

Original Article

# Effects of self-selected dehydration and meaningful rehydration on anaerobic power and heart rate recovery of elite wrestlers

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**Abstract.** [Purpose] This study aimed to verify the effects of self-directed weight loss on lower- and upper-body power, fatigue index, and heart rate recovery immediately before a meaningful competition (12 hours of recovery). In addition, this study tested the hypothesis that weight loss provides advantages in strength and power, as the relative power of the wrestlers is higher than that of opponents in the same weight class who do not reduce weight. [Subjects and Methods] Eleven well-trained wrestlers volunteered for the study. At baseline, their mean  $\pm$  SD age, body mass, and height were  $20.45 \pm 2.69$  years,  $74.36 \pm 9.22$  kg, and  $177 \pm 5.71$  cm, respectively. Repeated-measures one-way analysis of variance was performed to analyze differences. [Results] Rapid weight loss achieved by restriction of energy and fluid intake resulted in exercise-impaired decreases in peak power and increased fatigue index. Moreover, weight loss by dehydration negatively affected cardiovascular stability. [Conclusion] Most of the negative effects of rapid weight loss disappear after a 12-hour recovery period, and relative peak power increases after weight loss.

**Key words:** Power, Dehydration, Rehydration and recovery

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## INTRODUCTION

Anaerobic exercise capacity is defined as the capacity to supply the energy necessary for muscle contraction<sup>1)</sup>. Anaerobic activity causes fatigue because of lactic acid accumulation. Accordingly, the ability to rapidly remove accumulated lactic acid can enhance performance and reduce the risk of injury<sup>2)</sup>. Furthermore, heart rate recovery is a controversial issue, and obesity level could impact heart rate recovery<sup>3)</sup>. Dehydration amplifies stresses on the body, such as fatigue and heart rate. Intense competition periods often prompt wrestlers to reduce mass or “cut weight”. The main goal of accelerated weight loss is to gain advantages of strength and power over opponents in the same weight class who do not reduce weight<sup>4)</sup>. Rapid weight loss is usually performed in 1 week and generally entails dehydration<sup>5)</sup>. Wrestlers generally attempt to lose weight quickly through a combination of vigorous exercise, fluid intake limitation, and sweating during the days preceding a scheduled competition<sup>6, 7)</sup>. Although several organizations including the American College of Sports Medicine recommend avoiding rapid weight loss (RWL), many wrestlers do so 24–48 hours

prior to competitions because of tradition. Sadly, this practice has even reached children’s sports<sup>8)</sup>.

The adverse effects of dehydration on endurance are well established<sup>9)</sup>. A reduction of body weight exceeding 2% harms physical performance in various aerobic sports activities<sup>9–12)</sup>; nevertheless, the effects of dehydration on short-term high-intensity activities remain unclear. Wrestlers and other weight-regulated athletes might also experience decreased power<sup>13, 14, 18)</sup> due to RWL, although this remains controversial<sup>19–21)</sup>.

The procedures used by athletes for achieving RWL may induce dehydration, increased load on the cardiovascular system, impairment of the thermoregulatory system, depletion of glycogen stores, hypoglycemia, and losses of body protein, electrolytes, and vitamins<sup>6, 16)</sup>. Decreased total body water and plasma volume decrease sweating rate and skin blood flow, which can lead to increased core temperature. Sweating also reduces blood volume; in turn, this decreases the stroke volume of the heart, which consequently increases heart rate in order to maintain cardiac output to meet the demands of exercise<sup>22)</sup>. Sweat contains electrolytes (including sodium, potassium, and chloride); accordingly, sweat loss through dehydration may also lead to a significant loss of electrolytes, which may interfere with muscular contractions and thus strength and power output<sup>21, 22)</sup>.

In wrestling, there is usually 12–18 hours between weigh-in and the first match of a tournament. However, most studies use a recovery time  $\leq 5$  hours prior to performance testing<sup>13–21)</sup>. In addition, most investigations have not gathered data immediately prior to competition; thus,

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**Table 1.** Peak power, relative power, and fatigue index values before and after RWL and after 2 hours of recovery

Variable	Baseline (mean±SD)	RWL (mean±SD)	Recovery (12h) (mean±SD)
Leg			
Peak power	864.7±85.7	824.4±96.6	851.5±76.9
Relative power	10.7±1.1	11.1±.9	10.6±1.1
Fatigue index (%)	55.6±4.4	60.6±5.0	55.7±4.5
Arm			
Peak power	601.1±104.7	508.9±115.9	592.0±96.0
Relative power	7.4±1.4	7.5±1.4	7.4±1.4
Fatigue index (%)	64.9±7.6	71.0±8.2	65.2±7.1

RWL: rapid weight loss

much of the literature on this issue is not generalizable to real situations. Accordingly, few studies have determined the comprehensive effects of RWL on the real-life condition of wrestlers. Moreover, in many studies, the subjects were permitted to cut weight by using rubber suits, saunas, and diuretics. Therefore, this study aimed to (1) verify the effects of self-directed weight loss on lower- and upper-body power, fatigue index, and heart rate recovery immediately before a meaningful competition, allowing 12 hours of recovery; (2) determine if RWL provides advantages in strength and power, because the relative power of wrestlers would be higher than that of opponents in the same weight class who do not reduce weight; and (3) determine if the heart rate of wrestlers recover after 12 hours of rehydration.

### SUBJECTS AND METHODS

Eleven well-trained wrestlers volunteered for this study, and the university's ethics committee approved study protocol. The subjects signed an informed consent form to participate in the study. At baseline, the subjects' mean ± SD age, body mass, and height were 20.45 ± 2.69 years, 74.36 ± 9.22 kg, and 177 ± 5.71 cm, respectively. They had been involved in wrestling for a mean of 9.2 ± 2.8 years. The study was completed during the first half of the tournament period. The study aim and procedures were described to each participant. All procedures conformed to the Declaration of Helsinki as revised in 2008.

Body mass was recorded at baseline. The subjects were then instructed to decrease their body weight by 4–5% for the second weighing on day 4. The wrestlers were allowed to choose their own weight loss techniques according to experience. The Wingate anaerobic test for legs and arms was performed three times: on day 1 before RWL (test 1) with the wrestlers at their natural body weight, on day 4 after RWL (test 2), and after 12 hours of recovery (test 3). The heart rates of subjects were recorded before and after each test. A practice trial was performed, and the results were excluded from analysis. Each Wingate test was performed on a cycle ergometer (Monark Ergomedic 828E, Sweden) as described previously<sup>23</sup>.

The data were analyzed by SPSS version 22.0. All data are expressed as mean ± SD. The distribution of the data was

tested by the Shapiro-Wilk test. One-way repeated-measures analysis of variance (ANOVA) was used to determine differences among values before and after RWL, and after 12 hours of recovery. The level of statistical significance was set at  $p < 0.05$ . ANOVA assumes all physiological data are normally distributed. Accordingly, the rest of the data were normally distributed. However, ANOVA is considered robust against minor violations of this assumption<sup>24</sup>. The assumption of sphericity was assessed by the test of sphericity; any violations were adjusted for by using the Greenhouse-Geisser correction.

### RESULTS

The subjects reduced their body mass by  $5.03 \pm 1.01\%$  (from  $79.3 \pm 9.7$  to  $75.3 \pm 9.2$  kg) within 3 days. RWL was achieved by continuous reduction of food and fluid intake. The subjects followed their regular exercise schedule throughout the weight loss period.

The results of anaerobic power measurements of the lower body are shown in Table 1. Repeated-measures ANOVA with a Greenhouse-Geisser correction determined that the lower-body peak power of the wrestlers differed significantly between time points ( $F_{(1.229, 12.291)} = 9.588$ ,  $p < 0.007$ ). The Bonferroni post hoc test revealed that RWL significantly reduced peak power from baseline to RWL ( $p = 0.012$ ). However, peak power returned to baseline after 12 hours of recovery ( $p < 0.324$ ). Greenhouse-Geisser correction also showed that lower-body relative peak power did not differ significantly among time points ( $F_{(1.074, 10.743)} = 2.028$ ,  $p = 0.158$ ). The fatigue index differed significantly among time points ( $F_{(1.074, 10.744)} = 22.056$ ,  $p = 0.01$ ); the fatigue index increased significantly after RWL ( $p = 0.002$ ) but returned to baseline after 12 hours of recovery ( $p = 0.07$ ).

The results of anaerobic power measurements of the upper body are shown in Table 1. Upper-body relative power did not differ significantly among time points ( $F_{(1.006, 10.057)} = 3.305$ ,  $p = 0.099$ ). Relative peak power increased significantly after RWL ( $p = 0.025$ ) and it was still higher after the recovery period, although the difference was not significant ( $p = 0.521$ ). The fatigue index for the upper body increased significantly insignificantly after RWL ( $p = 0.115$ ) but returned to baseline after 12 hours of recovery.

**Table 2.** Heart rate recovery of wrestlers

	Heart rate (beats/min)		
	Before RWL	68.0 ± 1.4	82.0 ± 4.1
After RWL	169.4 ± 6.9	176.2 ± 4.0	170.0 ± 4.8

RWL: rapid weight loss

The heart rates of the wrestlers differed significantly among time points ( $F_{(1,818, 18,182)} = 2014.646, p < 0.000$ ). Bonferroni post hoc correction showed that RWL significantly increased heart rate before RWL ( $p = 0.000$ ) but not after RWL ( $p = 0.491$ ). However, heart rate returned to baseline after 12 hours of recovery (Table 2).

## DISCUSSION

Wrestling requires high anaerobic power and moderate aerobic power<sup>9</sup>). Weight loss exceeding approximately 1 kg per week must involve dehydration and/or fasting; this type of weight loss is most damaging to the body<sup>6</sup>). Many studies involved an insufficient recovery period before performance testing; wrestling competitions start at least 12 hours after weigh-in. This study is the first to test performance after 12 hours of recovery. Wrestlers' relative peak power, heart rate recovery, and anaerobic power were assessed after RWL and the recovery period.

The main hypothesis of this study was that self-directed weight loss affects lower- and upper-body power and fatigue. The primary findings of this study are that RWL (1) significantly decreased lower-body power; (2) increased upper- and lower-body fatigue; and (3) did not significantly change upper-body peak power, or lower- or upper-body relative peak power. No significant reductions in power were observed after 12 hours of self-directed recovery, although peak power and fatigue index values tended to indicate negative effects on performance. It is difficult to compare studies, because the results of the few studies on the effects of RWL on anaerobic power are inconsistent<sup>13, 21</sup>). A recent study<sup>7</sup>) suggests that self-selected RWL does not significantly affect the Wingate test or grip strength performance, although peak power and fatigue index slightly decreased and increased, respectively, after 10 days of 5% body weight loss. However, that study did not employ RWL methods like those in the present study. Kraemer et al.<sup>25</sup>) investigated the physiological and performance effects of typical weight loss techniques used by amateur wrestlers in a simulated freestyle wrestling tournament; 12 Division I collegiate wrestlers lost 6% of their total body weight during the week prior to a simulated 2-day freestyle wrestling tournament. As a result, lower-body power decreased significantly as the tournament progressed. While vertical jump power was unaffected at the time of the first prematch test on day 1 of the tournament, it had decreased significantly in the weight loss group by the first prematch test on day 2<sup>25</sup>). Others studies report that RWL decreased power<sup>13, 18</sup>) or does not change power<sup>19, 21</sup>). The discrepant results regarding the effects of RWL may be due to several factors including different performance tests, different recovery durations after RWL, and the amount of weight loss.

In the present study, the decrease in lower-body peak power after RWL was accompanied by increased lower-body fatigue index. Muscle fatigue is defined as a reduction in the maximum capacity of a muscle to generate force<sup>26</sup>). The stresses on the cardiovascular, thermoregulatory, metabolic, nervous, and endocrine systems to maintain such extreme responses during competition are certainly very challenging, especially if athletes must cope with the concurrent stresses of dehydration and hyperthermia. Therefore, dehydration and simultaneous hyperthermia can lead to early fatigue<sup>27</sup>). In the present study, RWL affected the fatigue index, which remained elevated, albeit not significantly, after 12 hours of recovery. Other studies also report that prematch fatigue after dehydration increases throughout the tournament, suggesting that optimal recovery does not occur overnight<sup>26</sup>).

One of the most interesting findings of the present study is the effect of RWL on the relative peak power of wrestlers. As mentioned above, this study determined if RWL provides advantages in strength and power, because the relative power of the wrestlers would be higher than that of opponents in the same weight class who do not reduce weight. It was speculated that RWL might increase power by improving power on a pound-for-pound basis<sup>3, 4</sup>). The results show that the lower-body relative peak power of the wrestlers did not differ significantly among time points, although there was an increasing trend after RWL; however, upper-body relative peak power increased significantly after RWL and was still higher after the recovery period, although not significantly higher. This implies that RWL does not reduce the relative power of wrestlers; conversely, it benefited the wrestlers by augmenting relative power after RWL and 12 hours of recovery.

As expected, heart rate was higher at rest and after recovery because of the RWL. The cardiovascular system plays a very important role during wrestling, and even mild dehydration stresses the bodies of wrestlers. Heart rate increases during submaximal exercise may be an indicator of hard training, water loss, and diminishing training effectiveness<sup>27</sup>). Other studies report similar findings. Heart rate is reported to increase more after dehydration<sup>28</sup>) when weight loss is accomplished over 48 hours by liquid and food limitations as well as alternating exercise. Meanwhile, Aghai et al.<sup>29</sup>) reported that heart rate was higher at rest and after 15 minutes of recovery in subjects during a dehydration trial than during a control trial. These results indicate weight loss via dehydration negatively affects cardiovascular stability. Such effects may interrupt the recovery of wrestlers during rest periods during competitions, consequently diminishing their performance.

In conclusion, self-directed RWL achieved through restriction of energy and fluid intake as well as increased exercise decreases peak power and increases fatigue in wrestlers. Moreover, weight loss via dehydration negatively affects cardiovascular stability. However, most of the negative effects of RWL disappear after 12 hours of recovery, and relative peak power increases after weight loss. Sports facilitators should consider this information not only when preparing athletes for competition, but also when formulating plans to continue wrestlers' development.

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