Physiological Function Is Not Fully Regained Within 24 Hours of Rapid Weight Loss in Mixed Martial Artists

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ABSTRACT

Alves RC, Bueno JCA, Borges TO, Zourdos MC, Souza Junior TP, Aoki MS. Physiological Function Is Not Fully Regained Within 24 Hours of Rapid Weight Loss in Mixed Martial Artists. JEPonline 2018;21(5):73-83. The aim of this study was to examine the effects of rapid weight loss (RWL) on body mass (BM), strength, and hydration status, and its effects on fight performance in mixed martial artists (MMA). Athletes had BM, handgrip strength, and hydration status assessed at baseline (the official match weigh-in) and at match time 24 hrs later. There were statistically significant changes and very large and large effect sizes (ES) demonstrating decreased BM and handgrip strength, and increased urine density from baseline to match time, indicating that athletes could not fully restore physiological function within the 24 hrs between the official weigh-in and match time. However, at match time only 2 subjects were well-hydrated, while 5 subjects had minimal dehydration, and 5 subjects were significantly dehydrated. Therefore, the findings indicate that the negative effects of RWL on physiological function are not fully regained in the 24-hr period between the official weigh-in and the start of a match in MMA athletes.

Key Words: Dehydration, Mixed Martial Arts, Training
INTRODUCTION

Mixed Martial Arts (MMA) merges techniques from different combat sports during a single bout. The athletes need a wide array of skills (strength, flexibility, motor coordination, agility, and reaction time) if they are to do well in MMA performance (2,11). Similar to other combat sports (boxing and wrestling), MMA is a weight class sport in which athletes must be below a certain body mass (BM) to fight an opponent who must also meet the same BM goal. The weigh-in for MMA bouts is commonly held 24 hrs prior to the actual match.

While athletes normally weigh considerably heavier than the weight class requirement, it is common for them to engage in rapid weight loss (RWL) to weigh under the weight class limit. Also, it is equally well-known that athletes rapidly regain BM in an effort to normalize their physiological function and performance within the 24-hr period between the weigh-in and the match (15). Fighters who regain their BM have an advantage over their opponent who does not increase BM above the weight class limit in a fight position (18).

To accomplish the RWL, fighters and coaches use strategies that place the competitor in a state of liquid privation (4,23). Typically, the RWL consists of losing at least 5 to 8 kg of BM within 4 to 10 days of competition. However, in some cases >10 kg of BM is lost by using extreme strategies such as consuming laxatives along with forced vomiting (3,17). Subsequently, the RWL may have a negative influence on the performance during competition and the final training sessions that lead up to the bout (5,7,14,25). The negative acute health effects that occur during and following the RWL are dehydration and hyponatremia. Both can result in chronically detrimental health conditions along with diminished performance (1,15). Moreover, to effectively regain BM while concomitantly restoring physiological function a period of 12 to 48 hrs may be needed (24), which means the 24 hrs between the official weigh-in for the MMA matches and the actual match may be insufficient.

Coswig et al. (7) observed that MMA adult fighters lost approximately 10% of their BM in the week leading up to an official competition weigh-in, which resulted in a decrease in energy availability compared to the athletes who did not practice RWL. Additionally, Jetton et al. (12) reported that the adult MMA athletes who gained 4.4% of BM within 22 hrs of competition were dehydrated (as assessed by urinary measures of hydration). However, limitations exist in these investigations as Coswig et al. (7) only examined 5 athletes who used RWL, while Jetton and colleagues (12) conducted the pre-match analysis 2 hrs prior to the competition. Thus, the athletes could have rehydrated further within that final 2-hr period. Interestingly, neither of the previous studies (7,12) assessed both the decrease and the regain of BM, strength, and hydration prior to competition along with the relationship between these factors and outcome of the match.

The primary purpose of the present study was to examine BM, strength, and hydration status at baseline (10 days before the onset of RWL), at the official match weigh-in, and again 24 hrs later (i.e., minutes before a match – match time) in experienced MMA athletes who engaged in liquid privation as a RWL strategy. Additionally, this study examined the relationship between the changes in BM, strength, and hydration status with subsequent fight performance. It was hypothesized that following RWL the physiologic measures would not fully return to baseline by match time testing.
METHODS

Subjects
Twelve male amateur MMA athletes (age: 20.1 ± 1.2 yrs, BM: 70.4 ± 1.2 kg, height: 174.2 ± 1.2 cm, and training experience: 4 yrs) volunteered as subjects for this study. Inclusion criteria were: (a) to be in a pre-competitive period without any type of restriction (food and fluids) prior to the study; (b) have an advanced degree of some type (Muay-tai, Brazilian jiu-jitsu, Wrestling, Boxing) in combat sport; and (c) reduction of at least 4 kg of BM within 10 d of the subsequent fight using only fluid restriction. Exclusion criteria were: (a) <18 yrs. of age; (b) not being classified as an amateur athlete; (c) having a self-reported renal disorder, based on the routine medical examinations required by the MMA Athletic Commission carried out within a 12-month period preceding the beginning of the study; (d) using any type of supplementation within 2 months of the study, and (e) <6 consecutive yrs of practice in MMA.

All the methodological procedures of the present study were performed in accordance with Brazilian Health Council (466/2012) involving research with human beings. Prior to participation all athletes provided a written informed consent and were aware of all risks. The research procedures were approved by the Ethics Committee of the Federal University of Paraná (CAAE: 34134514.6.0000.0102).

Procedures

Experimental Approach to the Problem
This study is characterized as a prospective longitudinal design and investigated the effect of liquid privation as a method of RWL on BM, handgrip strength, and hydration status loss and subsequent regain leading up to a fight in MMA athletes. The athletes had all outcome measures (BM, strength, and hydration status via urine density) assessed at the onset of liquid privation (baseline - 10 days prior to the official weigh-in), 24 hrs before competition (official weigh-in), and again minutes before the fight (match time). The implementation and execution of RWL along with attempts to rehydrate were conducted fully by the athletes without any assistance or influence from the investigators. Further, the fight was a true competitive match. It was believed that the athletes put forth their best effort in all facets of fight preparation and in the actual match.

Anthropometrics
Body mass was assessed using a standard scale (Toledo®, Model 2124, Curitiba, Brazil) to a precision of 0.1 kg. Height was measured in a standard model stadiometer (Sanny®, São Bernardo do Campo, Brazil), which was fixed on the wall and recorded to a precision of 0.1 cm. These measures of anthropometry were assessed at baseline, the official weigh-in, and at match time.

Handgrip Strength
Handgrip strength was determined in accordance with the guidelines of the American Society of Hand Therapy (ASHT). The best of three attempts was used for analysis. There was a 30-sec rest between attempts. This test was performed using a dynamometer (Smedley-Takey digital, Curitiba, Brazil).
**Urine Density**

At baseline the urine sample was collected at the first urination in the morning while at the official weigh-in. Match time urine was collected immediately following anthropometrics and hand grip strength measurements. The subjects were instructed not to urinate for at least 2 hrs prior to these measurements. Urine was collected in a vial (80 mL) and the subjects were instructed to dispense urine in the vial without interruption and avoid fully filling the vial so the cap would close. The cap was immediately closed after the vial was filled. The urine density was determined by a portable digital refractometer (Palm AbbeTM model PA202X; MISCO; Solon, OH). To classify hydration status, the American College of Sports Medicine (ACSM) and the National Athletic Trainers Association (NATA) guidelines were used as follows: euhydration (specific gravity-SG 1.000–1.020), hypohydration (SG 1.021–1.029), and significant hypohydration (SG <1.030) were adopted (7,28,33). Partial analysis of urine to assess urine density measures the dissolved solutes in the urine, which evaluates the renal capacity of concentration and maintenance of the body's homeostasis as well as hydration status.

**Statistical Analyses**

The data are presented as mean ± SD. A Shapiro-Wilk test was used to determine normality and when normality was violated, the data were log-transformed to reduce non-uniformity of errors. Mixed linear modeling was used to determine the individual responses of each dependent variable. Therefore, the athletes were considered as random effects, whereas the fixed effects were BM, handgrip strength, and hydration status. The t and chi-square statistics, derived from the mixed linear modeling, were then converted to Pearson’s r values using bespoke functions, and considered as an effect size (ES) (Cooper and Hedges 1994). The ES interpretation was based on thresholds of 0.0; 0.1; 0.3; 0.5; 0.7; 0.9 and 1 as trivial, small, moderate, large, very large, almost perfect, and perfect, respectively (16). When significance was observed in the mixed model analysis, a post hoc analysis using Bonferroni correction was performed. The effect sizes (ESs) were used to determine the magnitude of relationships between BM loss, handgrip strength, and hydration status with winning or losing the subsequent match. To determine relationships to match outcome the individual difference in outcome measures were determined (Match Time – Baseline), then a Pearson’s Product Moment correlation was used between the outcome variable difference and by coding winning a match as ‘1’ and losing a match as ‘2’. Finally, 90% confidence intervals (CI) were calculated for each variable. All statistical procedures were performed using R software (Team 2013) and the "Multilevel" package for R (16). The level of significance was set at an alpha level of P<0.05.

**RESULTS**

**Individual Changes**

Individual subject data for all outcome measures along with hydration status at match time and outcome of the match (win or lose) are provided in Table 1.
Table 1. Individual Subject Changes at All Time Points, Hydration Status, and Match Outcome.

<table>
<thead>
<tr>
<th>Subject No.</th>
<th>Body Mass</th>
<th>Handgrip</th>
<th>Urine Density</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Official Weigh-In</td>
<td>Match time</td>
<td>Baseline</td>
</tr>
<tr>
<td>1</td>
<td>63.0</td>
<td>56.6</td>
<td>62.4</td>
<td>47.2</td>
</tr>
<tr>
<td>2</td>
<td>72.0</td>
<td>65.0</td>
<td>69.0</td>
<td>58.3</td>
</tr>
<tr>
<td>3</td>
<td>74.0</td>
<td>68.5</td>
<td>71.0</td>
<td>50.4</td>
</tr>
<tr>
<td>4</td>
<td>82.0</td>
<td>70.0</td>
<td>77.0</td>
<td>50.1</td>
</tr>
<tr>
<td>5</td>
<td>71.0</td>
<td>65.0</td>
<td>70.0</td>
<td>40.0</td>
</tr>
<tr>
<td>6</td>
<td>73.0</td>
<td>67.0</td>
<td>72.0</td>
<td>54.0</td>
</tr>
<tr>
<td>7</td>
<td>59.0</td>
<td>56.0</td>
<td>59.0</td>
<td>56.0</td>
</tr>
<tr>
<td>8</td>
<td>62.0</td>
<td>54.0</td>
<td>61.0</td>
<td>48.0</td>
</tr>
<tr>
<td>9</td>
<td>75.0</td>
<td>66.0</td>
<td>73.0</td>
<td>49.0</td>
</tr>
<tr>
<td>10</td>
<td>72.0</td>
<td>66.3</td>
<td>70.0</td>
<td>50.0</td>
</tr>
<tr>
<td>11</td>
<td>99.0</td>
<td>92.0</td>
<td>98.0</td>
<td>58.0</td>
</tr>
<tr>
<td>12</td>
<td>84.0</td>
<td>71.0</td>
<td>70.3</td>
<td>59.0</td>
</tr>
</tbody>
</table>

Hydration status classified according to The American College of Sports Medicine (ACSM) and the National Athletic Trainers Association (NATA) criteria as follows: euhydration (EUH) = specific gravity-SG 1.000–1.020), hypohydration (HYPOH) = SG 1.021–1.029), and significant hypohydration = SG <1.030) (SHYPO) were adopted (7,28,33).

**Body Mass**
There was an ES of very large magnitude demonstrating a decline in BM from baseline to match time. Additionally, there was a statistically significant decrease in BM from baseline to both the official weigh-in (P<0.01) and match time (P=0.025), while there was a significant increase in BM from the official weigh-in to match time (P<0.001). The intraclass correlation coefficient associated with BM was 0.84. The data presented a significant quadratic trend during the three conditions [parameter estimation = 16.9 (90% CI: 14.5-19.4), t22 = 11.4, P<0.001. The specific values regarding BM changes can be observed in Table 2.

**Handgrip Strength**
There was an ES of large magnitude demonstrating a decline in handgrip strength from baseline to match time. Additionally, there was a significant decrease in handgrip strength...
from baseline to both the official weigh-in (P=0.001) and match time (P<0.001). The intraclass correlation for handgrip strength from the mixed model analysis was 0.81. The data presented a significant quadratic trend during the three conditions [parameter estimation = 7.6 (90% CI 4.0-11.2), t22 = 3.5, P=0.0021] (Table 2).

Urine Density and Hydration Classification
There was a large ES for urine density indicating and overall increase in urine density (i.e., greater dehydration). Correspondingly, there was a significant increase in urine density levels from baseline to the official weigh-in (P=0.05) and match time (P=0.05). The data presented a linear trend during the three conditions [Parameter estimation = 20.3 (90% CI 6.3 to 34.3), t23 = 2.5, P=0.02] (Table 2). The mean value of urine density at the official weigh-in was 1018.8 ± 7.1 indicating dehydration (Table 2). Additionally, at baseline all 12 (100%) subjects were classified as well-hydrated. However, at the official weigh-in zero subjects were classified as well-hydrated, 9 subjects were classified as having minimal dehydration (75.0%), and 3 subjects had significant dehydration (25.0%). When tested at match time, 2 subjects were well-hydrated (16.7%), 5 subjects had minimal dehydration (41.7%), and 5 subjects were significantly dehydrated (41.7%).

Match Performance Relationships
Eight athletes in this study lost their respective matches, while 4 athletes won (Table 2). Interestingly, there was no significant relationship (r=0.26, P=0.42) between BM loss from baseline to match time and either winning or losing a match. However, when removing subject 12 (an outlier), who had a 13.7 kg change in BM from baseline to match time yet still won his match, there was a non-statistically significant, but moderate correlation between BM loss and losing the match (r=0.41, P=0.21). Additionally, there was no relationship between change in handgrip strength and match outcome (r=0.23, P=0.47). However, there was a moderate non-significant relationship between change in urine density and losing a match (r=0.37, P=0.23), indicating a greater decrease in urine density was associated with losing.

Table 2. Mean ± SD of the Outcome Measures at Each Time Point.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Baseline</th>
<th>Official Weigh-In</th>
<th>Match Time</th>
<th>SWC</th>
<th>CV (%)</th>
<th>CV (raw)</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body Mass (kg)</td>
<td>73.8 ± 10.9</td>
<td>66.5 ± 9.8</td>
<td>71.1 ± 10.0</td>
<td>2.2</td>
<td>14.7</td>
<td>10.9</td>
<td>0.9 Very large</td>
</tr>
<tr>
<td>Handgrip (kgf)</td>
<td>51.7 ± 5.6</td>
<td>47.8 ± 6.0</td>
<td>49.3 ± 5.4</td>
<td>1.1</td>
<td>10.8</td>
<td>5.6</td>
<td>0.6 Large</td>
</tr>
<tr>
<td>Urine Density (g/mL)</td>
<td>978.6 ± 55.6</td>
<td>1018.8 ± 7.1</td>
<td>1019.2 ± 9.3</td>
<td>11.1</td>
<td>5.7</td>
<td>55.6</td>
<td>0.5 Large</td>
</tr>
</tbody>
</table>

SWC = Smallest Worthwhile Change; CV (%) = Coefficient of Variation as percentage; CV (raw) = Coefficient of Variation as raw scores; ES = Effect Size. aSignificantly greater than official weigh-in (P<0.001) and match time (P=0.025). bSignificantly lower than match time (P<0.001); cSignificantly different from official weigh-in (P=0.001) and match time (P<0.001); dSignificantly lower than official weigh-in and match time (P=0.05)
DISCUSSION

The purpose of this study was to examine the effects of RWL on BM, handgrip strength, and hydration status as well as the relationships between these measures and match outcome in MMA athletes. The main findings supported our hypotheses in that all outcome measures were significantly decreased from baseline to match time with either a very large or large ES. Additionally, we observed non-significant, but moderate performance correlations, which indicated that greater losses of BM were significantly related to losing the subsequent fight. The findings demonstrate that even though RWL can achieve the goal of BM reduction it may reduce dehydration status and possibly harm fight performance in the short-term.

Overall, the results are consistent with the previous data demonstrating that physiological function (7) nor hydration status and BM (12) are fully returned to homeostatic levels following RWL and subsequent rehydration attempts. Specifically, Jetton et al. (12) reported a significant increase in BM from the official weigh-in to 2 hrs prior to a match (+3.4 kg; +4.4%) in a similar population of MMA athletes, while presently we reported a mean increase of 4.6 kg (+6.9%). Both previous studies reported a statistically significant increase in BM, however, our final weigh-in was only minutes prior to the match, while Jetton and colleagues’ final weigh-in was 2 hrs prior, thus the nearly 2 extra hours in the present study may likely account for the 1.2 kg greater increase in BM.

Additionally, the current results report a very large ES (0.90) for change in BM including a 9.9% decrease (-7.3 kg) over a period of 10 days from baseline to the official weigh-in, which is almost identical to self-reported 10-day decline (-7.4 kg, -10.0%) up to the official weigh-in from Coswig et al. (7). Correspondingly, Jetton et al. (12) and the present study reported a similar magnitude of subjects with at least significant dehydration prior to the match with 39% and 41.7% classified as significantly dehydrated, respectively.

Regarding hydration, since only 16.7% of the fighters in the present study were classified as well-hydrated at match time and previous data has reported only 23% of MMA fighters to be well-hydrated prior to competition following RWL and BM regain, it seems that >24 hrs is needed to fully rehydrate following RWL. Despite not returning to baseline BM, we did report a 4.6 kg increase in BM (official weigh-in to match time) as athletes drank fluids ad libitum. Additionally, Pettersson and Berg (18) did not fully restore hydration since 42% of their combat athletes were classified as severely dehydrated, when attempting to rehydrate overnight (i.e., <24 hrs) following RWL. The results demonstrating the inability to fully rehydrate following short-term weight cycling provide support for the hypothesis of Costill and Sparks (6), in that 48 hrs may be required to fully restore fluid homeostasis.

Importantly, the present results reported a moderate relationship between urine density and losing the subsequent fight (r=0.37, P=0.23), in that a larger decline in urine density from baseline to match time was significantly related to losing the fight. Therefore, these findings demonstrate that the lack of ability to effectively rehydrate in <48 hrs may have negative outcomes for acute performance.

Mixed martial artists require a certain degree of muscular strength to be successful (8). Moreover, since strength can be negatively affected by RWL, the MMA athletes cannot simply be concerned with BM regain within 24 hrs of competition. The athletes must also
consider strength to effectively perform. Indeed, following RWL Filaire et al. (9) reported a decrease in upper body strength in Judo athletes, while Roemich and Sinning (19) observed a concurrent inefficient kcal intake and diminished strength from pre- to late-season in adolescent wrestlers. Thus, the data indicate that not only does acute RWL hinder strength, but also continued weight cycling throughout a season or series of matches is likely to decrease performance until normal behavior patterns are sustained. In fact, the present ESs of very large (0.9) and large (0.6) for BM and handgrip strength demonstrate a concurrent decrease in these measures. Moreover, acute strength loss is commonly indicative of fatigue or muscle damage (13,16,26), and occurs with impaired recovery.

The loss of strength may certainly have also occurred in part due to dehydration and the loss of BM (Tables 2 and 3), which is consistent with the findings of Cengiz (5) who collected survey data among well-trained wrestlers. The elite wrestlers reported a decrease in lower limb power 12 hrs into recovery after RWL. Similarly, Kraemer et al. (13) reported a concurrent 6% decrease in BM and decrease in vertical jump power over a 7-day RWL in wrestlers compared to no significant decrease in individuals who did not undergo RWL. Overall, the existing data seems clear that acute strength loss is unlikely to be fully regained within 24 hrs following RWL.

Mechanistically, the athletes’ acute strength loss could be caused by dehydration, given that inadequate water supply leads to a decrease in extracellular sodium concentration (Na+) and intracellular potassium (K+). Appropriate equilibrium of this intra-extracellular gradient allows for propagation of nerve impulses that are regulated by the balance of the electrochemical gradients of musculoskeletal nerve cells. Dehydration can cause a disruption of this gradient leading to disrupted nerve impulses and impaired calcium (Ca2+) release from the sarcoplasmic reticulum, which would comprise the excitation contraction coupling (EC-coupling) process. Ultimately, this sequence of events to compromise EC-coupling could have led to the decrease in handgrip strength. However, there was no statistically significant relationship observed presently between the changes in urine density and handgrip strength.

Limitations in this Study

The main limitation of this study was not controlling for the between subject food intake. In reality, not controlling for food intake is both an advantage and disadvantage of the present study design since athletes eating on their own allowed for the examination of actual habits that MMA athletes use. However, if food and fluid intake were prescribed by a dietitian between the official weigh-in and match time, it is possible that the attempt to rehydrate and replenish physiological function would have been more successful due to better dietary habits. Another limitation is that it is likely our correlations were not significant due to a small sample size. We suggest caution when interpreting the correlations in this study. Not only is the sample size of the correlations small, the outcome of the match also depends upon the opposing fighter. Also, since we did not collect data regarding hydration status, RWL, or strength of the opposing fighter, the conclusions that can be drawn from these correlations, are limited.
CONCLUSIONS

Rapid weight loss (RWL) by way of fluid restriction resulted in a decrease in BM, handgrip strength, and hydration status as measured by urine density over a 10-day period at an official MMA match weigh-in. Furthermore, following an athlete-structured attempt to rehydrate within 24 hrs of competition, no measures fully returned to baseline status as only 16.7% of athletes were well-hydrated at match time, and mean BM (3.7%) and handgrip strength (4.6%) were lower at match time compared to baseline. There was also a moderate relationship demonstrating that greater decreases in urine density were related to losing the subsequent match. Therefore, these findings indicate that an athlete and coach-directed rehydration program <24 hrs prior to an MMA match does not fully restore physiological function and may have negative consequences on the athletes’ performance.

The decision to use RWL is difficult. Indeed, RWL via fluid restriction can be effective in reaching a weight class within a short time if BM is significantly above the class restriction. However, it is unlikely that physiological function will be fully restored within the 24-hr allotted period for rehydration. Athletes and coaches should consider working with a sport dietitian to appropriately rehydrate if using a RWL technique. Athletes should also consider maintaining a BM closer to their weight class limit so that RWL is not necessary, thus the risk of depleting physiological function by losing little to no BM would be decreased.

Finally, athletes should consider the long-term negative health consequences of consistent weight cycling that includes a possible difficulty in maintaining a healthy BM later in life (20), and in turn may increase the athletes’ risk of chronic disease (21,22). While causality cannot yet be determined between consistent weight cycling and any chronic effects, athletes and coaches should use caution before consistently implementing RWL due to both the potential acute decrease in physiological function and athletic performance and the potential long-term negative health effects.

ACKNOWLEDGMENTS

We are grateful for all the athletes who participated voluntarily and all those who helped us recruit.

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