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Research article

Acute effects of self-selected regimen of rapid body mass loss in combat sports athletes

Saima Timpmann, Vahur Ööpik ✉, Mati Pääsuke, Luule Medijainen and Jaan Ereline
Institute of Exercise Biology and Physiotherapy, Centre of Behavioural and Health Sciences, University of Tartu, Tartu, Estonia

Abstract
The purpose of the study was to assess the acute effects of the self-selected regimen of rapid body mass loss (RBML) on muscle performance and metabolic response to exercise in combat sports athletes. Seventeen male athletes (20.8 ± 1.0 years; mean ± SD) reduced their body mass by 5.1 ± 1.1% within 3 days. The RBML was achieved by a gradual reduction of energy and fluid intake and mild sauna procedures. A battery of tests was performed before (Test 1) and immediately after (Test 2) RBML. The test battery included the measurement of the peak torque of knee extensors for three different speeds, assessment of total work (Wtot) performed during a 3-min intermittent intensity knee extension exercise and measurements of blood metabolites (ammonia, lactate, glucose and urea). Absolute peak torque was lower in Test 2 compared with Test 1 at angular velocities of 1.57 rad·s^{-1} (218.6 ± 40.9 vs. 234.4 ± 42.2 N·m; $p = 0.013$) and 3.14 rad·s^{-1} (100.3 ± 27.8 vs. 111.7 ± 26.2 N·m; $p = 0.008$). The peak torque in relation to body mass remained unchanged for any speed. Absolute Wtot was lower in Test 2 compared with Test 1 (6359 ± 2326 vs. 7452 ± 3080 J; $p = 0.003$) as well as Wtot in relation to body mass (89.1 ± 29.9 vs. 98.6 ± 36.4 J·kg^{-1}; $p = 0.034$), respectively. As a result of RBML, plasma urea concentration increased from 4.9 to 5.9 mmol·l^{-1} ($p = 0.003$). The concentration of ammonia in a post-test sample in Test 2 tended to be higher in comparison with Test 1 (80.9 ± 29.1 vs. 67.6 ± 26.5 mmol·l^{-1}; $p = 0.082$). The plasma lactate and glucose responses to exercise were similar in Test 1 and Test 2. We conclude that the self-selected regimen of RBML impairs muscle performance in 3-min intermittent intensity exercise and induces an increase in blood urea concentration in experienced male combat sports athletes.

Key words: Wrestlers, karatekas, muscular endurance, peak torque, ammonia, urea.

Introduction

The popularity of wrestling and other combat sports largely results from the weight class system, which provides opportunities for athletes of all body sizes to be competitive and successful. However, many athletes (Horswill, 1992; Kiningham and Gorenflo, 2001) involved in weight category sports seem to believe that it is necessary to qualify for the lowest weight class possible in order to gain a competitive advantage. The desire to be at a low weight has led to the common practice of reducing body mass in a short time period before a competition (Brownell et al., 1987; Kiningham and Gorenflo, 2001; Wilmore, 2000). Unfortunately, this practice has even reached children's sports (Sansone and Sawyer, 2005).

The methods used by athletes for achieving rapid body mass loss (RBML) may cause dehydration, an increased load on the cardiovascular system, impairment of the thermo-regulatory system, depletion of glycogen stores, hypoglycemia and loss of body protein, electrolytes and vitamins (Horswill, 1992; Oppliger et al., 1996; Wilmore, 2000). Several studies have revealed the negative impact of RBML on performance (Ööpik et al., 2002a; Rankin et al., 1996; Umeda et al., 2004; Webster et al., 1990). However, the results of other studies have shown there are some performance characteristics that do not change (Fogelholm et al., 1993; Greiwe et al., 1998; Kraemer et al., 2001; Serfass et al., 1984) or even improve (Ahlman and Karvonen, 1961).

The discrepancy in existing data on the performance effects of RBML is caused by numerous factors. Different performance tests have been employed in different studies (Ahlman and Karvonen, 1961; Fogelholm et al., 1993; Rankin et al., 1996). The duration of the recovery period allowed between RBML and the measurement of performance have varied (Ahlman and Karvonen, 1961; Fogelholm et al., 1993; Webster et al., 1990). In addition, the methods used for inducing RBML (Ahlman and Karvonen, 1961; Serfass et al., 1984; Webster et al., 1990) and the extent of the body mass loss achieved (Ahlman and Karvonen, 1961; Fogelholm et al., 1993; Umeda et al., 2004; Webster et al., 1990) have differed. It has been shown that the diet consumed during RBML (Horswill et al., 1990a; McMurray et al., 1991) and recovery (Rankin et al., 1996) has an influence on metabolism and performance. Therefore, it is difficult to come to a universal conclusion on the acute effects of RBML on performance in combat sports athletes. Moreover, the methods used for inducing RBML were in many cases prescribed by researchers, not chosen by the subjects, in the above-mentioned studies. Hence, the results of these 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 RBML they were accustomed to and had regularly practiced.

Proceeding from the above, the main goal of the present study was to assess the acute effects of the self-selected regimen of RBML on muscle performance and metabolic response to 3-min intermittent intensity exercise in experienced male combat sports athletes.

Methods

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Subjects

Seventeen healthy well-trained male combat sports athletes (12 wrestlers and 5 karatekas) volunteered for the study, the protocol of which was approved by the university's Ethics Committee. The subjects gave their informed written consent for participation in the study. At the beginning of the study, their mean (± SD) age, body mass and height were 20.8 ± 1.0 years, 74.3 ± 6.6 kg and 1.79 ± 0.05 m, respectively. They had been involved in regular combat sports training for 7.3 ± 3.3 years. They were used to reducing their body mass for competitions 4-7 times during a competition period. Their typical pre-competition body mass loss was in the range of 4-6%. The study was carried out during the second half of the competition period.

Study protocol

The subjects reported to the laboratory at 16:00 on Day 1 (in a 3-hour postabsorptive state). Their body mass was recorded and they were asked to reduce their body mass by 5% for the second weighing at 16:00 on Day 4. The techniques for reducing body mass were chosen by the subjects themselves according to their previous experience. However, they were instructed not to use pharmacological agents and to keep a detailed food and training diary during the period of RBML. The energy intake of the subjects during a normal training week was recorded by 7-day weighing-based food diaries two weeks before the beginning of the study.

Muscle performance was tested twice: on Day 1 before RBML (Test 1) with the subjects in their normal body mass and on Day 4 after RBML (Test 2) with the same subjects in reduced body mass.

Muscle performance tests

An isokinetic dynamometer of type Cybex II was used to determine the peak torque of the knee extensor muscles and to perform a muscle endurance test using an intermittent intensity exercise regimen. The details concerning the performance test as well as the calibration procedure of the dynamometer prior to testing each subject have been described in Ööpik et al. (1998).

The subjects performed their usual warm-up routine before each test trial. There were two tests performed on the Cybex II isokinetic dynamometer. Firstly, the subjects performed maximal knee extension at angular velocities of 1.57, 3.14 and 4.71 rad·s^{-1}. Three attempts were made at each velocity with a period of 10 s between successive extensions and a 1-min rest between each test velocity. The peak torque was measured during each contraction; the best result of the three attempts at each velocity was recorded.

Following a 5 min rest period at the end of the peak torque measurements, the muscle endurance test was performed. A special test was used simulating combat sports activity (by overall duration and intermittent intensity of work). The test consisted of submaximal knee extensions at 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. The following variables were measured: submaximal work (Wsmax) (i.e. the work performed during each 45 s period of submaximal extensions), maximal work (Wmax) (the work performed during each 15 s period of maximal extensions), and total work (Wtot) (sum of Wsmax and Wmax).

To avoid the possible effect of learning, the subjects were accustomed to the test procedures by performing two to three trials at least a week before the start of the study. Our previous research on 16 well-trained subjects has revealed that the variables measured in the muscle endurance test remain stable in experienced combat sports athletes during a 5-day normal training period without dietary and body mass manipulations (Ööpik et al., 2002b). Based on this observation and taking into account the invasive nature of the procedures employed, a control group was not included in the present study.

Biochemical analyses

Pre- and post-test blood samples (4.5 ml) were drawn from a median cubital vein. Participants were seated for at least 5 min prior to the procedure. To facilitate the sampling procedure, a tourniquet was used for a few seconds prior to insertion of the needle. Pre-test blood was drawn after a warm-up and a post-test sample was obtained 5 min after the cessation of the muscle endurance test.

The ethylenediamine tetra-acetic acid (EDTA) treated blood sample was used for the measurement of haemoglobin concentration (cyanmethaemoglobin method) and packed cell volume (by spun haematocrit). The values obtained were used to calculate changes in plasma volume (Dill and Costill, 1974).

The remaining blood was immediately cooled by placing the Vacutainer tubes into ice-cold water and centrifuged thereafter. The concentration of ammonia in plasma was always measured within 1.5 hrs after drawing the blood using the Reanal Finechemical Co (Hungary) diagnostic kit No 03931-2-99-80. The remaining plasma was stored at –25 °C until the analyses of other metabolites were performed using diagnostic kits purchased from Biocon (Germany): No 301 (lactate) and No 4342 (glucose) or from Roche Diagnostics GmbH (Germany) No 777510 (urea). The intra-assay coefficient of the variation for ammonia, lactate, glucose and urea in our laboratory is 2.7%, 1.0%, 1.2% and 1.0%, respectively (n = 10). Each sample was analysed in duplicate.

Statistical analysis

All data are expressed in mean (± SD). The distribution pattern of the data was tested using a one-sample Kolmogorov-Smirnov test. A one-way analysis of variance (ANOVA) for repeated measures was applied to identify differences between values measured before and after RBML. The dependent t-test was used to locate differences between the means. Statistical significance was set at $p < 0.05$ while the p values < 0.1 are reported to indicate trends. The Pearson product-moment correlation coefficients were computed to determine the relationship between variables. Statistical power analysis was used for non-significant outcomes.

Results

On average, the subjects reduced their body mass by 5.1 ±

1.1% (from 74.3 ± 6.6 kg to 70.6 ± 6.5 kg; $p < 0.0001$) within three days. The reports of the subjects revealed that the RBML was achieved by a gradual reduction of energy and fluid intake and mild sauna procedures. The latter was employed only during the last 24 hours of the period given for body mass reduction. The subjects followed their usual training schedule during the RBML period spending 1.5 – 2 hours per day in technical drill, training matches and developing sports specific physical abilities.

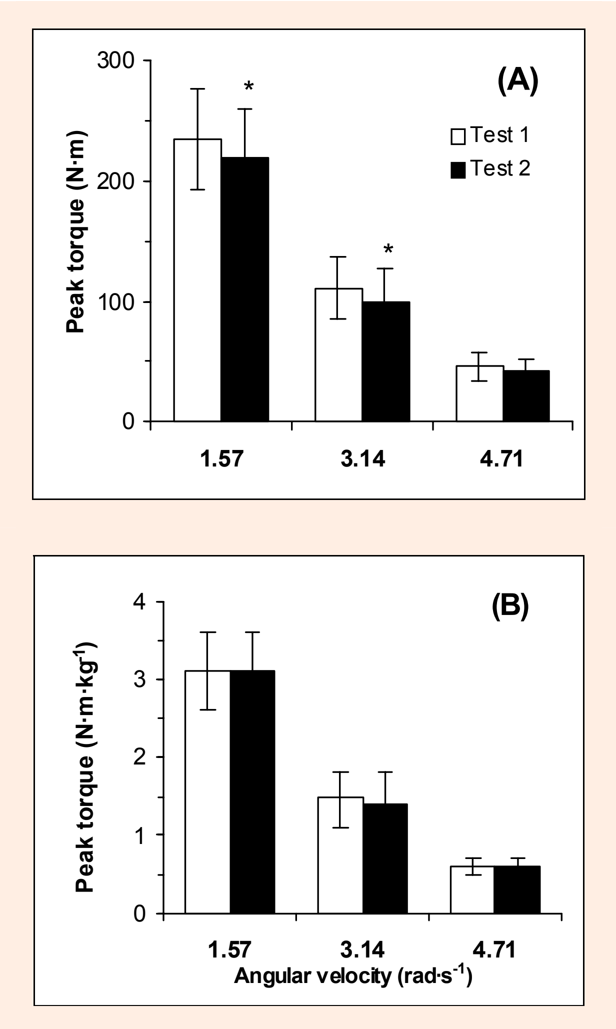

Figure 1. Peak torque (A) and relative peak torque (B) of knee extensor muscle measured before (Test 1) and after (Test 2) rapid body mass loss. Data are means (SD).
* Significantly different ($p < 0.05$) from corresponding value in Test 1.

Analysis of nutritional data (using Micro-Nutrica 2.0 software) revealed that the mean daily energy intake of the subjects during a normal training week was 10019 ± 978 kJ (2397 ± 234 kcal) and the fluid intake 2029 ± 456 ml. The energy intake during the RBML period decreased from 6376 ± 3281 kJ (1525 ± 785 kcal) consumed during the first day to 4759 ± 3243 kJ (1139 ± 776 kcal) and 861 ± 714 kJ (206 ± 171 kcal) consumed during the second and third day, respectively. The energy intake during the last day of RBML was significantly lower in comparison with the first ($p = 0.001$) and the second ($p = 0.003$) day. On average, fats, proteins and carbohydrates made up 31.4 ± 9.5%, 13.3 ± 4.8% and 55.3 ± 10.8%, respectively, of the total calories consumed by the subjects during the RBML period. The amount of proteins consumed by the subjects during the first, second and third day of RBML period in relation to initial body mass was 0.67 ± 0.37 $g \cdot kg^{-1}$, 0.52 ± 0.43 $g \cdot kg^{-1}$ and 0.11 ± 0.17 $g \cdot kg^{-1}$ and that of carbohydrates 2.66 ± 1.43 $g \cdot kg^{-1}$, 2.09 ± 1.14 $g \cdot kg^{-1}$ and 0.45 ± 0.40 $g \cdot kg^{-1}$, respectively. The total amount of water administered with drinks and food was 1280 ± 733 ml, 1160 ± 602 ml and 316 ± 256 ml during the first, second and third day, respectively. The amount of water consumed during the last day of RBML was significantly lower in comparison with the first ($p = 0.001$) and the second ($p = 0.002$) day.

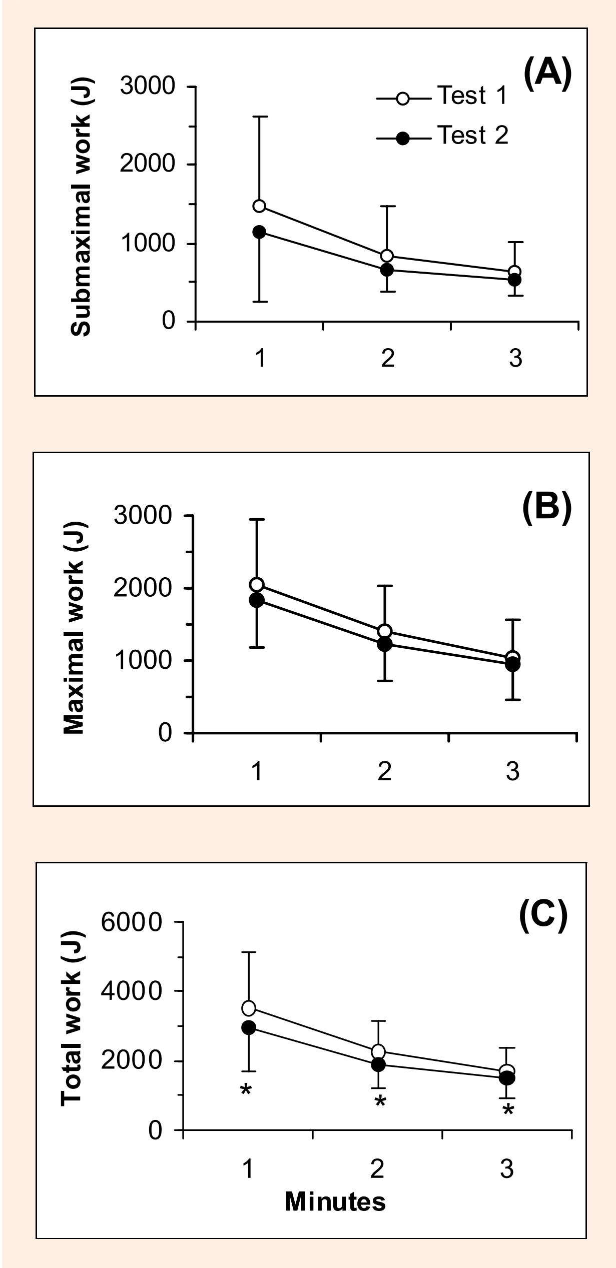

Figure 2. Submaximal (A), maximal (B) and total (C) work performed during each minute of the muscle endurance test before (Test 1) and after (Test 2) rapid body mass loss. Data are means (SD). * Significantly different ($p < 0.05$) from corresponding value in Test 1.

The results of peak torque measurements of the knee extensor muscles are given in Figure 1A. Peak torque measured after RBML was significantly lower in comparison with the values in Test 1 at angular velocities of 1.57 rad·s^{-1} (6.7%; $p = 0.013$) and 3.14 rad·s^{-1} (10.2%; $p = 0.008$). An explicit trend towards a lower value (6.5%; $p = 0.074$; statistical power = 0.13) was evident at angular velocity of 4.71 rad·s^{-1} (Figure 1A). However, peak torque in relation to body mass remained unchanged at all three angular velocities tested (Figure 1B).

The quantity of Wsmax and Wmax performed by the subjects during each minute of the muscle endurance test was not statistically different (range of statistical power 0.12-0.18) before and after RBML (Figure 2A,B). However, the quantity of Wtot was significantly lower after RBML in comparison with the value in Test 1 by 15.6% ($p = 0.022$), 15.8% ($p = 0.002$) and 11.2% ($p = 0.011$) during the 1st, 2nd and 3rd minute, respectively (Figure 2C).

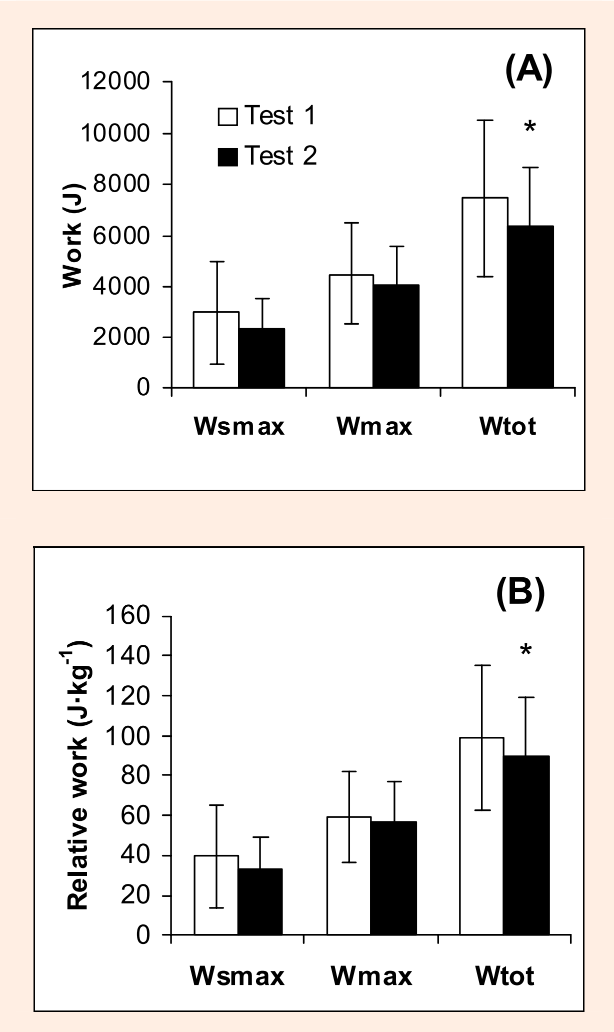

Figure 3. Submaximal (Wsmax), maximal (Wmax) and total (Wtot) work (A) and relative work (B) performed during the whole 3-min muscle endurance test before (Test 1) and after (Test 2) rapid body mass loss. Data are means (SD). * Significantly different ($p < 0.05$) from corresponding value in Test 1.

Similarly, there was a significant decrease in Wtot (14.7%; $p = 0.003$) accomplished during the whole 3-min muscle endurance test (Figure 3A), whereas merely a tendency towards a lower value was evident in respect of Wmax (10.6%; $p = 0.097$; statistical power = 0.12). Wtot was also significantly reduced (9.6%; $p = 0.034$) in relation to body mass (Figure 3B).

Pooling the data obtained before and after RBML revealed a significant relationship between body mass and absolute peak torque at angular velocities of 1.57 rad·s^{-1} ($r = 0.604$; $p < 0.001$), 3.14 rad·s^{-1} ($r = 0.550$; $p = 0.001$) and 4.71 rad·s^{-1} ($r = 0.613$; $p < 0.001$). In addition to that, body mass was significantly related to Wtot ($r = 0.656$; $p < 0.001$), Wtot in relation to body mass ($r = 0.490$; $p = 0.003$), Wmax ($r = 0.645$; $p < 0.001$), Wmax in relation to body mass ($r = 0.476$; $p = 0.004$) and Wsmax ($r = 0.392$; $p = 0.022$). However, the relationships between the change in body mass and the changes in the indices of peak torque, Wtot, Wmax and Wsmax during the RBML did not reach statistical significance.

Both haemoglobin concentration and haematocrit increased from the pre- to post-performance test samples in Test 1 and Test 2 (Table 1). A significant increase was observed in haemoglobin concentration ($p = 0.0008$) and haematocrit ($p = 0.0008$) as a result of RBML (Table 1).

RBML caused an average 6.0 ± 4.4% decrease in plasma volume. The decrease in plasma volume as a result of the performance tests was similar in Test 1 and Test 2 (Table 1).

The concentration of ammonia in the blood plasma of the subjects increased significantly ($p < 0.001$) as a result of the performance tests before as well as after RBML (Table 1). The concentration of ammonia in post-test blood in Test 2 tended to be higher in comparison with Test 1 (19.6%; $p = 0.082$; statistical power = 0.27).

There was a significant increase ($p < 0.001$) in the concentration of lactate in the blood plasma of the subjects induced by the performance tests on both occasions, before and after RBML (Table 1). The absolute plasma lactate concentration as well as the extent of change during the performance tests was similar in different body mass conditions (Table 1).

There was no effect of the performance tests or body mass status on the concentration of glucose in the blood plasma of the subjects (Table 1). There was no effect of the performance tests on plasma urea concentration (Table 1). However, a pronounced increase of the level of urea (20.4%; $p = 0.003$) was evident as a result of RBML (Table 1).

Discussion

The net loss of body water is considered to be the main mechanism through which RBML is achieved within a limited time period (Wilmore, 2000). Considering the methods used by our subjects for body mass manipulation, it is evident that dehydration was induced mainly by restricted fluid intake and stimulated water loss through sweating. Dehydration was reflected in a 6.0% decrease in plasma volume. Previous studies have shown that physical performance capacity in high intensity exercise may be significantly impaired even at low (1.8-2%) levels of dehydration (Burge et al., 1993; Walsh et al., 1994).

The nutritional data of our subjects show that in addition to the overall food energy consumption, the carbohydrate intake was also very low during the RBML

Table 1. Changes in biochemical parameters and plasma volume during performance tests before (Test 1) and after (Test 2) rapid body mass loss. Data are means (SD).

Metabolite	Test 1		Test 2	
	Pre 1	Post 1	Pre 2	Post 2
Ammonia (µmol·l^{-1})	20.3 (10.0)	67.6 (26.5)*	19.6 (9.7)	80.9 (29.1) *
Lactate (mmol·l^{-1})	1.8 (0.7)	6.9 (1.9) *	1.6 (0.8)	6.9 (2.2) *
Glucose (mmol·l^{-1})	4.1 (0.7)	3.9 (0.9)	4.0 (0.9)	3.9 (0.9)
Urea (mmol·l^{-1})	4.9 (0.8)	4.9 (0.8)	5.9 (1.2) †	5.9 (1.1) †
Haematocrit (%)	42.9 (2.5)	44.7 (3.0) *	44.8 (2.0) †	46.0 (2.7) * †
Haemoglobin (g·100 ml^{-1})	14.0 (0.9)	14.5 (1.1) *	14.4 (0.9) †	15.0 (1.1) * †
Change in plasma volume (%)	–6.6 (4.4)		–5.6 (3.8)	

Pre = before and Post = after performance test blood sample.
Significantly different ($p < 0.05$): * from corresponding Pre value; † from corresponding value in Test 1.

period. The effect of RBML on the glycogen content in skeletal muscles using the direct method (biopsy sample analysis) has only been assessed in few studies. The results show that RBML by 5-8% may be accompanied by a significant decrease (36-54%) in muscle glycogen concentration (Burge et al., 1993; Houston et al., 1981; Tarnopolsky et al., 1996). Hence, although muscle glycogen was not measured in the present study, the glycogen stores in our subjects were likely reduced as a result of restricted carbohydrate consumption during RBML and this could contribute to a decrease in muscle endurance capacity in intermittent intensity exercise.

The main finding of the present study was a significant reduction in Wtot performed during the 3-min muscle endurance test after RBML in comparison with the value in Test 1. At that, Wtot was not only reduced in absolute terms but also when the results were expressed per kilogram of body mass. There was also a significant reduction in peak torque of the knee extensor muscles at lower angular velocities as a result of RBML when expressed in absolute terms. On the other hand, the peak torque in relation to body mass was unchanged at all angular velocities tested. Altogether, these data suggest that the self-selected regimen of RBML has a more pronounced detrimental effect on muscle endurance capacity (absolute as well as relative reduction in Wtot) than on the ability to perform a single maximal effort (absolute but not relative reduction in peak torque).

The decrease in Wtot observed in the present study is in accordance with the data published by other researchers (Hickner et al., 1991; Rankin et al., 1996). Both Hickner et al. (1991) and Rankin et al. (1996) employed an intermittent, intense arm ergometer test of 6 and 5 min duration, respectively. The total duration of the muscle endurance test used in the present study was only 3 min. Thus, our finding extends the current knowledge about the effects of RBML demonstrating that it reduces physical performance capacity even during short periods of high intensity exercise. Consequently, the recent changes of the rules in wrestling, including shortening of the duration of a match, have not reduced the likelihood of the occurrence of a negative impact of RBML on wrestlers` physical performance capacity.

A tendency towards lower working capacity after 4.3% RBML was evident in karatekas (Ööpik et al., 1998). In two other experiments, the extent of body mass loss was 3.3% (Rankin et al., 1996) and 4.6% (Hickner et al., 1991) and the corresponding reduction in performance was 3.3% (Hickner et al., 1991) and 7.6% (Rankin et al., 1996). The data presented in this paper together with the data from Hickner et al. (1991) and Rankin et al. (1996) strongly suggest that RBML in the range of 3.3 – 5.1% impairs upper body as well as lower body muscle function during intermittent intensity exercise in combat sports athletes. However, it should be taken into account that the mean initial body mass of the subjects studied was 70.0 ± 3.3 kg (n = 6) (Rankin et al., 1996), 87.2 ± 4.8 kg (n = 5) (Hickner et al., 1991) and 74.3 ± 6.6 kg (present study). Thus, any conclusion about the effect of RBML on muscle endurance capacity in lighter and heavier combat sports athletes should be considered with caution.

Webster et al. (1990) examined RBML on isokinetic performance of the knee joint in wrestlers and observed no effect of a 5% RBML on knee extension or flexion peak torque at both fast and slow velocities. Our previous study (Ööpik et al., 1998) revealed that in well-trained karatekas, a RBML by 4.3% caused a decrease in knee extension peak torque at angular velocity of 4.71 rad·s^{-1} whereas no change was observed at velocities of 1.57 and 3.14 rad·s^{-1}. Similarly, Kraemer et al. (2001) observed that in collegiate wrestlers approximately 6% body mass loss during a week caused a significant reduction in peak torque of knee extension at fast angular velocity of 5.24 rad·s^{-1} but not at slow velocity of 1.05 rad·s^{-1}.In contrast, elbow extension peak torque was reduced at slow but not at fast angular velocity after body mass loss (Kraemer et al., 2001). However, the data of Kraemer et al. (2001) is not fully comparable to our data (Ööpik et al., 1998; Figure 1A and B in the present paper) because Kraemer et al. measured peak torque after about a 12 h recovery period following body mass loss. Thus, the available data show that the acute effect of RBML on peak torque may depend on the muscle group involved as well as on the speed of movement employed during measurement. Our results suggest that the ability of knee extensors to develop peak torque in relation to body mass is maintained, whereas muscle endurance capacity is reduced by the self-selected regimen of RBML in experienced combat sports athletes. Even though peak torque relative to body mass is maintained after RBML, it does not provide any performance advantage because absolute capacity for peak torque development is clearly impaired, especially at lower angular speeds.

The correlation analysis revealed a significant relationship between body mass and different indices of muscle performance (see Results). However, there was no relationship between the change in body mass and the changes in the indices of muscle performance during

RBML. These facts suggest that the cause of the impairment of muscle endurance capacity in our subjects was rather the self-selected regimen of RBML than the extent of RBML.

A considerably smaller increase in the concentration of lactate in blood following body mass reduction compared with normal body mass has been observed in many studies (Horswill et al., 1990a; Burge et al., 1993; Rankin et al., 1996) and this finding has been interpreted as an indirect conformation of decreased glycogen reserves in the organism (Horswill et al., 1990a; Rankin et al., 1996). In contrast, the data published by two groups (Caldwell et al., 1984; Spencer and Katz, 1991) show that the blood lactate response to high intensity exercise is not necessarily related to muscle glycogen concentration. Hence, the unchanged blood lactate response to the performance tests should not be taken as evidence about maintenance of muscle glycogen stores during RBML.

There was an explicit trend towards increased ammonia accumulation in blood during Test 2 in comparison with Test 1. The concentration of ammonia in blood during high intensity exercise could be considered a marker of adenine nucleotide degradation (Lowenstein, 1972). Hence, the increase in ammonia accumulation in blood may reflect a tendency towards impaired capacity for adenosine triphosphate resynthesis and an increased rate of adenine nucleotide degradation in intensely contracting skeletal muscle after RBML.

The increase in the concentration of urea in plasma accompanied by RBML confirms our earlier findings (Ööpik et al., 1998). The extent of the increase in the plasma urea level (20.4%) in our subjects was similar to that (21.2%) reported by Horswill et al. (1990b) for high school wrestlers who reduced their food intake and lost 3.5% of their body mass during 7 weeks at the beginning of a wrestling season. A significant difference between urea concentrations measured before and after RBML was evident even after adjusting the urea values for the individual changes in plasma volume (4.9 ± 0.8 vs. 5.6 ± 1.3 $mmol \cdot l^{-1}$; $p = 0.027$). Dietary protein could not have been involved in the elevated urea production in our subjects because their protein and energy intake was reduced, not increased, throughout the RBML period. Hence, the increase in plasma urea concentration may be caused by changes in renal function and/or by an increased rate of tissue protein degradation. The latter suggestion is supported by the finding of Walberg et al. (1988) that a protein intake of 0.8 $g \cdot kg^{-1} \cdot day^{-1}$ was not sufficient to maintain nitrogen balance during the RBML period, whereas 1.6 $g \cdot kg^{-1} \cdot day^{-1}$ was enough. In our subjects, the protein intake ranged from 0.67 ± 0.37 $g \cdot kg^{-1}$ during the first day to 0.11 ± 0.17 $g \cdot kg^{-1}$ during the third day of RBML. Moreover, Roemmich and Sinning (1997) reported that dietary restriction was involved in a 3.8% body mass loss accompanied by adverse effects on protein nutritional status (reduced prealbumin level in blood and slowed accrual of the cross-sectional areas of arm and thigh muscles) and impaired muscular performance in adolescent wrestlers during a wrestling season. These data together with that presented in the present paper suggest that methods applied by combat sports athletes for RBML may change the balance between protein synthesis and degradation in the body and thereby impair muscular performance. However, further research is needed before any firm conclusion in respect of this issue can be formulated.

The data of the present study reveal that the acute effect of the self-selected regimen of RBML is impaired muscle performance. Kraemer et al. (2001) have shown that tournament wrestling augments the physiological and performance decrements of RBML and its impact is progressive over two days of competition. We believe that athletes, coaches and team physicians should consider this information not only in preparing for a certain competition, but also in designing strategic plans for athletes' long-term development in combat sports.

Conclusion

In conclusion, the RBML achieved through the self-selected regimen (restriction of energy and fluid intake, thermal dehydration and exercise) impairs muscle performance in 3-min intermittent intensity exercise and induces an increase in blood urea concentration in experienced combat sports athletes.

Acknowledgments

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Key points

- Previous studies have revealed a negative effect of rapid body mass loss on performance. However, there are some performance characteristics that may not change or even improve.
- The methods used for inducing rapid body mass loss have been prescribed by researchers and not chosen by the subjects in many previous studies. The duration of tests, which have revealed a negative impact of rapid body mass loss on performance have also been rather long (5-6 min) in previous studies.
- We assessed the acute effects of the self-selected regimen of rapid body mass loss on muscle performance and metabolic response to 3-min intermittent intensity exercise in experienced male combat sports athletes.
- The results suggest that the self-selected regimen of rapid body mass loss impairs muscle performance in 3-min intermittent intensity exercise and induces an increase in blood urea concentration. Hence, the recent changes in the rules of some events (wrestling), including shortening of the duration of a match, have not reduced the likelihood of the occurrence of a negative impact of rapid body mass loss on athletes' performance capacity.

AUTHORS BIOGRAPHY

Saima TIMPMANN
Employment
Researcher at the Institute of Exercise Biology and Physiotherapy at the University of Tartu, Estonia
Degree
MSc
Research interests
Physiology and biochemistry of exercise and sports nutrition.
E-mail: saima.timpmann@ut.ee

Vahur ÖÖPIK
Employment
Professor of Exercise Physiology at the Institute of Exercise Biology and Physiotherapy at the University of Tartu, Estonia
Degree
PhD
Research interests
Physiology and biochemistry of exercise and sports nutrition.
E-mail: vahur.oopik@ut.ee

Mati PÄÄSUKE
Employment
Professor of Kinesiology and Biomechanics at the Institute of Exercise Biology and Physiotherapy at the University of Tartu, Estonia
Degree
PhD
Research interests
Biomechanical analysis of movement.
E-mail: mati.paasuke@ut.ee

Luule MEDIJAINEN
Employment
Lecturer at the Institute of Exercise Biology and Physiotherapy at the University of Tartu, Estonia
Degree
MSc
Research interest
Physiology and biochemistry of exercise and sports nutrition.
E-mail: luule.medijainen@ut.ee

Jaan ERELINE
Employment
Lecturer at the Institute of Exercise Biology and Physiotherapy at the University of Tartu, Estonia
Degree
PhD
Research interests
Biomechanical analysis of movement.
E-mail: jaan.ereline@ut.ee

✉ **Vahur Ööpik, PhD, Prof.**
Institute of Exercise Biology and Physiotherapy, University of Tartu, 18 Ülikooli St., 50090 Tartu, ESTONIA