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Effects of Rapid Weight Loss and Dehydration on Performance in Female Collegiate Wrestlers

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EFFECTS OF RAPID WEIGHT LOSS AND DEHYDRATION ON PERFORMANCE IN FEMALE COLLEGIATE WRESTLERS

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Symbols/Abbreviations

RWL- Rapid Weight Loss

VT- Ventilatory Threshold

CHAPTER 1

INTRODUCTION

Combat sports such as wrestling, MMA, jiu jitsu, judo, and boxing are beginning to see an increasing popularity amongst fans as well as athletes. These sports are gaining popularity among both male and female athletes because they all utilize a weight classification system, making it possible for athletes of all shapes and sizes to participate and be successful (Timpmann et. al. 2007). Combat sports alone represent about 25% of Olympic medals at the summer Olympic Games (Franchini et. al. 2012). As in any sport, combat sport athletes seek out ways to give them a competitive advantage over their opponents, including weight cutting. Athletes believe that by getting to the lowest weight classification possible that they will have considerable size, strength, and power advantages over their opponents who do not cut weight (Cengiz 2015). Before competitions, athletes undergo a period of rapid weight loss (RWL), in which they temporarily lose a considerable amount of weight in a condensed period of time. Common methods of RWL include intentional dehydration, calorie restriction, and excessive exercise leading up to a competition weigh in.

It has been well documented that RWL accompanied by intentional dehydration negatively affects aerobic performance. These negative performance effects include impaired temperature regulation, increase load on the cardiovascular system, and an overall decreased aerobic capacity (Cengiz 2015). For anaerobic performance, numerous studies provide inconclusive results on the impact of RWL and dehydration, mainly due to having multiple different study designs.

Due to the apparent list of adverse effects that come with undergoing a period of RWL, and the deaths of three male collegiate wrestlers in 1997, the National Collegiate Athletic

Association (NCAA), has implemented strict weight loss guidelines and restrictions on collegiate men's wrestling. These guidelines include a preseason body composition analysis, urine specific gravity testing, weigh in procedures, and restrictions on the amount of weight a wrestler can lose in one week (NCAA 2011).

Women's collegiate wrestling is governed by the Women's Collegiate Wrestling Association (WCWA), which does not have any guidelines or restrictions on weight cutting for female college wrestlers. This leaves room for female athletes to put themselves in dangerous situations with reducing their body weight too much or too quickly and can have negative effects on their overall performance. The lack of weight cutting guidelines is likely in large part due to WCWA being a relatively new organization, governing officials not understanding the prevalence of weight cutting among collegiate female wrestlers, or because female wrestlers have different, varying weigh-in procedures. Currently, a lack of scientific evidence is available that has examined the impact of weight cutting in female wrestlers. Adding to the problem is the current discordance between weigh-in procedures between the WCWA and NCAA. Currently, the WCWA follows an international model, which allows weigh-in procedures the day before competition, creating the opportunity for at least 12 hours of recovery time, while the NCAA requires same day weigh-ins allowing for only an hour of recovery time to athletes. To date there is currently no research on the affects that RWL and dehydration has on performance in female collegiate wrestlers and if one weigh-in protocol offers more advantages than another.

STATEMENT OF PROBLEM

RWL and dehydration have been shown to have negative effects on aerobic performance, though studies focusing on acute, anaerobic performance yield inconclusive results. Cengiz, (2015), stated that most studies evaluating performance effects of RWL and dehydration did not follow realistic situations of performance.

STATEMENT OF PURPOSE

The review by Franchini et. al. (2012), demonstrates that the prevalence of weight cutting amongst high school and college aged wrestlers is high, and that gender does not play a role in prevalence. While most studies on RWL focus on aerobic performance, this study proposes several unique factors. The purpose of this research is to examine, and determine the effects that RWL and dehydration has on anaerobic threshold by examining ventilatory threshold in female collegiate wrestlers through a series of testing scenarios: before a period of RWL, an hour after rehydration following a period of RWL, and after a 12-hour period of rehydration and recovery following a period of RWL. This testing protocol is designed to mimic both a same day weigh-in competition, and a day before weigh-in competition. The following variables will be collected and analyzed in the study: body composition, hydration status, metabolic gas exchange, and time to exhaustion, and anaerobic power.

SIGNIFICANCE OF STUDY

By collecting and analyzing multiple variables through different stages of a period of RWL, we will be able to provide valuable knowledge and insight to athletes as well as coaches on performance in female collegiate wrestlers who cut weight. This study will be able to contribute to current research on the effects of dehydration on athletic performance. With there being limited research on female combat sport athletes in relation to RWL, dehydration, and performance, this study can also contribute to future research. Potentially this study can have the ability to contribute to the WCWA adopting similar weight cutting guidelines and regulations as the NCAA to help better protect athletes participating in the sport.

HYPOTHESES

Ho: If a female wrestler loses 5% of her hydrated body weight in 4 days, then ventilatory threshold and anaerobic power one hour after the RWL period will be affected.

H1: If a female wrestler loses 5% of her hydrated body weight in 4 days, then ventilatory threshold and anaerobic power one hour after the RWL period will not be affected.

Ho: If a female wrestler loses 5% of her hydrated body weight in 4 days, followed by a 12-hour period of recovery and rehydration, then ventilatory threshold and anaerobic power will not be affected.

H1: If a female wrestler loses 5% of her hydrated body weight in 4 days, followed by a 12-hour period of recovery and rehydration, then ventilatory threshold and anaerobic power will be affected.

DELIMITATIONS

This study was delimited to:

1. 8, apparently healthy, female wrestlers who are currently active on Lindenwood University Women's Wrestling 2016-2017 season roster.
2. Female wrestlers who have previous experience cutting weight.
3. Having a set percentage of weight loss (5%) for the period of RWL.
4. Allowing 4 days for the wrestlers to lose their allotted amount of weight.
5. Requiring athletes to be hydrated upon their initial testing.
6. Requiring athletes to be hydrated upon their final stage of testing.

7. Having a set 1-hour recovery and rehydration period following the period of RWL for phase 2 of testing.
8. Having a set 12-hour recovery and rehydration period following the period of RWL for phase 3 of testing.
9. Following a ramp protocol on a treadmill
10. Prohibiting athletes from using any potential performance enhancing supplements.
11. Prohibit athletes from using dangerous/extreme measures to cut weight. Ex: diet pills, laxatives, self-induced vomiting, etc.

LIMITATIONS

This study was limited to the following:

1. Using a small, convenient sample size.
2. Allowing athletes to self-guide their RWL period using their own, previously used methods including dietary and exercise needs.
3. Training level of each athlete.

ASSUMPTIONS

Throughout the duration of this study, we will assume:

1. That all recruited participants will follow the study protocol.
2. All participants will lose the allotted amount of weight in the given period of time.
3. All participants remain in a healthy state during the whole duration of the study.
4. That the initial weigh-in weight obtained during the first stage of testing is the participant's natural, hydrated, bodyweight.

5. That all participants will truthfully answer health history, PAR-Q, and any additional questionnaires.
6. Participants will give maximal effort throughout the duration of each stage of testing.

DEFINITION OF TERMS

Rapid Weight Loss (RWL)- Greater than 2% total body weight loss in a shortened period of time in order to make a certain weight classification, usually involves some degree of dehydration (Cengiz 2015)

Anaerobic Threshold- an intensity of exercise, involving a large muscle mass, above which measurement of oxygen uptake cannot account for all of the required energy (Svedahl and MacIntosh, 2003)

Ventilatory Threshold- The exercise intensity at which the increase in ventilation becomes disproportional to the increase in power output or speed of locomotion during an incremental exercise test. (Svedahl and MacIntosh, 2003)

CHAPTER 2

REVIEW OF LITERATURE

HISTORY AND PREVALENCE OF WEIGHT CUTTING

Weight cutting, or temporarily losing a significant amount of weight in a short period of time, is commonly practiced amongst athletes in weight classified sports and believed by those athletes to give them a competitive advantage if they can get to their lowest weight possible (Timpmann et al. 2007). Popular sports where this rapid weight loss (RWL), is prevalent include wrestling, boxing, judo, and MMA. A review narrative by Franchini et. al. (2012), revealed that there is a high prevalence of RWL among high school, collegiate, and international style wrestling (60-90% of competitors). Franchini et. al. (2012), also found that athletes participating in RWL most commonly lost 2-5% of their normal hydrated body weight within a few days before competition, while 40% of athletes reported losing 10% or more of their bodyweight in a short period of time leading up to competition. Often athletes who use RWL as a way to make their weight classification use different methods of dehydration, calorie restriction, excessive sweating, and excessive exercise (Franchini et. al. 2012). In extreme cases athletes, have also been known to use harmful methods of weight loss such as diet pills, laxatives, self-induced vomiting, and diuretics (Franchini et. al. 2012).

In 1997, within one month of each other, 3 male collegiate NCAA wrestlers died from unsafe weight cutting (Loenneke et. al. 2011). After an investigation, it was found that the 3 wrestlers engaged in extreme weight cutting methods including restricting fluids and food intake, wearing plastic sweat suits under cotton warm up suits, and exercising in excessively hot environments with the hopes of maximizing sweat loss (Loenneke et. al. 2011). The combination of these methods resulted in the athletes becoming unresponsive and undergoing cardiac arrest, due to dehydrated related hyperthermia (Loenneke et. al. 2011). Following the tragic death of these athletes the NCAA has since adopted strict weight cutting regulations and guidelines for male collegiate wrestlers. These regulations include all wrestlers undergoing preseason hydration and body composition testing in order to establish a minimum weight that each wrestler is allowed to achieve. In a review of validity of the current NCAA Weight Management guidelines, Loenneke et. al. (2011), states that a euhydrated state was accepted as a urine specific gravity less than 1.020 g/ml when tested with a urine refractometer. Loenneke et. al. (2011), also states that body composition was determined using a three-site skin fold test as the primary method, and also accepted air displacement plethysmography and hydrostatic weighing as secondary methods. Through these tests the lowest weight an athlete is able to compete at is determined and is called the minimum weight. The minimum weight is set to where the athlete does not drop below 5% total body fat. In addition to this regulation, the NCAA, also implemented the 1.5% rule, which states, "the NCAA Weight-Loss Plan mandates that a wrestler shall not lose more than 1.5 percent of body weight per week from the weekly weigh-in (seven days) while making the descent to the lowest certified weight class," (Rule 8.3.4., NCAA Weight Management Handbook 2011).

These regulations and guidelines were put into place by the NCAA to help protect the athletes from the adverse effects of RWL. Methods used by athletes to make a certain weight class in a condensed period of time may induce dehydration, increased load on the cardiovascular system, impairment of the thermoregulatory system, depletion of stored glycogen, hypoglycemia, and loss of protein, electrolytes, and vitamins in the athlete (Timpmann et. al. 2008). Franchini et. al. (2012), reported that during RWL, aerobic performance impairments are largely due to dehydration, reduced plasma volume, increased heart rate, impaired thermoregulation, and muscle glycogen depletion. Additionally, Franchini et, al. (2012), reported that decreased anaerobic performance associated with RWL is mainly due to a decreased buffering capacity, glycogen depletion, and hydroelectric disturbances. Research on anaerobic performance and RWL has been a debated topic with inconclusive results. The majority of research discrepancy on the anaerobic effects of RWL is due to many different factors varying from each study including recovery period between weigh in and performance testing, the amount of total body weight lost, and if there was a diet protocol followed (Timpmann et. al. 2008). Franchini et. al. (2012), stated that anaerobic performance decrements are generally observed when the athletes are given no opportunity to recover or rehydrate following weighing in. Weigh-in procedures largely depend upon the governing body, level of competition, and style of wrestling. In high school and collegiate wrestling athletes are generally given one hour from the time of weigh-ins to the start of competition. International wrestling utilizes day before weigh-ins, where athletes are able to weigh in at least 12 hours before competition, giving them more time to re-hydrate and re-feed. "When followed by a relatively short recovery period (3-4 hours), RWL will probably have minimal or no impact on anaerobic performance," (Franchini et. al. 2012). This suggests that if given ample time to re-hydrate and re-feed following a period of RWL, an athlete's anaerobic performance will not be significantly affected.

RAPID WEIGHT LOSS, DEHYDRATION, AND ANAEROBIC PERFORMANCE

Anaerobic performance refers to the body's ability to perform and produce energy without the presence of oxygen. Sports that utilize anaerobic energy systems are short in duration and high in intensity. Cengiz (2015), states that "wrestling requires high anaerobic power, and moderate aerobic power," therefore making anaerobic performance an important part of being successful in the sport. There is conflicting evidence concerning RWL and dehydration on anaerobic performance. As stated earlier the majority of discrepancies are seen because of numerous reasons including using different tests, duration of recovery time between RWL and testing, extent of body mass loss, and methods used to achieve RWL (Timpmann et. al. 2008). Thus, it is difficult to come to a universal conclusion on the effects of RWL and dehydration has on anaerobic performance.

Artoli et. al. (2010), demonstrated that anaerobic performance is not affected by RWL when followed by ample recovery time. When compared to a control group, judo athletes who lost 5% of their normal hydrated body weight in 5 days saw no significant changes in simulated judo performance or arm power during repeated upper body Wingate tests after a 4-hour recovery period following their RWL.

Contrary to Artoli et. al. (2010), a study by Timpmann et. al. (2008), showed a significant decrease in total work during a three-minute intermittent intensity muscular performance test with no recovery time given after RWL. In this study, participants were also required to lose 5% of their total body mass but in four days. The muscle performance test examined the peak torque and muscular endurance of knee extension muscles using an isokinetic dynamometer. Results showed that total work was significantly reduced in the reduced body weight state, showing an impairment in muscular performance.

The previous two discussed studies show that when given the same amount of weight to lose, recovery time before testing measures after RWL plays a crucial role in determining acute performance effects. Moquin and Mazzeo (1999), examined the effects of mild dehydration on lactate threshold in women. Unlike the previous studies, the participants in this study were untrained in methods of RWL with dehydration, and were not instructed to lose a certain amount of their body weight. Instead they were instructed to exercise at submaximal levels in full sweat suits for 45 minutes prior to a graded exercise test where blood lactate would be evaluated. On average participants lost 1.5+/-0.2% of their hydrated body weight prior to testing, and elicited a significant shift in blood lactate concentrations at a lower absolute Vo2. Additionally time to exhaustion was significantly affected by the dehydration. Participants in this study lost significantly less weight than in the previous two mentioned studies, yet showed significant decreases in performance. This study proposes the following questions, does prior experience with methods of RWL play a role in performance decrements and at what level of body mass loss will performance decreases be seen with no recovery given?

Cengiz (2015), examined the effects of RWL and dehydration on upper and lower body anaerobic power immediately after a period of RWL and following a 12 hour recovery period. The study design used by Cengiz (2015), most closely followed a realistic day before weigh-in procedure. Participants were instructed to lose 4-5% of their normal hydrated body weight in 4 days. The results of this study showed that not only does the negative effects of RWL seen immediately after RWL and dehydration disappear after a 12 hour recovery period, but relative peak power also increases following 12 hours of recovery. Cengiz (2015), showed a positive relationship between RWL and performance, which is the ultimate goal of athletes who choose to engage in RWL by means of dehydration.

It is important to note that all of these previous mentioned studies that examined the acute effects on performance had different testing measurements, recovery periods, body mass loss, and experience levels with RWL. This falls in line with the statement made by Timpmann et. al. (2008), in that universal conclusions cannot be made about acute performance effects simply because each individual study followed a different protocol. In regards to realistic performance measures, besides the study done by Cengiz (2015), which followed a day before weigh-in procedure, the other studies did not follow a realistic time line of weigh-ins, to recovery, to performance. A wrestler is not going to perform immediately following a weigh in, nor will they be given more than 2 hours to recover if expected to perform on the same day.

ANAEROBIC THRESHOLD AND VENTILATORY THRESHOLD

Anaerobic metabolism is the replenishment of ATP without the use of oxygen (Svedahl and MacIntosh 2003). During glycolysis, a form of anaerobic metabolism, ATP is produced along with pyruvic acid. Depending on whether or not oxygen is present, pyruvic acid will either be converted into lactic acid, and subsequently lactate if oxygen is not present, or it will be converted to pyruvate and used in the Krebs cycle to further generate more ATP if oxygen is present. There have been various theories that have surrounded blood lactate its role in energy metabolism. Many first believed that lactate was just a by-product of anaerobic metabolism during high intensity exercise when oxygen was at a deficit, and could only be removed during recovery periods (Brooks 2000). The process of converting pyruvic acid to lactic acid supports glycolysis through the oxidation of cytoplasmic NADH using the enzyme lactic dehydrogenase, which gives a continuous supply of NAD+ for glycolysis and in turn produces lactic acid (Svedahl & MacIntosh 2003). Blood lactate begins to accumulate when lactate production exceeds lactate clearance (Brooks 2000). In regard to exercise, Goodwin et. al., (2007), reported that blood lactate has been seen to gradually increase at first, then it increases more rapidly as the workload and intensity increases, therefore, blood lactate concentrations can be used as a valid performance measure because it demonstrates the metabolic efficiency of the body to effectively oxidize or transport accumulated lactate.

Anaerobic threshold (AT), is defined as an intensity of exercise, involving a large muscle mass, above which measurement of oxygen uptake cannot account for all of the required energy (Svedahl and MacIntosh, 2003). Vo2max has been the established as the gold standard performance indicator of aerobic fitness in endurance sports, however when in relation to sports that utilize both aerobic and anaerobic properties, anaerobic threshold has been shown to be a more accurate reliable indicator of performance level (Moquin and Mazzeo, 1999). Anaerobic threshold is a concept and can be associated with certain intensities of exercise through several different testing methods including maximal lactate steady state, lactate minimum speed, lactate threshold, onset of blood lactate accumulation, and ventilatory threshold (Svedahl and MacIntosh 2003).

Ventilatory threshold is a common method used by researchers to assess anaerobic fitness because it is noninvasive when compared to other methods (Svedahl and MacIntosh 2003). Ventilatory threshold is defined as the exercise intensity at which the increase in ventilation becomes disproportional to the increase in power output or speed of locomotion during an incremental exercise test (Svedahl and MacIntosh 2003). As stated earlier, with increases in workload and intensity, come increases in lactate production. The dissociation of lactic acid to lactate also forms hydrogen ions (H+). An accumulation of H+ ions results in an increasing blood pH, making the blood and working muscle more acidic. Current studies and theories support that a rise in pH, resulting in an acidic environment for muscles is the main contributor to fatigue during maximal exercise, not the just the presence of lactate (Carins 2006). Svedahl and MacIntosh (2003), explain that in order to lessen the impact of the increasing blood pH, the body utilizes several buffering systems including the bicarbonate system. As H+ reacts with bicarbonate, carbonic acid is formed, and can be further dissociated to H2O and CO2. Excess

CO_2 production, along with a change in pH, stimulates ventilation (Svedahl and MacIntosh 2003). The point at which ventilation exceeds the rate at which oxygen is being utilized is known as the ventilatory threshold.

SUMMARY

Wrestling is a highly anaerobic sport. It is difficult for researchers to come to a universal conclusion on the effects that RWL and dehydration has on anaerobic performance in combat sports due to varying study design factors.

CHAPTER 3

METHODS

RECRUITMENT AND PARTICIPANTS

Upon IRB approval, recruiting from the 2016-2017 Lindenwood Women's Wrestling team will begin. All potential recruits will be given an informed consent form explaining the details of the study and a questionnaire asking basic inclusion and exclusion criteria questions. A briefing of the study will also take place in order to explain the study in detail, along with the risks and benefits of the study, and to answer any pertinent questions by potential participants. All participants will be required to be active wrestlers on the current roster. Participants will also be required to be in a healthy state, free of any injury or sickness. Due to the design of the study, only participants who have previous experience cutting weight will be accepted into the study. For ethical reasons, all participants will be instructed to not utilize any extreme measures to cut weight including the use of diuretics, diet pills, laxatives, and self-induced vomiting.

INSTRUMENTATION

The following instruments will be used for the collection of data in this study: RHC-200 (ATC) clinical urine refractometer, Hologic Discovery QDR 4500 DEXA (Bedford, MA), Woodway DESMO-EVO treadmill (Waukesha, WA), Monark Ergomedic 894E Wingate (Vansbro, Sweden), Parvomedics True One metabolic measuring system (Murray, UT), and Rice Lake digital physician scale 150-10-7 (Rice Lake, WI).

STUDY DESIGN

This study is designed to closely mimic a same day weigh-in procedure competition and a day before weigh-in competition. The study will take place over a six-day period of time. The initial weigh in and testing will be done on day 1. From here the participants will be instructed to lose 5% of their initial weight established on day 1, by day 5 of the study. On day 5 participants will be weighed again and given 1 hour from the time of weigh-ins to rehydrate and recover before testing will commence. Following testing on day 5 participants will be given approximately 12 hours to further recover. On day 6, participants will be weighed once more and final testing will take place immediately after.

PROCEDURE

Day 1, Phase 1 Testing

Upon acceptance into study, participants will report to the Lindenwood Sports Science Center (LUSCC), to begin initial testing. Resting blood pressure and heart rate will be taken after 10 minutes of sitting in a relaxed position. After resting measurements are taken, participants will be asked to provide a urine sample to undergo analysis using a urine refractometer. In order to move on to the next step of testing, participants must provide a hydrated urine sample defined as a urine specific gravity less than 1.020. After a hydrated urine sample is obtained, participants will weigh-in and undergo body composition analysis using DEXA. All official weigh in procedures before DEXA will be done in competition regulation singlets. Following the DEXA analysis, participants will then undergo ventilatory threshold (VT) testing. VT testing will begin with a 1 min warm up at 3.5 mph and 0% grade. Immediately following the warm up, the following protocol will be used, every minute for the first 5 minutes of testing the speed will increase 1 mph, starting at 5 mph for the first minute. The grade will stay at 0% until 9 mph is reached and then will increase by 2% every subsequent minute. Testing will go until volitional exhaustion of the participant. The following variables will be collected throughout the duration of VT testing: heart rate (HR) using Polar Heart Rate monitors, rating of perceived exertion (RPE) using the Borg Scale (6-20), and metabolic gas exchanges including respiratory exchange ratio (RER), rate of ventilation (VE), volume of carbon dioxide (VCo2), and volume of oxygen (Vo2). Vo2 peak will be accepted if two of the three following criteria are met, RER $\geq$1.1, RPE $\geq$15, and HR $\geq$85% of age predicted HRmax. Metabolic gas exchange collection will continue through an active cool down. VT will be determined by plotting Vo2 vs. VCo2, and observing the point at which there is a non-linear increase. After completion of VT testing, the participant will be given a rest time of 25 minutes before performing a single 30 second lower body Wingate bout. Resistance for Wingate testing will be set at .7kg/kg of body weight. It is important to note that the body weight and resistance used for this stage of testing will be used in the next 2 testing days for the Wingate test.

RWL Phase (Days 2-5)

Days 2-5 of the study will be used as the self-guided RWL phase. During this time, participants will lose 5% of their initial testing body weight. Participants will have until phase 2 of testing on day 5 to reduce their body weight using self-selected methods of weight reduction. As stated earlier, for ethical reasons, participants will be strictly prohibited from engaging in any extreme methods of weight reduction including the use of diuretics, laxatives, weight loss pills, or self-induced vomiting. During this stage participants will be instructed to keep an accurate food log using the My Fitness Pal application. Daily weigh-ins after practice will also be conducted in order to track accurate weight loss.

Day 5, Phase 2 Testing

Phase 2 of testing will follow the exact protocol of Phase 1 testing, with the following exceptions. Participants will arrive to the LUSCC approximately 1 hour before scheduled testing begins. Participants will then have that 1 hour to check weight and if needed to cut the rest of the weight in order to make the 5% cut. The urine sample provided by participants does not need to reflect a hydrated state upon analysis by urine refractometer. After the DEXA analysis, participants will be given one hour to recover, rehydrate, and re-feed prior to starting their 2nd VT test. Upon completion of their 2nd VT test, participants will again be given a 25 minute rest period before starting their second Wingate test.

Day 6, Phase 3 Testing

Approximately 12 hours following Phase 2 testing, Phase 3 testing will commence. Phase 3 testing will exactly replicate Phase 1 testing, with the exception that the participants do not need to have a hydrated urine sample.

STATISTICAL ANALYSIS

Statistical analysis will be conducted through the use of SPSS software and Microsoft EXCEL. All data will be expressed as a mean ± SD. A one-way analysis of variance (ANOVA) for repeated measures will be used to detect statistical differences between measured variables before RWL, 1 hour after RWL, and 12 hours after RWL. Statistical significance will be accepted at $p < 0.05$.

CHAPTER 4

RESEARCH MANUSCRIPT

This chapter presents a complete manuscript that describes the study in traditional journal article form including a title page, abstract, introduction, methods, results, discussion, acknowledgements, references, figures, and tables. The manuscript, entitled "Effects of Rapid Weight Loss and Dehydration on Performance in Female Collegiate Wrestlers" will be submitted to the Journal of Strength and Conditioning Research when all data collection and analysis is completed. It is currently authored by Brittany David, Kathryn Tessmer, Paul Wright and Chad Kerksick. The final manuscript will follow the formatting and style guidelines of the Journal of Strength and Conditioning Research (http://edmgr.ovid.com/jscr/accounts/ifauth.htm). The references cited are provided at the end of the manuscript.

EFFECTS OF RAPID WEIGHT LOSS AND DEHYDRATION ON PERFORMANCE IN FEMALE COLLEGIATE WRESTLERS

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ABSTRACT

BACKGROUND: Limited information is available on the physiological responses of female collegiate wrestlers to weight cutting practices and their impact on performance. The purpose of this study is to investigate the effects of rapid weight loss (RWL) and dehydration on the performance of female collegiate wrestlers one hour post RWL, and 12-hours post RWL. **METHODS:** Five female collegiate wrestlers (age = 20.0 ± 1.2 yrs, 62.9±2.2 in., 152.9±32.5 lbs., 27.24±3.33% body fat) underwent a pre-competition style period of RWL where they voluntary cut 5.3 ± 0.2% of their initial body mass in four days. Performance tests were performed prior to RWL, 1 h post RWL, and 12 h post RWL and included urine specific gravity, body composition (using DEXA), peak aerobic capacity, ventilatory thresholds and anaerobic capacity. **RESULTS:** From initial testing (1.008±0.007) to immediately post RWL (1.030±0.003) there was a significant increase in urine specific gravity ($p=0.02$). Absolute peak VO_2 values (L/min) did not change between testing conditions ($p>0.05$); as expected relative VO_2 values significantly increased one hour after RWL, but normalized after 12 hours ($p > 0.05$). Wingate peak power production tended ($p = 0.06$) to increase (PRE: 626 ± 200 W vs. 1 h post RWL: 653 ± 165 W) ($p = 0.06$). While mean values of fatigue index increased systematically, no statistical significance was revealed. **CONCLUSION:** This study found several confounding results in aerobic performance and anaerobic power when in a dehydrated state, but more testing must be done in order to confirm these findings.

INTRODUCTION

Combat sports such as wrestling, mixed martial arts (MMA), jiu jitsu, judo, and boxing are beginning to see an increasing popularity amongst fans as well as athletes. Combat sports alone represent about 25% of Olympic medals at the summer Olympic Games (Franchini et. al. 2012). These sports are gaining popularity among both male and female athletes because they all utilize a weight classification system, making it possible for athletes of all shapes and sizes to participate and be successful (Timpmann et. al. 2007). As in any sport, combat sport athletes seek out ways to give them a competitive advantage over their opponents, including weight cutting. Athletes believe that by getting to the lowest weight classification possible that they will have considerable size, strength, and power advantages over their opponents who do not cut weight (Cengiz 2015). Before competitions, athletes oftentimes self-submit to a period of rapid weight loss (RWL), in which they temporarily lose a considerable amount of weight, in most cases averaging losing between 2-5% of their original body weight, one to three days prior to competition weigh-ins (Franchini et. al. 2012). Common methods of RWL include intentional dehydration, calorie restriction, and excessive exercise leading up to a competition weigh in.

It has been well documented that RWL accompanied by intentional dehydration negatively affects aerobic performance. These negative performance effects include impaired temperature regulation, increase load on the cardiovascular system, and an overall decreased aerobic capacity (Cengiz 2015). For anaerobic performance, numerous studies (Ahlman et. al. 1961; Webster et. al. 1990; Rankin et. al. 1996), provide inconclusive results on the impact of RWL and dehydration, mainly due to having multiple, different study designs and in many situations evaluating performance effects of RWL and dehydration in unrealistic situations to assess performance.

Due to the apparent list of adverse effects that come with undergoing a period of RWL, and the deaths of three male collegiate wrestlers in 1997, the National Collegiate Athletic Association (NCAA), implemented strict weight loss guidelines and restrictions on collegiate men's wrestling. These guidelines include a preseason body composition analysis, urine specific gravity testing to assess hydration status, weigh in procedures, and restrictions on the amount of weight a wrestler can lose in one week (NCAA 2011). Women's collegiate wrestling is governed by the Women's Collegiate Wrestling Association (WCWA), which currently does not have any guidelines or restrictions on weight cutting for female college wrestlers, this can potentially be dangerous for female athletes engaging in RWL. The lack of weight cutting guidelines is likely in large part due to the WCWA being a relatively new organization, governing officials not understanding the prevalence of weight cutting among collegiate female wrestlers, or because female wrestlers have different, varying weigh-in protocols and procedures. To date there is currently no research on the affects that RWL and dehydration has on performance in female collegiate wrestlers and if one weigh-in protocol offers more advantages than another.

The review by Franchini et. al. (2012), demonstrates that the prevalence of weight cutting amongst high school and college aged wrestlers is high, and that gender does not play a role in prevalence. The purpose of this research was to examine, and determine the effects that RWL and dehydration has on body composition, anaerobic power production, time to exhaustion and anaerobic threshold in female collegiate wrestlers a three timepoints: before a period of RWL, one hour after rehydration following a period of RWL, and after a 12-hour period of rehydration following a period of RWL. This testing protocol is designed to mimic both a same day weigh-in competition, and a day before weigh-in competition.

By collecting and analyzing multiple variables through different stages of a period of RWL, we will be able to provide valuable knowledge and insight to athletes as well as coaches on performance in female collegiate wrestlers who cut weight. With limited research being available on female combat sport athletes in relation to RWL, dehydration, and performance, this study can contribute to current and future research. Potentially this study can have the ability to contribute to the WCWA adopting similar weight cutting guidelines and regulations as the NCAA to help better protect athletes participating in the sport.

METHODS

Experimental Approach to the Problem

This study was designed to closely mimic a same day weigh-in procedure competition and a day before weigh-in competition. The study took place over a six-day period of time beginning with initial weigh-ins and testing on day 1. Participants arrived at the Lindenwood Sports Science Center (LUSCC), and were asked to sit in a relaxed position for 10 minutes prior to their resting blood pressure and heart rate being taken. After resting measurements were established, participants were then asked to provide a small urine sample to be determine individual hydration status. After a hydrated urine sample was obtained, participants then officially weighed in for the first time and were given a DEXA examination. Following the DEXA, participants were prepared for a VO2Max test. Upon volitional exhaustion, participants were given a 25 minute rest period before performing a single 30 second lower body Wingate test.

Following testing on day 1, the rapid weight loss phase began and participants were instructed to lose 5% of their initial weight established on day 1, by day 5 of the study. During the rapid weight loss phase, normal practices were held and daily weigh-ins by a member of the research team were conducted. Participants were also instructed to keep track of their nutritional intake as well as any addition exercise that they engaged in.

On day 5, participants arrived approximately 1 hour before the official established weigh in time. During this time participants checked their weight, and if needed cut any additional weight in order to make the 5% weight cut. Once testing began, resting measurements were taken and a urine sample was provided by each participant. Participants were not required to provide a hydrated sample for this phase of testing. From here testing procedures followed the same structure of initial testing with the exception that after the initial DEXA, participants were given a 1 hour recovery period to rehydrate and recover from the RWL period. Following the 1 hour recovery period, participants were given a 2nd DEXA examination. The VO2Max testing and Wingate testing followed same as day 1.

Following testing on day 5 participants were given approximately 12 hours to further recover. On day 6, participants resting measurements, hydration level, and weight was recorded once more and final testing took place immediately after. Final testing exactly replicated day 1 of testing.

Subjects

Upon IRB approval, recruiting from the 2016-2017 Lindenwood Women's Wrestling team began. All potential recruits were given an informed consent form explaining the details of the study and a questionnaire asking basic inclusion and exclusion criteria questions. A briefing of the study took place in order to explain the study in detail, along with the risks and benefits of the study, and to further answer any pertinent questions by potential participants. All participants were required to be active wrestlers on the current roster. Participants were also required to be in a healthy state, free of any injury or sickness. Due to the design of the study, only participants who had previous experience cutting weight were accepted into the study. For ethical reasons, all participants were instructed to not utilize any extreme measures to cut weight including the use of diuretics, diet pills, laxatives, and self-induced vomiting

Procedures

Hydration Assessment

Hydration assessment took place on all 3 testing days using a RHC-200 (ATC) hand held clinical urine refractometer. Participants were required to provide a hydrated urine sample on day 1 of testing. Euhydration was defined as having a urine specific gravity less than 1.020. Day 5 and 6 of testing did not require participants to provide a hydrated urine sample.

Body Composition

DEXA examinations were conducted a total of 4 times throughout the duration of the study using a Hologic Discovery QDR 4500 DEXA (Bedford, MA). DEXA was used to depict body composition changes over the course of RWL and recovery. The following measurements were recorded using DEXA: bone mineral density (g), fat mass (kg), lean mass (kg), and body fat percentage.

Peak Oxygen Uptake

Participants then performed a VO_2 max test on a motorized treadmill (Woodway DESMO-EVO treadmill (Waukesha, WA), on each day of testing. VO_2 testing began with a one minute warm up at 3.5 miles per hour (mph) and 0% grade. Immediately following the warm up, the initial speed was set at 5 mph for one minute. Every minute that passed, the speed increased by an additional 1 mph until a speed of 9 mph was reached whereby the treadmill grade was increased by 2% for every subsequent minute. Testing went until volitional exhaustion of the participant. The following variables were collected every 30 seconds throughout the duration of

VO_2 testing using Parvomedics True One metabolic measuring system (Murray, UT): respiratory exchange ratio (RER), rate of ventilation (VE), volume of carbon dioxide (VCO_2), and volume of oxygen (VO_2). Heart rate (HR) was continuously collected using Polar Heart Rate monitors (model # FT1, CITY, STATE) with a chest strap placed snugly around the torso at the level of the xiphoid process and a watch transmitter. Rating of perceived exertion (RPE) was collected using the Borg Scale with a 6 representing no exertion and a 20 representing maximal exertion. VO_2 Peak was accepted if two of the three following criteria were met, RER $\geq$1.1, RPE $\geq$15, and HR $\geq$85% of age predicted HRMax. Ventilatory threshold was determined by plotting the intersection of VE/VO_2 and VE/VCO_2 across time.

Anaerobic Capacity

Each testing day following the VO_2Max test, the participants were given a rest time of 25 minutes before performing a single 30 second lower body Wingate bout using a Monark Ergomedic 894E Wingate (Vansbro, Sweden). Resistance for Wingate testing was standardized at 0.7 kg/kg of body weight. Due to the anticipated loss of body mass that would result from this study trial, the load on the Wingate was not changed from baseline throughout all testing days.

Rapid Weight Loss

Days 2-5 of the study were used as the self-guided RWL phase. During this time, participants were instructed to lose 5% of the body mass recorded at the beginning of the study trial. Participants had until phase 2 of testing on day 5, to reduce their body weight using self-selected methods of weight reduction. Participants were strictly prohibited from engaging in any extreme methods of weight reduction including the use of diuretics, laxatives, weight loss pills, or self-induced vomiting. Participants were required to attend all regularly scheduled practices during the week. During this stage, participants were also instructed to keep an accurate food and exercise log using the My Fitness Pal application. Daily weigh-ins after practice were also conducted by an assigned member of the research team to track weight loss and monitor health and any associated adverse events.

Statistical Analysis

All results were reported as mean ± standard deviation. A one-way ANOVA for repeated measures on time was used to detect statistical significance ($p<0.05$) for RWL, body composition, urine specific gravity, VO_2, and Wingate results. Assumption of sphericity was assessed and any violations were adjusted using the Huynh-Feldt correction. The Bonferroni post-hoc test was used to detect statistical significance between trials ($p<0.05$). All data was entered into Microsoft Excel and analyzed through SPSS version 23 (SPSS, Inc., Chicago, IL). Figures were produced using Microsoft Excel (Seattle, WA).

RESULTS

Rapid Weight Loss

Seven athletes from the current women's wrestling roster were recruited to participate in this study, all of which signed the consent form. Upon the start of the study, one participant voluntarily dropped out of the study due to commitment problems, leaving six athletes who started the trial. Of the six athletes who started the trial one athlete voluntarily dropped out from the study on the 5th day, and five athletes completed testing. When testing VO2 and looking at ventilatory thresholds, three out of the five participants that completed the study were able to reach satisfactory threshold values for all three trials. One participant achieved a threshold value on the first trial, but failed to reach satisfactory threshold values on the second and third trials. One participant failed to meet requirements for threshold values for all three trials. Participants on average reduced their total body weight by 5.3±0.2% (from 69.67±14.82 kg to 66.02±14.07

kg; p=0.003) within the allotted 4 day RWL period (Table 2). At the 1h post RWL timepoint, participants gained back 19.36 ± 7.04% (0.71 ± 0.50 kg) of the weight that they lost (from 66.02±14.07 kg to 66.73±14.19 p=0.003) (Table 2). The following day at the 12h post RWL period mark, participants had gained back 48.73±8.45% of weight lost (Table 2).

Table 2. Participant's Weight at Testing Times

	Initial Weight (kg)	Post Cut Weight (kg)	% Lost	1h Post Cut (kg)	% Gained	12 h Post Cut (kg)	% Gained
Subject 1	48.18	45.64	5.28	46.27	24.8	46.55	35.83
Subject 2	66.27	62.82	5.21	63.27	13.04	64.82	57.97
Subject 3	70.09	66.55	5.06	67.00	12.71	68.45	53.67
Subject 4	74.64	70.45	5.6	71.64	28.41	72.55	50.12
Subject 5	89.18	84.64	5.1	85.45	17.84	86.73	46.04
Average	69.67±14.82	66.02±14.07	5.25±0.21	66.73±14.19	19.36±7.04	67.82±14.51	48.73±8.45

Data is presented as means ± SD.

Body Composition

In regards to body fat mass, there was no significance found between trials (p=0.93). Body fat mass, was observed to slightly decrease from initial weigh-ins (19.5 ± 5.7 kg) to immediately post RWL (19.4 ± 5.1 kg) to 1 h post RWL (19.3 ± 5.1 kg). Body fat mass then increased from 1h post RWL (19.3 ± 5.1 kg) to 12 h post RWL (19.4 ± 5.4 kg). Lean body mass was seen to significantly decrease throughout the study (Fig. 3). From initial weigh-in, to immediately post RWL, participants saw a 3.4 ± 0.5 kg reduction in lean body mass (p=0.001). At 1 h post RWL, participants had a 2.5 ± 0.5 kg reduction from their initial lean body mass (p=0.003). 12 h post RWL participants had a 1.2 ± 0.4 kg loss in lean body mass when compared to their initial lean body mass (p=0.01).

Fig. 2 Fat Mass change in response to RWL

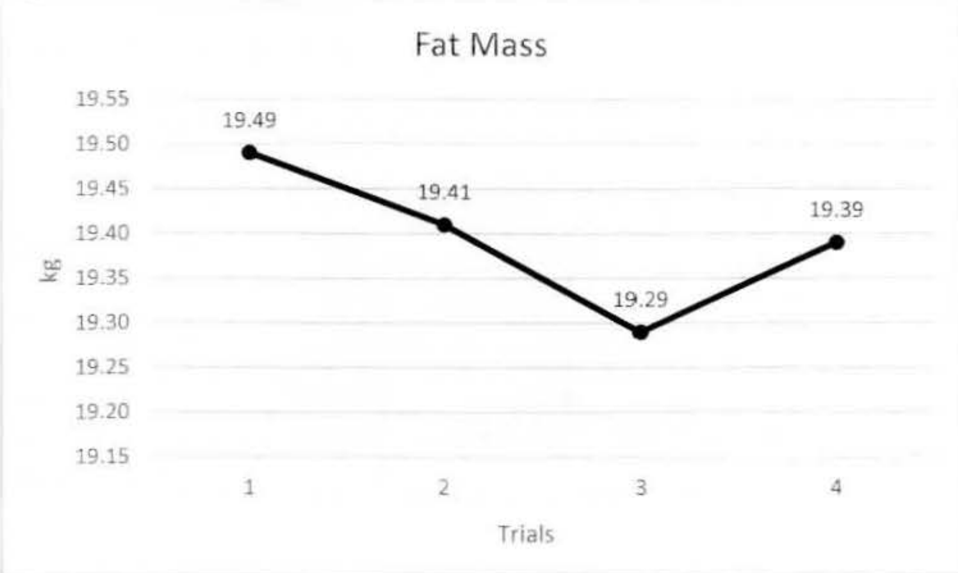
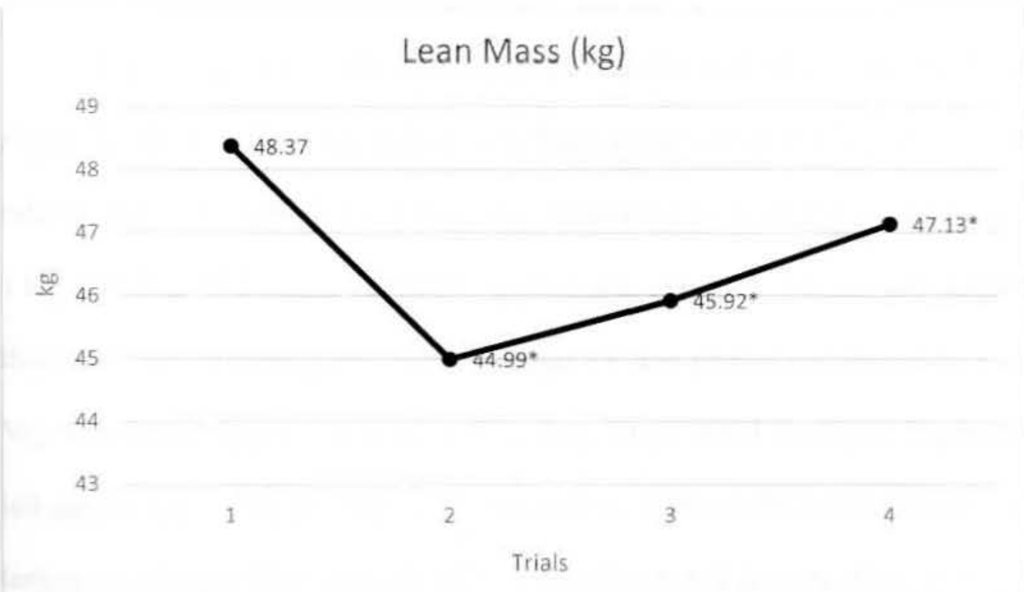


Fig. 3 Lean Mass (kg)



Urine Specific Gravity

Urine specific gravity saw a significant increase (p=0.02) from initial testing to immediately post RWL from 1.008±0.007 to 1.030±0.003 (Table 4). A significant decrease (p=0.002) was also seen from immediately after RWL (1.030 ± 0.003) to 12h post RWL (1.025 ±

0.004) (Table 4). Although there was an increase seen, there was no significance found from initial testing to 12 h post RWL (p=0.056).

Table 4. Urine Specific Gravity

	Pre (USG)	1 hr (USG)	12 hr (USG)
Subject 1	1.005	1.026	1.022
Subject 2	1.002	1.032	1.028
Subject 3	1.015	1.033	1.029
Subject 4	1.018	1.026	1.02
Subject 5	1.002	1.034	1.028
Average (mean±SD)	1.008±0.007	1.030±0.003	1.025±0.004

VO_2 and VT

There were no significant differences found at peak VO_2, between trials (Table 5). Figure 5A shows a decrease in peak VO_2 from initial testing to 1 h post RWL, however when relating peak VO_2 to body mass (Fig. 5B), there is an increase in peak VO_2 from initial testing to 1 h post RWL. Only three out of five participants appeared to reach and surpass their ventilatory threshold. Those three-participant's average VT was plotted and shown on a graph displaying VE/ VO_2 for all three separate trials (Fig. 6A). From initial testing to 1h post RWL, a shift to the left can be seen in VT (from 2.73 ± 0.34L/min to 2.56 ± 0.53L/min). When comparing initial testing to 12h post RWL, a slight shift to the left can still be seen (from 2.73±0.34L/min to 2.69±0.54L/min). With this, a shift to the right in VT can be seen from 1h post RWL to 12h post RWL (from 2.56±0.53L/min to 2.69±0.54L/min). Figures 6B, 6C, and 6D show individual ventilatory responses.

Table 5. Peak VO_2

	Pre (ml/kg/min)	Pre (L/min)	1 hr (ml/kg/min)	1 hr (L/min)	12 hr (ml/kg/min)	12 hr (L/min)
Subject 1	61.2	2.95	60.4	2.76	57.1	2.66
Subject 2	54.1	3.59	50.6	3.18	50.7	3.28
Subject 3	48.6	3.41	52.8	3.51	50.6	3.46
Subject 4	50.5	3.77	54.0	3.80	53.4	3.88
Subject 5	42.9	3.82	44.2	3.38	43.2	3.75
Average (mean±SD)	51.4 ± 6.8	3.5 ± 0.4	52.4 ± 5.9	3.3 ± 0.4	51.0 ± 5.1 1	3.4 ± 0.5

Fig. 5A Peak VO_2 (L/min)

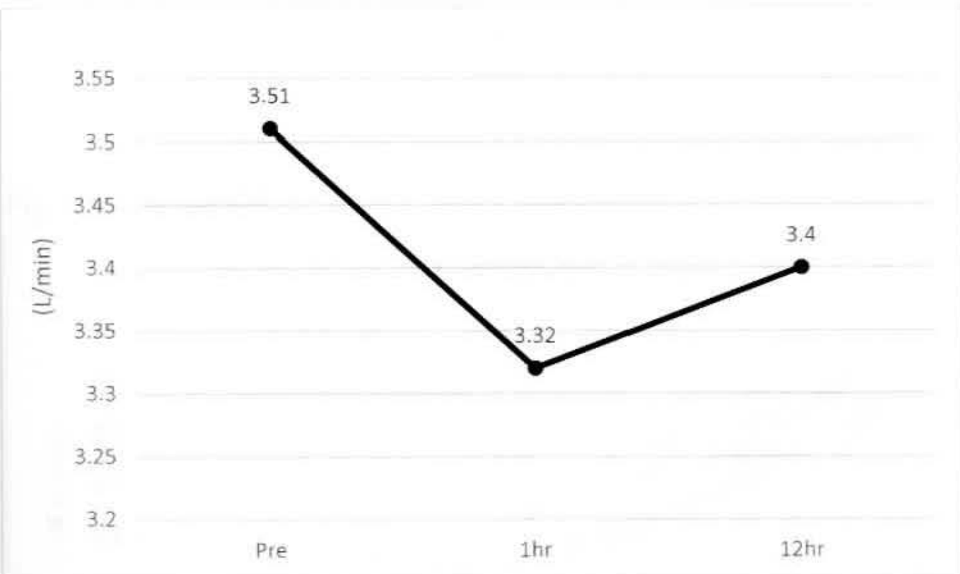


Fig. 5B Peak VO_2 (ml/kg/min)

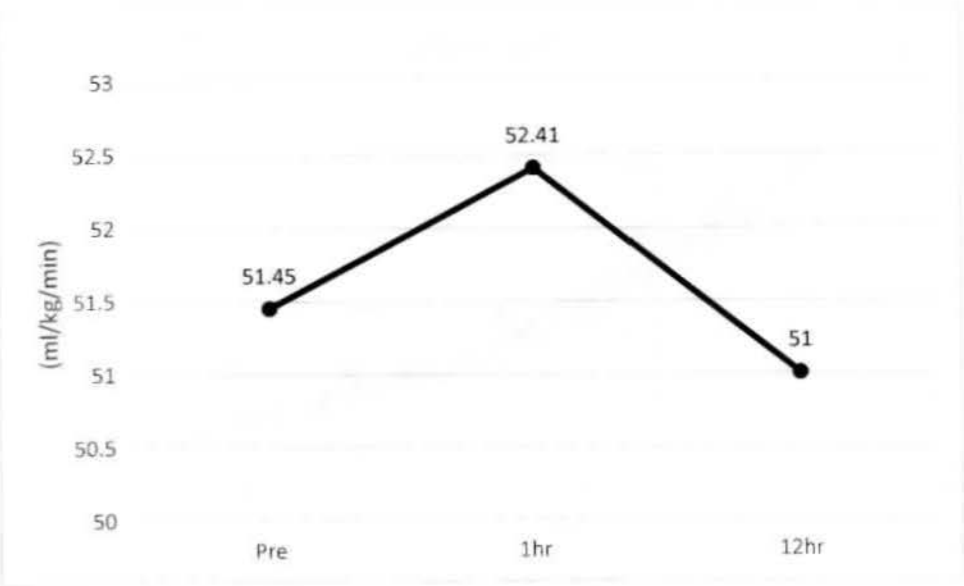


Fig. 6A Average VT

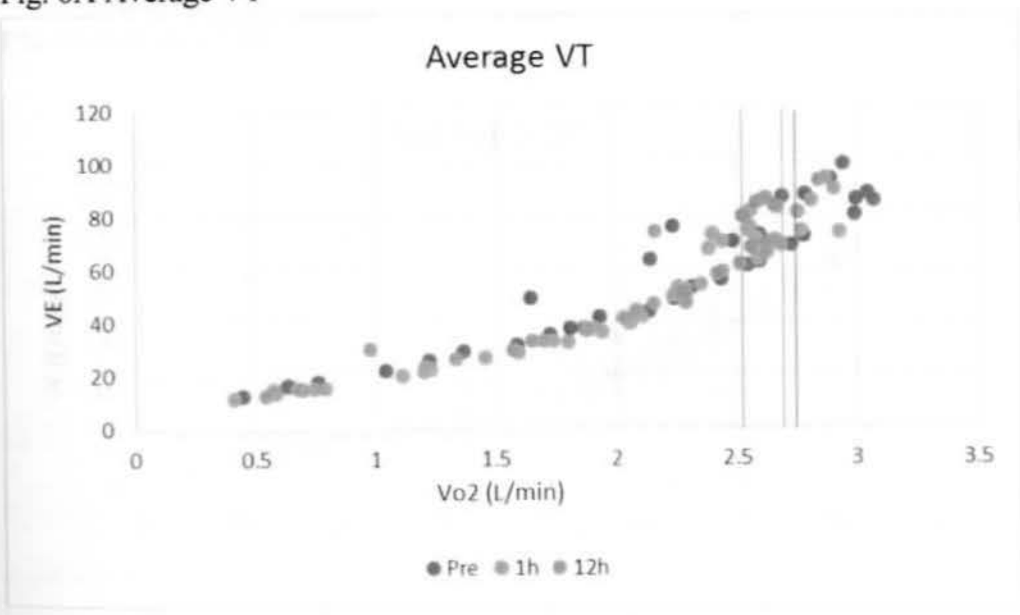


Fig. 6B Subject 1 VT

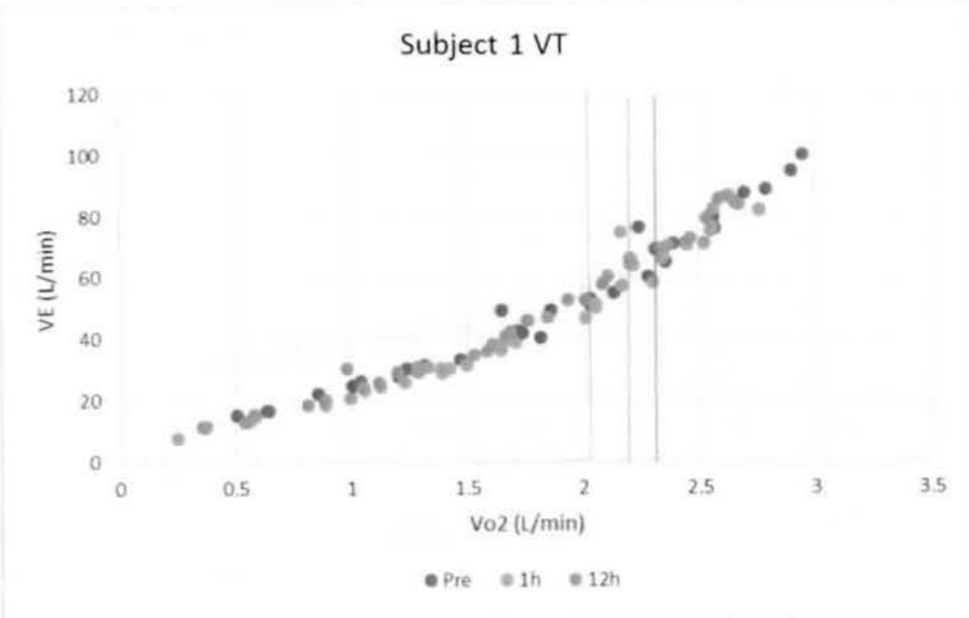


Fig. 6C Subject 2 VT

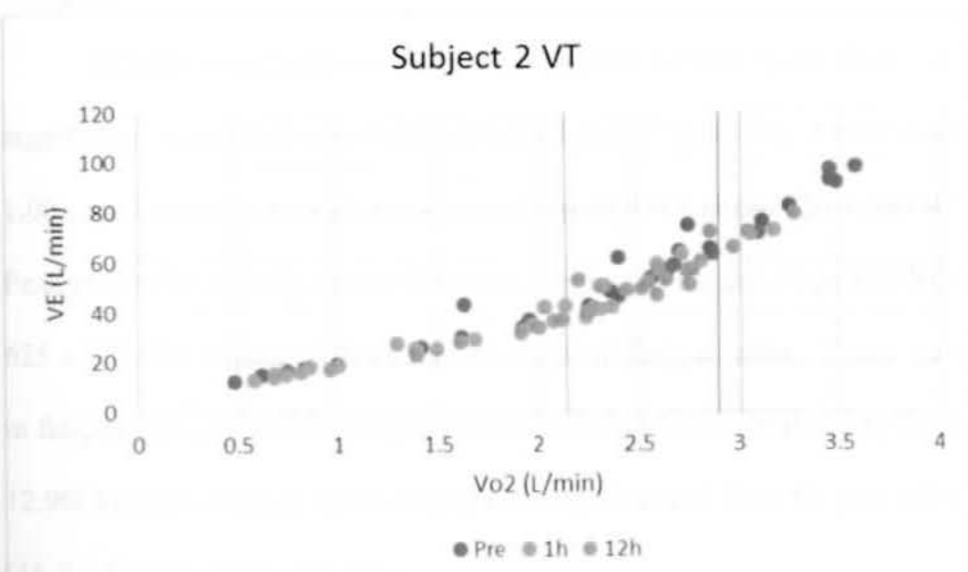
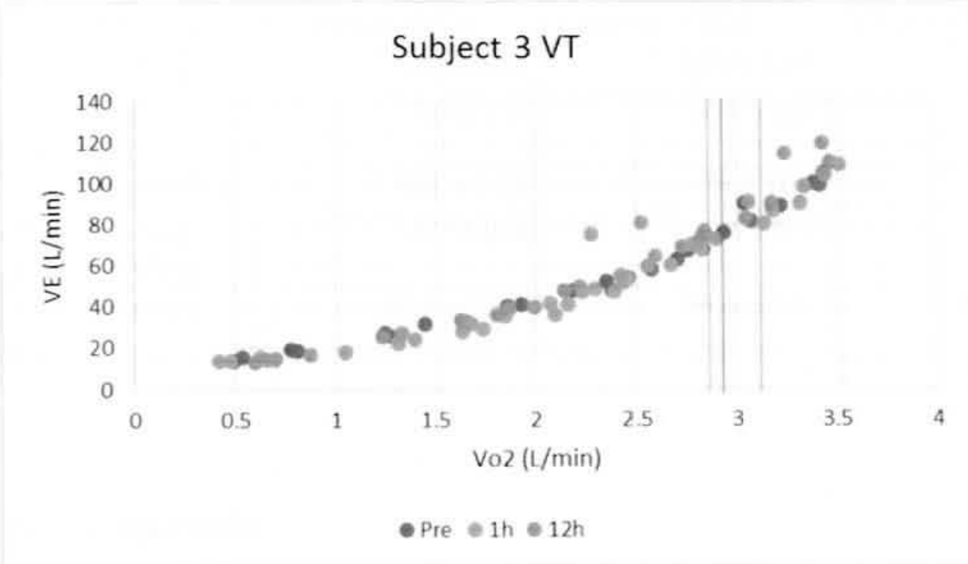


Fig. 6D Subject 3 VT



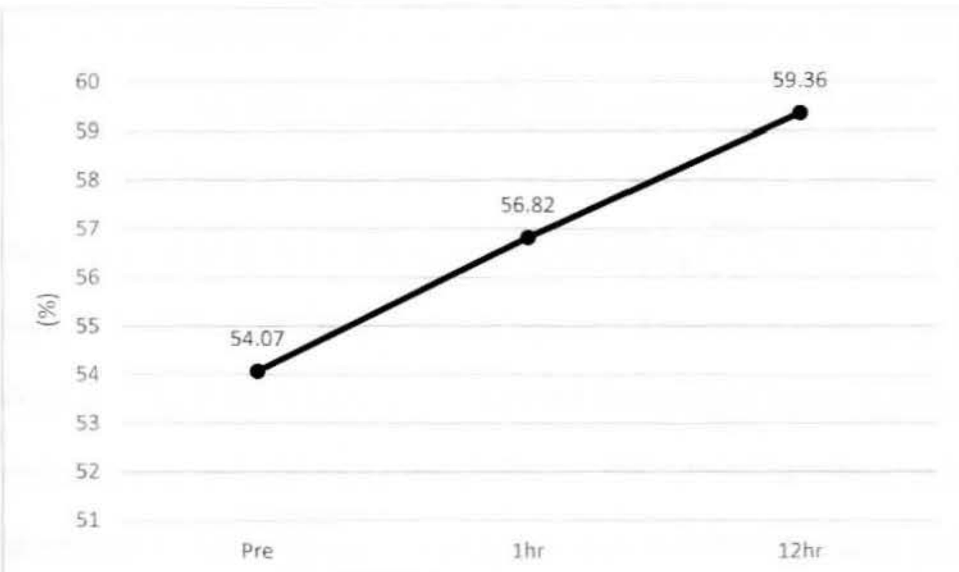
Wingate

Results from the lower body anaerobic power testing are shown in Table 6. There was no significance found between the trials in peak power (p=0.60). An increase in peak power (p= 1.00), can be seen from initial testing to 1h post RWL (from 626 ± 200 W to 653 ± 165 W). Peak power then nearly returned to initial testing levels at 12 h post RWL (from 653 ±165 W to 625 ± 173 W). Figure 8 illustrates the results of fatigue index. There was no significance found in fatigue index (p=0.78). Fatigue index increased from initial testing to 1h post RWL (54.1 ± 12.9% to 56.8 ± 5.8%). An increase was also observed from 1h post RWL to 12h post RWL (56.8 ± 5.8% to 59.4 ± 18.2%).

Table 6. Wingate Results

Variable	Pre (mean ±SD)	1h (mean ±SD)	12h (mean ±SD)
Peak Power (W)	626 ±200	653 ± 165	625 ± 173
Relative Power (W/kg)	8.9 ± 1.1	9.4 ± 0.8	8.9 ± 0.8
Avg. Power (W)	466 ± 122	479 ± 105	468 ± 119
Relative Avg. Power (W/kg)	6.7 ± 0.3	6.9 ± 0.5	6.7 ± 0.4
Fatigue Index (%)	54.1 ± 12.9	56.8 ± 5.8	59.4 ± 18.2

Fig. 8 Fatigue Index



DISCUSSION

Rapid weight loss (RWL), or weight cutting, is a prevalent practice among combat sport athletes. It has been reported that in wrestling, 60-90% of competitors have admitted to cutting weight (Franchini et. al., 2012). Franchini et. al. (2012), also reported that the majority of these wrestlers lost between 2-5% of their bodyweight in the days leading up to competition, while some admitted to losing 10% or more of their body weight prior to competing. Previous studies have shown a decrease in endurance performance (-22%) and in VO_2 max (-10%), when dehydration averaged 1.9% of body mass (McArdle et. al., 2010, p. 627). The design of this study was structured to closely mimic realistic competition, including a realistic 5% weight cut of the participant's normal body weight. Through this we were able to examine effects of RWL in relation to VO_2, VT, anaerobic power, body composition, and hydration status.

From initial weigh-ins through the 4 day RWL period, participants significantly reduced their body weight by 5.3±0.2% (from 69.67±14.82 kg to 66.02±14.07 kg; $p=0.003$). Participants reduced their body weight by attending regular 1.5 h practice sessions each day throughout the duration of the RWL period. It was observed through food diaries that participants reduced their overall calorie and fluid intake throughout the RWL period in order to make their 5% weight cut. In addition to regular practices, participants also conducted individual workouts outside of practice to reduce weight. At the 1 h post RWL period mark, participants gained back 19.4 ± 7.0% of the weight that they lost and the following day, at the 12h post RWL period mark, participants had gained back 48.7 ± 8.5% of weight lost. The amount of weight lost and gained back by participants is similar to findings reported by Artioli et. al. (2009), where participants lost 4.8±1.1% of their initial body weight in 5 days, and after a 4-hour period of recovery gained back 51±13% of their weight lost. Despite using different methods of measurement, body composition results closely reflected results from similar structured studies by Artioli et. al. (2009) and Filaire et. al. (2001), where the most weight lost was seen in lean mass and a slight loss in fat mass was seen. Our results in body composition are consistent with findings from Toomey et. al. (2007), where it was found that when manipulating hydration status and measuring body composition through DEXA examination, a greater loss in lean mass will be seen than in fat mass. Nana et. al. (2013), explains that upon examination of DEXA results, the loss in lean mass in a dehydrated state does not necessarily mean there was a true loss in mass, but should rather be interpreted as an error of measurement from hydration manipulation and therefore results should be interpreted cautiously.

Urine specific gravity significantly increased ($p=0.02$) from initial testing to immediately post RWL (from 1.008±0.007SG to 1.030±0.003SG). This shows a 2.14% decrease in hydration status, putting the participants in a dehydrated state (SG > 1.020). These results further support the theory that when manipulating hydration status, the error of measurement on body composition when using DEXA is increased (Nana. et. al. 2013). From immediately post RWL to 12 hours post RWL, a significant decrease in SG was seen ($p=0.002$). Participants nearly returned to a hydrated state (1.025±0.004SG) when given a 12h recovery period.

As stated earlier, McArdle et. al., 2010, p. 627, explains that a decrease in VO_2 Max can be seen when dehydration levels reach 1.9% of total body mass. Even though no significance was found ($p=0.211$), when looking at absolute values, our results are similar in that VO_2 Peak was reduced from initial testing (3.5 ± 0.4 L/min) to 1 hour post RWL (3.3 ± 0.4 L/min). At 12 hours post RWL, VO_2 Peak was still slightly lower than initial testing at 3.4 ± 0.5 L/min). The decrease in VO_2 Peak from a hydrated state to a dehydrated state, agree with finding from Moquin et al. (1998), where absolute VO_2 Max only slightly decreased between trials.

Interestingly, when looking at relative values, there is an increase in VO_2 Peak from initial weigh in to 1 hour post RWL (from 51.45±6.77ml/kg/min to 52.41±5.85ml/kg/min). Vo2Peak then decreased back to nearly what it was during initial testing at the 12-hour post RWL mark (51.00±5.11ml/kg/min). An explanation for these results can be that the participants produced results throughout the various testing stages of the study that were similar to their original absolute Vo2. When their body mass decreased throughout the study, their relative Vo2 had to rise since they were performing at a lower body mass.

One of the main research questions of this study was to find if ventilatory threshold would be impacted by a period of RWL, which could impact a reduced tolerance for increasing exercise intensity and potentially decrease in performance. Unfortunately, only three out of the five participants successfully reached and exceeded their ventilatory threshold. On average, a shift to the left in ventilatory threshold can be seen when comparing initial testing to 1 hour post RWL and 12-hours post RWL. This suggests that with RWL and dehydration, anaerobic performance decreases, which is similar to findings from Moquin et. al. (1998), where blood lactate was being measured during VO_2Max tests in hydrated and dehydrated trials to establish if a shift in the blood lactate curve was present.

Some of the most confounding results come from the anaerobic power testing. Although peak power did express a tendency to change ($p=0.06$) across all three measurement points, peak power increased from initial testing to 1h post RWL, and then decreased back to nearly identical pre-testing levels at the 12-hour post RWL mark (from 625.51±200.41W to 652.76±164.68W to 625.31±172.70W). These results are in agreement with Cengiz (2015) where they showed an increase in both upper and lower body relative peak power after RWL. This suggests that RWL may exert a minimal impact on the ability of female athletes to acutely produce power.

Reasoning's for why peak power decreased after 12-hours post RWL may be seen when looking at the fatigue index. Fatigue index can be seen linearly increasing across the trials from initial testing to 1 hour post RWL to 12-hours post RWL (54.07±12.86% to 56.82±5.83% to 59.36±18.21%). This suggests that the participants were experiencing more fatigue at the 12-hour post RWL mark than at the 1 hour post RWL mark, therefore not being able to produce at much power. These results are not consistent with what Cengiz (2015), found in his study. Cengiz (2015) reported that after his participant's lost 5% body weight in 3 days and having a 12-hour recovery, fatigue index returned back to levels similar to initial pre RWL testing. It is possible that gender differences in how male and females respond to dehydration and recovery of substrates may explain some of this difference, however, these conclusion are limited by our small sample size.

In conclusion, our body composition findings support current research where when manipulating hydration, body composition results should be interpreted cautiously. Results from our VO_2 Peak testing show that performance decreased from initial testing to 1h post RWL, and at 12h post RWL showed little improvement, but did not return to initial performance measurements. The ventilatory threshold findings revealed that with dehydration, came a shift to the left in the ventilatory curve, suggesting an anaerobic performance decrease. Similar to our results with VO_2 Peak, the results from our lower body anaerobic power testing suggest that peak power is not affected when in a dehydrated state. The participants actually performed better at their most dehydrated state than when compared to being in a euhydrated state. 12-hours post RWL however, we saw a drop in peak power, back down to initial testing levels. This may have to do with the fact that fatigue index increased from trial to trial, and was at its highest at the 12-hour post RWL trial. Though this study suggests that aerobic performance and anaerobic power is maintained and potentially even slightly increased 1 hour post RWL when compared to initial testing measurements in a hydrated and normal body weight state, more testing would need to be done to confirm these findings.

REFERENCES

Ahlman K, Karvonen MJ: Weight reduction by sweating in wrestlers and Its effects on physical fitness. J Sports Med Phys Fitness, 1961, 1: 58–62.

Artioli, G. G., Iglesias, R. T., Franchini, E., Gualano, B., Kashiwagura, D. B., Solis, M. Y., Lancha Junior, A. H. (2010). Rapid weight loss followed by recovery time does not affect judo-related performance. *Journal Of Sports Sciences*, **28**(1), 21-32.

BROOKS, G. A. (2000) Intra- and extra-cellular lactate shuttles. *Med. Sci. Sports Exerc.*, Vol. **32**(4), 790–799.

Cairns, S. P. (2006). Lactic acid and exercise performance. *Sports Medicine*, *36*(4), 279-291.

Cengiz, M., (2015) Effects of self-selected dehydration and meaningful rehydration on anaerobic power and heart rate recovery of elite wrestlers. *Journal of Physical Therapy Science* **27**, 1441-1444.

Filaire, E., Maso, F., Degoutte, F., Jouanel, P., & Lac, G. (2001). Food restriction, performance, psychological state and lipid values in judo athletes. *International journal of sports medicine*, *22*(06), 454-459.

Franchini, E., Brito, C. J., Artioli, G. G. (2012) Weight loss in combat sports: physiological, psychological and performance effects. *Journal of the Inernational Society of Sports Nutrition* **9**: 52.

Goodwin, M. L., Harris, J. E., Hernandez, A., Gladden, L. B. (2007). Blood Lactate Measurements and Analysis during Exercise: A Guide for Clinicials. *Journal of Diabetes Science and Technology*, **1**(4)

Loenneke J, P, Wilson J, M, Barnes J, T, Pujol T, J. (2011) Validity of the Current NCAA Minimum Weight Protocol: A Brief Review. *Ann Nutr Metab* **58**:245-249.

McArdle, W. D., Katch, F. I., & Katch, V. L. (2010). *Exercise physiology: nutrition, energy, and human performance*. Lippincott Williams & Wilkins p. 627.

Moguin, A., Mazzeo, R. (2000). Effect of mild dehydration the lactate threshold in women. *Journal of the American College of Sports Medicine*, **32**, 398-402.

Nana A, Slater GJ, Hopkins WG, Burke LM (2013) Effects of exercise sessions on DXA measurements of body composition in active people. Med Sci Sports Exerc 45:178–185.

NCAA: Memorandum: NCAA Wrestling Weight Management Program for 2010– 2011. August 20, 2010, pp 1–34

Rankin JW, Ocel JV, Craft LL: Effect of weight loss and refeeding diet Composition on anaerobic performance in wrestlers. Med Sci Sports Exerc, 1996, 28: 1292–1299.

Svedahl, K., MacIntosh, B.R. (2003). Anaerobic threshold: The concept and methods of measurement. *Ca. J. Appl. Physiol.* **28**(2): 299-232.

Timpmann, S., Oopik, V., Paasuke, M., Medijainen, L., Ereline, J., (2008) Acute effects of self-selected regimen of rapid body mass loss in combat sports athletes. *Journal of Sports Science and Medicine* **7,** 210-217.

Toomey, C.M., McCormack, W.G., Jakeman, P. (2017) The effect of hydration status on the measurement of lean tissue mass by dual-energy X-ray absorptiometry. *Eur J Appl Physiol*. **117**(3) 567-574

Webster S, Rutt R, Weltman A: Physiological effects of a weight loss Regimen practiced by college wrestlers. Med Sci Sports Exerc 1990, 22: 229–234

Fig. 1 Study Design Outline

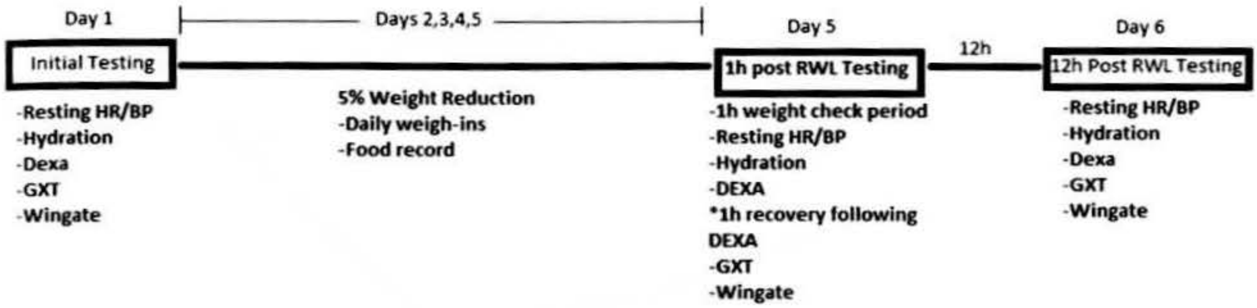


Fig. 2 Fat Mass change in response to RWL

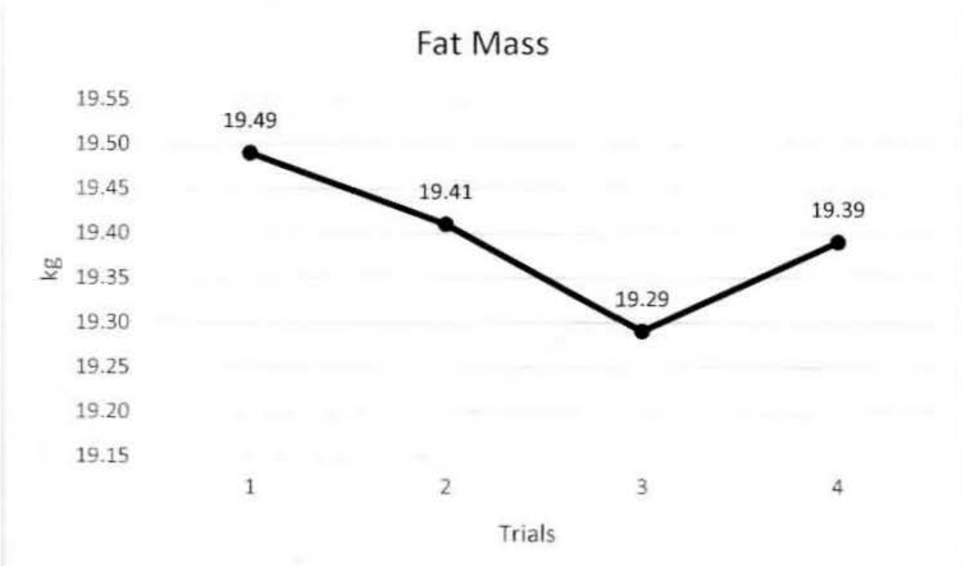


Fig. 3 Lean Body Mass change in response to RWL

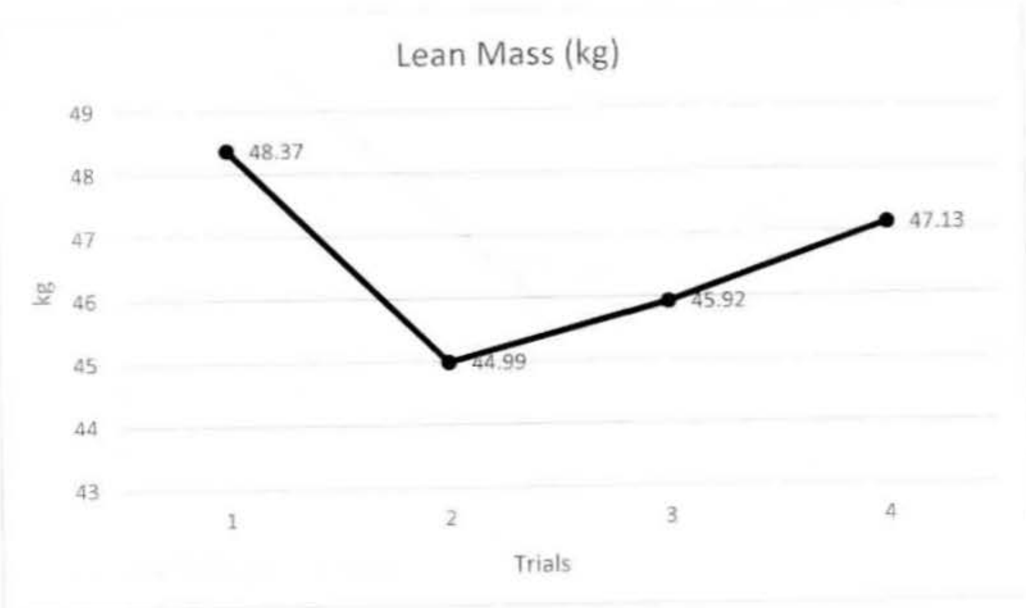


Fig. 4 Urine Specific Gravity change in response to RWL

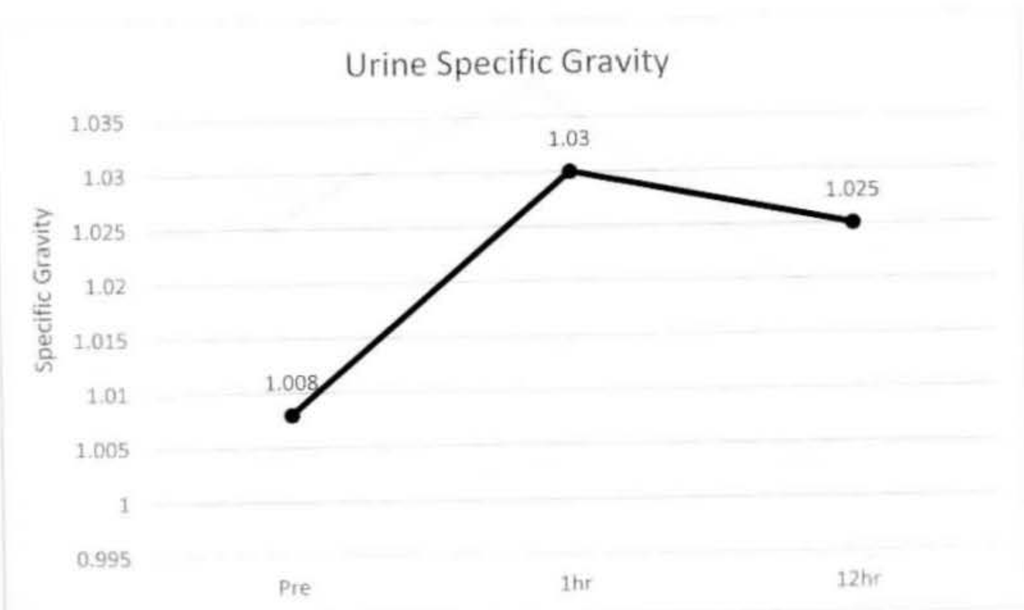


Fig. 5A Peak VO_2 (L/min)

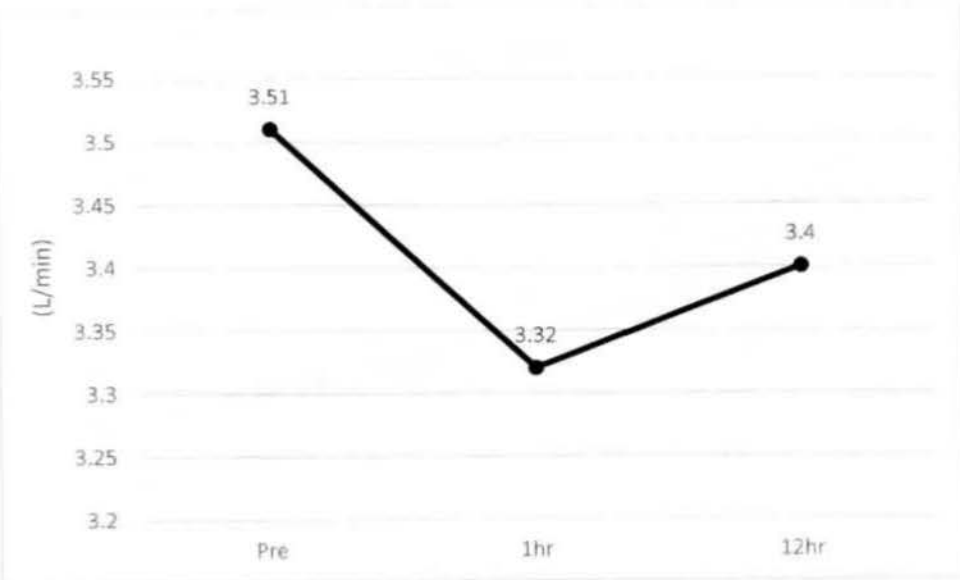


Fig. 5B Peak VO_2 (ml/kg/min)

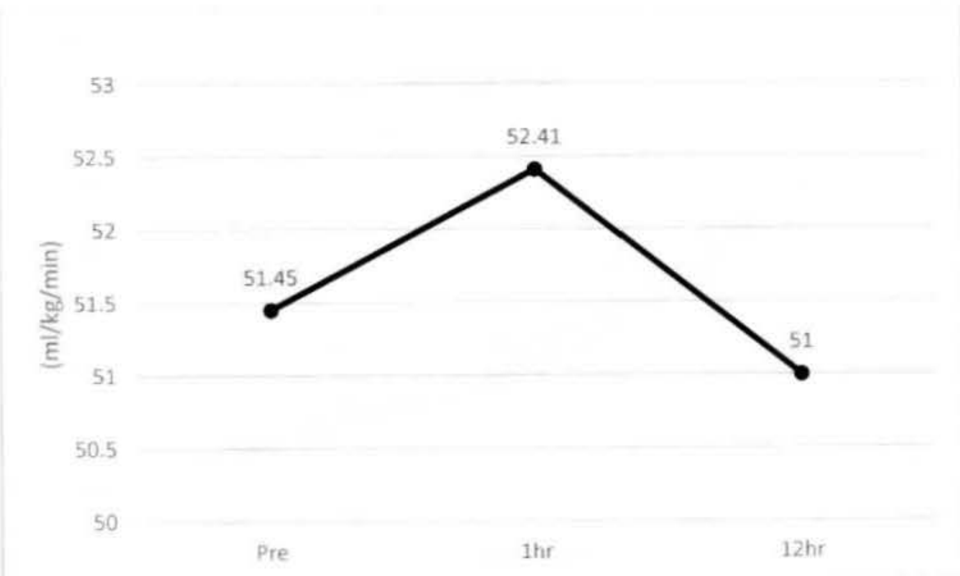


Fig. 6A Average VT

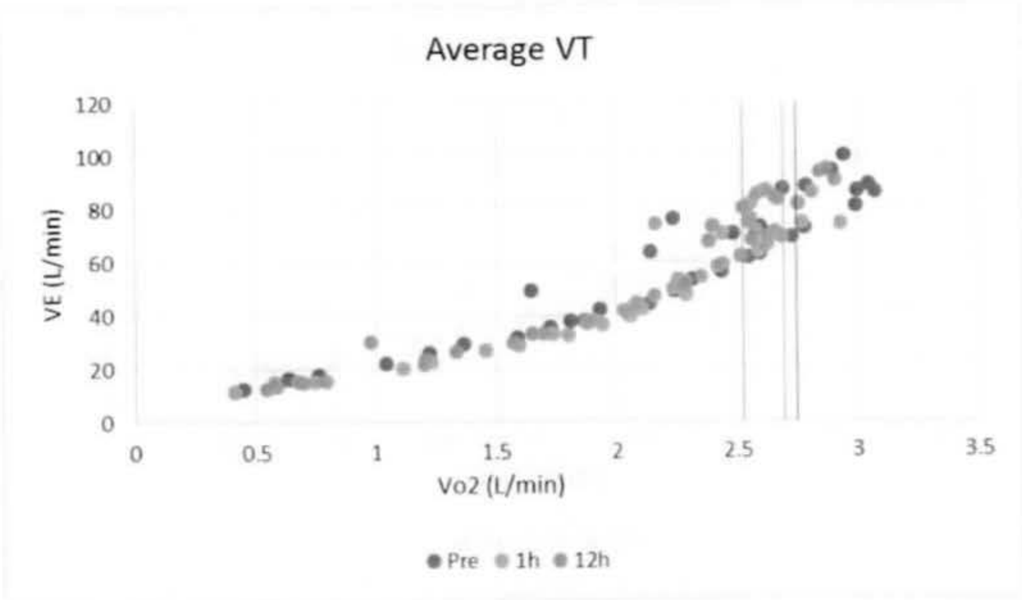


Fig. 6B Subject 1 VT

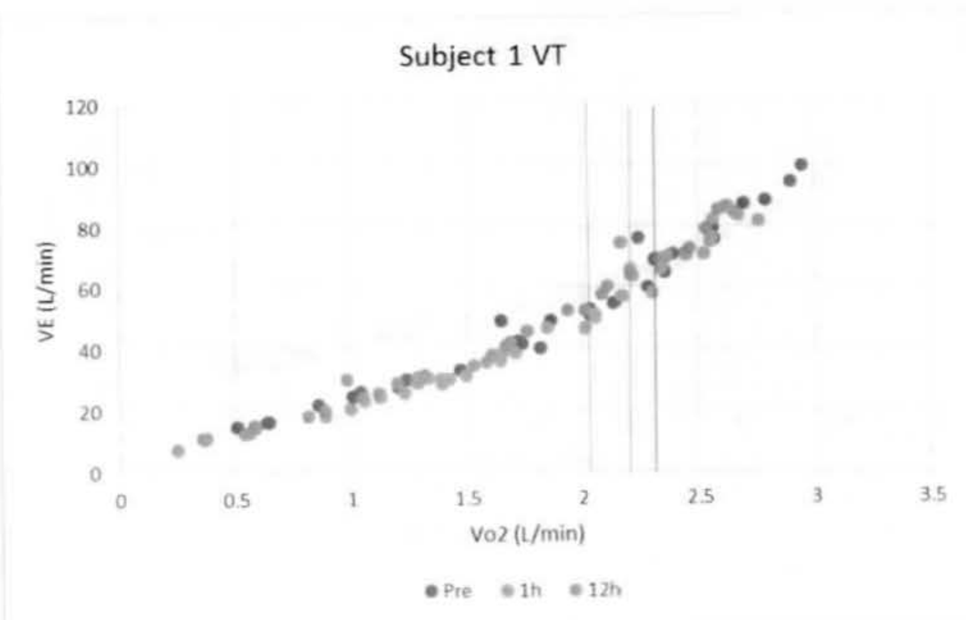


Fig. 6C Subject 2 VT

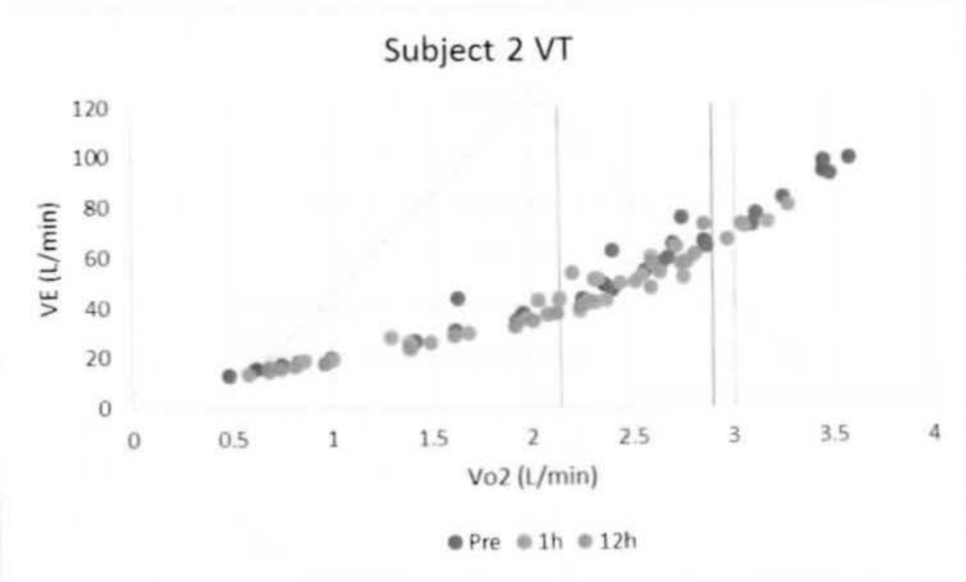


Fig. 6D Subject 3 VT

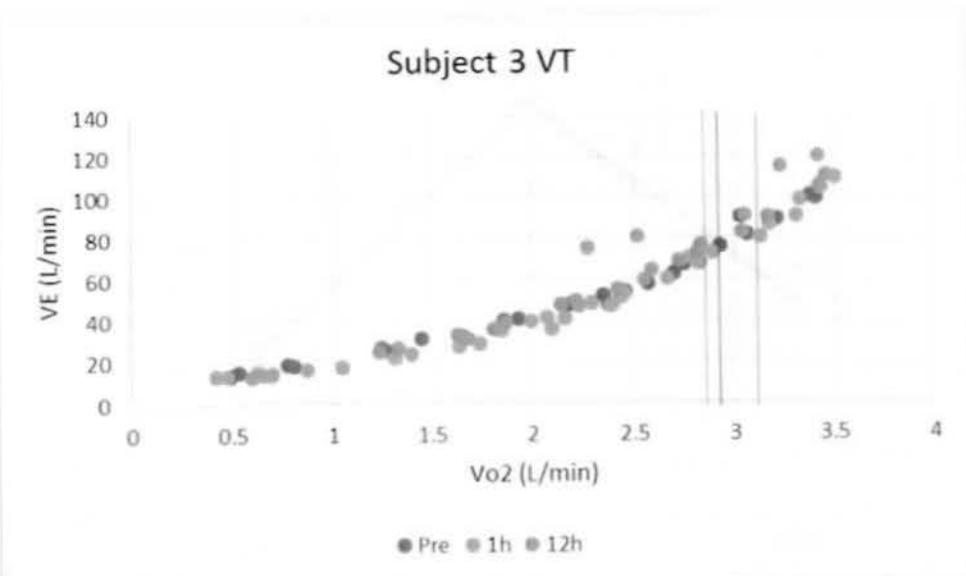


Fig. 7A Peak Power (W)

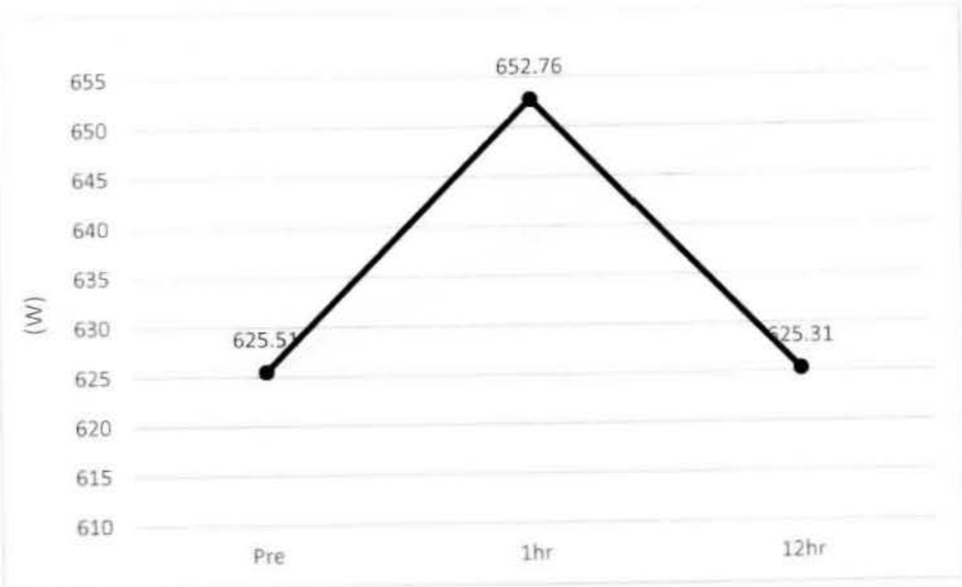


Fig. 7B Peak Power (W/kg)

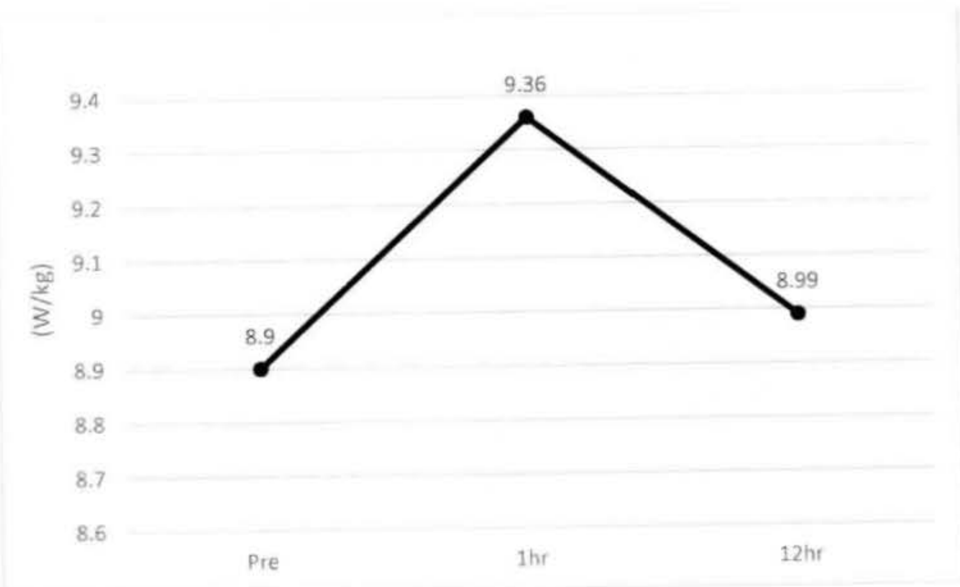


Fig. 8 Fatigue Index

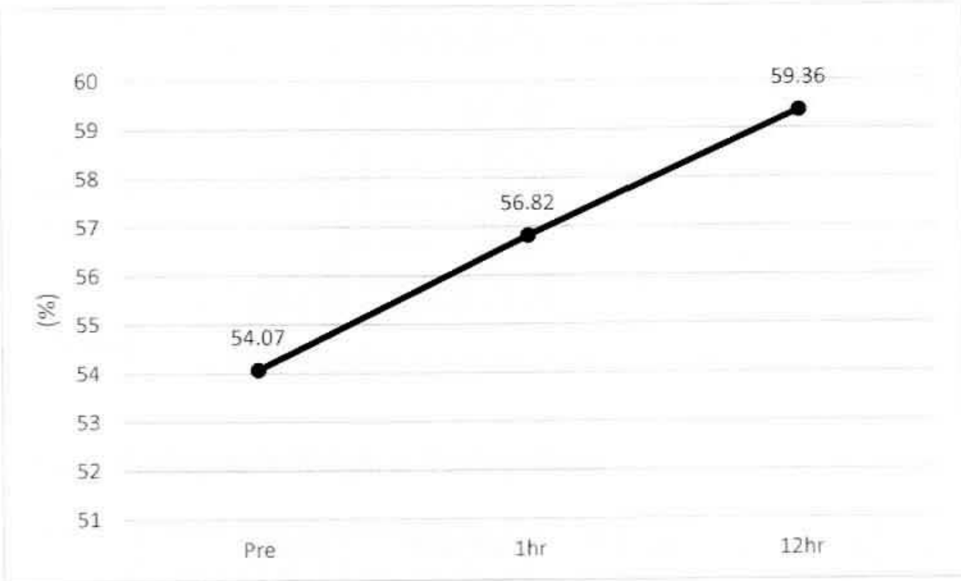


Table 1. Demographics

	Age (yrs.)	Height (cm.)	Weight (kg)	Yrs. Wrestling (yrs.)	% Body Fat	VO_2 (ml/kg/min)
Subject 1	20	151.67	48.18	5	21.8	61.147
Subject 2	20	156.97	66.27	6	28.3	54.111
Subject 3	22	160.78	70.09	5	30.3	48.638
Subject 4	19	163.83	74.72	5	26.6	50.482
Subject 5	19	165.1	89.18	4	29.2	42.879
Average (mean±SD)	20±1.22	159.66±5.46	69.51±14.76	5±0.71	27.24±3.33	51.45±6.77

Table 2. Participant's Weight at Testing Times

	Initial Weight (kg)	Post Cut Weight (kg)	% Lost	1h Post Cut (kg)	% Gained	12 h Post Cut (kg)	% Gained
Subject 1	48.18	45.64	5.28	46.27	24.8	46.55	35.83
Subject 2	66.27	62.82	5.21	63.27	13.04	64.82	57.97
Subject 3	70.09	66.55	5.06	67.00	12.71	68.45	53.67
Subject 4	74.64	70.45	5.6	71.64	28.41	72.55	50.12
Subject 5	89.18	84.64	5.1	85.45	17.84	86.73	46.04
Average	69.67±14.82*	66.02±14.07	5.25±0.21	66.73±14.19	19.36±7.04	67.82±14.51	48.73±8.45

Data is presented as means ± SD.

Table 3. Body Composition

Variable	Pre (mean±SD)	Dehydrated (mean±SD)	1h (mean±SD)	12h (mean±SD)
BMD (g/cm^2)	1.24±0.10	1.27±0.10	1.27±0.11	1.25±0.11
Fat Mass (kg)	19.49±5.66	19.41±5.12	19.29±5.14	19.39±5.38
% Body Fat	27.24±3.30	28.7±2.44	28.16±3.02	27.7±3.03
Lean Mass (kg)	48.37±8.90	45.00±8.84	45.92±9.05	47.13±9.28

Table 4. Urine Specific Gravity

	Pre (USG)	1 hr (USG)	12 hr (USG)
Subject 1	1.005	1.026	1.022
Subject 2	1.002	1.032	1.028
Subject 3	1.015	1.033	1.029
Subject 4	1.018	1.026	1.02
Subject 5	1.002	1.034	1.028
Average (mean±SD)	1.008±0.007	1.030±0.003	1.025±0.004

Table 5. Peak VO_2

	Pre (ml/kg/min)	Pre (L/min)	1 hr (ml/kg/min)	1 hr (L/min)	12 hr (ml/kg/min)	12 hr (L/min)
Subject 1	61.2	2.95	60.4	2.76	57.1	2.66
Subject 2	54.1	3.59	50.6	3.18	50.7	3.28
Subject 3	48.6	3.41	52.8	3.51	50.6	3.46
Subject 4	50.5	3.77	54.0	3.80	53.4	3.88
Subject 5	42.9	3.82	44.2	3.38	43.2	3.75
Average (mean±SD)	51.4 ± 6.8	3.5 ± 0.4	52.4 ± 5.9	3.3 ± 0.4	51.0 ± 5.1 1	3.4 ± 0.5

Table 6. Wingate Results

Variable	Pre (mean ±SD)	1h (mean ±SD)	12h (mean ±SD)
Peak Power (W)	626 ±200	653 ± 165	625 ± 173
Relative Power (W/kg)	8.9 ± 1.1	9.4 ± 0.8	8.9 ± 0.8
Avg. Power (W)	466 ± 122	479 ± 105	468 ± 119
Relative Avg. Power (W/kg)	6.7 ± 0.3	6.9 ± 0.5	6.7 ± 0.4
Fatigue Index (%)	54.1 ± 12.9	56.8 ± 5.8	59.4 ± 18.2

CHAPTER 5

SUMMARY, RECCOMMENDATIONS, FUTURE DIRECTIONS

The objective of this study was to find how RWL and consequently dehydration affected female collegiate wrestler's performance. Previous studies looking at RWL did not pose realistic competition scenarios in the structure of their methods. Furthermore, there has never been a RWL study that specifically looked at female collegiate wrestlers. This study was unique in that we were able to measure body composition, hydration status, Vo2Peak, and lower body anaerobic power over the course of a 5% total body weight reduction in female collegiate wrestlers, while nearly mimicking realist competition procedures.

Our results both agreed and disagreed with current research. Results from our body composition analysis over the duration of the study supports current published research on using DEXA to assess body composition while in a dehydrated state. On the other hand, upon examination of the Vo2Peak results, it seems like our results go against current studies, in that Vo2Peak relative to body weight improved in a dehydrated state. Similar to the Vo2Peak results, lower body anaerobic power also seemed to increase in a dehydrated state. These findings are certainly confounding, however more testing would need to be done in order to state their significance.

The biggest shortcoming of this study was the number of participants. With only 5 completing the study, the power in the inferential statistics is low. Further research will benefit from recruiting more participants to undergo the testing procedures. Future research on this topic can include using different treatments to see how they affect RWL and performance. For example, have different nutrition or exercise interventions for participants to follow during RWL and see which intervention yields the best performance results after RWL. I hope with this research, that one day we will be able to fine the best practices for female collegiate wrestlers to safety cut weight, and that the WCWA will adopt similar rules and regulations that the NCAA has in place in order to protect the athletes.

LINDENWOOD

INFORMED CONSENT FOR PARTICIPATION IN RESEARCH ACTIVITIES

Effects of Rapid Weight Loss on Ventilatory Threshold in Female Collegiate Wrestlers

Principal Investigator: Brittany David (Student)
Phone: 925-813-9024
Email: bdavid1@lindenwood.edu

Chad Kerksick, PhD
Phone: 636-627-4629
Email: ckerksick@lindenwood.edu

Explanation of Study Purpose

1. You are invited to participate in a research study conducted by Brittany David under the guidance of Dr. Chad Kerksick. The purpose of this research is to see what the effects of weight cutting are on performance after a period of rapid weight loss (RWL), following set times of recovery.

Explanation of Study Participation

2. This study is designed to simulate competition performance following a period of RWL 1 hour after recovery (same day weigh-in) and 12 hours after recovery (day before weigh-in). For this study you will be required to lose 5% of your normal, hydrated, body weight in 4 days. Testing procedures for each stage of testing will include: urine specific gravity testing, DEXA scans, and an incremental exercise test performed on a treadmill where metabolic gas exchanges will be collected.

Initial Testing Stage 1 (Study Visit 1, Day 1)

- Upon arrival to the testing facility you will be asked to sit for a period of 10 minutes so that we can record your resting heart rate and blood pressure values.
- After resting values are taken you will be asked to provide a urine sample to be tested for your current hydration level.
- You will be required to be in hydrated state for this stage of testing.
- After hydration level is established we will then conduct a DEXA scan to for your current body composition.
- Once the DEXA is complete you will be asked to perform a graded exercise test to volitional exhaustion.

RWL Period (Days 2-5)

- Following your initial testing you will be given 4 days to lose 5% of your initial testing weight.
- This period will consist of self-directed weight cutting procedures dependent upon how you prefer to cut weight.
- You must make weight by day 5 at your RWL Testing day.
- You may not use any extreme measures to cut weight including the use of direutics, laxatives, weight loss pills, or self-induced vomiting.

RWL Testing Stage 2 (Study Visits 2, Day 5)

- Initial testing procedures from day one will be completely replicated for your second visit.
- A hydrated state is not required for this stage of testing.
- Following the DEXA scan, you will be given 1 hour to recover and rehydrate to simulate a same day weigh-in.
- After 1 hour you will be asked to perform the same graded exercise test done on day 1, again to volitional exhaustion.

Post Hydration Testing Stage 3 (Study Visit 3, Day 6)

- Initial testing procedures will be completely replicated again for the 3rd time in the morning following approximately a 12 hour recovery period.
- You will be required to be in a hydrated state for this stage of testing.

Risks Involved in Study Participation

3. There may be certain risks or discomforts associated with this research. They include dehydration, muscle soreness, and physical and mental exhaustion. Injury risk is reduced as you will have a USA Certified Bronze level coach who has been trained to see when a weight cutting situation starts to turn dangerous overseeing and conducting all testing procedures. Additionally coaches and athletic trainers will be present during practices during the RWL period to ensure the safety of all participants. If you feel like you are unable to complete the RWL stage you may withdraw at any time.

Benefits of Study Participation

4. There will be no compensation available to you upon completion of this study, however, other possible benefits exist to you from participating in this research include knowledge about your performance measures, body composition and current weight cutting strategies. In addition, will have contributed to the valuable knowledge of weight cutting amongst female combat athletes.

Voluntary Participation

5. Your participation is voluntary and you may choose not to participate in this research study or to withdraw your consent at any time. You may choose not to answer any questions that you do not want to answer. You will NOT be penalized in any way should you choose not to participate or to withdraw.

Privacy and Confidentiality

6. We will do everything we can to protect your privacy. As part of this effort, your identity will not be revealed in any publication or presentation that may result from this study and the information collected will remain in the possession of the investigator in a safe location. All data collected as part of your study involvement will be kept in filing cabinets located at the Sports Science Center inside the faculty investigator's office where only research team members and building supervisors will have access. All data will remain in this filing cabinet for three years whereby at that time it will be shredded.

Study-Related Questions and Concerns

7. If you have any questions or concerns regarding this study, or if any problems arise, you may call the Investigator, Brittany David at 925-813-9024 or the Supervising Faculty, Dr. Chad Kerksick at 636-627-4629. You may also ask questions of or state concerns regarding your participation to the Lindenwood Institutional Review Board (IRB) through contacting Dr. Marilyn Abbott, Provost at mabbott@lindenwood.edu or 636-949-4912.

I have read this consent form and have been given the opportunity to ask questions. I will also be given a copy of this consent form for my records. I consent to my participation in the research described above.

Participant's Signature Date	Participant's Printed Name
Signature of Principal Investigator Date	Investigator Printed Name