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Rapid weight loss can increase the risk of acute kidney injury in wrestlers

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ABSTRACT

Objective Restrictive diets, forced starvation or voluntary weight loss are attracting more and more attention from scientists. Overall trends show that about 80% of combat sports athletes use specific methods of reducing body mass. Rapid weight loss could be a risk factor for kidney-related adverse outcomes. This study aimed to examine the impact of high-intensity specific training combined with rapid weight loss in the first and without rapid weight loss in the second phases on body composition and biochemical markers of kidney function.

Methods The study was conducted on 12 male wrestlers. Kidney function markers were measured, including blood urea nitrogen, serum creatinine, uric acid and serum Cystatin-C. Alterations in analysed markers were noted in both phases of the research.

Results According to the data, a significant increase was noted in blood urea nitrogen (p=0.002), uric acid (p=0.000) and serum creatinine (p=0.006) during the first phase in comparison with the second phase. The levels of serum Cystatin-C were slightly elevated after both phases compared with the initial measurement.

Conclusion It is evident that high-intensity specific training combined with rapid weight loss significantly affects the increase in kidney function markers compared with identical training without rapid weight loss. The findings in this study suggest that rapid body mass reduction is associated with an increased risk of acute kidney injury in wrestlers.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Fluid restriction is considered one of the most commonly used methods to reduce body mass in weight-classified sports by competitors.

WHAT THIS STUDY ADDS

⇒ High-intensity sport-specific training accompanied by rapid weight reduction increases the risk of acute kidney injury in combat sports athletes.

⇒ There is evidence that a certain percentage of body mass reduction affects an alteration in kidney function biomarkers.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The knowledge provided in this research should encourage combat sports athletes to carefully approach the weight reduction process as it could negatively affect the individual's health.

INTRODUCTION

The benefits of weight loss through lifestyle interventions are well documented regarding health outcomes. However, kidney alterations induced by rapid weight loss (RWL) are still incompletely understood. Previous studies have reported that body mass fluctuation is associated with an increased risk of rapid kidney function decline in participants with normal kidney function.[1] Many weight-class athletes try to lose weight rapidly before a competition.[2] RWL is described as a rapid weight reduction over a short period. Abrupt reduction of body mass refers to methods an athlete uses to reduce body mass in the last week before a competition, with an average loss of 2%–10%.[3–6] RWL methods are generally intended to give the athlete a certain advantage, but there are also potential negative aspects of losing weight rapidly. It was documented that RWL practice negatively impacts athletes' health, with noted dead cases as a consequence of RWL.[7 8] Still, evidence shows that around 80% of combat sports athletes use specific methods of reducing body mass.[9–15] Usually, RWL techniques involve more intensive exercise, using a sauna and rubber or plastic suits, reducing energy intake, fasting, laxatives and primarily dehydration.[16–18]

The kidney is an organ that can tolerate exposure to various factors, whereby a predisposing factor such as dehydration may represent an additional risk for the development of acute kidney injury (AKI). Although dehydration was thought not to be associated with long-term adverse effects on kidney function, this opinion has been disproved.[19] The possible factor causing acute kidney failure is dehydration, and even mild dehydration can be a risk factor in the progression of kidney disease. Since athletes in combat sports reduce their body mass up to 10 times yearly,[20] frequent dehydration can affect kidney function. There is no evidence that sport practising can lead to chronic kidney problems. However, early detection of AKI in athletes who regularly use RWL methods is of utmost importance for preventing more severe kidney disease. Dehydration and soft drink intake during and following exercise may lead to acute kidney dysfunction.[21] Also, repeated episodes of acute kidney failure may lead to chronic kidney disease.[22] Several classification systems have been developed to streamline research and clinical practice concerning AKI.[23] Changes in serum creatinine (CRE) levels, blood urea nitrogen (BUN), uric acid (URCA) and Cystatin-C (CysC) levels are indicators of kidney function.[24] However, CRE and BUN are influenced by many renal and nonrenal factors independent of kidney function.[25 26] Unlike CRE and BUN, CysC levels are much less influenced by factors such as gender, age and muscle mass.[27–29] CysC is a suitable marker for assessing kidney functions during and after exercise.[30] Elevating URCA levels are also associated with strenuous exercise.[31 32]

Athletes are usually healthy by definition, but the combination of RWL and high training workload may modify their homeostasis, inducing pathological biochemical kidney marker values. This study examined the impact of high-intensity specific training combined with RWL and without RWL on body composition and biochemical markers of kidney function.

METHODS

Study population

Twelve male Greco-Roman wrestlers (mean body mass 73.48±4.52 kg, mean age 24.3±5.1 years, mean height 175.22±3.68 cm) participated in this study. The sample size was calculated using the power analysis (effect size 0.4, α 0.05, power 0.80) for the primary outcome measures (G-Power 3, Heinrich-Heine-Universität Düsseldorf, Germany). All participants were currently active athletes with at least 5 years of competitive experience and at least 10 hours of practising sport per week. Only those who had already implemented RWL techniques over the last 2 years were selected for the study.

Study design

This open-label, repeated-measure pilot study was designed to investigate the impact of high-intensity specific training combined with RWL and without RWL on body composition and AKI markers. After the initial measurement (IM), the experiment consisted of two phases (figure 1). The first phase (P1) of the research was conducted with the implementation of high-intensity sport-specific training (HISST) with a 5% reduction in body mass. In the above-mentioned phase of the experiment, lasting 3 days, the subjects had the usual training and independently applied different methods of reducing body mass. All participants used methods such as increased physical activity, plastic suit training, caloric deficit, reduced fluid intake and sauna to lose weight rapidly. On the last day of the first phase (day 3), all athletes performed a HISST in the morning, followed by a second measurement (P1). The second phase of the experimental treatment was conducted 7 days after the P1 and included the same athletes who participated in the first phase. The research's second phase (P2) was carried out with an identical training protocol without the mandatory reduction of body mass. This phase consists of a single training episode (HISST) without RWL. Testing and blood sampling were conducted immediately after HISST in the morning.

The experiment took place in the sports hall of the wrestling club. Both HISST protocol and weight loss procedures were supervised by two experienced wrestling coaches who had been training the athletes (respondents) for 5 years at the time of the experiment, along with three senior researchers with expertise in combat sports, who conducted weight measurements and body

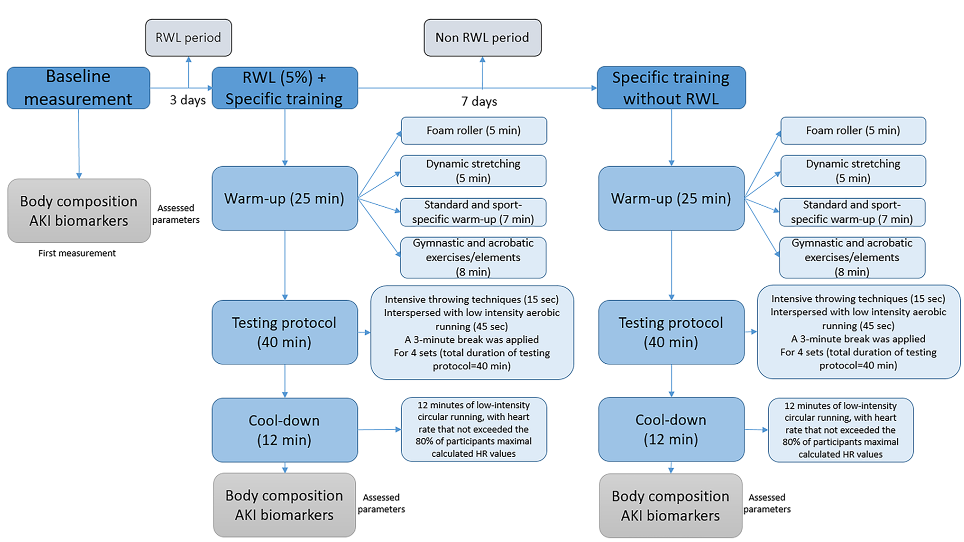

Figure 1 Flow chart of the study procedure. AKI, acute kidney injury; RWL, rapid weight loss.

composition assessments in all phases. Blood sampling was performed by trained laboratory personnel.

Anthropometric measures

Body composition characteristics were measured before and after the first and second phases simultaneously during each study day (08:00 local time.) Body mass, body fat percentage, amount of fat mass and muscle mass were measured using the bioelectrical impedance (Omron 511BF, OMRON HEALTHCARE, Kyoto, Japan). Participants' body mass was measured to the nearest 0.1 kg. Subjects were instructed not to eat after 21:00 local time.

Blood sample collection

Venous blood was collected from the antecubital vein in a fasted state before and after each phase. Biochemical parameters were determined routinely using standard methods. Commercially available routine assays were used to determine BUN, URCA and CRE (Sysmex America, Lincolnshire, Illinois, USA). Serum CysC was measured with a Particle-Enhanced Turbidimetric Immunoassay for in vitro diagnostic testing of CysC in human plasma and serum samples.

High-intensity sport-specific training

The total duration of training (test protocol) was 90 min. Before performing specific training, all subjects warmed up. The total duration of the warm-up was 25 min. After a warm-up, working in pairs, the subjects started a specific training session consisting of four series of the maximum number of throws. Each set lasted 10 min with a ratio of work (throwing) lasting 15 s and low-intensity jogging lasting 45 s. The subjects had a break of 3 min between each set. Wrestlers performed arm throw as a throwing technique for this test. The test started with a low-intensity circular run (45 s). Five seconds before the throwing part, the subject was instructed to take place at a point 9 m away from the sparring partner and prepares to perform the throw. At the sound signal of the coach, the athlete runs to the sparring partner as fast as possible and performs the throwing technique. Immediately after the throw, he had to return to the starting point of 9 m. The subject performs this cycle continuously for 15 s, intending to make as many throws as possible. At the end of 15 s, the subject starts a new set of low-intensity running for 45 s. After the subject completes the 10 described sequences, a 3 min break was applied. The main part of the training ends after the athlete has completed four series of intense throwing and jogging. The total duration of this part (test protocol) was 40 min. The cool-down phase consisted of 12 min low-intensity circular running, with heart rate not exceeding 80% of participants' maximal calculated HR values. A heart rate was monitored (Polar-H10 heart rate sensor, Polar Pro chest strap) from the beginning to the end of the training session for all athletes. The heart rate monitoring was performed using an iPad Pro 10 Polar Team application.

Statistical analysis

Basic descriptive statistics were calculated for all variables, and values were presented as arithmetic mean (M) and SD. Statistical analysis was performed using the one-way RM analysis of variance and post hoc Bonferroni analysis of the Statistical Package for the Social Sciences—IBM SPSS Statistics for Windows, V.20.0 (IBM). Statistical significance level was set at $p<0.05$.

Equity, diversity and inclusion statement

Our authors comprised four women and six men, including senior and less experienced researchers from various research areas such as exercise physiology, biomedical science, sports science and sports medicine. Nevertheless, the authors of the research group are from two different countries. The current study included white male junior and senior Greco-Roman wrestlers from different socioeconomic backgrounds. Each respondent performed the experimental protocol equally regardless of educational and socioeconomic differences.

RESULTS

Twelve participants completed and fulfilled the study requirements. Significant differences were observed in the body composition characteristics in both phases. There was a significant decrease in body mass, body mass index (BMI), and body fat compared with the initial measurement. Furthermore, an increase in muscle mass (%) in both phases was observed. Differences are also visible when P1 and P2 values are compared. Body mass, BMI and fat percentage were significantly higher in the second phase, while the percentage of muscle was lower compared with P1.

Changes in analysed markers of AKI are presented in figure 2. All analysed markers were elevated during the P1 compared with the initial measurement. The level of BUN ($p=0.011$), URCA ($p=0.000$) and creatinine ($p=0.001$) increased significantly. No significant changes were observed in CysC values during P1, but elevated values in relation to IM are evident. When we compared P2 with IM, significantly higher values were noted in the second phase for URCA ($p=0.003$) and creatinine ($p=0.011$). Comparing the second phase with the first, significantly higher values were observed during P1 in the levels of urea ($p=0.002$), URCA ($p=0.000$) and creatinine ($p=0.006$).

DISCUSSION

In this study, HISST with RWL among wrestlers was associated with an increased risk of AKI. This study demonstrated changes in the analysed markers of AKI in both phases of the research. However, during P1, some values of AKI markers exceeded the reference range (BUN: 2.5–7.5 mmol/L; URCA: 155–428 mmol/L; CRE: 49–115 mmol/L). Kidney injury begins by inducing biological and molecular changes, which biomarkers can detect early.[33–35] The incidence of AKI is likely due to a combination of different factors.[36] Of these factors,

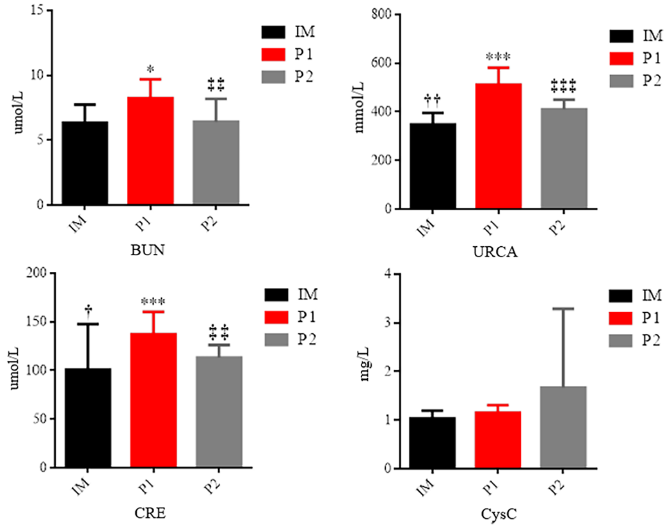

Figure 2 Changes in the analysed markers of AKI. ***Statistically significant difference in relation to the baseline values IM, p≤0.001; *statistically significant difference in relation to the baseline values IM, p≤0.05; ††statistically significant difference in relation to P2, p<0.01; †statistically significant difference in relation to P2, p≤0.05; ‡‡‡statistically significant difference in relation to P1, p≤0.001; ‡‡statistically significant difference in relation to P1, p<0.01. BUN, blood urea nitrogen; CRE, creatinine; CysC, Cystatin C; HISST, high-intensity sport-specific training; IM, initial measurement; P1, phase 1: RWL, rapid weight loss; URCA, uric acid.

hypohydration may be particularly interesting, as it is commonly seen during RWL in combat athletes.[37] According to the literature, dehydration appeared to be the primary RWL strategy practised by a number of combat sports athletes.[38 39] Dehydration has multiple effects on the kidney. Moreover, the current literature recognises that even mild dehydration may be a risk factor in the progression of all types of chronic kidney diseases.[19] According to Lakicevic *et al*,[40] RWL caused dehydration and subsequent acute kidney damage despite various degrees of weight loss. Based on obtained results, high-intensity specific training combined with RWL significantly affects the increase of kidney function markers compared with identical acute training without RWL. This study showed that RWL affects CRE, BUN and URCA but not CysC. Conversely, the mean serum CysC remained remarkably stable during the RWL phase. Also, serum CysC did not differ significantly between the phases. A study conducted on a sample of judokas reached similar results.[41] After a rapid reduction in body mass (6%) within 7 days, a significant increase in creatinine concentration was recorded (p≤0.05). A significant increase in creatinine level was also recorded in wrestlers after reducing a greater percentage of body mass (~8%) over a longer period (2–3 weeks).[42] One study reported high CRE levels during the final phase of the weight cutting, consistent with AKI.[43] Also, previous studies demonstrated that CRE concentrations might increase due to exercise-induced muscle breakdown.[44] Similar to creatinine, kidney injury biomarkers such as BUN and URCA were significantly increased. There is a greater trend of rise in the mentioned marker's concentration during RWL compared with acute training without RWL. Elevated BUN and creatinine concentrations often serve as biomarkers of AKI.[45] URCA concentration also increased significantly during P1 compared with the initial measurement. In addition, URCA concentration exceeded the reference range after RWL. Significantly higher values were also noted after the acute training session (HISST) measurement (P2) compared with the initial measurement but remained within the normal reference range. Similar results were obtained in a study where an increase in the concentration of URCA was recorded in judokas after 7 days of a restrictive diet and a 5% reduction in body mass.[46 47] The kidney is the main excretory organ for URCA. The high URCA concentration after P1 and P2 can be due to increased purine nucleotide degradation and damage to fast-twitch fibres under conditions of high energy demand. Also, the elevated concentration of this marker may be due to insufficient hydration as a consequence of RWL. It is critical to point out that the biomarkers (BUN, URCA and CRE) that changed significantly throughout the experimental phases surpassed the reference range only in the phase when RWL was applied together with HISST.

These results suggest that RWL with regular exercise has detrimental effects on kidney function. Moreover, acute exercise (HISST) barely impacts kidney injury biomarkers, following the previous study.[48] Thus, HISST in relation to RWL leads to abnormalities observed on biochemical screening for the factors related to kidney functions such as BUN, URCA and CRE. Contrary, HISST without RWL induces alteration in mentioned markers but with no clinical significance. Therefore, obtained data confirm reports of the harmful effects of RWL in combat sports athletes. This is the first study to monitor kidney function biomarkers during the weight reduction and training phases in wrestlers. Also, further research is needed to understand better and elucidate alterations in kidney function biomarkers related to RWL.

Limitations

The study has limitations. HISST presents a non-standardised protocol developed to imitate the intensity of actual training sessions wrestlers often engage in during the season. Additionally, this study examined only male participants, so the response of female athletes to RWL and vigorous training remains to be determined. Moreover, the dietary plan of participants was not monitored throughout the study. In particular, athletes did not report precise food and beverage intake in the phase when RWL methods were implemented.

CONCLUSION

Although strong evidence points to the harmful health consequences of practising RWL, aggressive weight reduction methods are still prevalent among combat sports athletes. In this study, RWL was associated with an increased risk of AKI. Therefore, these results suggest that rapid weight reduction with regular exercise has detrimental effects on the kidney. All athletes should be advised of avoiding RWL and the importance of adequate hydration. There is also a need to increase awareness among coaches about the long-term risk of a repeated episode of AKI as a possible consequence of RWL. A better understanding of the pathophysiology in the progression of AKI related to RWL would help to identify and formulate weight management strategies for athletes. Also, future research could focus on biomarkers that more specifically reflect kidney dysfunction in combat athletes and identify those at greatest risk.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval All screened participants agreed to participate in the study voluntarily and provided written informed consent. The study was approved by the Institutional Review Committee of the University of Novi Sad, Serbia (Ref. No. 46-06-02/2020-1) and was conducted under the Declaration of Helsinki.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. The datasets generated during and analysed during the current study are available from the corresponding author on reasonable request.

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