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Shorter Fasting Periods Improve Athletic Performance among Mixed Martial Artists

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Abstract

Objective: This study aimed to relate weight management practices to athletic performance in Mixed Martial Arts (MMA). MMA athletes reduce body mass through intentional dehydration and fasting, known as Rapid Weight Loss (RWL), to qualify for weight-class competitions.

Methods: Nine male MMA athletes were observed during a week of competition. Food journals were collected to measure fasting duration. Urine Specific Gravity (USG), body composition, and peak punch velocity were assessed at baseline and endpoint. USG and body mass were assessed at weigh-ins. Self-rated performance was also assessed. Descriptive statistics, Pearson correlation coefficients, and chi-square analyses assessed the significance of relationships between variables.

Results: After reducing body mass through RWL (M=14.54 lb, SD=4.21 lb), eight participants (88.9%) were dehydrated at weigh-ins. Only one participant (11.1%) failed to achieve euhydration prior to competition. Muscle-and-bone mass changes were positively correlated with changes in punching velocity (r=0.698, p<0.05). Shorter fasting periods, defined as less than 24 hours, had a statistically significant relationship with improved punching velocity χ^2 (1, N=9)=5.760, p<0.05. Additionally, improved punching velocity was positively correlated with self-rated performance (r=0.676, p<0.05).

Conclusions: These findings suggest athletes and coaches in combat sports may benefit from utilizing shorter fasting periods of less than 24 hours during RWL to improve athletic performance after reducing body mass by 5%-12%. However, a more robust study of these factors across a larger sample is warranted before drawing conclusions.

Keywords: Athletic performance; Hydration; Fasting; Combat sports; Nutrition

Introduction

Weight divisions are often utilized in combat sports to prioritize fairness between competitors. For athletes competing in sports such as boxing, kickboxing, wrestling, judo, jiu-jitsu, karate, taekwondo, and Mixed Martial Arts (MMA), there is an incentive to gain a competitive edge by rapidly losing weight and refeeding after weigh-ins to achieve a higher weight at the time of competition.

This process of Rapid Weight Loss (RWL) and refeeding, popular among athletes of all age groups, 1 involves voluntary dehydration, fasting, and behavioral strategies to achieve significant weight loss prior to qualifying for weight-class competition in combat sports [1-14].

There is no consensus opinion on which RWL strategies produce the best results for health and performance. However, this pervasive practice has been linked to hospitalizations [15,16] and death, [17,18] as there are cardiac risks associated with RWL which may be explained by the dumping of water and electrolytes through perspiration and urine. [1,5,7] The largest observed weight reductions observed by researchers were among MMA athletes, [2,7] suggesting that MMA athletes may undergo extreme RWL compared to other combat sports athlete populations.

Additionally, the merit of the weight-management practices utilized in combat sports has faced little scrutiny. This study aimed to investigate hydration, nutrition, and body composition in relation to performance among MMA athletes practicing RWL.

It is common knowledge that water is essential for life. However, combat sports athletes regularly deny their bodies this essential nutrient. [3,7,8,12] While mild dehydration resulting in a 1%-2% decrease in body weight [19] may be the threshold for impaired athletic ability [20,21] and cognitive function, [22,23] modest observations among athletes practicing RWL exceed this amount. [2,4,7,14,24] Due to the potential lethality of the practice of RWL and its nearly universal practice among MMA fighters, [25] the California State Athletic Commission passed stringent regulations on RWL in weight-class competitions in the United States in 2017 [26].

The increasing popularity of the sport and the prevalence of RWL among the population warrant investigation from the scientific community to examine its role in predicting performance and health outcomes. In the scope of performance, dehydration has significant metabolic implications.

The observed role of water in muscle glycogen uptake [27-29] is of significance to athletes and coaches in combat sports. Maximizing hydration during the RWL process may provide protein-sparing benefits [30,31] while also upregulating lipolysis. [30-33] However, the body of knowledge regarding hydration and nutrient metabolism in healthy males is far from conclusive in the scope of athletic performance and in reference to RWL and refeeding cycles.

In addition to the metabolic and performance implications of intentional dehydration, it is among the few life-threatening aspects of modern sport. The recorded hospitalizations and deaths involving RWL have all been the result of acute changes in cardiac performance, which can lead to stroke, heart attack, cardiopulmonary failure, and sudden death.

In theory, this phenomenon may be the result of dehydration leading to the neutralization of the electrical gradient across cellular membranes due to an imbalance in the electrolytes sodium and potassium. Research is needed to build on the theory of the causal factors associated with cardiac events during RWL and refeeding cycles.

Optimal performance in competition and training is dependent on the proper fuel. Combat sports athletes must consume enough carbohydrates, fats, proteins, vitamins, and minerals to provide adequate nutrition for activities while also meeting weight-regulation goals. As mentioned, the importance of water in transporting materials through the body and preserving homeostasis in many processes cannot be understated.

However, research has observed the practice of limiting nutritional intake during RWL among many combat sports athletes. [3,4,34-39] Despite its apparent place in the culture of combat sports, there is a lack of clear parameters by which athletes and coaches approach sports nutrition during the RWL and refeeding stage of training. Research efforts to assess the acute effects of low nutritional intake and fasting on performance in this population are scarce.

Fighters often choose to reduce carbohydrate consumption in the early stage of RWL. [3,11,13] This has metabolic implications, resulting in the release of glycogen to fuel activities and provide ATP to the body's cells. This impairs anaerobic energy production, but the release of glycogen is partnered with the release of the water that is stored in the muscles, aiding the athletes in losing weight rapidly.

As glycogen stores and free glucose are utilized, the ratio of AMP-Activated Protein Kinase (AMPK) to ATP increases. [40] The enzyme AMPK is the primary signaling force behind the shift from glycogenolysis to lipolysis. [41] Energy pathways shifting substrate preference to free fatty acids in the scarcity of glycogen reserves has been observed under short-term fasting conditions. [42] This metabolic response to utilize fat substrates to meet metabolic needs has been observed over the first 24 hours of fasting periods [42-44].

The primary concern, under limited nutritional resources, is the preservation of lean mass. The Academy of Nutrition and Dietetics previously suggested that athletes consume between 1.2–2.0 g/kg body weight of protein daily. [45,46] For additional strength benefits, it has been suggested that power athletes consume more than 2.0 g/kg protein each day. [47] This high requirement for protein presents a complicated situation for combat sports athletes practicing RWL as they seek to maintain lean mass while reducing their body mass, sometimes by more than 15% during the week of competition.

Despite adaptations to preserve body proteins during prolonged fasting, [48,49] previous studies have observed that long fasting periods result in muscle loss. [50-52] However, research has failed to identify significant protein catabolism among fasting combat sports athletes who utilize fasting periods that are typically much shorter than the 60+ hour fasts that are associated with muscle loss.

Though the literature suggests the metabolic adaptations to short-term fasting may not present a significant risk for protein catabolism, little is known of its effects on performance in this population.

Aside from substrate metabolism, the relevance of Low-Energy Availability (LEA) among combat sports athletes cannot be understated. With targeted weight loss often exceeding 10% of body weight, almost all fighters would be diagnosed with LEA according to parameters suggested by previous research [53].

In a consensus statement, the International Olympic Committee (IOC) listed male combat sports athletes as a population at risk for Relative Energy Deficiency in Sport (RED-S). [54,55] The RED-S model developed by the IOC places LEA at the center, with a wide array of biological responses that may be detrimental to health and performance. With little research relating LEA and RED-S to combat sports athletes, there is a need for deeper understanding of the weight-management practices involved in RWL and their implications for health and performance.

Materials and Methods

Participants

Nine male MMA fighters participated in this study. Three participants competed as amateurs, while 6 participants competed as professionals. All participants were 18 years or older and competed in sanctioned competitions in the southeastern United States during 2019. Recruitment was continued in 2020. However, the COVID-19 pandemic resulted in the conclusion of this study. Recruitment occurred via written invitation with follow-up contact occurring via phone communication. Participants were provided informed consent and contact information to the primary investigator prior to participation.

Data collection

Data collection involved three separate timeframes: baseline measurement 7-10 days prior to weigh-ins; RWL measurements taken at weigh-ins where the RWL timeframe was defined as the time between the participants' last meal before weigh-ins and the time the participants weighed in; and endpoint measurements collected 24 or more hours after weigh-ins during a 4-hour period prior to competition. Participants were asked to provide demographic and other general information. These data included, age race/ethnicity, sex, level of competition, weight-loss tactics such as sauna-suit use, diuretics use, and sauna use.

Hydration status was determined using urine specific gravity. Urine Specific Gravity (USG) was measured using a digital refractometer. The dichotomous variable dehydration was scored as "1" for subjects with USG>1.020 and scored as "0" otherwise. These reference ranges are in accordance with National Collegiate Athletic Association standards for determining dehydration among collegiate wrestlers.

Seven-day food journals were distributed at the time baseline measurements were taken and instructions were delivered to all participants. For the purposes of this study, the food journals were used to determine the time athletes spent fasting prior to weigh-ins.

The participants' height and weight were assessed at baseline. The principal investigator, an International Society for the Advancement of Kinanthropometry (ISAK) Level 1 certified anthropometrist, attained bone girth and skinfold measurement for each participant at baseline and endpoint. The ISAK method of assessing bone girths and Skinfolds (SF) was utilized to provide consistency and validity to the measurements as well as an accurate estimate of muscle-and-bone mass.

Body fat was estimated using Civar's equation which is as follows: (Body Fat%=(0.432 × triceps SF)+(0.193 × abdomen SF)+(0.364 × biceps SF)+(0.077 × BM)-0.891).

Athletic performance includes a complex array of physical and cognitive functions. For this study, we measured peak punching velocity using Everlast's PIQ Blue System, a wearable technology that utilizes two 3-axis accelerometers and a 3-axis gyroscope to assess the movement and performance of fighters during training.

The PIQ sensors were wrapped around the participants' wrists during a short, one-minute bout of 80% effort. The PIQ sensors collected data on punching velocity, sending the data to a mobile app in real time. Punching velocity was assessed at baseline and endpoint.

The absolute change in peak punch velocity was assessed after data collection and expressed by the variable ∆Velocity. Participants were also asked to self-rate their performance using the question, "How would you rate your performance in the fight?" Self-rated performance was reflected on a 5-point scale (1: Very Poor to 5: Very Good). Competition results will also be utilized as a measure of performance, being coded as "1" for a win and "0" otherwise.

Data analysis

Measurement protocols were followed appropriately for each measurement time frame. Weigh-in weights were taken on the same scale as baseline and endpoint measurements. However, official weigh-in results, success or failure to make weight, were based on the official results of weigh-ins conducted by the organization overseeing the administration of the competition. There were no discrepancies between the recorded weigh-in weights and official weigh-in results to report.

The IBM SPSS statistical software was used for all statistical analyses. All statistical tests used a two-tailed 95% confidence interval or a significance level of $\alpha=.05$. Descriptive statistics such as frequencies, means, and standard deviations were calculated for the relevant variables and measurements of dehydration, fasting, and body composition.

Pearson correlation coefficients and chi-squared values were estimated to determine if statistically significant relationships existed between the changes in body composition, hydration, nutritional intake, and performance experienced during RWL and refeeding cycles. This study did not conduct regression analysis due to the limited sample size.

Results

Within the sample, three participants competed in amateur-level fights with the other six competing professionally. An overview of the participants' characteristics, fasting duration, and the changes associated with the RWL and refeeding cycle are expressed on Table 1. Participants were ages 24 to 35 (M=29.44, SD=3.71). Participants experienced significant RWL prior to refeeding (M=14.54 lb, SD=4.21 lb), with weight loss representing a large percentage of baseline body mass (M=8.10%, SD=1.93%).

Intentional dehydration was almost universal across the sample (n=8, 88.9%). Despite the prevalence of intentional dehydration, most fighters (n=8, 88.9%) achieved euhydration on the day of competition. Short-term fasting was prevalent among the sample (M=33.39 h, SD=20.73), where two outliers practiced extended fasting periods of 67 and 72 hours. Among the sample, the RWL practices were adequate for most fighters to achieve the targeted weight at the time of weigh-ins (n=7, 77.8%).

Baseline		
	M	**SD**
Age	29.44	3.71
Body Fat (%)	11.09	1.85
Muscle-and-Bone Mass (%)	52.81	2.31
Body Mass (lb)	178.81	20.19
Urine Specific Gravity	1.006	0.004
Peak Punching Velocity (mph)	18.44	5.99
Rapid Weight Loss		
	M	**SD**
∆Body Fat (%)	-0.39	0.52
∆Muscle-and-Bone Mass (%)	0.39	1.24
Body Mass Reduced (%)	8.1	1.93
∆Body Mass (lb)	-1.78	2.39
Weigh-in USG	1.024	0.006
Endpoint USG	1.008	0.008
Fasting Duration	33.39	20.73
∆Peak Punching Velocity (mph)	-1.32	7.33
Self-Rated Performance	3.56	1.13

Table 1: Participant characteristics & descriptive statistics for rapid weight loss factors (N=9).

Significant Pearson correlation coefficients were found for the relationship between Fighter age and USG at weigh-in and endpoint measurements. Age was negatively correlated with weigh-in USG ($r=-0.691$, $p<0.05$) and positively correlated with endpoint USG ($r=0.677$, $p<0.05$). Endpoint USG had a significant negative correlation with self-rated performance ($r=-0.678$, $p<0.05$). Changes in body fat percentage, from baseline to endpoint, were negatively correlated with changes in muscle-and-bone mass across the same timeframe ($r=-0.709$, $p<0.05$). Muscle-and-bone mass changes through the RWL-refeeding cycle were positively correlated with changes in punching velocity ($r=0.698$, $p<0.05$). Additionally, improved punching velocity was positively correlated with self-rated performance ($r=0.676$, $p<0.05$). Improvement in punching velocity after the RWL-refeeding cycle had a statistically significant positive correlation with shorter-fasting periods of less than 24 hours ($r=.800$, $p<0.01$).

Chi-squared analyses revealed associations between factors related to successful RWL, self-rated performance, fight result, and improved punching velocity. There was a statistically significant relationship between euhydration status prior to competition and fighters successfully meeting weight requirements $\chi2$ (1, N=9)=3.938, $p<0.05$. Shorter fasting periods, defined as less than 24 hours, had a statistically significant relationship with improved punching velocity $\chi2$ (1, N=9)=5.760, p<.05. This study found no other significant relationship among improved punching velocity and the factors observed. No factors expressed statistically significant relationships with self-rated performance or fight result.

Discussion

This study sought to measure and observe relevant factors related to rapid weight loss and performance among a sample of nine male MMA fighters. The data-collection protocols provided insights into the hydration status, nutritional-fasting strategies, body composition, changes in punching velocity, self-perceived quality of performance of MMA fighters practicing rapid weight loss during the period encompassing the week of competition. The participants in this study were generally successful at achieving adequate weight loss through RWL (n=7, 77.8%). Consistent with previous research, [3,7,8,12] the sample primarily (n=8, 88.9%) utilized intentional dehydration as a RWL strategy. Additionally, intentional nutritional fasting was practiced by all participants. These findings suggest that both amateur and professional MMA fighters utilize several strategies to achieve RWL within 1 to 3 days of the qualifying weigh-ins prior to competition, consistent with other observations among various combat sports athletes. [1-14,25,34-39]

Rehydration during the time between weigh-ins and competition appeared to be a priority among participants. Most participants in the sample (n=8, 88.9%) were successful in hydrating during this time frame. However, there was a significant correlation between endpoint urine specific gravity and self-rated performance, suggesting that subclinical dehydration may affect performance in discrete ways beyond the scope of this study. Interestingly, the age of fighters was negatively correlated with weigh-in USG (r=-0.691, p<0.05) and positively correlated with endpoint USG (r=0.677, p<0.05). This suggests that an athletes' ability to dehydrate and rehydrate may be influenced by age, resulting in increased difficulty to achieve optimal hydration among older athletes. This is of particular importance due to the observed correlation between endpoint USG and self-rated performance. While this finding is inconclusive due to the sample size, there may be merit to coaches advising MMA fighters to pursue competition in weight classes that require less-extreme RWL practices, particularly as those practices related to intentional dehydration. This study utilized a novel approach to relate weight management practices in MMA to a quantitative measure of performance, punching velocity, with the aim of identifying how common practices in the sport are related to RWL and performance outcomes. Short fasting periods, defined as shorter than 24 hours, had a statistically significant relationship with improved punching velocity according to results from chi-squared analysis $\chi2$ (1, N=9)=5.760, p<0.05. This study also observed a statistically significant Pearson's correlation coefficient between the variables (r: 0.800, p<.01). Among the sample, only one participant experienced improved punching velocity after a relatively long fasting period of 26 hours. Changes in muscle-and-bone mass were positively correlation with absolute changes in punching velocity (r=0.698, p<0.05). This is a novel observation among combat sports athletes. The observed changes in muscle-and-bone mass were negatively correlated with changes in body fat percentage (r=-0.709, p<0.05), suggesting that substrate-level metabolic changes during RWL may significantly impact body composition outcomes. The mechanism of this outcome is likely a metabolic adaption resulting in a preference for protein catabolism over lipolysis to fuel gluconeogenesis. Due to its correlation with changes in punching velocity, prioritizing lean mass preservation during RWL should be a priority for fighters and coaches in combat sports.

Significant, though anecdotal, differences were observed among the two participants that utilized very long fasting periods of 60+ hours. Subject 2, a 24-year old male amateur MMA fighter, successfully reduced his weight through RWL. Subject 2 fasted for 67 hours, reducing his body mass 22.90 lb (11.87%), resulting in small changes to body-fat percentage (-0.63%) and bone-and-muscle lean mass (+1.58%). Subject 2 experienced reduced peak punching velocity (-1.2 mph) after successfully achieving euhydration prior to competition, winning his fight by knocking out his opponent in the first round of his fight. Subject 9, a 27-year old male professional MMA fighter fasted for 72 hours with markedly different results compared to Subject 2. Subject 9 had reduced body mass mildly (13.5 lb, 6.79%) compared to Subject 2. Subject 9 successfully achieved euhydration prior to competition; however, his body-fat percentage increased (+0.67%) while his muscle-and-bone lean mass decreased (-2.26%). These changes in body composition represent the greatest observed among the sample for both body-fat and muscle-and-bone mass percentages. The 72-hour fast and negative changes in body composition coincided with a reduction in peak punching velocity (-19.9 mph). Despite failing to meet the 10% weight-loss criteria for LEA, [53] Subject 9 had experienced a marked decline in peak punching velocity. Subject 9 suffered a defeat during competition. However, the defeat was secondary to suffering a fracture of the right femur of Subject 9.

The observations of Subjects 2 and 9 in this study highlight challenges for future research. Despite a comparatively, very-long fasting period, Subject 2 experienced an increase in muscle-and-bone mass, contradicting previous observations among adult males. [50-52] Though Subject 2, as well as Subject 5, reduced body mass beyond the 10% criteria for LEA, [53] both experienced favorable changes to body composition through the RWL-refeeding cycle. With consideration of Subject 9, the findings of this study suggest our understanding of low energy availability and performance predictors is undeveloped. Low energy availability and relative energy deficiency in sport are deserving of extensive attention from future research.

This study observed novel findings among this population. Chief among these is the observed relationship between shorter fasting periods and changes in punching velocity among combat sports athletes. Specifically, fasting periods of less than 24 hours correlated with improved punching velocity after rapid weight loss and re-feeding. This finding provides direction for coaches involved in MMA that are guiding athletes through the RWL process. Additionally, this study observed a positive correlation between changes in muscle-and-bone mass and the absolute change in punching velocity following RWL and refeeding. However, more research is required to identify the specific mechanisms involved in performance improvements achieved through RWL. Training load, recovery, technical skill-level, and fasting-adaptation were not parameters included in this study, but they may play a significant role in changes during the RWL-re-feeding cycle.

Limitations

Recognizing the limitations of the present study is important when highlighting its implications for practice and future research. Analyzing the independent role of each predictor variable for the dependent variables punching velocity, fight result, and self-rated performance, was difficult due to the small sample size. A larger sample would allow for regression analyses to measure the independent associations between predictors and outcomes related to rapid weight loss in combat sports. The present study did not include parameters related to training load and subsequent recovery, technical skill-level, fasting-adaptions, as well as specific dietary approaches that may yield benefits to fighters practicing RWL. A larger sample with more-comprehensive parameters would provide more valid estimations of the effects diet, hydration, training, and body composition have on performance markers among combat sports athletes. However, the present study provides novel insights into relationships between fasting, hydration, body composition, and athletic performance among a sample of MMA fighters going through a natural, non-simulated, cycle of rapid weight loss and re-feeding prior to competition.

Conclusion

This study investigated hydration, nutrition, and body composition in relation to performance among MMA athletes practicing RWL. Combat sports athletes rapidly reduce weight during the week of competition through intentional dehydration and fasting. This sample observed MMA fighters reducing body mass by 5%-12% during a six-day period to qualify for competition in their respective weight classes. This study observed euhydration status in only one participant at the time of qualifying weigh-ins, suggesting that many MMA fighters may intentionally dehydrate to the point of clinical dehydration during RWL. Each participant in this study utilized fasting to reduce body mass rapidly during the 1 to 3 days prior to qualifying weigh-ins. While nearly every participant fasted between 19 and 27 hours, two MMA fighters in the sample utilized very long fasting periods of 67 hours or more. After qualifying for competition in their respective weight-class, combat sports athletes "re-feed" to replenish glycogen stores and achieve euhydration prior to competition. During re-feeding, a period of 26 to 30 hours, all but two participants in this study achieved euhydration. Interestingly, this study observed a statistically significant positive correlation between fighter age and endpoint USG, suggesting that older fighters may experience some difficulty rehydrating after qualifying for competition. After weigh-ins and re-feeding, peak punching velocity was assessed to obtain an endpoint measurement for comparison with baseline data. Other performance parameters included fight result and self-rated performance. The only predictor variable correlated with self-rated performance was endpoint USG ($r=-0.678$, $p<0.05$). This study found no potential predictors of fight result, suggesting that predicting the results of MMA competition may be complex and beyond the scope of this study protocol.

This study produced novel findings related to changes in peak punching velocity after RWL-re-feeding cycles. Changes in muscle-and-bone mass were positively correlated with changes in punching velocity. A negative correlation between changes in body fat percentage and muscle-and-bone mass percentage was indicative of potential substrate-level metabolic changes related to the scarcity of fuel involved in RWL, with some fighters experiencing a loss of muscle mass. Chi-square analysis revealed a statistically significant relationship between fasting periods of less than 24 hours and improved punching velocity.

While the implications of these findings for coaches and athletes in combat sports are significant, larger future studies with more robust measuring protocols are required to identify definitive predictors of various performance markers. This study utilized a novel approach and observed significant relationships with practical implications for athletes and coaches in combat sports. Specifically, these findings suggest athletes and coaches in combat sports may be able to utilize RWL-re-feeding cycles to improve athletic performance after significant RWL of 5%-12% body mass. However, strategies aimed to preserve lean mass may be important in achieving desired results. Future studies should aim to recruit larger samples of fighters from various disciplines of combat sports to address the wide array of factors impacting athletic performance in this population. Despite the evidence suggesting improved athletic performance can be achieved after RWL-re-feeding cycles, research has yet to place scrutiny on the implications of weight-management practices in combat sports on health, particularly acute cardiac changes. Further evaluation of the safety of the practice of RWL is warranted.

Declaration of Conflicting Interests

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Data Accessibility Statement

The data that supports the findings of this study are available from the corresponding author, KH, upon request.

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