Habit or lack of education? Hypohydration is present in elite senior judo athletes even during a weight-stable training camp

Abstract

It has been well documented that high-level judo athletes presented a high level of hypohydration during weight-cutting and competition periods. However, there is a lack of studies investigating the hydration status of high-level judo athletes during a weight-stable training period. Therefore, this study aimed to investigate elite judo athletes' hydration status, body mass change, and fluid intake during a weight-stable training camp. Twenty-seven judo athletes (women n=8, men n=19, body weight=79.6±20.9 kg) from the senior national judo team voluntarily participated in this study. Data were collected in the morning after waking up and before and after the morning and evening training sessions. On the second day, the measurements were taken again in the morning after waking up. Urine-specific gravity (USG) was classified as hydrated (USG<1.020) and hypohydrated (USG ≥1.020). The athletes' USG values measured on two consecutive mornings increased (1.025±0.007 to 1.029±0.006) during 24h, in which athletes performed judo training in the morning and evening. Moreover, sex and weight category did not affect the changes in USG values (p>0.05). Most of the elite judo athletes presented hypohydration (92.6%). The relationship between the fluid intake of the athletes and the changes in USG and body weight values during 24 hours was not significant (p>0.05). The current study's findings revealed that high-level judo athletes present a high level of hypohydration even during a weight-stable training camp. Furthermore, the training sessions during the experiment period (24 h) worsened the hydration status of the senior athletes in all weight categories for both women and men.

Keywords: dehydration, combat sports, fluid intake, body weight

Introduction

Judo is an Olympic combat sport, and athletes compete according to weight categories in all age groups.[1] As in many other combat sports, judo athletes frequently resort to rapid weight loss within the week preceding the competition.[2-4] Moreover, the previous research makes it evident that athletes use hypohydration-induced methods to lose weight.[2, 5] The current literature supports these findings as judo athletes present a high level of hypohydration before, during, and following official judo competitions.[6-8] Moreover, even the increased 15 h of recovery provided by the International Judo Federation (IJF) under the current refereeing rules does not change this situation as it was reported that judo athletes presented a higher percentage of hypohydration despite a higher amount of rapid weight gain (RWG) in this time.[8]

Hypohydration has adverse effects on athletes' health and performance. For example, hypohydration has been associated with decreased plasma volume as well as adverse effects on cardiovascular functioning.[9] It also reduces muscle endurance, strength, and anaerobic power and capacity in the athletic population.[10] In addition, poor body water balance may result in decreased cognitive functioning, such as impaired decision-making time,[11] reduced levels of alertness,[12] and reduced psychomotor performance.[13] Similar effects of hypohydration on performance and its high prevalence (i.e., 84 %) have also been found in competitive combat sports athletes. [14]

Previous research investigated hydration status of judo athletes before, during, and after the official competitions and training from different age categories and competitive levels. [6-8, 15-17] Ceylan and Balci [7] investigated the effect of sex on short-term weight change and hydration status in judo athletes and stated that both sexes were hypohydrated (minimal [USG 1.010–1.020] to serious [USG > 1.030]) before official weigh-in and competition. In another study, Ceylan et al.[6] monitored hydration changes of elite judo athletes a week before the competition, official weigh-in, and 24 hours after competition via urine specific gravity (USG) and the urine colour. The authors stated that athletes presented a relatively higher level of hypohydration a week before the competition (USG=1.023±0.002) and at the official weigh-in (USG=1.030±0.001) compared to 24 h post-competition (USG=1.017±0.007). Thus, it can be stated that judo athletes from both sexes and different competitive levels present a high level of hypohydration during the competitive week. In the training conditions, young judo athletes (U-15) showed hypohydration in the morning, before, and after the training despite *ad libitum* water intake.[15] In another study, adolescent judo athletes started the training in a hypohydrated state (mid puberty athletes=1.029 ± 0.004; late puberty athletes= 1.024 ±0.005) and completed the training in even worse conditions. Afterwards, these athletes could not compensate for water deficit even 24 h following the training, with most of the athletes presenting significant hypohydration in a high-heat-stress environment (USG 1.021-1.030).[17] Stefanovsky et al.[16] monitored the hydration status of young judo athletes for four times during an off-season training camp and found that the hydration of young judo players was considered suboptimal, despite no weight reduction or control requirement with USG values of 1.024 on the first day, 1.026 on the third day, 1.020 on the fourth day and, 1.018 on the fifth day.

Previous studies highlighted that judo athletes are frequently exposed to hypohydration during competition and training parts of the season. However, previous research investigating hydration status during training focused only on young and inexperienced athletes.[15-17] Also, elite athletes are expected to maintain optimal hydration status for recovery,[18] especially when they are not obliged to control their body weight for a competition, unlike the studies mentioned above. Furthermore, suboptimal hydration status in athletes before, during, and after physical activity may hazard athletic performance. Suboptimal hydration may result in a decrease in performance and training productivity by leading to fatigue and exhaustion.[19, 20] Therefore, it is of great importance to monitor the hydration status of judo athletes during not only weight cutting period but also a weight-stable period to optimise their performance and protect their health. Nonetheless, there is a lack of studies investigating if elite senior judo athletes maintain optimal hydration status during a weight-stable period, which would provide an insight into the hydration adaptations of the elite-level judo athletes. Thus, this study aimed to monitor elite senior judo athletes' hydration status, body weight change, and fluid intake during a training camp where they were not obliged to lose or regulate their body weight. It was hypothesised that high-level athletes would present optimal hydration status as well as appropriate fluid intake.

Material and Method

Study design

This descriptive study aimed to demonstrate high-level judo athletes' hydration status, body weight changes, and fluid intake during a weight-stable international training camp. Athletes’ body weight and hydration status were measured during two consecutive days as follows: T1- the first morning following a day-off; T2- before the first training; T3- after the first training; T4- before the second training; T5- after the second training; T6- next morning (24 h following the T1 measurement).

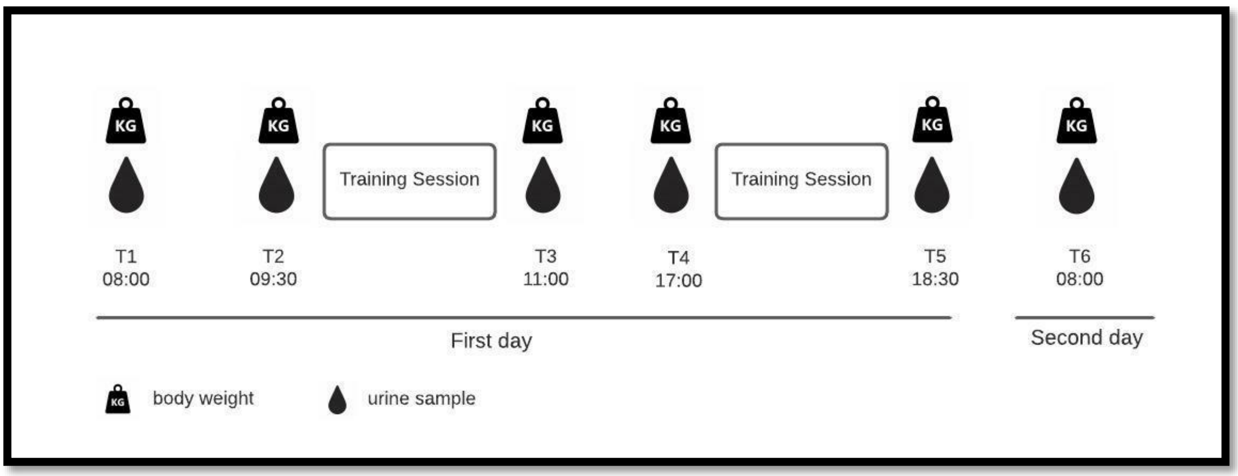

Figure 1. Study design with measurement times

Following a day off, the measurements were taken in the morning after waking up and before and after the morning and evening training sessions. On the second day, the measurements were taken in the morning after waking up. The break between training sessions lasted for 6 hours. Athletes have trained in a standardised environmental temperature (approx. 24 C˚). Detailed information related to training sessions can be found in Table 1.

Table 1. Training content of the judo athletes during measurement day

Content	**Morning Training Session (09:30-11:00)**	**Evening Training Session (17:00-18:30)**
	Duration (min)	Duration (min)
Warm-up	10	10
"*Uchikomi*" (Technique repetition)	15	15
2 min×5 "*Ne-waza randori*" (groundwork battle)	-	10
"*Ipponchange ne-waza randori*" (groundwork battle)	15	-
4 min×5 "*Tachi-waza Randori*" (standing battle)	20	-
4 min×6 "*Tachi-waza Randori*" (standing battle) with golden score	-	30
Complimentary exercises	15	15
Cool-down	5	5
Total	80	85

Participants

The number of participants was determined with a priori power analysis using G*Power 3.1.9.7 (Version 3.1.9.7; Universität Kiel, Kiel, Germany).[21] The assumptions used were a significance level of $\alpha = 0.05$ and the power of 0.90 for one-way within-factor repeated measures ANOVA (6 measurement times) and actual power of 0.91 with a total sample size of 24 participants were determined. Nevertheless, twenty-seven judo athletes from ……. national judo team voluntarily agreed to participate in this study. All athletes were in a weight-stable period, i.e., not losing or regulating body weight for an upcoming competition and without any musculoskeletal injuries. All athletes were black belt and had a mean judo experience of 10.2±3.2 years. Data were collected during an international training camp in ………. A written informed consent form was obtained from each athlete before the experiment, and the study was carried out in accordance with the latest version of the Declaration of Helsinki. The local

Clinical Research Ethics Committee provided ethical approval for the study (2020-KAEK-143-136).

Measurements

Body weight: Athletes' body weight was measured with a calibrated scale (Seca 880 Digital Floor Scale, Seca: UK) to the nearest 100 grams. Athletes were weighed naked and dry after each urine sample collection. The first measurement was carried out on the first morning after the day off upon waking up. Afterwards, the athletes were weighed immediately before and after each training session. Finally, the last measurement was taken the following day upon waking up (24h after the first one).

Hydration status: A midstream urine sample[22, 23] was collected from each athlete immediately before each body weight measurement. The samples were placed in plastic cups, and urine-specific gravity (USG) was determined with a digital refractometer (ATAGO PAL-10S, Japan). All samples were refrigerated and analysed at 20º C within 8 hours.[24] USG was classified as hydrated (USG<1.020) and hypohydrated (USG ≥1.020) according to suggestions by the ACSM position stand.[19]

Fluid intake: For 24 hours, subjects were asked to complete a fluid diary in which the type, amount, and time of fluid consumed were recorded. The photos of standard sizes of packaged beverages, glasses, and containers were provided to estimate the amount for each fluid ingested. An example of a proper fluid recording was shown to the participants so that they could reference during their 24 h of record keeping. Total fluid intake was calculated by adding the volume of all fluids consumed.

Statistical analysis

The analysis was conducted with JASP (0.15.0.0 Version, The Netherlands) and IBM SPSS 20 (IBM Corporation Inc. Armonk, NY, the USA). The variables' mean, standard deviation, and 95% confidence interval (CI) were reported. The data normality was checked with the Shapiro-Wilk test and descriptive methods using skewness and kurtosis coefficients.[25] The differences in USG measured four times at rest throughout the 24 hours were determined with one-way repeated measures ANOVA, and the differences between USG measured before and after morning and evening training sessions were determined with two-way (2×2) repeated measures ANOVA. Also, the effect of sex (2×4) and weight category (3×4) on USG was checked with split-plot ANOVA, and pairwise comparisons were made via Bonferroni correction. The changes in body weight were analysed with a paired-samples t-test. The relationship among variables was investigated with the Pearson correlation coefficient. Effect sizes for pairwise comparisons, analysis of variance, and correlation analysis were classified according to Cohen's d and eta-squared (η^2) and correlation coefficient (r) value [26], respectively. Significance was set at $p<0.05$.

Results

Athletes' physical characteristics and fluid intake are presented in Table 2.

Table 2. Participants' physical characteristics and fluid intake

	Women (n=8)		Men (n=19)		Total (n=27)	
	Mean±SD	95% CI	Mean±SD	95% CI	Mean±SD	95% CI
Age (year)	20.8±1.3	(19.7-21-8)	21.6±3.3	(21.1-23.2)	21.4±2.8	(20.3-22-5)
Body height (cm)	163.6±5.5	(159.1-168.1)	179.4±8.3	(175.4-183.4)	174.7±10.5	(170.6-178.9)
Body weight (kg)	61.4±10.1	(53.2-69.7)	87.3±19.6	(77.9-96.6)	79.6±20.9	(71.3-87.9)
BMI (kg/m^2)	21.9±2.6	(19.8-24.1)	24.7±3.2	(23.1-26.2)	23.9±3.2	(22.6-25.1)
Experience (year)	10.2±3.2	(6.1-10.4)	11.1±3.1	(9.6-12.5)	10.2±3.2	(9.0-11.5)
Fluid intake (L/day)	3.7±1.5	(2.6-5.0)	4.4±2.0	(3.3-5.5)	4.1±1.8	(3.4-4.9)

SD= standard deviation; CI= confidence interval; BMI= body mass index

The changes in USG and body weight can be found in Figure 2. The changes in athletes' USG values at different measurement times were significant ($F_{3,\ 78}$= 7.972; $p<0.001$; η^2=0.24 [Medium]). According to multiple comparisons, athletes' USG values at T6 were significantly higher compared to other at rest measurement times (T1, T2 and T4). When pairwise comparisons were carried out, the same results were obtained. Effect sizes calculated with

Cohen's d during these analyses ranged from medium to large. There was no main effect of sex ($F_{1, 25}$= 1.544; p=0.226) and weight category ($F_{1, 25}$= 0.115; p=0.892) on USG values. The changes in USG values were the same between men and women at different measurement times (sex × time interaction= $F_{1, 25}$= 1.319; p=0.274) and among weight categories (weight category × time interaction= $F_{3, 72}$= 0,506; p=0,802). USG values increased following both training sessions ($F_{1, 26}$= 13.636; p=0.001; η^2=0.171 [Medium]). Increase in athletes' USG values were not significant between before (1.024±0.006) and after (1.026±0.004) the morning training session (t (26)= -1.811; p=0.082). However, athletes' USG values increased during the evening training session (before=1.023±0.007; after=1.027±0.006) (t (26)= -4.297; p<0.001; d=-0.827; large effect). USG values were not different before the morning and evening training sessions ($F_{1, 26}$= 0.382; p=0.542). Moreover, the increase in USG values following the exercise was similar in the morning and evening training sessions ($F_{1, 26}$= 1.489; p=0.233). The changes in USG pre-post morning training session (-0.002±0.006) and pre-post evening training session (-0.004±0.005) were found similar (t (26)=1.220; p=0.233).

There was a significant positive relationship between athletes' USG values at T1 and T6 (r=0.568; p=0.002; Large effect). However, there was no significant relationship between fluid intake and the changes in USG values and body weight (p>0.05).

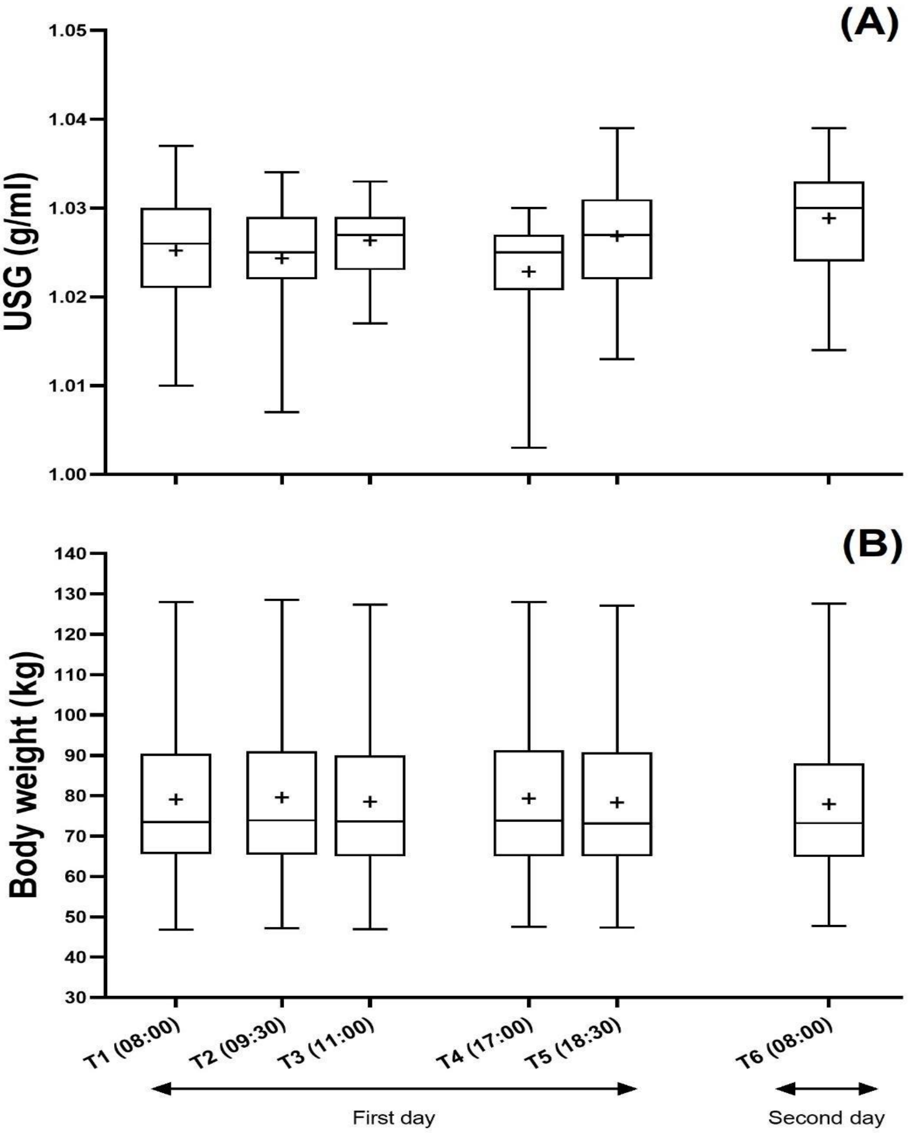

Figure 2. The changes in USG levels and body weight during the experiment. Within each box, horizontal black lines denote median values; boxes extend from the 25th to the 75th percentile of each group's distribution of values;+ indicates means.

There was no significant difference in athletes' body weight between T1 (78.0±21.315) and T6 (77.9±21.2) (t (26)=0.909; p=0.373). The decrease in body weight of the athletes in the 24h period was 0.18%. Athletes' body weight significantly decreased (1.39%) between before (79.6±20.9) and after (78.5±20.7) the morning training sessions (t (26)= 6.356; p<0.001; d=1.223; large effect). Likewise, athletes' body weight significantly decreased (1.22%) during the evening training session (before=79.3±20.8; after=78.4±20.6) (t (26)= 7.363; p<0.001; d=1.417; large effect). The difference in body weight change pre-post the morning training session (-1.1±0.9) and pre-post the evening training session (-0.9±0.7) were similar (t (26)=

0.644; p=0.525). Athletes' body weight following both morning (T3) (t (26)= 2.887; p=0.008; d=0.556; medium effect) and evening (T5) training sessions (t (26)= 3.973; p=0.001; d=0.765; medium effect) were found lower than the body weight measured in the first morning (T1).

Athletes' hydration status according to USG values is presented in Figure 3. As seen in the figure, most athletes presented hypohydration throughout the measurements. 22.2% of the athletes were classified as hydrated, while 77.8% were classified as hypohydrated according to the first measurement. The percentage of the hydrated athletes decreased to 7.4% according to athletes' USG values the following day, while 92.6% of the athletes presented hypohydration.

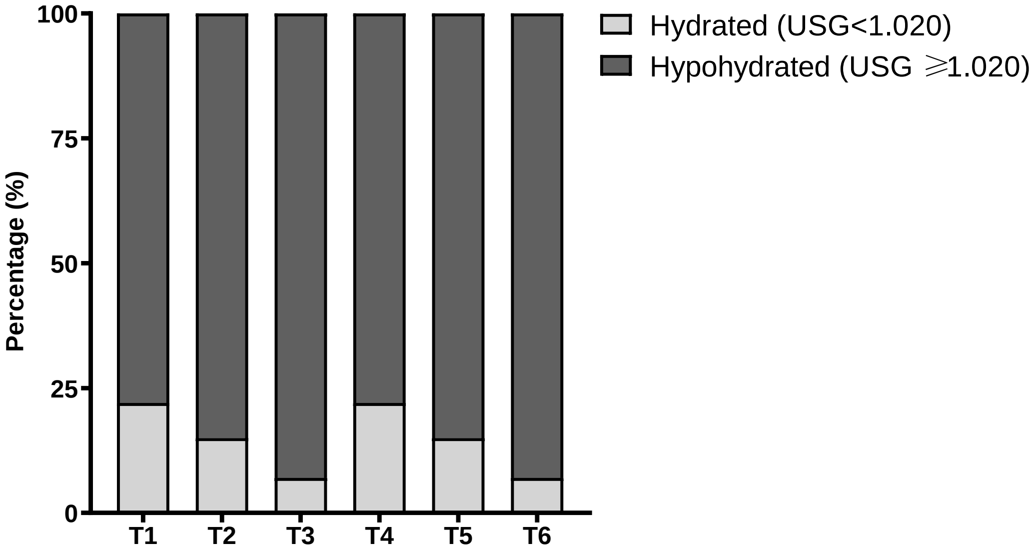

Figure 3. Hydration status of athletes at different measurement times

Discussion

This study investigated hydration status and body weight changes of national senior judo team athletes for 24 h during a weight-stable international training camp. The study's main finding was that most athletes (92.6%) presented insufficient hydration status during 24 h at a weight-stable international training camp despite presenting no significant change in body weight. The training sessions increased athletes' urine concentration despite *ad libitum* fluid intake. There was no effect of sex and weight category on the changes in hydration status. Thus, the data of both men and women athletes were evaluated together. No significant relationship was determined between athletes' fluid intake and the changes in USG values and body weight.

Different approaches and suggestions have been made to body weight management in weight-categorised sports, including judo.[27, 28] Despite the additional regulations implemented by International Judo Federation, the fact remains that judo athletes resort to rapid weight loss, which is accompanied by insufficient hydration status and presents a severe problem.[6, 7] Moreover, hypohydration is known to affect judo-specific performance adversely.[29] Research highlighted that when athletes were additionally educated about the importance of fluid intake during exercise, this resulted in improved hydration status of the athletes.[30] Therefore, providing athletes and especially their coaches with educational programs related to weight management and hydration status to decrease the adverse effect of rapid weight loss and hypohydration on health and performance has been widely highlighted.[7, 28, 31] Previous studies related to the hydration status of judo athletes during training were carried out on younger and inexperienced judo athletes. However, those studies also reported a high level of hypohydration in judokas during the training period.[15-17]

Compared to youth and inexperienced athletes, high-level athletes are expected to have more experience and knowledge to maintain optimal hydration, especially during the non-competitive period. However, the current study shows that high-level athletes presented hypohydration following an off day and additionally, they also presented worse hydration status following two training sessions during the day. Again this occurred with *ad libitum* fluid intake and showed that athletes must be reminded to consume fluids during training.[32] The changes in insufficient hydration status were the same in both women and men athletes. It was reported that most of the athletes from different team sports presented a high level of hypohydration, men athletes presented worse hydration status than women athletes, and menstrual period did not affect the hydration status of women athletes.[33] This information suggests that athletes' insufficient hydration status is related to insufficient fluid intake habits rather than sex. Especially in sports such as judo, where the exercise intensity is high, the risk of hypohydration can be even higher.[34] The findings of the current study support this idea, as the hydration status of athletes worsened from pre-training to post-training, despite the high level of fluid intake during 24h, and athletes' body weight decreased. Athletes' body weight losses were 1.4% and 1.2% before and after morning and evening training, respectively. The percentage of body weight loss at the end of exercise should be kept between ±1 for active individuals and ±2 for the athletic population for optimal performance.[35] Although the changes in body weight of elite judo athletes in the current study stayed within limits (±2%), the increase in USG values shows that athletes did not rehydrate enough to eliminate hypohydration. Moreover, the fact that 1% fluid loss may adversely affect athletic performance should be considered.[36, 37] The change in body weight (0.18%) and USG values in 24h were not compatible. Although athletes' body weight did not significantly decrease, their USG values worsened, and the percentage of hypohydrated athletes increased. In combat sports athletes, a high prevalence of hypohydration has been reported via USG with no significant change in body weight. This may have resulted from the effect of training duration and intensity on USG values, athletes' adaptation to repetitive hypohydration/weight loss, and the same cut-off values used for the athletes with high lean body mass from different weight categories.[22] In addition, weight loss and USG measurements show similar patterns during dehydration via restricting fluid intake and exercise. This pattern presents inconsistency in the case of dehydration; this inconsistency is explained by the differences in hormonal control of water and solutes (i.e., K, Na, sugar).[38, 39]

The USG values taken at rest and different measurement times are consistent with the natural daily change in urinary concentration.[40] While high USG values are determined in the first morning measurement of the athletes, the USG values before the morning training decrease with the increase in fluid intake, and it is seen that it is at the lowest level before the evening training (Figure 2A). There was a positive correlation between the USG value obtained on the first morning and that obtained on the second day in the morning. This shows that athletes were hypohydrated on both the first and second morning; moreover, the number of athletes with insufficient hydration status increased, and the level of hypohydration worsened following each training session. Despite the off day in the training camp, the athletes may not have consumed enough fluid and thus did not sufficiently hydrate. Moreover, they presented the worst hydration status the following morning after two training sessions on the same day, despite having time to recover adequately with unrestricted nutritional and fluid intake and adequate time to sleep. This would imply that athletes maintain habits and regimes from their weight loss periods as the trend in weight loss is noted. However, whether this is due to habits or lack of knowledge remains unclear and needs further investigation. Previous studies also support the present study finding, as high-level athletes showed alarming hypohydration levels during training camps despite fluid availability and consumption. Thus, monitoring and increasing fluid consumption could prevent hypohydration.[41]

The current study reported that weight categories did not affect the hydration status of the judo athletes during a weight-stable training camp. There is no information related to hydration status and change in hydration status of heavyweight athletes in the literature because they are not concerned about losing weight during the competitive period. This study showed that judo athletes present non-optimal hydration status during the training period independently of the weight category. Athletes in weight-classified sports cut weight to gain an advantage against lighter and weaker opponents.[42] Zubac et al.[43] reported that lightweight and middleweight athletes are more prone to hypohydration than heavyweight athletes during training before competitions. It is possible that lightweight and middleweight athletes had worse hydration status than heavyweight athletes due to the continuous weight loss processes before the competitions. No relationship between weight category and hydration status of the athletes in the current study may have stemmed from the fact that this study was carried out during a weight-stable training camp.

Although athletes' fluid intake was recorded, the content was not monitored. This may have affected determining the total fluid intake. Moreover, environmental temperature is known to affect athletes' hydration status negatively. The current study's ambient temperature was between optimal ranges (~10°C to 25°C).[44] However, judo athletes are at risk due to high environmental heat and thermal stress as they wear judo uniforms (*judogi*) which are made from cotton and have a thick texture that may increase sweating and body temperature during training.[17]

We are aware of some limitations of this study. Firstly, the measurements were not done at the beginning of the training camp to get the athletes' baseline and hydration status. Furthermore, researchers had limited access to athletes. Nonetheless, this is the first study that presents an insight into elite athletes' hydration status in judo and can be a foundation for further research. Second, it is known that large muscle mass may lead to incorrect classification of hypohydration based on USG in athletic population[45]; however, USG assessment represents a valuable tool providing hydration in athletes with being low-cost, practical, reliable, and valid.[22] The content of athletes' drinks was not monitored as this could give us a better understanding of judokas' hydration strategies. Further research should account for that. Body composition was not monitored due to time restrictions and availability of athletes pre and post-training; therefore, researchers had to optimise the tests used in this research. Further research should try to cover the whole elite athletes' training camp and get the baseline before starting the stable weight period

Conclusion

This study shows that high-level judo athletes whom we assessed via USG appeared hypohydrated despite being in a weight-stable training period. Furthermore, the training sessions during the training camp worsened the hydration status of the athletes from the first to the last morning measurement. Although there was no significant decrease in body weight during the 24-h period, the increase in urine concentration may have been caused by the ongoing insufficient hydration status of the athletes. This shows that high-level judo athletes cannot acquire sufficient fluid intake to eliminate hypohydration and maintain the hypohydration they may acquire due to weight loss, even during a weight-stable period. Sex and weight category did not affect the hydration status of judo athletes during a weight-stable training camp. Monitoring hydration status (i.e. USG, urine color and body weight) of atheletes during the training period and encouragement to create and use hydration schedules for such athletes can be taken into account, which may help protect and improve their athletic performance.

References

1. IJF. International Judo Federation Sport and Organization Rules (SOR), (2022, accessed 01/12 2022).
2. Artioli G, Gualano B, Franchini E, et al. Prevalence, magnitude, and methods of rapid weight loss among judo competitors. *Med Sci Sports Exerc* 2010; 42: 436-442.
3. Kons RL, Athayde MSDS, Follmer B, et al. Methods and magnitudes of rapid weight loss in judo athletes over pre-competition periods. *Human Movement* 2017; 18: 49-55.
4. Barley OR, Chapman DW and Abbiss CR. Weight loss strategies in combat sports and concerning habits in mixed martial arts. *International Journal of Sports Physiology and Performance* 2018; 13: 933-939.
5. Jetton AM, Lawrence MM, Meucci M, et al. Dehydration and acute weight gain in mixed martial arts fighters before competition. *J Strength Cond Res* 2013; 27: 1322-1326.
6. Ceylan B, Barley OR and Balci SS. Changes in body mass and hydration status in judo athletes before and after a top-level competition: a descriptive case study. *Phys Sportsmed* 2022: 1-6. 2022/01/07. DOI: 10.1080/00913847.2022.2026200.
7. Ceylan B and Balci SS. Dehydration and Rapid Weight Gain Between Weigh-in and Competition in Judo Athletes: The Differences between Women and Men. *Research in Sports Medicine* 2021: 1-11. DOI: 10.1080/15438627.2021.1989435.
8. Ceylan B, Baydil B and Aydos L. Weigh-in time affects hydration status and acute weight gain in combat sports: A comparison of judo and wrestling. *Revista de Artes Marciales Asiáticas* 2021; 16: 80-88.
9. González-Alonso J, Mora-Rodríguez R, Below PR, et al. Dehydration markedly impairs cardiovascular function in hyperthermic endurance athletes during exercise. *J Appl Physiol (1985)* 1997; 82: 1229-1236. 1997/04/01. DOI: 10.1152/jappl.1997.82.4.1229.

10. Savoie FA, Kenefick RW, Ely BR, et al. Effect of Hypohydration on Muscle Endurance, Strength, Anaerobic Power and Capacity and Vertical Jumping Ability: A Meta-Analysis. *Sports Med* 2015; 45: 1207-1227. 2015/07/17. DOI: 10.1007/s40279-015-0349-0.
11. Cian C, Barraud PA, Melin B, et al. Effects of fluid ingestion on cognitive function after heat stress or exercise-induced dehydration. *Int J Psychophysiol* 2001; 42: 243-251. 2002/01/29. DOI: 10.1016/s0167-8760(01)00142-8.
12. Shirreffs SM, Merson SJ, Fraser SM, et al. The effects of fluid restriction on hydration status and subjective feelings in man. *Br J Nutr* 2004; 91: 951-958. 2004/06/09. DOI: 10.1079/bjn20041149.
13. Smith MF, Newell AJ and Baker MR. Effect of acute mild dehydration on cognitive-motor performance in golf. *J Strength Cond Res* 2012; 26: 3075-3080. 2011/12/23. DOI: 10.1519/JSC.0b013e318245bea7.
14. Pallarés J, Martínez-Abellán A, López-Gullón J, et al. Muscle contraction velocity, strength and power output changes following different degrees of hypohydration in competitive olympic combat sports. *Journal of the International Society of Sports Nutrition* 2016; 13: 1-9.
15. Ceylan B and Santos L. Fluid intake, hydration status and body mass changes in U-15 judo athletes during a training day. *Acta Scientiarum Health Sciences* 2022; 44: e57233-e57233.
16. Stefanovsky M, Clarys P, Cierna D, et al. Hydration status of youth Judo athletes during an off-season training cam. *Ido Movement for Culture Journal of Martial Arts Anthropology* 2019; 19: 56-68.
17. Rivera-Brown AM and De Félix-Dávila RA. Hydration status in adolescent judo athletes before and after training in the heat. *Int J Sports Physiol Perform* 2012; 7: 39-46. 2011/09/24. DOI: 10.1123/ijspp.7.1.39.
18. Wong S, Williams C, Simpson M, et al. Influence of fluid intake pattern on short-term recovery from prolonged, submaximal running and subsequent exercise capacity. *Journal of Sports Sciences* 1998; 16: 143-152. DOI: 10.1080/026404198366858.
19. Sawka MN, Burke LM, Eichner ER, et al. Exercise and Fluid Replacement. *Medicine & Science in Sports & Exercise* 2007; 39: 377-390. DOI: 10.1249/mss.0b013e31802ca597.
20. Rothenberg JA and Panagos A. Musculoskeletal performance and hydration status. *Current Reviews in Musculoskeletal Medicine* 2008; 1: 131-136. DOI: 10.1007/s12178-008-9020-9.
21. Faul F, Erdfelder E, Lang A-G, et al. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods* 2007; 39: 175-191. DOI: 10.3758/BF03193146.
22. Zubac D, Reale R, Karnincic H, et al. Urine specific gravity as an indicator of dehydration in Olympic combat sport athletes; considerations for research and practice. *European journal of sport science* 2018; 18: 920-929.
23. Casa DJ, Armstrong LE, Hillman SK, et al. National Athletic Trainers' Association position statement: fluid replacement for athletes. *Journal of athletic training* 2000; 35: 212.
24. Wardenaar F, Ortega-Santos CP, Vento K, et al. Reliability of 3 Urine Specific Gravity Meters for Measuring Brix and Urine Solutions at Different Temperatures. *Journal of Athletic Training* 2021; 56: 389-395. DOI: 10.4085/1062-6050-0142.20.
25. Ghasemi A and Zahediasl S. Normality tests for statistical analysis: a guide for non-statisticians. *Int J Endocrinol Metab* 2012; 10: 486-489. 04/20. DOI: 10.5812/ijem.3505.
26. Cohen J. *Statistical power analysis for the behavioral sciences (2nd Edition)*. New York: Routledge, 1988.
27. Artioli GG, Franchini E, Nicastro H, et al. The need of a weight management control program in judo: a proposal based on the successful case of wrestling. *Journal of the International Society of Sports Nutrition* 2010; 7: 15. 2010/05/06. DOI: 10.1186/1550-2783-7-15.

28. Burke LM, Slater GJ, Matthews JJ, et al. ACSM Expert Consensus Statement on Weight Loss in Weight-Category Sports. *Curr Sports Med Rep* 2021; 20: 199-217. 2021/04/02. DOI: 10.1249/jsr.0000000000000831.
29. Ceylan B, Kons RL, Detanico D, et al. Acute Dehydration Impairs Performance and Physiological Responses in Highly Trained Judo Athletes. *Biology* 2022; 11: 872.
30. Magee PJ, Gallagher AM and McCormack JM. High Prevalence of Dehydration and Inadequate Nutritional Knowledge Among University and Club Level Athletes. *International journal of sport nutrition and exercise metabolism* 2017; 27: 158-168. 2016/10/07. DOI: 10.1123/ijsnem.2016-0053.
31. Reale R, Slater G and Burke LM. Individualised dietary strategies for Olympic combat sports: Acute weight loss, recovery and competition nutrition. *European journal of sport science* 2017; 17: 727-740. 2017/03/21. DOI: 10.1080/17461391.2017.1297489.
32. Hoffman JR and Maresh CM. Nutrition and Hydration Issues for Combat Sport Athletes. *Strength & Conditioning Journal* 2011; 33: 10-17. DOI: 10.1519/SSC.0b013e318237247e.
33. Volpe SL, Poule KA and Bland EG. Estimation of prepractice hydration status of National Collegiate Athletic Association Division I athletes. *J Athl Train* 2009; 44: 624-629. 2009/11/17. DOI: 10.4085/1062-6050-44.6.624.
34. Belval LN, Hosokawa Y, Casa DJ, et al. Practical Hydration Solutions for Sports. *Nutrients* 2019; 11 2019/07/22. DOI: 10.3390/nu11071550.
35. McDermott BP, Anderson SA, Armstrong LE, et al. National athletic trainers' association position statement: fluid replacement for the physically active. *Journal of Athletic Training* 2017; 52: 877-895.
36. Pichan G, Gauttam RK, Tomar OS, et al. Effect of primary hypohydration on physical work capacity. *International Journal of Biometeorology* 1988; 32: 176-180. DOI: 10.1007/BF01045276.
37. Walsh RM, Noakes TD, Hawley JA, et al. Impaired high-intensity cycling performance time at low levels of dehydration. *Int J Sports Med* 1994; 15: 392-398. 1994/10/01. DOI: 10.1055/s-2007-1021076.
38. Armstrong LE, Herrera Soto JA, Hacker FT, et al. Urinary Indices during Dehydration, Exercise, and Rehydration. *International Journal of Sport Nutrition* 1998; 8: 345-355. DOI: 10.1123/ijsn.8.4.345.
39. Nielsen B, SjØgaard G, Ugelvig J, et al. Fluid balance in exercise dehydration and rehydration with different glucose-electrolyte drinks. *European Journal of Applied Physiology and Occupational Physiology* 1986; 55: 318-325. DOI: 10.1007/BF02343806.
40. Perrier E, Demazières A, Girard N, et al. Circadian variation and responsiveness of hydration biomarkers to changes in daily water intake. *European Journal of Applied Physiology* 2013; 113: 2143-2151. DOI: 10.1007/s00421-013-2649-0.
41. Vescovi JD and Watson G. Variability of Body Mass and Urine Specific Gravity in Elite Male Field Hockey Players During a Pre-Olympic Training Camp. *International journal of sport nutrition and exercise metabolism* 2019; 29: 46-50. 2018/06/13. DOI: 10.1123/ijsnem.2018-0121.
42. Reale R, Cox GR, Slater G, et al. Regain in body mass after weigh-in is linked to success in real life judo competition. *International journal of sport nutrition and exercise metabolism* 2016; 26: 525-530.
43. Zubac D, Karninčić H and Žaja M. Hydration status assessment among elite youth amateur boxers. *J Sports Med Phys Fitness* 2016; 56: 731-736. 2015/02/11.
44. Valenzuela PL, Mateo-March M, Zabala M, et al. Ambient Temperature and Field-Based Cycling Performance: Insights From Male and Female Professional Cyclists.

International Journal of Sports Physiology and Performance 2022; 17: 1025-1029. DOI: 10.1123/ijspp.2021-0508.
45. Hamouti N, Del Coso J, Avila A, et al. Effects of athletes' muscle mass on urinary markers of hydration status. *Eur J Appl Physiol* 2010; 109: 213-219. 2010/01/09. DOI: 10.1007/s00421-009-1333-x.