reactance-to-height ratio, Phase angle, Combat sports, Athlete monitoring.

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INTRODUCTION

Combat sports are defined as disciplines in which the competitive objective is to overcome an opponent through striking, takedowns, holds, chokes, or joint locks. Given that performance in these sports is inherently linked to one athlete exerting physical dominance over another. That force equals mass multiplied by acceleration. Weight-class systems were developed to promote fairness in competition. These systems require athletes to meet a particular yet physiologically atypical condition: presenting an exact body mass at the official weigh-in (Mohamad et al., 2016).

Although initially designed to safeguard athlete welfare and competitive equity, weight-class regulations have historically motivated many athletes to seek ways to retain anatomical advantages such as greater size or mass relative to their opponents. This has led to the widespread practice known as rapid weight loss (RWL), commonly referred to as "*weight cutting*." RWL strategies involve the accelerated reduction of total body mass, typically within less than two weeks, followed by an equally rapid regain of body weight (rapid weight gain, RWG). Over time, these practices have become deeply embedded in the culture and competitive logic of combat sports (Wilbraham et al., 2024).

Most RWL methods converge on a central physiological aim: reducing total body water by manipulating intramuscular, extracellular, and fundamental physiological fluid compartments (Ricci et al., 2025). Carbohydrate restriction is among the most widely employed strategies, given that glycogen storage in skeletal muscle and the liver contains a substantial water component; approximately 3 grams of water are required for each gram of glycogen stored. Consequently, reducing carbohydrate intake can yield a meaningful decrease in body mass (Melkonian et al., 2022; Mendes-Netto et al., 2023). Nevertheless, misinformation disseminated online has led some athletes to adopt this strategy too early or for unnecessarily long periods. Although a daily intake of nearly 50 g over three days can almost deplete glycogen stores, extended periods of low-carbohydrate availability may increase protein catabolism and contribute to bone demineralization (Greene et al., 2018; Margolis & Pasiakos, 2023; Mountjoy et al., 2023).

Historically, fighters also commonly reduced fluid intake as early as one month before competition. However, current evidence supports a different approach to fluid manipulation. Contemporary protocols typically involve markedly increasing fluid intake in the days leading up to weigh-in, sometimes reaching 80–100 ml/kg, followed by a controlled reduction to approximately 30 ml/kg. This approach promotes a transient rise in urine output while maintaining adequate electrolyte balance, thereby facilitating acute weight reduction without the pronounced risks of prolonged dehydration (Ceylan et al., 2022; Reale et al., 2018).

Sodium, a key electrolyte in sport physiology, plays essential roles in fluid regulation, muscle contraction, and carbohydrate metabolism, and is therefore abundant in plasma (Barley & Harms, 2025; McCubbin, 2022). Its relevance to RWL stems from its direct influence on water retention: reducing sodium intake to below 500 mg per day in the three days preceding weigh-in can increase total body water loss. However, when sodium restriction is combined with increased fluid intake, the risk of exercise-associated hyponatremia becomes salient. This condition can lead to severe, potentially life-threatening consequences, underscoring the need for systematic monitoring of sodium concentration during RWL interventions (Stachenfeld, 2008). Therefore, the present study aimed to identify which factors were associated with the competitive outcome (win/loss) using binary logistic regression with stepwise selection.

MATERIALS AND METHODS

Study design

A cross-sectional observational analytical study was conducted to evaluate the association between raw bioimpedance variables (resistance, reactance, and phase angle) after official weigh-in and competitive outcome (win/loss) in amateur combat athletes. Measurements were recorded at a single point in time, according to a protocol established before the fight.

Participants

The sample comprised 54 athletes from various combat sports (boxing, MMA, and Muay Thai) who participated in a competitive event. The subjects were aged 12-39 years and underwent weight cutting before the official weigh-in.

The inclusion criteria were: (a) voluntarily agreeing to participate, signing an informed consent form, and, in the case of minors, obtaining consent from the responsible guardian; (b) not having any injuries or medical conditions that would prevent bioimpedance measurement; (c) completing the official weigh-in. Athletes who did not complete the rest period before measurement or who had electrical implants were excluded.

Procedure

Upon arrival at the weight-in location, each athlete completed the official weight category verification procedure. Once the weigh-in was complete, they proceeded to the assessment area, where they were weighed again for internal control and measured in accordance with the ISAK protocol. They were then instructed to lie supine on a stretcher.

Participants remained at complete rest for 10 minutes, without speaking or moving, to allow body fluids to stabilize and reduce variability induced by exercise or the stress of weighing.

After the rest period, electrical bioimpedance was measured using an AKERN BIA 101 PRO, a tetrapolar alternating-current device. Following international recommendations for full-body BIA, electrodes were placed at standard anatomical hand-foot sites: distal electrodes on the dorsal surfaces of the hand and foot, and proximal electrodes at the wrist and ankle, with inter-electrode distances respected and adequate skin contact ensured.

During measurement, the athlete was instructed to remain completely still and silent, with limbs slightly apart, to avoid any muscle tension that could interfere with the impedance values.

The equipment recorded the raw variables: resistance (R), reactance (Xc), and phase angle (PhA). Once the recording was complete, the electrodes were carefully removed, the athletes were thanked for their participation, and the athlete continued their pre-fight recovery routine.

Data analysis

A general description of the athletes' characteristics was provided, including anthropometric, bioelectrical, and water-composition variables. These are summarized using means, standard deviations, ranges, and, for competitive results and sports modality, frequencies and percentages.

To explore factors associated with winning or losing the match, a binary logistic regression was performed. Before adjusting the model, each predictor was evaluated individually using the score test. The model was estimated using a stepwise procedure. Its contribution was verified using the omnibus test, pseudo-R^2 values, and the Hosmer–Lemeshow test, as well as through the percentage of correctly classified cases. In addition, its coefficient, significance level, odds ratio, and confidence interval were reviewed.

Ethical considerations

This study was conducted in accordance with the Declaration of Helsinki and Resolution 8430 of 1993 of the Colombian Ministry of Health for research involving human subjects. In addition, it was previously approved by the ethics committee in October 2025, as recorded in institutional paper No. 320.02-07-2025. Each participant voluntarily provided their written informed consent before participating.

RESULTS

Participants had a mean age of 21.38 ± 6.09 years, ranging from 12.6 to 39.3 years. Combat time averaged 9.93 ± 2.59 minutes, ranging from 1.75 to 11 minutes. Height averaged 168.98 ± 7.54 cm, with values ranging from 152 to 190 cm.

In bioelectrical measurements, the resistance/height (R/H) ratio had a mean value of 294.45 ± 43.17 ohm/m, with a range of 195.73 to 467.21 ohm/m. Reactance/height (XC/H) recorded an average of 33.88 ± 4.22 ohms/m, with values ranging from 22.11 to 47.40 ohms/m. Phase/height (PhA/H) averaged 6.62 ± 0.46 degrees/m, with a range of 5.6 to 7.8 degrees/m. Standardized impedance (Z/H) averaged 294.10 ± 40.39 ohms/m, with values ranging from 196.90 to 469.60 ohms/m.

Regarding water compartments, total body water (TBW) averaged 42.51 ± 5.15 litres, ranging from 32.6 to 55.9 litres. Intracellular water (ICW) averaged 25.23 ± 3.15 litres, with a range of 19.3-32.9 litres. Extracellular water (ECW) averaged 17.31 ± 1.95 litres, with values between 13.3 and 23.0 litres.

In the analysis of the XC/H variable by match outcome, the losing group recorded an average of 34.93 ± 4.00 ohm/m, with a 95% confidence interval of 33.54-36.33 ohm/m. In the group that won, the mean was 32.59 ± 4.00 ohm/m, with a 95% confidence interval of 30.72-34.46 ohm/m. (Figure 1)

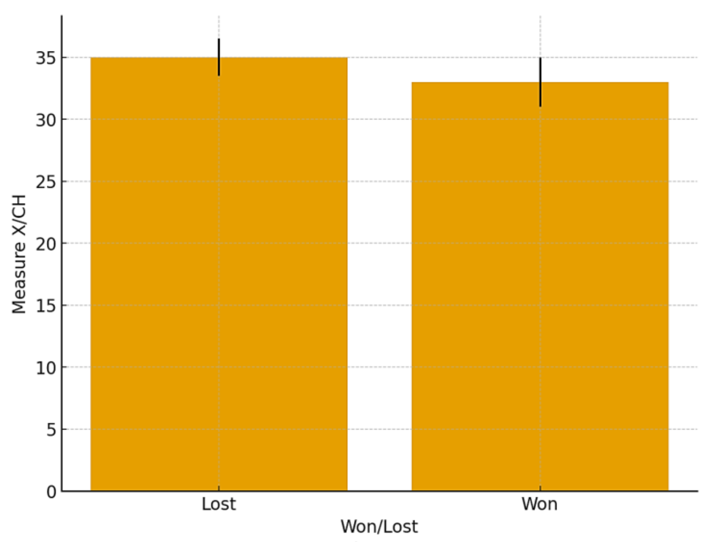


Figure 1. Comparison of XC/H Values by Match Outcome (Xc/H = reactance/height).

In terms of competitive outcomes, 53.7% of athletes lost (n = 29), whereas 46.3% won (n = 25). Regarding the sport, 35.2% were boxers (n = 19), 24.1% MMA fighters (n = 13), and 40.7% Muay Thai fighters (n = 22). (Figure 2)

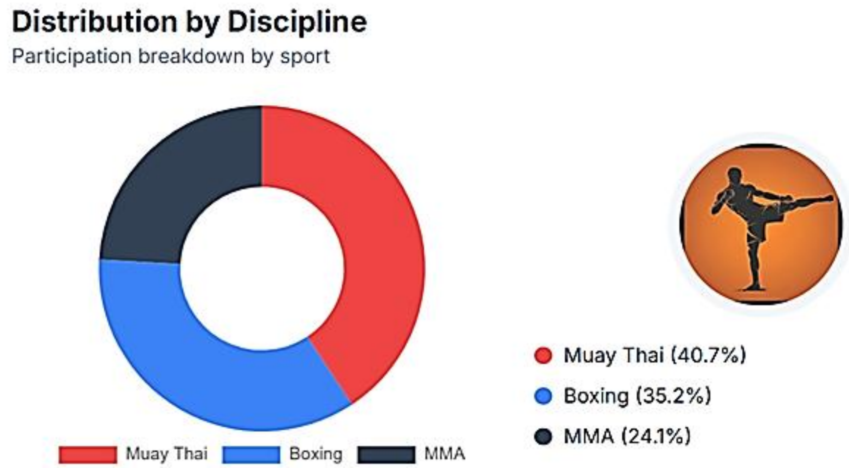


Figure 2. Distribution by Discipline. Participation breakdown by sport (MMA = Mixed Martial Arts).

When initially examining individual associations using the scoring test, most predictors did not show sufficient statistical evidence to be included in the model. However, two variables, height and the reactance-to-height ratio (XC/H), showed significant effects and were therefore considered for selection.

After applying the stepwise procedure, only XC/H was retained in the final equation. The inclusion of this predictor significantly improved model fit, as indicated by the omnibus test (χ^2 = 4.535, df = 1, *p* = .033). The pseudo R^2 showed values of .081 for Cox and Snell and .108 for Nagelkerke. The Hosmer–Lemeshow test indicated an adequate fit between predicted and observed values (χ^2 = 12.759; df = 8; *p* = .120), supporting the model's consistency.

In terms of discrimination capacity, the model correctly classified 66.7% of cases, with a 72.4% accuracy rate for athletes who lost and 60.0% for those who won. The variable retained in the model was XC/H, which showed a negative coefficient (B = –0.155) and a p-value at the threshold of statistical significance (*p* = .053). Its odds ratio (Exp(B) = 0.857) indicates that, for each additional unit in this relationship, the odds of winning decrease by approximately 14.3%. The 95% confidence interval (0.732–1.002) mainly remained below the null value, suggesting a relatively consistent inverse effect, though it was close to the significance threshold. The exclusion test confirmed that removing this predictor would significantly impair model fit (χ^2 = 4.535, *p* = .033), underscoring its contribution to the final equation.

DISCUSSION

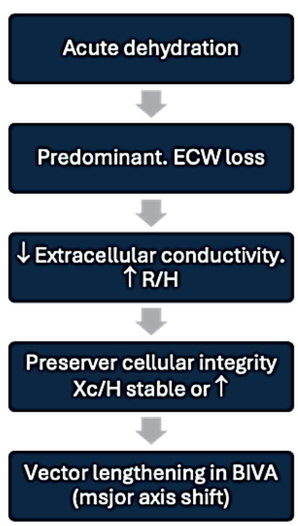
The main findings of this study indicate that each 1 Ω/m increase in Xc/H before the fight was associated with a +/-14% decrease in the probability of victory. In contrast, a relatively low Xc/H in the post-weigh-in period is associated with a higher likelihood of winning. This pattern appears to contradict the traditional view that high values of Xc/H and phase angle (PhA) indicate greater cell mass and better muscle quality (Ward & Brantlov, 2023); however, the acute response of reactance to changes in hydration accounts for this pattern in Xc/H.

Physiology of weight cutting

Strategies such as gradually reducing sodium intake affect rehydration physiology in these athletes, potentially leading to a decrease in Xc (Malbarin, et al., 2024). The absence of glycolytic reserves and reduced plasma sodium levels create a gradient that slows fluid entry into the cell, even when the athlete is consuming fluids, given the possible increase in serum potassium levels during the cutting process (Brinkman et al., 2023; Ly et al., 2023).

In weight-cutting among combat athletes, acute fluid loss occurs predominantly from the extracellular water (ECW) compartment, primarily when dehydration is induced by exercise in a hot environment or by fluid and sodium restriction. This pattern extends the Bioimpedance vector analysis on the BIVA graph, as reflected by significant increases in R/H and Xc/H, and its magnitude is proportional to the degree of total water loss. In experimental studies in men subjected to exercise in heat, dehydration produced a shift of the vector along the central axis, without a reduction in Xc/H, indicating that membrane capacitance is preserved despite the volumetric decrease in ECW (Gatterer et al., 2014; Galloway & Maughan, 2000). On the other hand, although it is recognized that glycogen depletion can contribute to changes in intracellular water (ICW), Shiose et al. (2018) demonstrated that, under controlled conditions, a marked reduction in muscle glycogen (≈60% decrease) does not alter the segmental ECW/ICW distribution according to BIS, suggesting that most of the vector displacement observed after acute cutting responds mainly to changes in the extracellular compartment and not to direct changes in glycogen-bound water (Shiose et al., 2000).

Recent evidence supports this interpretation from a physiological and biophysical multicompartmental approach, highlighting that ECW is the primary determinant of conductivity due to its high electrolyte concentration. At the same time, capacitance is primarily associated with cell membrane integrity and body cell mass (BCM) volume. In conditions of acute dehydration, a reduction in ECW decreases conductivity and increases R/H, whereas the preservation of cell membranes and ICW maintains or slightly increases Xc/H (Rosa et al., 2025). The article by Rosa et al. (2025) emphasizes that acute variations in PhA and raw BIA parameters should be interpreted with respect to the differential dynamics of compartments, rather than solely in terms of total body water volume. Thus, the findings reinforce that the vectorial elongation characteristic of weight loss primarily reflects contraction of the extracellular space, with maintenance of cellular integrity, rather than a significant loss of intracellular volume. (Figure 3)



Note. ECW = Extracellular Water; R/H = resistance/height; Xc/H = reactance/height; BIVA = Bioelectrical impedance vector analysis.

Figure 3. Fluid dynamics in weight cutting.

Rehydration and glycogen replenishment after weighing

Immediate rehydration expands extracellular volume (ECV), which increases conductivity and reduces resistance; at the same time, dilution of the extracellular space decreases membrane density per unit volume and reduces reactance (Xc/H); in a second phase lasting 24 to 48 hours, glycogen synthesis and the re-entry of potassium into the cell draw water into the intracellular compartment (ICW), gradually restoring cell mass and reactance (Carrasco-Marginet et al., 2017). Glycogen replenishment can cause increases of 1 to 2 kg in body weight in a matter of hours, because each gram of glycogen stores several grams of water (Murray & Rosenbloom 2018; Dynka et al., 2025). These fluctuations explain the increases of up to 10% in weight observed between weigh-in and competition in mixed martial arts fighters (Burke et al., 2017; Bagot et al., 2024).

Bioelectrical interpretation of resistance and reactance

In combat sports, the interpretation of the BIVA allows for sensitive monitoring of variations in hydration status and cell mass associated with processes such as weight cutting and rehydration. Resistance (R) is inversely related to total body water (TBW) content, so increases in R reflect reductions in body fluids and are valuable indicators of dehydration after weighing. Reactance (Xc), on the other hand, expresses the capacitive properties of cell membranes and is linked to cell mass content and the ICW/ECW ratio; lower Xc values may suggest reduced cell integrity and functionality. Among karate practitioners evaluated under euhydrated conditions, Rossi (2021) observed significant sex differences in R and Xc, highlighting their sensitivity to relevant physiological variations. Therefore, in contexts where body weight is acutely manipulated, the upward and rightward shift of the bioelectrical vector indicates water loss and possible alteration in muscle hydration, making it a key parameter for guiding nutritional and recovery decisions (Rossi, 2021).

R represents opposition to current flow through body fluids (especially ECW) and decreases as the volume of water and electrolytes increases. Xc expresses the capacity of cell membranes and dielectric structures to store charge, increases with the integrity and quantity of membranes, and decreases when extracellular water predominates. The length of the impedance vector in the RXc graph is a continuous indicator of hydration: short vectors (lower R/H) correspond to water overload, while long vectors (higher R/H) reflect dehydration. Lateral shifts (influenced mainly by Xc/H) indicate changes in the dielectric mass of tissues, i.e., in the quantity or quality of cell membranes (Carrasco-Marginet et al., 2017). After a session of exercise with dehydration, the vector lengthens and shifts upward and to the right, whereas after rehydration it shortens and shifts downward and to the left (Gatterer et al., 2014).

At rest and over the long term, higher Xc/H and a larger phase angle are typically associated with greater cell mass and better muscle quality (Carrasco-Marginet et al., 2017). Still, it should be noted that following rehydration, the expansion of the extracellular space reduces Xc/H because there is more water outside the cell and a lower membrane density per unit volume. Therefore, a short vector with lower Xc/H may reflect adequate rehydration rather than a decrease in cell mass. Studies involving exercise in heat show that changes in Xc/H are inversely correlated with variations in plasma osmolarity, suggesting water shifts between the intracellular and extracellular compartments (Gatterer et al., 2014). It is also essential to consider that classic BIVA assumes the body is a uniform cylinder and does not account for segmental geometry; therefore, heavier fighters or those with wider limbs may have lower Xc/H without this indicating poorer cellular condition—methods such as specific BIVA correct for this limitation.

The physiological changes described above help explain why a lower Xc/H before combat was associated with a higher probability of victory in our sample. Fighters who rehydrated and reloaded glycogen more effectively increased their extracellular and total volumes; this results in shorter vectors and lower reactance due to membrane dilution (Gatterer et al., 2014; Carrasco-Marginet et al., 2017). In turn, glycogen replenishment brings water into the intracellular compartment, but this process takes several hours. When the measurement is taken 1 to 3 hours before the fight, extracellular expansion is likely to predominate, which is why the winners showed lower Xc/H without negatively affecting their cell mass. This hypothesis is consistent with the findings of Gatterer et al., who observed that, after exercise and subsequent rehydration, the impedance vector shortens, and that changes in Xc/H are inversely related to variations in plasma osmolarity. Another contributing factor may be the efficiency of weight cutting. Fighters who arrive at the weigh-in less dehydrated, or who have more time to rehydrate, may need to reduce glycogen loss less, which reduces intracellular water loss. The literature suggests that changes in Xc/H may reflect the relationship between intracellular and extracellular water loss (Gatterer et al., 2014). Thus, a high Xc/H could indicate that the athlete still has a high osmotic gradient and has not yet fully recovered intracellular water. This condition can decrease strength and endurance during combat.

CONCLUSIONS

From a physiological perspective, weight cutting causes depletion, particularly in the extracellular compartment, thereby lengthening the impedance vector and increasing reactance. Subsequent rehydration and carbohydrate replenishment, especially in the early hours, increase extracellular volume and reduce reactance through dilution. Fighters who achieved lower Xc/H after recovery were more likely to win, suggesting that adequate rehydration status before combat may provide a competitive advantage. However, due to methodological limitations and the exploratory nature of the data, this observation should be interpreted with caution and confirmed in future studies.

AUTHOR CONTRIBUTIONS

MSS & DFG: conceptualization and methodology. JGCh: methodology and formal analysis. MSS, DFG, JGCh & ICR-P: data curation, writing – original draft, preparation, visualization, writing – review and editing. All authors have read and agreed to the final version of the manuscript.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Barley, O. R., & Harms, C. A. (2025). Rapid weight loss across combat sports and the relationships between methods and magnitude. In M. Hansen (Ed.), Translational Sports Medicine, 2025(1), 2946317. https://doi.org/10.1155/tsm2/2946317

Bagot, S., Pélissier, L., Pereira, B., Chanséaume Bussiere, E., Duclos, M., Dulloo, A., et al. (2024). Weight regain, body composition, and metabolic responses to weight loss in weight cycling athletes: A systematic review and meta-analyses. Obesity Reviews, 25(2), e13658. https://doi.org/10.1111/obr.13658

Brinkman, J. E., Dorius, B., & Sharma, S. (2023). Physiology, body fluids. StatPearls Publishing.

Burke, L. M., Van Loon, L. J. C., & Hawley, J. A. (2017). Postexercise muscle glycogen resynthesis in humans. Journal of Applied Physiology, 122(5), 1055-1067. https://doi.org/10.1152/japplphysiol.00860.2016

Ceylan, B., Kons, R. L., Detanico, D., & Šimenko, J. (2022). Acute dehydration impairs performance and physiological responses in highly trained judo athletes. Biology, 11(6), 872. https://doi.org/10.3390/biology11060872

Dyńka, D., Rodzeń, Ł., Rodzeń, M., Pacholak-Klimas, A., Ede, G., Sethi, S., et al. (2025). Ketogenic diets for body weight loss: A comparison with other diets. Nutrients, 17(6), 965. https://doi.org/10.3390/nu17060965

Galloway, S. D. R., & Maughan, R. J. (2000). The effects of substrate and fluid provision on thermoregulatory and metabolic responses to prolonged exercise in a hot environment. Journal of Sports Sciences, 18(5), 339-351. https://doi.org/10.1080/026404100402403

Gatterer, H., Schenk, K., Laninschegg, L., Schlemmer, P., Lukaski, H., & Burtscher, M. (2014). Bioimpedance identifies body fluid loss after exercise in the heat: A pilot study with body cooling. PLoS ONE, 9(10), e109729. https://doi.org/10.1371/journal.pone.0109729

Greene, D. A., Varley, B. J., Hartwig, T. B., Chapman, P., & Rigney, M. (2018). A low-carbohydrate ketogenic diet reduces body mass without compromising performance in powerlifting and Olympic weightlifting athletes. Journal of Strength and Conditioning Research, 32(12), 3373-3382. https://doi.org/10.1519/JSC.0000000000002859

Ly, N. Q., Hamstra-Wright, K. L., & Horswill, C. A. (2023). Post-exercise rehydration in athletes: Effects of sodium and carbohydrate in commercial hydration beverages. Nutrients, 15(22), 4759. https://doi.org/10.3390/nu15224759

Malbarin, M., Wong, A., Nasa, P., & Gosh, S. (2024). Volume and distribution of water and its major solutes between plasma, the interstitium and intracellular fluid. In Rational use of intravenous fluids in critically ill patients (1ª ed.). Springer.

Margolis, L. M., & Pasiakos, S. M. (2023). Low carbohydrate availability impairs hypertrophy and anaerobic performance. Current Opinion in Clinical Nutrition and Metabolic Care, 26(4), 347-352. https://doi.org/10.1097/MCO.0000000000000920

Mendes-Netto, R. S., Matos, R. C., Maynard, D. da C., de Lima, L. E., Nardelli, C., Brito, C. J., et al. (2023). Acute carbohydrate restriction induces a higher weight loss and preserves the athletic performance of Brazilian jiu-jitsu athletes. Ido Movement for Culture. Journal of Martial Arts Anthropology, 23(2), 50-57.

McCubbin, A. J. (2022). Modelling sodium requirements of athletes across a variety of exercise scenarios: Identifying when to test and target, or season to taste. European Journal of Sport Science, 1-9. https://doi.org/10.1080/17461391.2022.2083526

Mohamad, N. I., Chinnasee, C., Hemapandha, W., Vongjaturapat, N., Makaje, N., Ratanarojanakool, P., et al. (2016). Sports science-based research on the sport of Muay Thai: A review of the literature. Walailak Journal of Science and Technology (WJST), 14(8), 615-625. Retrieved from [Accessed 2026, 11 March]: https://wjst.wu.ac.th/index.php/wjst/article/view/2243

Mountjoy, M., Ackerman, K. E., Bailey, D. M., Burke, L. M., Constantini, N., Hackney, A. C., et al. (2023). 2023 International Olympic Committee's (IOC) consensus statement on Relative Energy Deficiency in Sport (REDs). British Journal of Sports Medicine, 57(17), 1073-1097. https://doi.org/10.1136/bjsports-2023-106994

Reale, R., Slater, G., Cox, G. R., Dunican, I. C., & Burke, L. M. (2018). The effect of water loading on acute weight loss following fluid restriction in combat sports athletes. International Journal of Sport Nutrition and Exercise Metabolism, 28(6), 565-573. https://doi.org/10.1123/ijsnem.2017-0183

Ricci, A. A., Evans, C., Stull, C., Peacock, C. A., French, D. N., Stout, J. R., et al. (s.f.). International Society of Sports Nutrition position stand: Nutrition and weight cut strategies for mixed martial arts and other combat sports. Journal of the International Society of Sports Nutrition, 22(1), 2467909. https://doi.org/10.1080/15502783.2025.2467909
Rossi, L. (2021). Bioimpedance to assess the body composition of high-performance karate athletes: applications, advantages and perspectives. Journal of Electrical Bioimpedance, 12(1), 69-72. https://doi.org/10.2478/joeb-2021-0008
Rosa, G. B., Lukaski, H. C., & Sardinha, L. B. (2025). The science of bioelectrical impedance-derived phase angle: Insights from body composition in youth. Reviews in Endocrine and Metabolic Disorders, 26(4), 603-624. https://doi.org/10.1007/s11154-025-09964-7
Shiose, K., Yamada, Y., Motonaga, K., & Takahashi, H. (2018). Muscle glycogen depletion does not alter segmental extracellular and intracellular water distribution measured using bioimpedance spectroscopy. Journal of Applied Physiology, 124(6), 1420-1425. https://doi.org/10.1152/japplphysiol.00442.2017
Stachenfeld, N. S. (2008). Acute effects of sodium ingestion on thirst and cardiovascular function. Current Sports Medicine Reports, 7(Suppl. 1), S7-S13. https://doi.org/10.1249/JSR.0b013e31817f23fc
Ward, L. C., & Brantlov, S. (2023). Bioimpedance basics and phase angle fundamentals. Reviews in Endocrine and Metabolic Disorders, 24(3), 381-391. https://doi.org/10.1007/s11154-022-09780-3
Wilbraham, S. J., Elliott, D., & Miller, P. K. (2024). It's just how we do it: Social processes in rapid weight loss for combat sports. Health Psychology & Behavioral Medicine, 12(1), 2433517. https://doi.org/10.1080/21642850.2024.2433517