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OPTIMAL RECOVERY FROM THE MAKING WEIGHT PROCESS FOR WRESTLERS

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INTRODUCTION
The popularity of wrestling largely results from the weight category system, which is designed to reduce the risk of injury between opponents and provides opportunities for athletes of all body sizes to compete on an equal level. However, many (Horswill, 1992; Walberg Rankin, 2006) or even most wrestlers (Kiningham and Gorenflo, 2001) seem to believe that it is necessary to qualify for the lowest weight category possible in order to gain a competitive advantage. Therefore, bodyweight reduction prior to competition is common among wrestlers (Walberg Rankin 2006), despite a number of potentially detrimental health consequences of such behavior (Wilmore, 2000) and, regrettably, the practice of making weight has reached even children's sports (Sansone and Sawyer, 2005).

Depending on the duration, distinction is made between rapid (i.e. within 24-72h), moderate (from 72h to several weeks) and gradual (from several weeks to months) bodyweight reduction (Wilmore, 2000). The techniques for achieving weight loss are quite varied and include, for example, limiting food and fluid intake, using sauna procedures, exercising in a sweat or rubber suit, taking laxatives etc. These techniques, especially if they are employed for achieving rapid or moderate weight loss, may impair physiological functions and physical performance (Horswill et al., 1990; Hickner et al., 1991; Ööpik et al., 1996; Walberg Rankin et al., 1996; Tarnopolsky et al., 1996; Umeda et al., 2004; Karila et al., 2008; Timpmann et al., 2008) and have a negative impact on mood state and cognitive ability (Choma et al., 1998; Filaire et al., 2001; Landers et al., 2001). However, a wrestling match requires strength and power of both upper and lower body musculature, as well as isometric force for various wrestling techniques. Therefore, optimal recovery from the making weight process is apparently of great importance for achieving success in wrestling. The main goal of this brief review is to summarize the results of research work regarding the impact of nutritional factors on the recovery after rapid bodyweight loss in relation to physical performance in wrestlers.

Weight loss techniques, physiological functions and physical performance Limiting food and fluid intake and stimulating dehydration by using sauna procedures and/or exercising in a sweat or rubber suit are common techniques employed by wrestlers for achieving bodyweight loss prior to competition. In case of rapid or moderate rate of bodyweight reduction, dehydration and a decrease in skeletal muscle and liver glycogen stores as well as in the capacity of body buffer systems are among the most noteworthy physiological changes that can potentially impair physical performance of athletes (Horswill, 1992; Wilmore, 2000).

![Diagram of weight loss techniques, physiological functions and physical performance](image)

Figure 1. Relationship between weight loss techniques, physiological functions and physical performance.
Impact of weight loss on physical performance in wrestlers  The data on the impact of bodyweight loss on physical performance in combat sports athletes are quite controversial. However, analysis revealed that in studies where performance was assessed by testing procedures that took into account the specific features of combat sports, rapid and moderate bodyweight reduction had a substantial negative effect on the physical performance of athletes. On the other hand, in cases when the performance did not decrease or, according to some characteristics, even improved on the background of bodyweight reduction, the applied testing procedures did not consider the specific features of a sport event (Timpmann and Ööpik, 2001).

In many cases, the results of studies may have been influenced by the fact that the subjects were instructed to follow an experimental design that did not enable them to employ the approach to bodyweight reduction they were accustomed to and had regularly practiced. However, our data reveal that even in experienced combat sports athletes the use of a self-selected regimen for rapid bodyweight reduction may result in a significant decrease in physical performance (Timpmann et al., 2008). Our subjects (wrestlers and karate athletes) reduced their bodyweight on an average by 5.1% within 3 days. The bodyweight loss was achieved by a gradual reduction of energy and fluid intake, employing mild sauna procedures and maintaining normal training load. A battery of tests was performed before and immediately after bodyweight loss. The test battery included the measurement of the peak torque of knee extensors at three angular velocities (1.57, 3.14, and 4.71 rad·s⁻¹) and an assessment of the amount of work performed during an intermittent intensity knee extension exercise. The latter test consisted of submaximal knee extensions at an angular velocity of 1.57 rad·s⁻¹ for 45 s at the rate of 30 contractions per minute followed by 15 s maximal efforts. The total duration of the test was 3 min.

Peak torque measured after rapid bodyweight loss was significantly lower in comparison with the values observed before bodyweight manipulation at angular velocities of 1.57 rad·s⁻¹ (by 6.7%) and 3.14 rad·s⁻¹ (by 10.2%). However, peak torque in relation to bodyweight remained unchanged at all three angular velocities tested. There was a significant decrease in total work (by 14.7%) accomplished during the whole 3-min muscle performance test. More importantly, the amount of total work was also significantly reduced (by 9.6%) in relation to bodyweight as a result of rapid weight loss.

Altogether, these data (Timpmann et al., 2008) suggest that a self-selected regimen of rapid bodyweight loss has a more pronounced detrimental effect on muscular endurance (absolute as well as relative reduction in the amount of total work performed during a 3-min muscle performance test) than on the ability to perform a single maximal effort (absolute but not relative reduction in peak torque of knee extensors) in experienced combat sports athletes.

Dietary interventions during recovery from rapid and moderate weight loss  In wrestling athletes are expected to weigh-in only once at the start of a competition. Official weigh-in takes place on the evening before a competition and athletes may have approximately 12-18 hours between weigh-in and the first match of a tournament.

Walberg Rankin et al. (1996) conducted a study with the aim to assess the dependence of physical performance on the content of food consumed during a short-term (5 hours) recovery period following rapid bodyweight loss. Their wrestlers lost ca 5% of their initial bodyweight within 72 hours consuming a low-calorie diet while avoiding dehydration. During the following 5-hour recovery period, the subjects consumed an isoenergetic diet containing either a high (75% of energy) or moderate (47% of energy) proportion of carbohydrates. The anaerobic performance of the subjects was tested on a hand-pedalled ergometer for three times: at normal weight (baseline), after bodyweight reduction, and after a 5-hour recovery period. Decreased performance was observed after bodyweight loss in comparison with baseline conditions. The wrestlers who were re-fed a low carbohydrate diet over 5 hours did not recover their performance to baseline levels, while those fed a high carbohydrate diet had a performance similar to the baseline after recovery. These data suggest that during short-term recovery from rapid bodyweight loss a high proportion of carbohydrates in a diet may promote normalization of physical performance in trained wrestlers.

The hypothesis that creatine ingestion together with carbohydrate supplementation during recovery period after rapid bodyweight reduction accelerates the restoration of bodyweight and physical performance in well-trained wrestlers was controlled in our study (Ööpik et al., 2002). The subjects reduced their bodyweight by 4.5 – 5.3% within 56 hours in two series of investigations separated by one month. The bodyweight loss was achieved by a gradual reduction of energy intake, maintaining a close to normal training load and using a mild sauna procedure. During the 17-hour recovery period after bodyweight loss, the subjects consumed a controlled isoenergetic diet.
supplemented with 320 g of glucose (glucose trial) or with 320 g of glucose plus 30 g of creatine monohydrate (glucose plus creatine trial). Muscle performance was tested three times in both trials: with normal bodyweight (baseline), after bodyweight loss and after 17 hours of recovery following bodyweight loss. The muscle performance test consisted of submaximal knee extensions at an angular velocity of 1.57 rad·s⁻¹ for 45 s at the rate of 30 contractions per minute followed by 15 s maximal efforts. The total duration of the test was 5 min in this study.

The amount of total work was smaller after rapid bodyweight loss in comparison with baseline values in both trials. At that, the decrease in the amount of total work was mainly induced by the fall in maximal work, i.e. the amount of work performed during the 15s periods of maximal effort. Comparing the amount of total work and especially that of maximal intensity work performed by the subjects during the 5-min muscle performance test after rapid bodyweight loss and after 17 hours of recovery following bodyweight loss revealed that muscle performance capacity was better restored in the glucose plus creatine trial than in the glucose trial. Indeed, the average increase in the amount of total work over 17 hours of recovery was only 3.6% in the glucose trial instead of 12.8% in the glucose plus creatine trial. Moreover, the average increase in the amount of maximal work over the same time period was 7.3% in the glucose trial and 19.2% in the glucose plus creatine trial. A strong positive correlation (r = 0.92) was observed between the whole body creatine retention during 17 hours of recovery and the extent of an increase in the amount of maximal work over the same period. More careful analysis of the muscle performance of the subjects revealed that there was a significant increase in the amount of maximal work over 17 hours of recovery during the 1ˢᵗ (by 13.8%), 2ʰ (by 16.1%) and 4ʰ (by 44.5%) minute of the test in the glucose plus creatine trial, while a much less pronounced and insignificant improvement was evident in the glucose trial.

Creatine ingestion has been shown to increase bodyweight supposedly by stimulating an increase in body water content (Burke et al., 2006). Green et al. (1996) demonstrated that the whole body as well as muscle creatine retention in humans was significantly increased when subjects ingested creatine together with carbohydrates and that the mean bodyweight gain was approximately 78% higher in the creatine plus carbohydrate trial in comparison with the creatine-only trial. Taking these facts into account and considering the rather short supplementation period, we expected to see an approximately 0.2 – 0.25 kg greater increase in bodyweight during 17 hours of recovery after rapid bodyweight loss in the glucose plus creatine trial in comparison with the glucose trial in our subjects. Faster bodyweight gain in this range could be considered an important factor having an impact on success in wrestling (Wroble and Moxley, 1998). However, the absolute as well as relative change in bodyweight during the recovery period was practically the same in the two trials.

Altogether, our data suggest that dietary creatine supplementation with concomitant glucose ingestion during 17 hours of recovery from rapid bodyweight loss enhances the rate of restoration of physical performance during maximal intensity efforts in well-trained wrestlers. The extent of the increase in physical performance during recovery from rapid bodyweight loss is correlated to the rate of whole body creatine retention but not to the rate of bodyweight restoration.

An important issue during recovery from rapid weight loss is rehydration. Recently we assessed urinary indices of hydration status of Greco-Roman wrestlers in an authentic pre-competition situation at the time of official weigh-in (Ööpik et al., 2013). Altogether 51 wrestlers out of 89 competing in the Estonian Championship in 2009 donated a urine sample for measuring urine specific gravity and osmolality. Questionnaire responses revealed that 27 wrestlers reduced bodyweight before the competition, whereas 24 wrestlers did not. In 42 wrestlers, values of urine specific gravity ≥ 1.020 and urine osmolality ≥ 700 mOsmol·kg⁻¹ revealed a hypohydrated status. The prevalence of hyphydration in the bodyweight losers (96.3%) was higher than in the rest of the wrestlers (66.7%; χ² = 7.68; p < 0.05). Serious hyphydration (urine specific gravity values > 1.030) was observed in 14 wrestlers and the prevalence of serious hyphydration was 5.3 times greater (χ² = 8.32; p < 0.05) in bodyweight losers than in non-bodyweight losers. The extent of bodyweight gain during 16 h recovery in bodyweight losers (2.5 ± 1.2 kg) was associated (r = 0.764; p < 0.05) with self-reported pre-competition bodyweight loss (4.3 ± 2.0 kg) and exceeded the bodyweight gain observed in non-bodyweight losers (0.7 ± 1.2 kg; p < 0.05).

Altogether, these data (Ööpik et al., 2013) reveal that hypohydration is prevalent among Greco-Roman wrestlers in authentic pre-competition conditions at the time of weigh-in. The prevalence of hypohydration and serious hypohydration is especially high among wrestlers who are used to reducing bodyweight before competition. These results suggest that an effective rehydration strategy is needed for Greco-Roman wrestlers.
Recovery of fluids lost due to dehydration may take 24-48 hours, i.e. much longer than is commonly appreciated by athletes and coaches (Walberg Rankin, 2006). The effectiveness of rehydration strongly depends on the volume and composition of fluids consumed. The volume of fluid needed for full rehydration may be 150% or even more of the volume of water lost through dehydration (Shirreffs et al., 1996). Rehydration occurs more rapidly if fluids consumed contain electrolytes, primarily sodium. Sodium maintains thirst drive, stimulates water absorption in the gut and improves water retention in the body. A sodium content of at least 50 mmol · L$^{-1}$ is considered optimal for a rehydration beverage (Shirreffs and Maughan, 2000). However, drinks with high sodium content (over 40 mmol · L$^{-1}$) are unpalatable to many people, which results in reduced consumption (Jeukendrup and Gleeson, 2004). According to current recommendations, athletes having less than 24 hours for recovery after weight loss should not lose more than 2% of their bodyweight through dehydration (Walberg Rankin, 2006).

A reduction in buffering capacity has been observed as a result of rapid bodyweight loss and this may induce a decrease in performance (Horswill et al., 1990). However, ingestion of sodium bicarbonate or sodium citrate has been shown to increase blood buffering capacity, to improve performance in different types of exercise (Requena et al., 2005), and to increase water retention, bodyweight and plasma volume (Ööpik et al., 2010). Therefore, sodium citrate ingestion after rapid bodyweight loss may be expected to facilitate rehydration, regaining normal body mass, plasma volume, buffering capacity, and physical performance. Moreover, dehydration concomitant with rapid bodyweight loss is a factor inducing affective disturbances (Landers et al., 2001; D’Anci et al., 2009). Hence, if sodium citrate use stimulates rehydration, it could also be expected to improve the affective state.

Therefore we recently conducted a study with aim to assess the effects of dietary sodium citrate supplementation during 16 h recovery from 5% rapid bodyweight loss on physiological functions, affective state and performance in trained wrestlers (Timpmann et al., 2012). Sixteen wrestlers performed an upper body intermittent sprint performance test in 3 conditions: before and after rapid bodyweight loss and following 16 h recovery. During recovery, the subjects ate a prescribed diet supplemented with sodium citrate (600 mg·kg$^{-1}$; CIT group) or placebo (PLC group) and drank water ad libitum. Rapid bodyweight loss reduced ($p < 0.05$) mean power in upper body intermittent sprint performance test and increased urine specific gravity. Reduction in mean power was associated with changes in plasma volume ($r = 0.649; p = 0.006$) and urine specific gravity ($r = -0.553; p = 0.026$). During 16 h recovery, increases in bodyweight and plasma volume were greater ($p < 0.05$) in CIT than in PLC group. Bodyweight gain was associated with water retention in CIT ($r = 0.899; p = 0.002$) but not in PLC group ($r = 0.335; p = 0.417$). Blood pH, HCO$_3^-$ concentration and base excess increased ($p < 0.05$) only in CIT group. Changes in upper body intermittent sprint performance, General Negative Affect and General Positive Affect did not differ in the two groups.

Altogether, these results (Timpmann et al., 2012) reveal that ingestion of sodium citrate increases blood buffering capacity and plasma volume and stimulates bodyweight regain during 16 h recovery from rapid bodyweight loss in trained wrestlers. However, sodium citrate does not improve upper body intermittent sprint performance nor does it have an impact on the affective state.

**SUMMARY**

Depending on the duration, distinction is made between rapid (i.e. within 24-72h), moderate (from 72h to several weeks) and gradual (from several weeks to months) bodyweight reduction. Rapid and moderate bodyweight loss by approximately 5% or more may impair physical performance capacity in well-trained wrestlers. Research data suggest that high carbohydrate intake as well as creatine supplementation with concomitant glucose ingestion promotes recovery of physical performance after rapid/moderate bodyweight loss. Recovery of fluids lost due to dehydration may take 24-48 hours, i.e. much longer than is commonly appreciated by athletes and coaches. Therefore, athletes who have less than 24 hours for recovery after weight loss should not lose more than 2% of their bodyweight through dehydration. Rehydration occurs more rapidly if fluids consumed contain electrolytes, primarily sodium. Dietary sodium citrate supplementation during recovery after rapid bodyweight loss increases blood buffering capacity and plasma volume and stimulates bodyweight regain in trained wrestlers.

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