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Observing the Effects of Comparing Rest Periods Within a Lower-Body Resistance Training Program on Selected Strength, Power, Aerobic and Cognitive Outcomes

Mitchell S. Moyer

OBSERVING THE EFFECTS OF COMPARING REST PERIODS WITHIN A LOWER-BODY RESISTANCE TRAINING PROGRAM ON SELECTED STRENGTH, POWER, AEROBIC, AND COGNITIVE OUTCOMES

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Title: Observing the Effects of Comparing Rest Periods Within a Lower-Body Resistance Training Program on Selected Strength, Power, Aerobic, and Cognitive Outcomes

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PURPOSE: To investigate physiological and cognitive changes following a resistance training protocol. METHODS: Eight healthy males volunteered to participate in a 6-week protocol consisting of 3 sets of 5 repetitions at 85% of 1-repetition maximum for the squat and deadlift. The two groups were 90-seconds (n= 5) and 3-minutes (n= 3) rest. RESULTS: Analysis of variance (ANOVA) revealed a main effect of time for the squat ($p = 0.026$), and main effect of group for vertical jump ($p = 0.041$). The 3-minute group increased squat performance ($p = 0.020$), while the 90-second group improved vertical jump ($p = 0.031$). Group by time interactions were observed for Interference ($p = 0.048$), Word-Color ($p = 0.050$), and TMD ($p = 0.004$). Despite the trending increase of executive function in the 3-minute group, a worsened mood post-intervention was observed ($p = 0.008$). CONCLUSION: Minimal rest improved power within the 90-second group while the 3-minute group significantly improved in lower body strength. Cognitive function only appeared to improve in the 3-minute rest group. Further research is necessary to improve strength, power, and mood following resistance training.

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CHAPTER I

INTRODUCTION

Resistance training is known to provide numerous physiological benefits. According to Fisher, Steele, Bruce-Low, and Smith (2011) benefits experienced from resistance training include increased muscle hypertrophy, increased muscular strength and power, and muscular endurance. Physiological improvements from strength training can benefit various populations including athletes, youth, elderly (Pollock et al., 2000), military personal, and first responders. In addition to an increase in physiological performance, resistance training has been found in previous studies to improve cognitive ability (Lui-Ambrose at el al, 2012). Furthermore, in order to gain a better understanding of resistance training, it is critical to recognize that comparing variables within a given program provides an additional stimulus, potentially leading to further adaptations. The purpose of this study is to observe the effects of comparing rest periods during a lower-body resistance-training program on strength, power, cognitive function, and aerobic performance.

Resistance training not only leads to increased strength and muscle size, but according to Wisloff et al. (2004), resistance training has a positive effect on power in athletes. Power is defined as force multiplied by velocity. The present study will examine the effects of both traditional and non-traditional rest intervals on strength and power. This is similar to previous methodology carried out by Masters et al. in 2016, who looked at three different rest periods consisting of five, three, and one-minute during a training protocol for the squat and bench press. Subjects were to complete four sets of eight repetitions at an eight repetition maximum (RM) load. They found that subjects were able to maintain a higher volume with the five-minute rest interval (Masters, 2016). While this study observed volume, it did not specifically look at strength or power adaptations following the three visits. Common strength training movements such as the back squat appear to have the greatest carry over to explosive movements (Baker, 1996). For example, the back squat is implemented into many strength and conditioning programs where jumping is a requirement for a specific athlete. Baker (1996) mentioned in a previous study that the back squat and the vertical jump possess similar biomechanics (Baker, 1996). The similar relationship between the biomechanics is what may illicit the improvements in the vertical jump. Improvement in jumping ability can aid in the performance for a variety of athletes, ranging from tactical athletes to basketball players as it aids in lower body power (Ribeiro et al., 2015).

Along with the squat, the deadlift also has been shown to increase power. An additional study performed by Blatnik, Goodman, Capps (2014) observed how performing two repetitions of the deadlift at loads ranging from 30-90% of the subjects 1RM effects peak power of the bar, body, and bar accompanied with the body. The findings concluded that peak power was greatest at 70% of 1RM for body and bar where bar peak power was observed at 50% of 1RM and body at 30% of 1RM. These results can be incorporated within a strength and conditioning program for athletes to train for specific goals. For instance, athletes that compete in throwing events or weightlifting competitions would experience greater performance training at loads of 50% of 1RM where bar power is produced the greatest. Ultimately, when training the deadlift to increase power, loads should be implemented based on specific performance goals (Blatnik et al, 2014).

At the core of any well designed resistance training program are aspects of training that must be implemented intelligently. Among these variables are sets, volume, intensity, frequency and rest periods (Freitas de Salles at el., 2009**)**. Over time, the development of standard guidelines have been established pertaining to these aspects of training. These standards are what many coaches base their programming on in order to achieve a specific training goal for athletes (Sajad et al., 2014). In terms of developing strength, intensities equal to or greater than 85% of 1RM were performed for sets of two to six repetitions, while the rest period between sets is two to five minutes (Haff & Triplett, 2016). To further discuss strength training, it is essential to know that strength, according to Young & Bilby (1993), is described as the amount of force that can be provided to an outside factor (Young et al., 1993). Ultimately, the previous guidelines serve as a baseline for professionals within the human performance and strength training industry.

While there are basic guidelines, further enhancements in performance requires greater adaptations which can be stimulated by the manipulation of specific aspects of a program. This can be observed in the manipulation of specific training protocols that lead to cardiovascular benefits. Freitas de Salles (2009) found that when rest periods remain under one minute, muscular endurance increases from the increase in oxygen consumption**.** Many experts in the strength and conditioning field use the altering of rest periods to adhere to the specific demands that are required of particular athletes.

During a resistance training program, adaptions commonly occur both structurally and functionally (Ahtiainen et al., 2003). Research has been conducted to observe how rest periods affect overall training volume during three testing sessions consisting of performing the squat and bench press for four sets of eight repetitions at an 8RM load when incorporating rest intervals of five, two, and one minute (Willardson & Burkett, 2005). Findings illustrated that overall volume was able to be maintained with the five-minute rest period compared to the one-minute rest period. While this specific study focused on how rest intervals affect volume, it did not assess intensity relative to rest period length. While research may show that a greater amount of rest in between sets may allow for greater volume to be performed during resistance training, there is not a significant amount of research observing how rest periods affects strength training in regards to intensity (Senna at el., 2009, Willardson & Barkett, 2005). If adaptations are able to occur with decreased rest periods, this could aid in the overall training economy of a strength-training program.

It is important to note all the benefits strength training can have on both physiological and cognitive performance. While many methods of strength programs can yield results, certain aspects can be manipulated and adjusted to achieve results. For this specific study, the comparison of rest periods was incorporated to try to improve strength, power, aerobic capacity, and cognitive performance.

Problem Statement

The purpose of the present study is to challenge the currently accepted rest-interval guidelines established from the National Strength and Conditioning Association (NSCA) while observing effects on strength, power, aerobic capacity, and cognitive performance.

Research Question

What are the effects of comparing rest periods within a lower-body resistance-training program on selected strength, power, aerobic, and cognitive outcomes?

Hypotheses

1. A) Lower body strength will significantly improve at the post-test in the group exposed to the treatment protocol (90s). B) Lower body power will significantly improve at the post-test in the group exposed to the treatment protocol (90s).

2. A) Lower body strength will not improve at the post-test in the group being exposed to the control protocol (3m). B) Lower body power will not improve at the post-test in the group being exposed to the control protocol (3m).
3. A significant improvement in aerobic performance will be observed in the 90s group, but not the 3m group.
4. Both groups will experience improved cognitive performance following the training protocol.

Assumptions

1. Subjects did not participate in any high intensity or high volume lower body training outside the experimental protocol throughout the duration of participation.
2. Subjects adhered to the guidelines set forth regarding a three-hour fast, and no vigorous exercise in the previous 24 hours for all assessments and training sessions.
3. Subjects did not exceed the allowed number of minutes per week of moderate-vigorous aerobic exercise (60 minutes vigorous – 150 minutes moderate).

Limitations

1. The researchers were not able to control dietary intake, as well as quality of sleep. Fasting state was confirmed before each training session.
2. The stressors associated with college-aged males such as school and work could have potentially affected physiological performance.
3. The population was limited to college-aged, Caucasian males, in order to create an extremely homogenous sample. For this reason, the results of the current study are not generalizable to larger, more diverse populations and females.
4. Participants self-reported physical activity levels and diet for inclusion in the study.

Significance

Resistance training entails a variety of factors that may be controlled in order to achieve specific performance goals. Varying rest periods within a resistance training program have been studied to observe their effects on overall volume during training sessions but there is not a significant amount of research in regards to varying rest periods in regards to training intensity (Ratemess, Falvo, Mangine, Hoffman, Faigernbaum, & Kang, 2007). This present study aims to observe how the comparing of rest intervals may affect strength and overall training intensity. Also, aerobic training has been found to elicit cognitive improvements which was illustrated by Fabre, Chamari, Mucci, Massé-Biron, Préfaut, 2002 on elderly adults that engaged in 90-minutes of walking one day a week for two months. Little research has been done to observe how resistance training effects cognitive performance. Therefore a second aim of this study is observing how two varying intensities affects cognitive performance. Correctly implemented resistance training programs can positively affect muscle hypertrophy, muscular strength, muscular power, and muscular endurance (Fisher et al., 2011). The purpose of the present study challenges commonly accepted rest period guidelines in order to observe the effects on strength, power, aerobic, and cognitive performance.

Definition of Terms

Repetition*:* successful and complete range of motion.

Set*:* consists of numerous repetitions. In the present study, three “sets” each consisting of five repetitions are being implemented.

***1* Repetition Maximum (1RM):** greatest amount of weight lifted for one successful attempt.

Conventional Deadlift*:* lifting a barbell off the floor with feet approximately shoulder width apart while maintaining a straight back.

Back Squat*:* With a barbell placed on the upper back, the squat begins with flexion at the hips knees and ankles to the point of the thighs reaching a parallel position with the ground, or a 90-degree angle at the hip.

Spotter*:* Individual assigned to assist with all phases of the lift.

Rest Period*:* duration of time between lifting sets.

Volume*:* total amount of weight lifted in one training session.

Intensity*:* Specific amount of work prescribed for an exercise.

Vertical Jump*:* performing a quarter squat followed by a rapid explosion upward to maximum height.

Training Cycle*:* duration of time in which a specific exercise program is implemented.

Cognitive Performance: ability to perform tests related to mood, memory, and problem solving.

ANAM4: cognitive performance testing software.

Strength*:* greatest amount of force applied to an exercise.

Power*:* the maximum amount of force applied to an object at a maximum velocity.

Aerobic Capacity*:* energy production through oxidative energy sources for a maximum duration ($ml \bullet kg^{-1} \bullet min^{-1}$).

Maximum Oxygen Consumption (VO_2 Max): greatest amount of oxygen that can be utilized during aerobic training.

Vertec: equipment used to measure vertical jump.

Polar Heart Rate Monitor*:* watch and chest strap to monitor heart rate during exercise.

Metabolic Cart*:* Machine that measures expiratory gases (Oxygen and Carbon Dioxide). Gases are represented as milliliters per kilogram of body weight per minute

($ml \bullet kg^{-1} \bullet min^{-1}$).

Treadmill*:* Machine with a belt that allows individuals to run or walk at a predetermined speed and incline.

Body Fat Percentage*:* Amount of fat-mass on an individual represented as a percent.

Performance*:* Improvements in physiological and cognitive ability.

CHAPTER II

REVIEW OF LITERATURE

Introduction

Resistance training has been shown to enhance numerous physiological and cognitive functions. A properly designed resistance training program can lead to the following benefits: increased muscle hypertrophy, increased muscular strength and power, as well as muscular endurance (Fisher et al., 2011). Accompanied with physiological adaptations, Perrig- Chiello et al. (1998) found that resistance training increases self-attentiveness and memory. Additionally, strength is another important variable within a resistance training program as it can provide significant increases in performance among various populations ranging from athletes to firefighters and other service men and women (Rhea et al, 2004). Along with strength, power also has an influence on performance, which was demonstrated by Harries et al. (2012) in a study that showed resistance training increased vertical jump performance among young athletes. Lastly, other factors of resistance training leading to performance improvements include training frequency, volume, intensity, as well as rest periods (Willardson & Burkett, 2005). The scientific manipulation of these variables can ultimately lead to the efficacious progression of athletes and general exercisers alike.

Strength Training

Designing a resistance training program takes planned thought and effort, and considers the fact that multiple variations of training protocols can aid in achieving success. Three popular types of resistance training methods are known to be used in order to increase strength. These methods include high-intensity strength training with low repetitions, moderate-intensity strength training with a moderate number of repetitions, and low-intensity strength training with a high number of repetitions (Campos et al., 2002). Campos et al. (2002) observed how the implementation of these three types of resistance training methods affected strength. Thirty-two healthy male subjects that did not partake in physical activity participated in an eight-week resistance training program. This eight-week period was focused on a progression-based program and observed the "strength-endurance continuum." Of the 32 subjects, 27 males were randomly placed within the three types of training groups which were categorized as either low, moderate, or high repetition.

Subjects engaged in a total of eight weeks of training for the lower body. The initial four weeks of training consisted of a frequency of two days per week while the last four weeks consisted of three days per week. To observe changes in the training group, pre- and post-test muscle biopsies were collected to observe fiber-type and cross-sectional area, myosin heavy chain as well as the capillary density. At the conclusion of the training, all groups demonstrated a significant rise in maximal dynamic strength and relative strength for the squat, leg press and knee extension. Specifically, the leg press and squat showed the greatest improvement in maximal dynamic strength within the low repetition group. Opposite to the muscular strength, muscular endurance was achieved through the use of training at moderate intensities for the squat. There were no significant differences in the moderate and low repetition groups for the leg press and the leg extension. In terms of changes in muscles, all three experimental groups experienced a rise in Type IIAB muscles while only the moderate and low repetition groups experienced cross-sectional growth. Lastly, changes in strength were seen to the greatest extent in the low repetition group while the high repetition group experienced enhanced cycling ability without a change in maximal oxygen consumption (VO_2 max).

An additional study performed by Hagerman et al. (1997) was done to observe the effects that high intensity training has on cardiovascular function and localized muscle metabolism in elderly males. The study was performed on 18 men that were not trained. Nine of the subjects were randomly placed into a resistance-training program which lasted a duration of 16-weeks where they trained two times per week. The other half served as the control group or the untrained group. The training group performed half squat and leg extension at 85-90% of their 1RM. The men were tested prior to and after the 18-week period to measure muscle fiber and metabolic changes. This study demonstrated that following a high intensity resistance training protocol, there was change from Type IIB muscle fibers to Type IIA fibers as well as an improvement in maximal oxygen consumption. Ultimately, this study showed that high intensity resistance training has a positive effect on muscle fiber type and VO_2max.

Effects of Strength Training on Power Output

While resistance training is known to elicit improvements in both muscular endurance as well as relative and absolute strength, strength training can also have impacts on other aspects of performance. A study conducted by Wisløff et al (2004) observed the effects of maximal squat training on power activities. Specifically, sprinting and vertical jump performance in 17 competitive soccer players. The study tested the 1RM in the back squat, VO_2 max, sprint performance, and vertical jump. Over an eight-week period subjects performed five reps on the back squat while increasing the weight by five-kg for each week that all reps were completed. This study found that a high max squat has a positive impact on both the vertical jump and sprinting.

While studies have been shown to indicate that a higher back squat 1RM can lead to increases in vertical jump height, Izquierdo et al (2000) studied how strength training can further impact power performance. This specific study observed the change in power and serum hormone levels on eleven middle-aged males and eleven older males. Subjects performed a 16-week strength training program for maximal strength following four weeks of baseline testing. The initial testing session consisted of a 1RM in the concentric portion of the half squat while load-velocity was tested using loads of 0, 15, 30, 45, 60, and 70%. The second bout of testing consisted of measuring unilateral isometric torque in the knee extensor muscles. Contrary to the lower body, a maximal concentric 1RM bench press was implemented to observe velocity and power during loads of 0, 30, 45, 60 and 70% in regards to the upper body. For all lower body movements, bar displacement, power, velocity, and max average were recorded using an infrared sensor.

Once baseline testing was complete, subjects began the resistance training intervention. Subjects trained at a frequency of two days per week. After 16-weeks of strength training accompanied with explosive movements, there were improvements in both dynamic strength and power in the leg and arm extensors between both groups. In addition, absolute strength was found to be the greatest in the middle-aged group while strength improvements were seen in both groups. Additionally, it is appropriate to train both strength and endurance within the same time period as individuals or athletes can simultaneously yield benefits in both strength and endurance performance.

An additional study was conducted by Brennan et al (2015) to observe how deadlift training affects rapid torque on the knee extensors and flexors. This study also examined the connection between rapid torque development through training and its effects on jumping.

This study recruited 54 subjects ranging from 19-28 years of age and randomly placed them into one of two groups; control or trained. Subjects that were placed in the trained group partook in deadlifting two times per week at a volume of five sets of five repetitions. Additionally, subjects performed isometric strength for the knee extensors and flexors. The isometric strength training was performed using the Biodex isokinetic dynamometer on only the left leg. During the training cycle, the countermovement vertical jump was measured pre and post intervention.

The findings for this study illustrated that there were no significant differences between ages among the subjects but there was a strong relationship between deadlifting and knee extensors as well as flexors, thus increasing vertical jump height. The deadlift displayed a greater and more distinct bar velocity during the concentric phase of the lift.

Concurrent Strength Training

Certain strength training programs are paired with other types of training in order to improve overall performance. For instance, concurrent strength training protocols are commonly used by athletes to improve both strength and endurance performance (Hakkinen, K. at el., 2002). Certain studies illustrate that training both strength and endurance will simultaneously impact the overall performance of both training variables. Kramer et al. (1995) found that when strength training and endurance training are combined, there is a diminishing effect of Type I muscle fibers. It is important to note that these changes have not been experienced in all concurrent training programs (Balabinis et al., 2003)

In the study conducted by Balbinis et al. (2003), 26 male basketball players were recruited for the study where the athletes performed different types of training programs over a seven-week period. The training programs were categorized into strength, endurance, strength and endurance, and a control group that did not partake in any additional training. The study tested strength using 1RM in the half squat, bench press, lateral pull down, and the leg press.

Additionally, anaerobic power was accessed using the Wingate test while aerobic capabilities were tested using the one mile walk test. Lastly, anaerobic power was measured using the vertical jump test. At the conclusion of this study, they illustrated that strength training will elicit improvements in strength and power but will cause a decline in aerobic capabilities. While strength improvements were seen in those training specifically for strength, the same held true for those training for endurance. Subjects training for endurance ultimately seen an increase in aerobic performance with nearly no changes in strength, power and speed during this period of training. The major finding of this study was the performance benefits seen from those that participated in both the strength and endurance training protocol. Athletes that trained simultaneously for strength and endurance noticed improvements in strength, power, VO_2 max, and body fat levels. It was emphasized that the benefits seen from the concurrent strength training protocol may be caused from the demands of utilizing energy reserves caused from the combination of strength and endurance training. The use of this present study can be applied within the realm of the strength and conditioning industry in order to elicit improved performance in athletes. This specific studied mentioned that to benefit from concurrent training, it is essential to take into account the athletes sport specific demands, rest periods, and the athletes overall training age. Taking these factors into account will aid in reducing the chances of injury or overtraining.

An additional study was conducted by Bell et al. (2000) to observe the effects that concurrent training has on both muscle and hormones. Similar to the Balbinis et al. (2003), a total of 45 males and females that were active college students with a resistance training background were placed by random selection into four groups that consisted of strength, endurance, strength and endurance, and lastly a control group (no structured exercise). The training cycle lasted for a total of 12-weeks with the strength and endurance group both training three days per week and the concurrent group training six days per week.

Biopsies were taken specifically from the lateral portion of the right vastus lateralis muscle. Additionally, a quantitative histochemical method was used in order to define the activity of the enzymes: myofibrillar-ATPase, SDH and alphaGDP. Capillary per fiber ratio was determined by subtracting half the number of capillaries in the periphery from the total number of capillaries, a method previously validated by Brodal et al. in 1977. Lastly, strength was tested using a 1RM for the bilateral incline leg press as well as unilateral knee extension on the dominant leg. No upper body strength was assessed as the training was predominantly lower body. Strength training consisted of predominately machines and free weights while the endurance training was performed on a Monark cycle ergometer.

At the start of training, findings showed that males possessed a significantly higher VO_2 max, bilateral leg press, and unilateral knee extension. Following initial assessments, similar developments were observed throughout the training protocol by both males and females. For muscle size, men were found to have greater muscle size regardless of the muscle type. Strength groups had a significant increase in areas of type I and II muscle fibers following the six and 12-weeks of training. Type II muscle fibers for the strength and endurance group also significantly increased following 12-weeks of training. A significant increase in capillary per fiber ratio was noted in only the concurrent group following the 12-weeks of training. Additionally, a significant main effect occurred among fiber types and enzyme roles. Myofibrillar ATPase and alphaGDP showed to be significantly greater in type II muscle compared to type I. Lastly, no significance was seen in serum testosterone, human growth hormone (hGH), or sex hormone binding globulin.

Upon observing the results, the study concluded that concurrent strength and endurance training elicits an increase in VO_2 max which has also been found in other concurrent strength and endurance studies (Balbinis et al (2003). Additionally, strength may be impacted during concurrent strength and endurance training which may be due to the specific movements being performed. Concurrent training over a long duration, may lead to decreased skeletal muscle hypertrophy and strength. It is important to note that concurrent strength and endurance training can improve capillarization more than endurance training alone but does not improve testosterone or hGH.

Cognitive Performance and Resistance Training

While resistance training provides a plethora of physiological adaptations, it has also been shown to improve cognitive ability. In a study performed by Cassilhas et al (2007), cognitive ability was measured in regards to resistance training between two different intensities.

The subjects for this study consisted of 62 sedentary males that ranged from 65-75 years old. Three groups were randomly assigned to control (n = 23), moderate (n = 19), and high (n = 20) intensity training. All exercises were performed at 50% of the 1RM for the moderate intensity group and 80% of the 1RM for the high intensity group with two sets of eight repetitions. Neurological tests were performed in one session for less than one hour. The tests consisted of the Wechsler Adult Intelligence Scale III (WAIS III) which looked at the central executive function and short-term memory; Wechsler Memory Scale-Revised (WSM-R), Toulouse-Pierson's concentration attention test, and the Rey-Osterrieth complex figure. Additionally, the Medical Outcomes Study SF-36 questionnaire was used to address the quality of life while the Geriatric Depression Scale (GDS) was utilized for depression. Lastly, the Profile of Mood States (POMS) was used to monitor mood. Additionally, hemodynamics, blood viscosity, erythrocytes, hematocrit, and insulin-like growth factor-one were measured.

At the end of the study, cognitive improvements were observed at various prescribed intensities. Upon reviewing the results, it was found that both groups of training at moderate and high intensity improved their mood. After further observing mood, the moderate group showed the greatest improvement in mood compared to the high intensity group. Overall, this study illustrates that moderate intensity resistance training has a beneficial impact on mood. Improved mood might augment overall cognitive function over time.

Cognitive Performance and Aerobic Training

Fabre et al (2002) looked at how aerobic training affects cognitive ability. Thirty-two older adults from ages 60-67 years, were randomly placed into one of four groups. The groups were categorized into aerobic training, mental training, combined aerobic and mental training, and a control group. Pre-tests on health and cognitive ability were performed. To monitor physical changes. An incremental exercise test was performed on a cycle ergometer while cognitive ability was observed using the BEC 96 questionnaire. Specifically, the BEC 96 questionnaire observed cognitive problems and included tests such as recall, learning, orientation, manipulation, verbal fluency, mental problems, visual reproducing and denomination. The max grade for each test was 12 and any grade lower than a nine illustrated a mental impairment. For the duration of the study, subjects were enrolled in a one-hour physical training session that trained two times per week for two months. Training consisted of intervals of jogging and walking. Lastly, subjects involved in mental training received training once per week for 90-minutes throughout the two-month period.

Findings showed that aerobic training had a significant increase on cognitive ability. Lastly, another finding showed that aerobic training had the same results on cognitive ability as did mental training.

An additional study performed by Baker et al. (2010), had similar findings relating aerobic exercise to increased cognitive performance. This particular study consisted of 17 females and 16 males in the age range of 55 to 85 years, all with mild cognitive impairments. Subjects were randomly placed into a high-intensity aerobic exercise group or a stretching group which acted as the control. Executive function and memory were measured. At the conclusion of the study, researchers found that high intensity aerobic training has a greater impact on females in delaying cognitive impairments compared to males. Ultimately, this study illustrates that aerobic training can elicit benefits for some individuals with mild cognitive impairments.

Power

Developing strength and endurance can be achieved through multiple modalities. This idea also holds true for the development of power. Various movements can be implemented into a resistance-training program in order to achieve an increase in power. Power is the product of maximal force and velocity. Kawamori et al. (2005) studied how the hang power clean, a multi-joint high-velocity weightlifting movement, performed at various intensities affected power.

Subjects consisted of 15 males that had previous experience performing the hang power clean movement. All subjects took part in a session to become familiar with the testing as well as two separate sessions to first test static jumps (SJ) and countermovement jumps (CMJ) as well as a 1RM in the hang power clean. The second bout of testing was used to measure ground force that occurred in the hang power clean with intensities varying from 30-90% of their 1RM. During the CMJ, hands remained at the sides and two jumps were completed. Likewise, the SJ test was performed the same way except the test began in the squat position. Additionally, the 1RM was tested using a protocol defined from previous work conducted by Stone and O'Bryant (1987). Lastly, power was tested using submaximal loads at 30, 40, 50, 60, 70, 80, and 90% of 1RM. All subjects had two attempts at each required intensity with three- minutes of rest prescribed between reps.

The significance of this study relates specifically to how manipulating various intensities affects power output. The study looked at a single bout of exercise monitoring the hang power clean, CJ and CMJ. Overall, it was found that training at submaximal loads can elicit increases in the vertical jump. Performing the hang power clean at 70% yielded the highest effects on peak power. An association between having a higher 1RM and maximal power produced at 70% of the 1RM was observed. Further research must be established to observe how a higher 1RM can increase power output. The current study that will be conducted will observe how training at higher intensities with two lengths of rest periods may initiate power and strength improvements.

Another study performed by Baker et al. (2003) was conducted on 16 national or state league rugby players with previous experience in power training. For this test, the experimental group was assigned to perform six reps on the bench press at a load of 65% of 1RM. Prior to the testing, both groups performed the Post BT P50 test to measure power while the experimental group performed it again 3 minutes after their bench press session. In conclusion, using both heavy and light loads can impact power output.

Manipulating Rest Periods

While the intensity of strength training affects the development of strength, there are additional variables that are able to be manipulated to achieve additional improvements. A study conducted by Freitas de Salles (2009) observed how rest intervals affect strength training. The first major finding was that a 10RM can be achieved while the rest interval is at three minutes. Additionally, researchers concluded that when looking to achieve a 12RM, three to five minutes is not adequate, while five minutes is more applicable to achieving a true 12RM. Lastly, the authors mentioned that taking an abundant amount of rest between sets is not necessary but two to four minutes seemed to be adequate at developing strength. There are clearly varying results, leading to the need for developing new research in the area of rest periods related to strength and power.

Ratemess et al. (2007) showed how the implementation of various rest intervals effect metabolic responses in the bench press. Subjects consisted of eight males who had at least three years of resistance training experience. The strength-training regimen consisted of the bench press exercise alone for a total of ten sessions. Out of the ten sessions, five sessions used loads at 75% of the 1RM for sets of 10 reps while the other five sessions were conducted using loads of 85%. Groups were chosen at random and either given 30-seconds, one, two, three, four, or five minutes to rest. For this study, loading was appropriately adjusted for all repetitions to be reached.

Oxygen consumption, heart rate, and blood lactate were measured. At the end of the training, oxygen consumption showed the greatest increase when the rest intervals were low, specifically one-minute. The major findings for this study showed that as the rest intervals decreased so did the overall volume, but as the rest intervals were low, there were greater metabolic adaptations. The study demonstrates that there were great effects seen in the 30-second and one-minute rest group. Overall, this study showed that increased oxygen consumption is achieved with minimal rest and higher repetitions.

The current literature explains that shorter rest intervals will have a greater impact on VO_2. Ratemess et al. (2007) showed that as the rest intervals decreased in time so did the overall volume. This test did not observe how the decrease in rest intervals affects the intensity that could be achieved or maintained. The present study was conducted to observe how altering exercise intensity via manipulating rest periods can lead to physiological adaptations relating to strength, power, and oxygen consumption.

CHAPTER III

METHODOLOGY

Participants & Inclusion

Eight apparently healthy college age males ranging from ages 18-29 volunteered for this study. Subjects were required to have been engaged in resistance training three to four days per week for a minimum of six months. Additionally, subjects were required to be familiar with resistance training exercises such as the back squat and the conventional deadlift. Subjects must have been able to the meet the total time requirements of the study. The total duration of the study for group 1 (90s) consisted of a total of 600 minutes and for group 2 (3m), 720 minutes.

Recruitment

Subjects were recruited by receiving permission from various professors to enter their classroom and discuss the present study for five-minutes. It was emphasized that this study was not for a grade and nothing would be held against them if they did not participate. This was simply presented as an opportunity to be engaged in research. Recruitment was continuous until an appropriate number of subjects were recruited.

Exclusion

Subjects were not enrolled in the study if they were currently competing in strength or physique competitions. Subjects were not enrolled in the study if they were taking illegal ergogenic aids, smoking, not familiar with the back squat or conventional deadlift, or had contraindications to exercise. Lastly, subjects could have had been exceeding 150-minutes of moderate aerobic exercise in the form of walking or 60-minutes of vigorous running per week.

Pre-Assessment

Participants that met the specific criteria for this study reported to the Center for Health Promotion and Cardiac Disease Prevention located in Zink Hall, Room 111. During all pre-assessment visits, subjects were asked to fast for three hours while also refraining from vigorous activity twenty-four hours prior to each session. Additionally, informed consent (Appendix A) was provided along with the administering of a health history form (Appendix B). Height was measured using a physician's scale and body weight and body fat was measured using the BodPod. Participants were given instruction on keeping a three-day food diary (Appendix D) Results from the food diary were analyzed using Food Processor 11.1.620 database structure version 11.1.0 Average participant total kilocalories (kcal), protein (grams; % kcal), carbohydrate (grams; % kcal), and fat (grams; % kcal) were assessed. All nutritional analyses was performed by a graduate assistant in IUP's Department of Food and Nutrition. Additionally, an assessment was conducted to measure vertical jump height using a Vertec as a reflection of lower body power. Subjects performed a total of three jumps with one-minute rest between jumps (Wisløff at el, 2003). Prior to the training session, subjects completed a warm-up for five-minutes on a stationary bike followed by an additional five-minutes to perform stretching and mobility exercises if necessary. Subjects were provided a cool down following the training session to monitor their status post-training to ensure that it was safe to leave our supervision. Visit one lasted approximately 60-minutes.

Following a twenty-four hour rest after visit one, subjects reported back to James G. Mill Fitness Center located in Zink Hall. Here subjects tested their squat and deadlift 1RM, which is the greatest amount of weight that can be lifted one time. The 1RM back squat and deadlift served as a method to test and observe strength development. For the squat, subjects lifted the greatest amount of weight for one repetition while the barbell was resting on their back. Subjects were instructed to squat down until the hips were in line with the top of the thigh which was followed by returning to the standing position. Spotters were on either side of the barbell and one at the back of the subject (Haff & Triplett, 2016). The deadlift required subjects to maintain a straight back in order to pick up the barbell off the floor for one repetition. A spotter stood behind the subject. To find the 1RM, subjects performed the following recommended guidelines from the National Strength and Conditioning Association for determining a 1RM (Haff & Triplett, 2016). This assessment was administered again post-intervention. Subjects began with a warm-up set for 10 repetitions. This was followed by a one-minute rest period before a 10-20% increase in weight was added onto the bar. This new set weight was performed for five-repetitions. Subjects then took two-minutes of rest before increasing the load on the bar by 10-20% where they performed two to three repetitions. An additional 10-20% load was added to the bar and would be performed for one repetition following a two to four-minute rest period. If the subject was able to complete this for a 1RM they were able to take another two to four minutes of rest before an additional attempt with a 10-20% load increase. Subjects that were not able to complete a true 1RM would have the load decreased by 50-10% until an adequate 1RM was reached (Haff & Triplett). To complete the 1RM testing, 60-minutes of training was required.

Following 48 hours of rest, subjects returned for visit three to verify their back squat and deadlift 1RM. Upon arrival, subjects became familiarized using a practice test with Automated Neuropsychological Assessment Metrics-4th Edition (ANAM4) which is the test being utilized to observe attention, concentration level, reaction time, memory, processing speed and decision-making. After completing familiarization with the ANAM4 cognitive software, subjects completed verification of their 1RM back squat and deadlift. Visit three took approximately sixty-minutes to complete.

Automated Neuropsychological Assessment Metrics-4th Edition (ANAM4), is a computerized cognitive test battery. This test was first developed by the Department of Defense. The subtests were designed to test a variety of cognitive areas. The specific subtests for this study included the Running Memory Continuous Performance Task (RMCPT), Stroop Color Word Test (SCWT), and Mood State.

RMCPT assessed attention, concentration, and working memory. Single characters were presented on the display in rapid sequence. The user had to press the designated buttons to indicate if the displayed character matched or did not match the preceding character.

MRT is average response time.

Throughput is number of correct in a minute.

Percent Correct is total percentage of correct responses.

SCWT assessed processing speed, selective attention, interference, and executive functioning. The SCWT entailed three tests that lasted 45-seconds. The first test consisted of pressing a corresponding key for each word (one for red, two for green, three for blue). The second test required pressing the corresponding key based on color. A series of colors that included red, green or blue were presented on the screen. In the final test, a series of words (red, green, blue) were presented in a color. The presented color did not match the name of the color displayed by the word. The participants were required to press the response key assigned to color.

Selective attention and processing speed.

Interference is the ability to prevent conflicting response.

The mood state test was designed to assess seven categories of mood. The seven categories included; anger, anxiety, depression, fatigue, happiness, restlessness, and vigor. Using a laptop, 42 words signifying various emotions were presented to the subject and they were instructed to pick a number between zero and six. Zero represented “Not at all” and six represented “Very Much” for each emotion. These emotions were connected with the seven categories of mood state. To calculate total mood disturbance (TMD) all of the positive scores were subtracted from the negative scores. A higher score signified a greater negative mood, while a lower score signified a greater positive mood.

Visit four occurred twenty-four hours following visit three. Subjects reported back to the Center for Health Promotion and Cardiac Disease Prevention. Initially, participants completed the cognitive testing, and this served as the baseline score prior to randomization for the intervention. After completing the ANAM4, subjects completed a maximum oxygen consumption test (VO_2 max). In order to test VO_2 max, subjects performed a Balke Treadmill Test. Prior to testing, the principle investigator calibrated the airflow and gas for the metabolic cart (TrueOne 2400 Metabolic Measurement System). Upon subject arrival, subjects were fitted with a Polar Heart Rate Monitor. Subjects were then fitted with a nose clip and mouth piece connected to a head peace which was connected to the metabolic cart. Subjects were instructed to straddle the treadmill resting measurements were taken from the metabolic cart to ensure our values were accurate and appropriate to start testing. Observed resting measures included resting VO_2 and respiratory exchange rate (RER). Once resting values were established, the treadmill belt was started and the subject was asked to step on. Speed gradually increased until 3.3 miles per hour (mph) was reached. The grade for the treadmill began at 0% grade and increased by 2.5% every three minutes. Speed for the Balke Protocol remained at 3.3 mph the entire duration of the test. Subjects were asked to keep exercising until they were unable to maintain the speed and grade of the treadmill or volitional fatigue occurred. Visit four lasted approximately 40 minutes. This concluded all baseline assessments (Table 1).

Table 1

Pre-Assessment Week

VISIT 1		**VISIT 2**		**VISIT 3**		**VISIT 4**
-Informed Consent -Fasting Checklist -Health History -Anthropometrics -Body fat -Food Diary	24 Hour Rest	-Determination of Squat and Deadlift 1RM	48 Hours Rest	-Verification of 1RM	24 Hours Rest	-ANAM 4 -$VO_{2\ MAX}$
60 minutes		60 minutes		60 minutes		40 minutes

Experimental Design and Training Protocol

Upon completing baseline testing, subjects were placed into one of two groups via random selection. Subjects completed a training regimen for six weeks, performing the squat followed by the deadlift for three sets of five repetitions at 85% of their previously determined 1RM. The intervention included Group 1 (90-sec) which was allotted 90-seconds of rest periods in between sets while the control, group 2 (3-min) had 3-minutes of rest periods between each set. Subjects warmed-up for five-minutes on a stationary bike and had an additional five-minutes to focus on individual stretching needs. Prior to all sessions, subjects had resting blood pressure and heart rate monitored using a Polar Heart Rate Monitor. Heart rate was recorded following each set of exercise (Appendix E) (Table 2). Blood pressure and heart rate was taken again at five and ten minutes during recovery of each session. Subjects were required to reach appropriate values for heart rate and blood pressure prior to leaving the gym. Training sessions for the 3m group lasted approximately 60-minutes while the 90s group trained for approximately 50-minutes.

Table 2

Intervention Training Protocol

Day 1		**Day 2**	
-Resting Values	48 Hours Rest	-Resting Values	48 Hours Rest
-Warm-up		-Warm-up	
-Squat 3 sets of 5 @ 85% 1RM		-Squat 3 sets of 5 @ 85% 1RM	
-Deadlift 3 sets of 5 @ 85% 1RM		-Deadlift 3 sets of 5 @ 85% 1RM	
-Recovery Values		-Recovery Values	
Group 1 (90 second rest group) =50 minutes		Group 1 (90 second rest group) =50 minutes	
Group 2 (3 minute rest group) =60 minutes		Group 2 (3 minute rest group) =60 minutes	

Post Assessment and Timeframe

Upon completion of the six-week training cycle, each participant completed a post-test that was similar to the pre-assessment in order to determine and observe any changes in strength, power, cognitive ability, and endurance after being exposed to manipulated rest periods. Visit one of the Post-assessment in included, resting heart rate, and resting blood pressure, BodPod to assess body weight and body-fat levels, and vertical jump. For Visit two of the post assessment, subjects reported to James G. Mill Fitness Center after 24-hours to perform a 1RM squat and deadlift. After 48-hours of completing Visit two, subjects reported to the human performance lab to complete ANAM4 and VO_2 max using the same protocol used in Pre-assessment (Table 3).

Table 3

Post-Assessment Week

VISIT 2		**VISIT 2**
Food Diary	48	ANAM 4
Skin Folds	Hours	
Vertical Jump	Rest	VO_2 max
Determination of Squat and		
Deadlift 1RM		
80 minutes		40 minutes

Statistical Analyses

Descriptive statistics will describe the mean, median and mode of the data collected; specifically, squat and deadlift 1RM, maximum oxygen consumption, vertical jump height, cognitive performance, and body fat percentages. Additionally, a mixed model ANOVA was performed to access any significant interaction or main effects from pre- to post-intervention. Post hoc analyses using paired and independent samples t-tests assessed differences within and between groups, respectively. In the case of a non-normal distribution, a non-parametric Wilcoxon-Signed Ranks Test will be used post hoc.

Instruments

For this specific study, numerous instruments were used to observe and measure anthropometric values, strength, power, VO_2 max, and cognitive performance. Below is a description of the instruments used within the current study.

Stadiometer

This instrument was used to measure and record subject height. The stadiometer was located within The Human Performance Lab within Zink Hall.

BodPod

The BodPod measured weight and body fat for each subjects. Subjects sat in a tiny capsule while the BodPod took measurements.

Vertec

The Vertec was used to measure vertical jump height. This piece of equipment measures subjects' reach height and vertical jump height as subjects jump and touch the highest level possible.

Polar Heart Rate Monitor

This piece of equipment was used to monitor heart rate. A watch was placed on the subject's wrist and a chest strap with a monitor was placed on the subject's sternum.

TrueOne 2400 Metabolic Measurement System

This machine measures expiratory gases (Oxygen and Carbon Dioxide). Gases are represented as milliliters per kilogram of body weight per minute ($ml \bullet kg^{-1} \bullet min^{-1}$).

Treadmill

This machine with a belt allows individuals to run or walk at a predetermined speed and incline.

Aneroid Sphygmomanometer

This instrument is used when determining systolic and diastolic blood pressure. It is commonly called a blood pressure cuff.

Barbell

This piece of equipment was used for the squat and the deadlift. It was a forty-five pound bar that weights are loaded onto.

Weight Plates

This equipment was the main source of adding load onto the barbell. The plates used within this specific study ranged from 2.5 lbs, 5 lbs, 10 pounds, 25 pounds, 35 pounds, and 45 pounds.

Collars

This equipment was placed on either side of the barbell once weight plates were put on the barbell. Collars keep the weight safely on the barbell.

Automated Neuropsychological Assessment Metrics-4th Edition (ANAM4)

This computer-based software was used to test cognitive ability, specifically, Stroop Test, RMCPT, and TMD.

Food Processor 11.1.620 database structure version 11.1.0

This software was used to analyze participant food diaries in order to determine macronutrients and total kilocalories intake for subjects.

CHAPTER IV

RESULTS

Participants

Eight apparently healthy college age males (90s, n= 5) (3m, n= 3) (18-28 years) completed this study. Four subjects that previously enrolled in the study dropped out due to scheduling conflicts. Additionally, two individuals met with the principle investigator regarding interest to being enrolled within the study, and failed to follow up. The principle investigator also met with one other interested individual but upon reviewing inclusion criteria, this individual could not be included in this study since this individual had no previous resistance training experience. This totals seven additional potential participants who were unable to complete the study, resulting in a final sample size of eight. For data, assumptions were tested and met.

The average age for the study sample was 22.38 ± 1.84 years (group 1= 90-sec, 22.60 ± 2.07 years; group 2= 3-min, 22.00 ± 1.73 years). Average pre-intervention body fat (BF) for the subject population was 16.03 ± 5.68% (90s, 15.7 ± 7.10%; 3m, 16.5 ± 3.33%). Average post-intervention body fat for the subject population was 18.19 ± 7.24% (90s, 18.84 ± 9.50%; 3m, 17.10 ± 1.06%). Remaining demographics and anthropometrics can be found in Table 4.

Table 4

Demographics and Anthropometrics

Group	Age (yr.)	Height (in)	BF (% body fat)		Resting HR (BPM)	
	Mean ± St. Dev.		Pre	Post	Pre	Post
90s	22.60 ± 2.07	69.68 ± 1.96	15.72 ± 7.10	18.84 ± 9.47	70.00 ± 11.74	62.00 ± 12.80
3m	22.00 ± 1.73	67.32 ± 4.47	16.53 ± 3.33	17.10 ± 1.05	71.67 ± 17.21	71.33 ± 7.57
Total	22.38 ± 1.84	68.79 ± 3.07	16.02 ± 5.67	18.18 ± 7.23	70.63 ± 12.81	65.50 ± 11.55
	BW (lb)		Resting BP (mmHg)		BMI	
	Pre	Post	Pre	Post	Pre	Post
90s	187.54 ± 14.73	192.78 ± 21.21	123.20 ± 10.35	115.60 ± 12.28	27.260 ± 2.72	27.99 ± 3.93
3m	173.27 ± 10.04	170.74 ± 13.87	120.67 ± 13.31	118.00 ± 9.16	27.29 ± 4.86	26.90 ± 5.34
Total	182.19 ± 14.40	184.51 ± 21.02	122.25 ± 10.66	116.50 ± 10.56	27.27 ± 3.315	27.58 ± 4.16

Note. Data are mean ± SD. Values presented include Age (years), Height (in), BF (Percent bodyfat), Resting HR No significance between groups was observed for the following variables: age (p = 0.69), height (p = 0.32), BF (p = 0.92), HR (p = 0.34), BW (p = 0.17), BP (p = 0.99), and BMI (p = .086).

Hypothesis 1A stated lower body strength will significantly improve at the post-test in the 90s group versus the 3m group. Hypothesis 1A is rejected. A mixed model ANOVA revealed no significant group by time interaction (F = 0.0, p = 1.00) or main effect of group (F = 2.07, p = 0.20) (Table 6). Post hoc analyses revealed no significance increase in squat performance pre- to post-intervention of the 90s group (Table 6).

Table 5

Mixed Model Analysis of Variance Summary: 1RM Back Squat

Source	df	MS	F	p
Time	1	1500.00	8.57	0.03
Group	1	25420.42	2.07	0.20
Time*group	1	0.00	0.00	1.00

Table 6

1RM Back Squat

Group	Pre	Post
90s	344 ± 73.18	364.00 ± 64.75
3m	261.67 ± 92.92	281.67 ± 97.77#
Total	313.13 ± 85.69	333.13 ± 83.32*

Note. Data are mean ± SD.
**p* = 0.03, significantly greater than total pre.
#*p* = 0.02, significantly different compared to the 3m group pre.
Values are presented in pounds (lb).

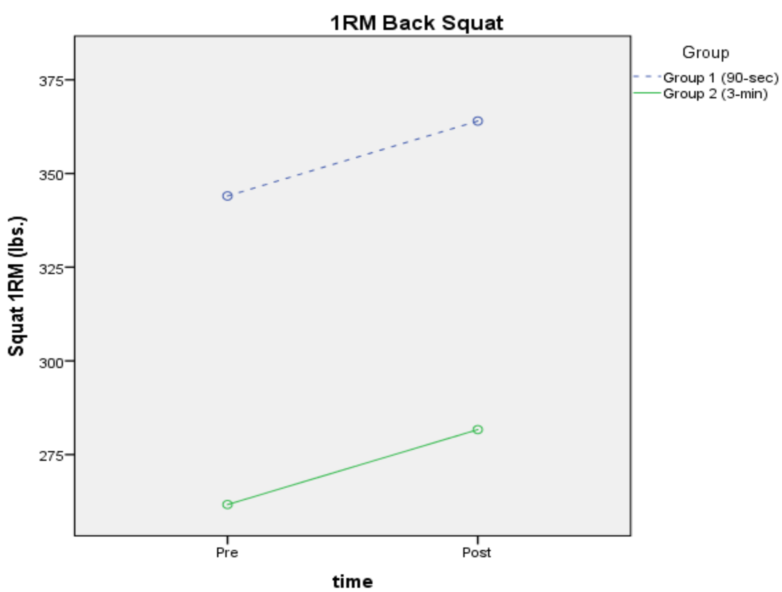

Figure 1. 1RM back squat. Post-hoc shows significance within the 3m group post-intervention (*p* = 0.02).

Deadlift was illustrated to have no significant change in strength pre- to post-intervention. A mixed model ANOVA revealed no significant group by time interaction (F = 1.02, p = 0.35), main effect of time (F = 3.49, p = 0.11), or main effect of group (F = 1.20, p = 0.32) (Table 7).

Table 7

Mixed Model Analysis of Variance Summary: 1RM Deadlift

Source	**df**	**MS**	**F**	**p**
Time	1	1237.60	3.50	0.11
Group	1	16917.60	1.20	0.32
Time*group	1	362.60	1.03	0.35

Table 8

1RM Deadlift

Group	**Pre**	**Post**
90s	359.00 ± 71.27	387.00 ± 62.71
3m	301.67 ± 107.86	310.00 ± 116.51
Total	337.50 ± 84.30	358.13 ± 87.83

Note. Data are mean ± SD.
Values are presented in pounds (lb).

Hypothesis 1B stated lower body power will significantly improve at the post-test in the 90s group which was exposed to the treatment protocol versus the 3m group. Hypothesis 1B is rejected. A main effect of group (F = 6.76, p = 0.04) was displayed (Table 9), further explained by the 90s group scoring higher in the vertical jump at post-testing time point (F = 0.46, p = 0.03) (Figure 2).

Table 9

Mixed Model Analysis of Variance Summary: Vertical Jump

Source	**df**	**MS**	**F**	**p**
Time	1	5.86	5.41	0.06
Group	1	114.13	6.76	0.04
Time*group	1	0.23	0.22	0.66

Table 10

Vertical Jump

Group	Pre	Post
90s	27.6 ± 3.11	29.1 ± 2.49*
3m	22.33 ± 3.25	23.33 ± 3.40
Total	25.63 ± 4.00	26.94 ± 4.00

Note. Data are mean ± SD.
*p = 0.041, significantly different compared to 3m group post.
Values are presented in inches (in).

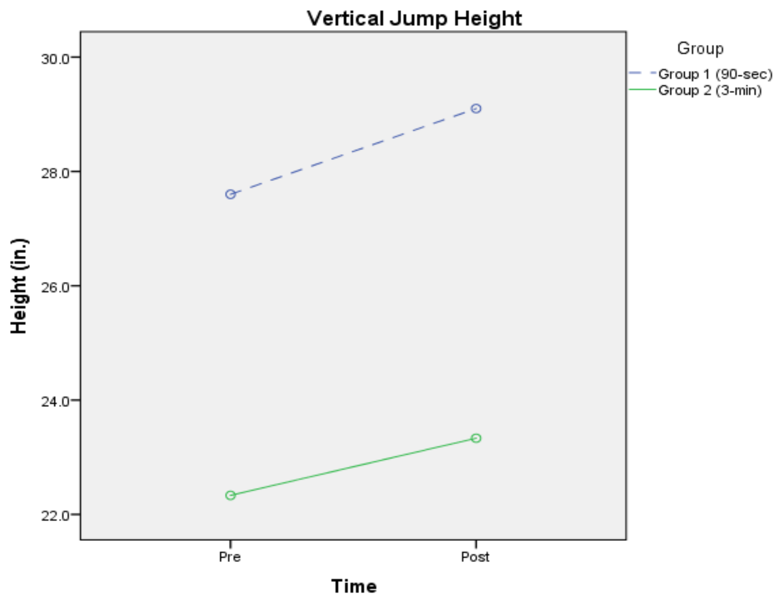

Figure 2. Vertical jump height. Main effect of group at post-testing time point (F = 6.76, p = 0.04), computed using alpha = 0.05.

Hypothesis 2A stated that lower body strength would not improve at the post-test in the group being exposed to the control protocol (3m). This hypotheses is rejected. The first test of strength was a 1RM in the back squat. A mixed model AVOVA showed a significant main effect of time (F= 8.57, p = 0.02), which was driven by the significant increase in squat performance of the 3m group post-intervention (p = 0.02). (Figure 1). The second test of lower body strength was the 1RM deadlift. No significant group by time interaction (F = 1.03, p =

0.35), main effect of time ($F = 3.50$, $p = 0.11$), or main effect of group ($F = 1.20$, $p = 0.32$) was observed (Table 8).

Hypothesis 2B stated that lower body power would not improve at the post-test in the group being exposed to the control protocol (3m). This hypothesis is accepted.

No significant group by time interaction ($F = 0.21$, $p = 0.65$) or main effect of time ($F = 5.40$, $p = 0.05$) was observed for vertical jump (Table 10).

Hypothesis 3 stated that a significant improvement in aerobic performance would be observed in the 90s group, but not the 3m group. A Balke Treadmill test measure maximum oxygen consumption pre- and post-intervention. No significant group by time interaction ($F = 5.07$, $p = 0.07$), main effect of time ($F = 0.01$, $p = 0.92$), or main effect of group ($F = 0.09$, $p = 0.77$) was found (Table 11). Neither the 90s group or the 3m group increased in maximum oxygen consumption which lead to a rejection of hypotheses three.

Table 11

Mixed Model Analysis of Variance Summary: Maximum Oxygen Consumption

Source	**df**	**MS**	**F**	**p**
Time	1	0.13	0.01	0.93
Group	1	6.18	0.09	0.77
Time*group	1	66.68	5.07	0.07

Table 12

Maximum Oxygen Consumption

Group	**Pre**	**Post**
90s	46.10 ± 6.10	41.70 ± 6.70
3m	40.60 ± 8.71	44.63 ± 4.52
Total	44.04 ± 7.14	42.80 ± 5.41

Values are presented in milliliters of oxygen per kilogram of bodyweight per minute (ml ·kg^{-1} · min^{-1}).

Hypothesis 4 stated that both groups would experience improved cognitive performance following the training protocol. The 3m group experienced a significant increase in executive function, which aligns with the initial hypothesis. The 90s group had no change in cognitive performance, leading to rejection of the hypothesis.

Interference Score

A Mixed model ANOVA revealed a significant group by time interaction (F = 6.79, p = 0.04) (Table 13). This interaction was driven by the significant main effect of time (F= 11.24, p = 0.02), despite no main effect of group (F = 4.47, p = 0.09) (Table 14). In this case, the main effect of time was influenced by the trend of an increasing Interference score at time point post-in the 3m group (p = 0.08) (Figure 3).

Table 13

Mixed Model Analysis of Variance Summary: Interference Score

Source	**df**	**MS**	**F**	**p**
Time	1	39.054	11.24	0.02
Group	1	270.05	4.47	0.09
Time*group	1	23.63	6.80	0.05

Table 14

Interference

Group	**Pre**	**Post**
90s	20.75 ± 5.44	21.50 ± 7.72
3m	27.00 ± 3.61	33.00 ± 3.60
Total	23.43 ± 5.50	26.43 ± 8.48*

Note. Data are mean ± SD.
*p = 0.02, significantly greater compared to total pre.

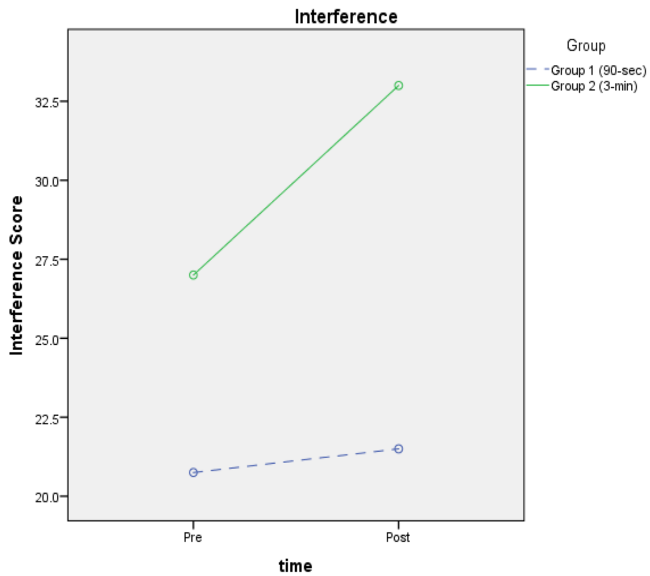

Figure 3. Interference score. Shows significant group by time interaction (*F* = 6.78, *p* = 0.05), computed using alpha = 0.05.

Word Score

A mixed model ANOVA showed no significant group by time interaction (*F* = 0.27, *p* = 0.62), main effect of time (*F* = 1.93, *p* = 0.22), or main effect of group (*F* = 0.37, *p* = 0.57) was found (Table 15).

Table 15

Mixed Model Analysis of Variance Summary: Word Score

Source	df	MS	F	p
Time	1	45.05	1.93	0.22
Group	1	39.05	0.37	0.57
Time*group	1	6.48	0.27	0.60

Table 16

Word Score

Group	Pre	Post
90s	61.00 ± 8.16	58.75 ± 10.81
3m	59.00 ± 5.29	54.00 ± 4.35
Total	60.14 ± 6.61	56.71 ± 8.44

Note. Data are mean ± SD.
Values are presented as scored units.

Color Score

A mixed model ANOVA showed no significant group by time interaction (F = 0.00, p = 0.93), main effect of time (F = 0.33, p = 0.59), or main effect of group (F = 0.52, p = 0.50) was observed (Table 17).

Table 17

Mixed Model Analysis of Variance Summary: Color Score.

Source	df	MS	F	p
Time	1	10.50	0.33	0.59
Group	1	36.21	0.52	0.50
Time*group	1	0.21	0.00	0.93

Table 18

Color Score

Group	Pre	Post
90s	61.00 ± 1.63	62.50 ± 11.26
3m	64.00 ± 5.29	66.00 ± 5.29
Total	62.29 ± 3.63	64.00 ± 8.73

Note. Data are mean ± SD.
Values are presented as score units.

Word-Color Score

A mixed model ANOVA showed a significant group by time interaction ($F = 6.42$, $p = 0.05$). This interaction was driven by the significant main effect of time ($F = 9.60$, $p = 0.03$), despite no main effect of group ($F = 4.05$, $p = 0.10$) (Table 19). In this case, the main effect of time was influenced by the trend of an increasing Word Color score at time point post- in the 3m group ($p = 0.08$) (Figure 4).

Table 19

Mixed Model Analysis of Variance Summary: Word-Color Score

Source	**df**	**MS**	**F**	**p**
Time	1	25.92	9.60	0.02
Group	1	257.52	4.05	0.10
Time*group	1	17.36	6.43	0.05

Note. Data are mean ± SD.

Table 20

Word-Color Score

Group	**Pre**	**Post**
90s	51.25 ± 5.90	51.75 ± 8.34
3m	57.67 ± 2.02	62.67 ± 2.08
Total	54.00 ± 5.54	56.43 ± 8.38*

Note. Data are mean ± SD.
*p = 0.027, significantly greater compared to total pre.
Values are presented as score units.

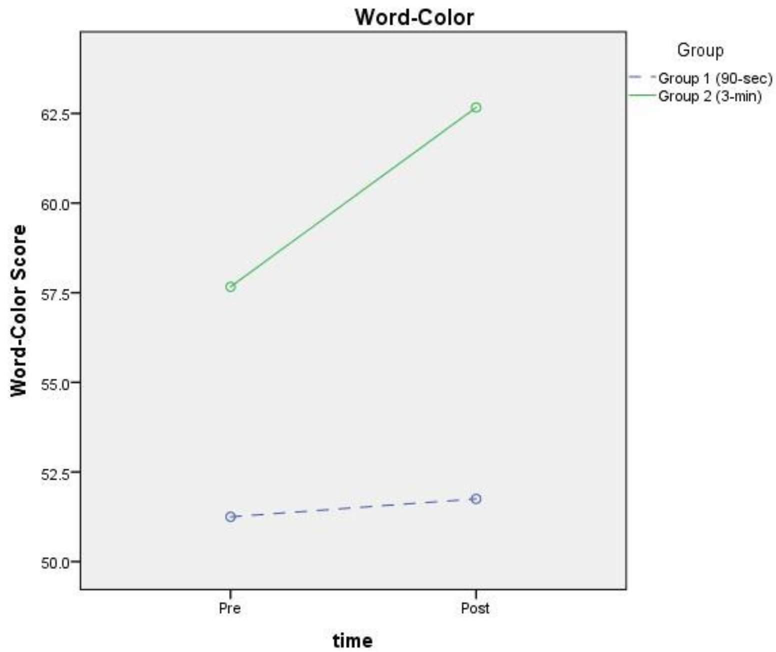

Figure 4. Word-color. Shows significant group by time interaction (*F* = 6.42, *p* = 0.05), and significant main effect of time (*F*= 9.60, *p* = 0.02), computed using alpha = 0.05.

MRT Score

No significant group by time interaction (*F* = 1.39, *p* = 0.29), main effect of time (*F* = 0.04, *p* = 0.83), or main effect of group (*F* = 0.00, *p* = 0.94) was found (Table 21).

Table 21

Mixed Model Analysis of Variance Summary: MRT Score

Source	**df**	**MS**	**F**	**p**
Time	1	110.09	0.04	0.84
Group	1	100.09	0.00	0.94
Time*group	1	3224.38	1.40	0.29

Table 22

MRT Score

Group	Pre	Post
90s	560.00 ± 76.48	535.00 ± 59.03
3m	535.00 ± 129.64	571.33 ± 152.32
Total	549.29 ± 93.30	550.57 ± 99.26

Note. Data are mean ± SD.
Values are presented as score units.

Percent Correct

A mixed model ANOVA showed no significant group by time interaction (F = 0.55, p = 0.48), main effect of time (F = 1.50, p = 0.28), or main effect of group (F = 0.94, p = 0.37) was found (Table 23).

Table 23

Mixed Model Analysis of Variance Summary: Percent Correct

Source	df	MS	F	p
Time	1	250.14	1.49	0.27
Group	1	115.00	0.94	0.3
Time*group	1	93.00	0.60	0.50

Table 24

Percent Correct Score

Group	Pre	Post
90s	95.75 ± 3.94	82.00 ± 21.41
3m	96.33 ± 2.30	93.00 ± 2.64
Total	96.00 ± 3.10	86.71 ± 16.31

Note. Data are mean ± SD.
Values are presented in score units.

TP Score

No significant group by time interaction ($F = 0.08$, $p = 0.77$), main effect of time ($F = 1.95$, $p = 0.22$), or main effect of group ($F = 0.32$, $p = 0.59$) was observed (Table 25).

Table 25.

Mixed Model Analysis of Variance Summary: TP Score

Source	**df**	**MS**	**F**	**p**
Time	1	841.52	1.95	0.22
Group	1	528.59	0.32	0.59
Time*group	1	38.09	0.08	0.77

Table 26

TP Score

Group	**Pre**	**Post**
90s	103.25 ± 9.94	84.25 ± 47.12
3m	112.33 ± 26.50	100.00 ± 31.48
Total	107.14 ± 17.52	91.00 ± 38.88

Note. Data are mean ± SD.
Values are presented in score units.

TMD

A mixed model ANOVA showed a significant group by time interaction ($F = 21.17$, $p = 0.00$) was observed. This interaction was driven by the significant main effect of time ($F= 14.87$, $p = 0.00$), despite no main effect of group ($F = 0.01$, $p = 0.92$) (Table 27). The main effect of time can be further explained by the worsening mood at time point post- (increasingly positive score) in the 3m group ($p = 0.00$) (Figure 5).

Table 27

Mixed Model Analysis of Variance Summary: TMD Score

Source	**df**	**MS**	**F**	**p**
Time	1	8166.66	14.87	0.00
Group	1	79.35	0.01	0.00
Time*group	1	11620.41	21.17	0.00

Table 28

TMD Score

Group	**Pre**	**Post**
90s	-78.60 ± 66.46	-87.60 ± 78.01
3m	-129.67 ± 51.81	-27.33 ± 41.55#
Total	-97.75 ± 63.16	-65.00 ± 70.31*

Note. Data are mean ± SD.
*p = 0.01, significantly worsened mood compared to total pre.
#p = 0.01, significantly worsened mood compared to the 3m group pre.
Values are presented as score units.

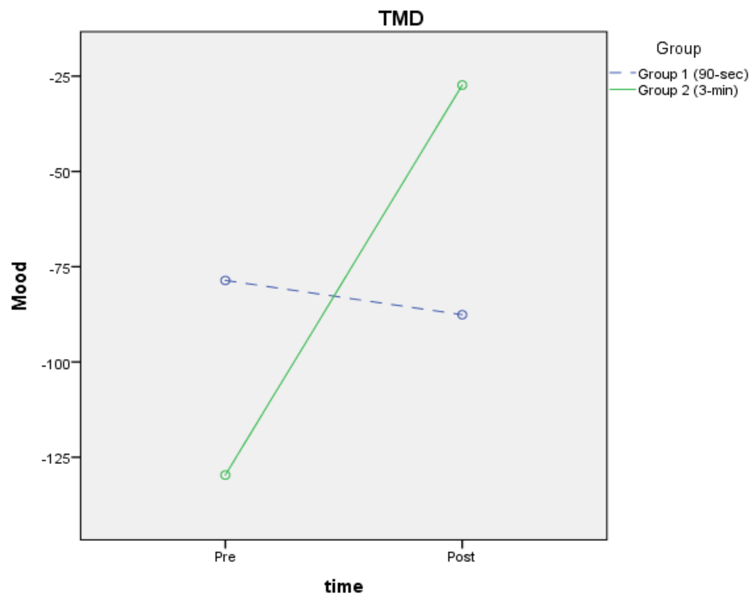

Figure 5. TMD. Significant group by time interaction (F = 21.17, p = 0.00), computed using alpha = 0.05.

Percent Body Weight Squatted

Although percent of bodyweight lifted in the back squat is not a primary dependent variable, statistics observed any significances that occurred from pre- to post-intervention. As previously discussed, a mixed model ANOVA was performed to access any significant interaction or main effects from pre- to post-intervention. A significant main effect of time (F = 7.87, p = 0.03) was observed, which could be explained by the increase in weight lifted relative to bodyweight in the 3m group (p = 0.00) (Table 30). This illustrates that squatting at three sets of five repetitions at eighty-five percent of 1RM with three-minute rest periods leads to a significant increase in relative strength (Figure 6). Additionally, post hoc analyses using paired and independent samples t-tests assessed differences within and between groups. No significant group by time interaction (F = 1.01, p = 0.35) or main effect of group (F = 1.11, p = 0.33) was found (Table 29).

Table 29

Mixed Model Analysis of Variance Summary: Percent Body Weight Squatted

Source	**df**	**MS**	**F**	**p**
Time	1	366.14	7.87	0.03
Group	1	3211.40	1.11	0.33
Time*group	1	47.41	1.01	0.35

Table 30

Percent Body Weight Squatted

Group	**Pre**	**Post**
90s	182.71 ± 34.4	189.03 ± 30.20
3m	149.89 ± 47.87	163.32 ± 47.65#
Total	170.40 ± 40.26	179.39 ± 36.70*

Note. Data are mean ± SD.
$*p = 0.03$, significantly greater than total pre.
$\#p = 0.00$, significantly different compared to group 2 pre.
Values are presented as percent body weight.

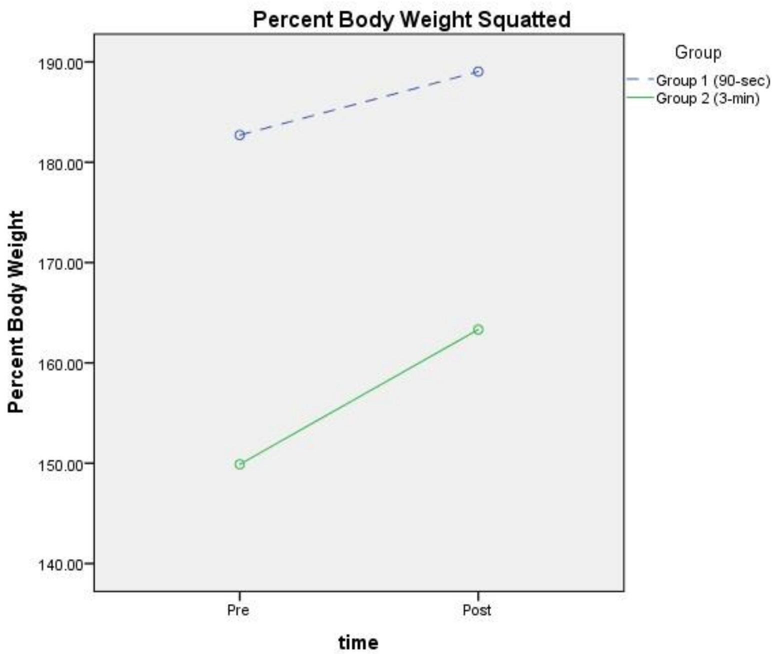

Figure 6. Percent body weight squatted. Significant main effect of time (*F* = 7.87, *p*= 0.03) was found for percent bodyweight squatted, computed using alpha = 0.05.

Percent Bodyweight Deadlifted

Percent body weight deadlift was also observed even though it was not a primary dependent variable. Unlike the 1RM back squat, a Mixed Model ANOVA illustrated no significant group by time interaction (*F* = 0.17, *p* = 0.68) or main effect of time (*F* = 2.35, *p* = 0.18) (Table 31). Post hoc analyses using paired and independent samples t-tests showed no main effect of group (*F* = 0.41, *p* = 0.54) was found (Table 32). This shows relative strength did not improve relative strength in the deadlift following the current intervention.

Table 31

Mixed Model Analysis of Variance Summary: Percent Bodyweight Deadlifted

Source	**df**	**MS**	**F**	**p**
Time	1	258.36	2.35	0.17
Group	1	1619.17	0.41	0.54
Time*group	1	19.54	0.17	0.68

Table 32

Percent Body Weight Deadlifted

Group	Pre	Post
90s	191.54 ± 37.61	202.13 ± 36.74
3m	173.04 ± 56.21	179.06 ± 56.82
Total	184.61 ± 42.46	193.48 ± 42.85

Note. Data are mean ± SD.
Values are presented as percent body weight

Breakdown of Kilocalories

The mean kcals for both groups were 606.72, 1134.80 and 867.80 from protein, carbohydrate, and fat, respectively. The total mean Kcal for both groups was 2606.80 (Table 33).

Table 33.

Average Breakdown of Kilocalories

Value	Minimal	Maximum	Total Kcal
Kcal from protein	434.25	1101.4	606.72
Kcal from carbohydrate	750.36	2385.04	1134.80
Kcal from fat	250.21	1505.69	867.73
Total average kcal	1297.57	5252.95	2606.80

Note. Data are means.
Values represented in Kcal.

Total Macronutrient Breakdown

Total percent of kcal from protein for the 90s group and the 3m group combined was 24%. Total percent of kcal from carbohydrates for the 90s group and the 3m group combined was 44%. Total percent of kcals from fat for the 90s group and the 3m group combined was 33% (Figure 7)

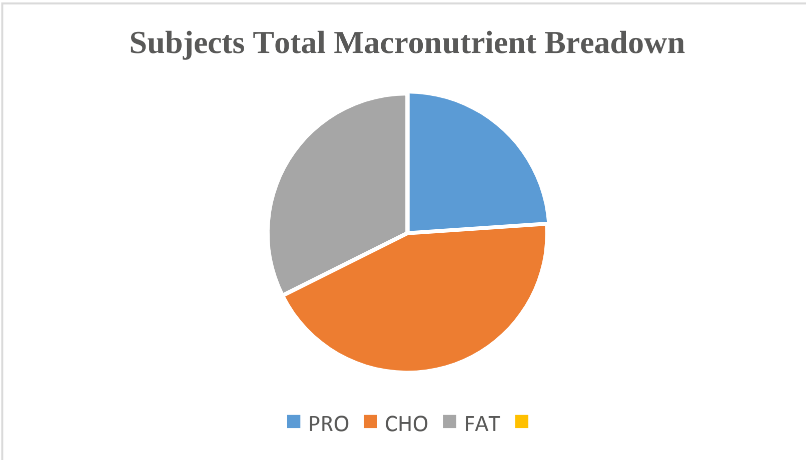

Figure 7. Subjects total macronutrient breakdown. Percent of kcal from protein (24%), carbohydrates (44%), and fat (33%) from food diaries from the 90s group and 3m group.

CHAPTER V

DISCUSSION/CONCLUSION

Summary/Discussion

Upon reviewing the results, it is noticeable that both groups increased in lower body strength following the six-week protocol. The 3m group significantly improved in lower body strength while the 3m group significantly improved in lower body power. Only the 3m group appeared to improve in terms of cognitive function. No significant differences in pre- and post-intervention anthropometric data were expected. However, the minimal change in body fat over the course of the present eight-week intervention conflicts with previous finding. Smith et al. (2013) observed a significant reduction in body fat following a 10-week high-intensity interval exercise. In the present study, no significant change in body fat levels were observed following high intensity training with minimal rest. Additionally, researchers did not seen a significant change in resting HR from pre- to post-intervention in the 90s group, since the participants in this group were exposed to greater cardiovascular demand during training sessions. This finding was in contrast to current literature. It is possible that a larger sample, or a sample of untrained males, may lead to significant change in both resting HR and BP. Hagerman et al. (2000) observed high intensity resistance training significantly improved numerous physiological variables among untrained older men, specifically improvements in VO_2 max, strength, cross-sectional area, and serum lipid profiles. In terms of bodyweight, the 90s group had a rise in bodyweight while the 3m group had a decrease in bodyweight (Table 4). Body weight is difficult to predict when individuals are participating in a resistance-training program since lean mass has the potential to rise while body-fat levels may fall. Heydari et al. (2012), observed that 12-weeks of high-intensity resistance training significantly decreased abdominal, trunk, and visceral fat while significantly increasing lean body mass among overweight young males.

Squat strength significantly improved from pre-intervention to post for the 3m group. This finding contradicts the hypothesis that the 90s group would significantly improve in strength relative to the three-minute rest group. While the 90s group did not significantly improve, there was a trending increase in strength from pre- to post-intervention. Researchers suggest the small sample size may have led to this significant improvement with the 3m group while the 90s group who displayed a similar increase in the amount of weight lifted, did not elicit a significant improvement. It appears that the high intensity exercise is responsible for improved strength. Similarly, Hoffman and Kang (2003) found that resistance training during the course of a football season has a positive impact on lower body strength while squatting at approximately 80-percent of their 1RM. A significance increase in the squat was found but not in the bench press. This study is similar to the present study where 85-percent of 1RM was used. This allows coaches to safely and effectively implement higher intensities into programming for lower body strength improvements, especially for in-season athletes.

As the amount of weight lifted for the squat improved in both groups, there was a significant increase in the percent of bodyweight squatted. This illustrates that squatting two days per week with the current study's protocol can aid in improving squat strength relative to total body weight. This finding is very beneficial for sports that place a high demand on relative strength. Specific sports include wrestling, mixed martial arts (MMA), boxing, as well as other sports where extra body weight does not specifically lead to enhanced performance. Garcìa-Pallarès et al. (2011) recruited 92 male wrestlers and took them through a battery of tests which included a sprint test, arm-cycle Wingate, jumping, muscle extensibility, 1RM strength and load-power relationship. Upon completion of the study, it was found that wrestlers who possess a greater amount of absolute and relative strength, power, and anaerobic capacity have a distinct advantage while wrestling at high levels of competition.

During the course of the six-week training intervention, there was no significant increase in strength development for the deadlift. This does not align with the hypothesis that the 90s group would improve in strength. The deadlift was performed following the squat throughout the entirety of the study. The reason for the non-significant increase in deadlift strength could have been fatigue while performing the deadlift immediately following the squat. While all subjects reported previous experience with the deadlift, technique was not observed following the self-reported claim of moderate experience with the designated lifts. A limitation of the present study is that the participants may not have been completely honest regarding their resistance training history and experience, due to self-report.

It is understood that performing three sets of five repetitions at eighty-five-percent of a 1RM requires a unique combination of muscular strength and power. With the added variable of minimal rest and elevated heart rates during exercise, muscular endurance and recovery also play key roles in successfully completing all repetitions (Haff & Triplett, 2016). Gill et al. (2006) observed 23 elite rugby players and various recovery methods. Researchers found that contrast water therapy, compression garments, and low intensity exercise aids in recovery following a rugby match. Due to the unrealistic likelihood of successfully completing all repetitions at the prescribed intensity, researchers dropped weight minimally if participants could not successfully complete five repetitions during any set. This was done in order to maintain the appropriate rest and relative intensity throughout the protocol.

The significant improvement in vertical jump could potentially be the result of subjects performing the squat and the deadlift at eighty-five-percent of their 1RM for three sets of five repetitions. A recent study conducted by Thompson et al. (2015) observed that subjects who resistance trained using the deadlift for 10-weeks significantly improved their vertical jump height. As seen, many studies do not implement both the back squat and the deadlift within a program design. To our knowledge, this is the first study to focus solely on both of these movements at this prescribed intensity. To improve maximal lower body power, it appears that implementing high intensity lower body resistance training using the back squat and traditional deadlift is effective.

The findings of VO_2 max did not align with the current study's hypothesis. The current study hypothesized that the 90s group would significantly improve in terms of VO_2 max while the 3m group would not change. Astorino et al. (2012) observed improved VO_2 max from anaerobic bouts of exercise using the Wingate Test. While this test implemented the use of the bike, the current study implemented resistance training as the training stimulus. Both studies placed a great demand on the anaerobic energy system regardless of the training stimulus, which is why it was a surprise not to observe a significant change in VO_2 max within the 90s group. Sample size was a limitation within this study the 90s group if the sample were larger.

Interference score displayed a significant group by time interaction ($F = 6.79$, $p = 0.04$), driven by the improvement in the 3m group. This signifies that this group possessed a greater ability to differentiate between conflicting responses. This misaligns with the current study's hypothesis that both groups would have a greater improvement in post-intervention cognitive testing. Sample size is a limiting factor for the current results found.

When subjects were tasked with the Stroop Test, no significance was found in either groups for both word and color score. A significant group by time interaction ($F = 6.42$, $p = 0.05$), and significant main effect of time ($F= 9.60$, $p = 0.02$), was found for word-color in the 3m group (figure 4). A previous study where sport-specific exercise at bouts of intensity of 70-100% of max power output produced improvements in simple tasks and information processing (McMorris & Graydon, 1997). Two experiments were conducted where players were tested on game and non-game areas. Experiment 1 tested the speed and visual search to locate a soccer ball. Experiment two observed how exercise affects how fast a player makes a decision upon locating a ball, speed of the players search, as well as accuracy of the decision. Upon observing past research, the reason that only the word-color improved significantly may be because of the type of training implemented. Combining both strength and endurance training or strength and sport-specific drills could potentially lead to a further increase in cognitive performance for future studies.

No significance was found for the RMCPT test. Previous research shared similar findings where HIT training improved word-color scores but had no effect on short-term memory (Alves et al., 2014). It appears that training at high intensity does not improve short-term memory.

The significant interaction observed for TMD was driven by the change among the 3m group. Specifically, the 3m group had a decline in mood over the course of the intervention. The 90s group appeared to increase in mood but not enough to cause a significant finding. These findings do not align with previous studies where high intensity resistance training was found to improve mood states in an elderly population (Cassilhas, 2010). Sample size was a limitation for the current study, which could have limited a significant finding among the 90s group. It is also possible that after the six-week exercise intervention, participants were no longer as focused on the protocol, with both physical and mental fatigue influencing performance and mood.

Observing the mean kcal intake for all subjects illustrated subjects were taking in approximately 2606.80kcals. Additionally, it is important to recognize that no subjects were included within the study that consumed less than 1200 kcals per day (Table 33). Lastly, total macronutrient breakdown can be seen in Figure 7.

Limitations

This present study does possess certain limitations. The first limitation is the sample size (n= 8). Five subjects were included within the 90-second rest group while there were three subjects within the 3-minute rest group. Secondly, this study included college-aged, moderately trained males. No females were included within this study. The results of the present study cannot be generalized to competitive, sedentary, or highly-trained individuals. Future studies should observe different ethnic backgrounds and various training backgrounds. In order to recruit a more homogenous sample, initially an inclusion criteria was in place to ensure that habitual dietary intake fell within the daily Acceptable Macronutrient Distribution Range (AMDR) for carbohydrates (45-65% of kilocalories), protein (10-35% of kilocalories), and fat (20-35% of kilocalories) (Manore, 2005). Potential participants were provided verbal instruction and detailed handouts on how to keep a 3-day food diary. They were instructed not to change their habitual food intake and to record their food and beverage intake for two weekdays and one weekend day. Dietary data was analyzed using Food Processor (The Food Processor 11.1.620 database. Version 11.1.620. Salem). Upon initial recruitment, many potential participants were just below the carbohydrate threshold of at least 45% of daily kilocalories from carbohydrate. This could be due to a number of reasons. It is not uncommon for dietary intake to be underreported or for dietary habits to be altered when keeping a 3-day food diary due to the burden of having to write down everything that is consumed (Macdiarmid, & Blundell, 1997) Because the other inclusion criteria already made recruitment challenging, the nutrition inclusion criteria was eliminated in order that a greater number of participants would be potentially eligible for enrollment.

Although the nutrition criteria was dropped, enrolled participants were still instructed and required to keep a 3-day food diary (Appendix D). Mean macronutrient composition was 44%, 24%, and 33% of daily kilocalories for carbohydrate, protein, and fat, respectively. All participants' macronutrient intake fell into the AMDR guidelines, except for carbohydrates, which fell just below the threshold of 45-65% of daily kilocalorie intake. An independent t-test was run and no significant differences were found for macronutrient intake between the 90-second and 3-minute groups (data not shown). Additionally, macronutrient intake in the current study was very similar to the habitual dietary intake in a study by Sawyer et al of trained males and females (40.7%, 22.2%, and 34.4% of daily kilocalories from carbohydrate, protein, and fat, respectively).

Summary

This study is opening up the doors of challenging the current rest period guidelines of the NSCA for the development of strength and power. The current study illustrated that short rest periods did not have a significant effect on strength development. The current did illustrate that training at eighty-five percent for three sets of five repetitions did significantly improve squat strength over the course of a six-week training regime regardless of the rest periods. However, the 90s group improved lower body power significantly, indicating that training for power and explosive sport activity may be more likely to improve at a lower rest interval than is currently prescribed by the NSCA.

Future Implication/Direction of Research

Future studies should utilize different populations and ethnic groups to conduct similar research. Populations include athletes from various sports, reactional athletes, manual laborers, military, and first responders. If strength and power improvements are observed with minimal rest time, this will decrease the amount of time in the gym which in turn improves training economy. Training economy is extremely critical especially for those where time is not of the essence: elite athletes, recreational athletes, and highly trained first responders. Ultimately, the goal is to achieve the greatest benefits in the least amount of time in order to allow individuals to focus on recovery and the technical side of their sport or profession. Additional studies should implement different lifts to observe how varying rest periods effect strength and power development. Movements may include the bench press or Olympic lifts. Olympic lifts place a greater demand on focus and technique compared to powerlifts. McMorris et al. (1997) found that assigning focus tasks to a group of soccer players improves cognitive performance. Future research should focus on observing the effects of more technical lifts on cognitive outcomes over the course of six-weeks at a high intensity. Implementing different intensities and varying the sets and reps are both ways to manipulate the current study. The current study had subjects perform three sets of five repetitions at eighty-five percent of 1RM. Future studies should manipulate these variables by adjusting load, sets, and repetitions performed. Lastly, adding assistance and recovery exercises into the current study could potentially improve further strength and power development when observing minimal rest periods. As observed by Gill et al. (2006), recovery can play a major role upon completion of a high intensity bout of work. Putting subjects through a form of recovery following their session would be an interesting aspect of the study to observe performance in daily training as well as strength, power, and cognitive improvements over the course of the intervention.

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Appendix A

Consent

Informed Consent to Participate in a Research Study

Study Title: OBSERVING THE EFFECTS OF MANIPULATING REST PERIODS WITHIN A LOWER-BODY RESISTANCE TRAINING PROGRAM ON SELECTED STRENGTH, POWER, AEROBIC, AND COGNITIVE OUTCOMES

The purpose of the present study is to observe the effects of a 6-week lower body resistance training program on strength, power, aerobic and cognitive outcomes. You are invited to participate in the current study on a volunteer basis. Please contact us using the contact information provided on top of the page if you have any questions.

You have been asked to participate in this study because you are a male between the ages of 19 to 29 that has been engaged in resistance training program for a minimum of six months and are familiar with resistance training exercises such as the back squat and the deadlift. Also subjects must not be currently engaging in more than 150 minutes of moderate walking or 60 minutes of vigorous running a week. If the information is not accurate please notify the principle investigator provided at the top of the page.

Participants that meet the criteria will report to the Center for Health Promotion and Cardiac Disease Prevention located in Zink Hall, Room 111. During Visit 1, participants will complete a consent form, health history, nutritional questionnaire, skin folds, height, weight, and vertical jump (from a standing position jump to maximum height). This session will last approximately 60 minutes. After 48 hours of rest, participants will return to test their 1-repetition maximum (1RM) back squat and deadlift. The 1RM back squat and deadlift serves as a method to test and observe maximal strength. For the squat, subjects will lift the greatest amount of weight for 1 repetition while the barbell is resting on their back. Subjects will squat down until the hips are in line with the top of the thigh which is followed by returning to a fully extended standing position (Haff & Triplett, 2016). Additionally, the deadlift requires subjects to keep a straight back in order to pick up the barbell off the floor for one repetition. Following 48 hours of rest, subjects will return for Visit 3 to verify their back squat and deadlift 1RM, and familiarize with all cognitive assessments. This familiarization is in place to control for a learning effect prior to cognitive data collection.

Visit 4 will occur 24 hours following visit 3. Subjects will report back to the Center for Health and Cardiac Disease Prevention located in Zink Hall, room 111. Participants will complete the cognitive testing (ANAM4), and this will serve as the baseline score prior to randomization for the intervention. After completing the ANAM4, subjects will complete a maximum oxygen consumption test (VO_2 Max). To test VO_2 Max, subjects will perform a Balke Treadmill Test. First, subjects will be fitted head gear that consists of a mouth piece that attaches to a metabolic cart. Additionally, subjects will be asked to wear a nose clip. Resting measurements will be taken from the metabolic cart to ensure our values are appropriate to begin testing. Subjects will be asked to straddle the treadmill while the administrator starts the treadmill. The grade for the treadmill begins at 0% grade and increases by 2.5% every 3 minutes. Speed for the Balke Protocol remains at 3.3 mile per hour (mph) for the duration of the test. Subjects are asked to keep exercising until they physically cannot keep up with the increasing work demand or they begin to feel uncomfortable. Visit 4 will last approximately 40 minutes. This concludes all baseline testing visits.

Upon completing baseline testing, subjects will be placed into one of two groups via random selection. Subjects will complete a training regimen consisting of two sessions per week for 6 weeks where they perform the squat followed by the deadlift for 3 sets of 5 repetitions at 85% of their previously determined 1RM. Group 1 (90s) will be allotted a 90 second rest in between sets while group 2 (3min) will have 3-minutes of rest periods between each set. The warm-up will consist of 5-minutes on a stationary bike and subjects will have an additional 5-minutes to focus on individual stretching needs. Prior to all sessions subjects will have resting blood pressure and heart recorded using a Polar Heart Rate Monitor. These values will be recorded following each set of exercise, and again at minute 5 and minute 10 during recovery. Subjects will be required to reach resting values for heart rate and blood pressure prior to leaving the facility. Training sessions for the 3m group will last approximately 60 minutes while the 90s will train for approximately 50 minutes.

Upon completion of the 6-week training cycle, each participant will complete a post-test that is similar to the pre-assessment in order to determine and observe any changes in strength, power, cognitive ability, and endurance after being exposed to manipulated rest periods. The total duration of testing for the 3m group will be 720 minutes while the 90s group totals 600 minutes throughout 6-weeks.

You are responsible for disclosing your medical history on the health history form prior to your participation in the research. You are also expected to report all medications including non-prescription and supplements taken recently to the research staff prior to participating in each research session.

If you decide to participate in this research, we will ask you to complete the following procedures:

Cognitive Function and Mood Assessment tests

For these tests we will ask that you use a computer to complete the Automated Neuropsychological Assessment Metric 4th edition (ANAM4) test. The results of this tests provide us with information about your attention and concentration level, reaction time, memory, processing speed and decision-making.

Risks and Discomforts:

Due to the nature of resistance training, participants have a potential risk and possibility of developing discomforts such as muscle soreness and exercise induced fatigue (becoming tired resulting from the exercise). Additionally, the level of intensity for the maximum oxygen consumption test is associated with an intensity of exercise at your maximum level of effort which may result in shortness of breath and increased heart rate. Participants will not be required to perform any exercise above their capability and are able to drop out at any time point within the study.

Benefits

Participants will learn about their aerobic fitness through the testing of maximal oxygen consumption. Muscular strength will also be observed through training and testing of the back squat. Lastly, this test will observe and provide knowledge to possible changes in power and cognitive function following a resistance training program. This information may be applicable to future exercise programming as it could increase training economy if positive changes occur in power, aerobic performance, cognitive performance and strength during a strength training program with unconventional rest periods.

Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing. Emergency equipment and trained personnel are available to deal with unusual situations that may arise. Researchers conducting this study are not medical doctors and are not qualified to diagnose a participant's illness or state of disease.

You may stop the test or training session at any time if you feel excessive fatigue or experience any changes you uncomfortable with.

Privacy and Confidentiality

Your personal information will be kept confidential. Only the principle investigator and educational advisor will have access to the information which will be locked away in a secure location. Research participants will not be identified in any publication or presentation of research results; only aggregate data will be used.

Your research information may, in certain circumstances, be disclosed to the Institutional Review Board (IRB), which oversees research at the Indiana University of Pennsylvania, or to certain federal agencies. Confidentiality may not be maintained if you indicate that you may do harm to yourself or others.

EMERGENCIES

For research related injuries, 911 will be called. You or your medical insurance will be billed for this service.

Voluntary Participation

Taking part in this research study is entirely voluntary. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled. You will be informed of any new, relevant information that may affect your health, welfare, or willingness to continue your study participation.

Contact Information

If you have any questions or concerns about this research, you may contact *Mitchell Moyer* at *484-629-4680 or Hayden Gerhart* at *717-371-5197*. This project has been approved by the Indiana University of Pennsylvania Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 724.357.7730.

Consent Statement and Signature

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I understand that a copy of this consent will be provided to me for future reference.

Participant Signature **Date**

___________________________________ _______________________

THIS PROJET HAS BEEN APPROVED BY THE INDIANA UNIVERSITY OF PENNSYLVANIA INSTITUTIONAL REVIEW BOARD FOR THE PROTECTION OF HUMAN SUBJECTS (PHONE: 724-357-7730)

Appendix B

Medical and Health History

Indiana University of Pennsylvania

Center for Health Promotion and Cardiac Disease Prevention

HEALTH HISTORY

Thank you for volunteering to be a participant for a study to be conducted in the Center for Health Promotion and Cardiac Disease Prevention. *You may be asked to perform a test that requires you to exercise at or near your maximum capability. Consequently, it is important that we have an accurate assessment of your past and present health status to assure that you have no medical conditions that would make the tests dangerous for you. Please complete the health history as accurately as you can. This medical history is confidential and will only be seen by researchers to determine your qualifications for this study.*

Name____ Date____/____/____

Date of Birth____/____/____ Present Age_____yrs

Ethnic Group:_____White
____ African American
____ Hispanic
____ Asian
____ Pacific Islands
____ American Indian
____ Other_____________

HOSPITALIZATIONS AND SURGERIES

If you have ever been hospitalized for an illness or operation, please complete the chart below. Do not include normal pregnancies, childhood tonsillectomy, or broken bones.

YEAR_____________
OPERATIONS OR LLNESS
____
____

YEAR_____________
OPERATIONS OR ILLNESS
____
____

YEAR_____________
OPERATIONS OR ILLNESS
____
____

Are you under long-term treatment for a protracted disease, even if presently not taking medication? [ ] Yes [ ] No

If Yes,
explain:____
____
____

MEDICATIONS
Please list all medications that you have taken within the past 8 weeks: (Include prescriptions, vitamins, over-the-counter drugs, nasal sprays, aspirins, birth control pills, etc.)
Check this box [ ] if you have not taken any medication.
MEDICATION________________
REASON FOR TAKING THIS
____
____

MEDICATION________________
REASON FOR TAKING THIS
____
____

MEDICATION________________
REASON FOR TAKING THIS
____
____

ALLERGIES
Please list all allergies you have (include pollen, drugs, alcohol, food, animals, etc.)
Check this box [ ] if you have no allergies.
1.____
2.____
3.____
4.____

When was the last time you were "sick"? (e.g. common cold, flu, fever, etc.)

____

PROBLEMS AND SYMPTOMS
Place an X in the box next to any of the following problems or symptoms that you have had:
General
[ ] Mononucleosis
If yes, when____
[ ] Excessive fatigue
[ ] Recent weight loss while not on a diet
[ ] Recent weight gain
[ ] Thyroid disease
[ ] Fever, chills, night sweats
[ ] Diabetes
[ ] Arthritis
[ ] Sickle Cell Anemia

PROBLEMS AND SYMPTOMS, continued

Heart and Lungs

[ ] Abnormal chest x-ray
[ ] Pain in chest (persistent and/or exercise related)
[ ] Heart attack
[ ] Coronary artery disease
[ ] High blood pressure
[ ] Rheumatic fever
[ ] Peripheral vascular disease
[ ] Blood clots, inflammation of veins (phelebitis)
[ ] Asthma, emphysema, bronchitis
[ ] Shortness of breath
    [ ] At rest
    [ ] On mild exertion
[ ] Discomfort in chest on exertion
[ ] Palpitation of the heart; skipped or extra beats
[ ] Heart murmur, click
[ ] Other heart trouble
[ ] Lightheadedness or fainting
[ ] Pain in legs when walking
[ ] Swelling of the ankles
[ ] Need to sleep in an elevated position with several pillows

G-U SYSTEM

[ ] Get up at night to urinate frequently
[ ] Frequent thirst
[ ] History of kidney stones, kidney disease

G.I. TRACT

[ ] Eating disorder (e.g. anorexia, bulimia)
[ ] Yellow jaundice
If yes, when____
[ ] Hepatitis
If yes, when____
[ ] Poor appetite
[ ] Frequent indigestion or heartburn
[ ] Tarry (black) stool
[ ] Frequent nausea or vomiting
[ ] Intolerance of fatty foods
[ ] Changes in bowel habits
[ ] Persistent constipation
[ ] Frequent diarrhea
[ ] Rectal bleeding
[ ] Unusually foul smelling or floating stools
[ ] Pancreatitis

Nervous System
[ ] Alcohol problem
[ ] Alcohol use
If yes, how many drinks ingested per week? ________________
[ ] Frequent or severe headaches
[ ] Stroke
[ ] Attacks of staggering, loss of balance, dizziness
[ ] Persistent or recurrent numbness or tingling of hands or feet
[ ] Episode of difficulty in talking
[ ] Prolonged periods of feeling depressed or "blue"
[ ] Difficulty in concentrating
[ ] Suicidal thoughts
[ ] Have had psychiatric help

Explain any items checked (when, severity, treatment)

____
____
____
____
____
____

Have you ever passed out during or after exertion? YES NO
Do you have a family history of coronary artery disease YES NO
If yes, Who? (Grandparents, parents, siblings, uncles, and aunts)

____
____
____

Are you currently taking supplementation that is considered an ergogenic aid? YES NO
If so, please list supplements

____
____
____

Are there any other reasons not mentioned above that you feel you should not participate in this research study? YES NO

Do you currently smoke cigarettes? YES NO

Do you currently use any smokeless tobacco products? YES NO

EXCLUSION CHECKLIST

This form is intended to identify any signs, symptoms, or conditions that would exclude any person from participating in a study involving maximum 1-Repetition Deadlift, Squat, maximum oxygen consumption test, and a cognitive performance test. Please mark if any of the following statements apply.

Have you been resistance training for at least 6 months with a frequency of 3-4 times per week?
Yes [ ] No [ ]

Are you familiar with the deadlift exercise?
Yes [ ] No [ ]

Are you familiar with the back squat exercise?
Yes [ ] No [ ]

Do you engage in in more than 150 minutes of moderate cardiorespiratory exercise per week?
Yes [ ] No [ ]

Do you engage in more than 60 minutes of vigorous cardiorespiratory exercise per week?
Yes [ ] No [ ]

Are you currently taking any supplement that is considered an ergogenic aid?
Yes [ ] No [ ]

Have you ever experienced syncope (loss of consciousness) or dizziness during exercise?
Yes [ ]   No [ ]

Do you have any known metabolic, cardiovascular, or pulmonary disease?
Yes [ ]   No [ ]

Have you been told that you have a heart arrhythmia?
Yes [ ]   No [ ]

Have you ever coughed blood after exercising?
Yes [ ]   No [ ]

Have you been diagnosed with orthostatic hypotension, or experience extreme dizziness upon standing?
Yes [ ]   No [ ]

Do you currently take any over-the-counter or prescription medications including antihistamines, decongestants, anti-hypertensives, anti-anxiety, wake or alert promoting, CNS stimulants, systemic steroids or topical skin lotions?
Yes [ ]   No [ ]

Have you ever experience Angina? (a pain or discomfort in the chest, neck, or jaw during exertion that is not attributed to muscle or joint pain)
Yes [ ]   No [ ]

Have you ever experience shortness of breath at rest or with mild exertion (Dyspnea)?
Yes [ ]   No [ ]

Do you have a history of heat exhaustion/illness?
Yes [ ]   No [ ]

Do you or have you ever had ankle edema? (fluid retention in the ankles causing swelling)
Yes [ ]   No [ ]

Do you every experience tachycardia or palpitations at rest? (do you ever feel that your heart is beating very rapidly and forcefully without exercise, caffeine, or another stimulus?)
Yes [ ]   No [ ]

Do you have intermittent claudication? (a pain in the leg due to exercise caused by a lack of blood flow, usually caused by a clot)
Yes [ ]   No [ ]

Have you ever been told that you have a heart murmur?
Yes [ ]   No [ ]

Do you smoke, or have you quit smoking within the last 6 months?
Yes [ ]   No [ ]

Appendix C

Fasting Checklist

Fasting Checklist

When was the last meal that you ate, and what did it contain?

Have you use any recreational drugs or alcohol in the last 24 hours?

Have you performed any vigorous physical activity in the last 24 hours?

Appendix D

Food Journal

How to record food intake using a food diary

Instructions:

Please use the template below to record everything that you eat and drink for 3 days. The days do not need to be consecutive, but please choose at least 1 weekday (Monday through Thursday) and 1 weekend (Friday-Sunday).

1. Please be as detailed as possible with your food descriptions, including brand names, flavors and preparation methods. Please also use standardized measurements, such as ounces, cups, tablespoons and teaspoons. Please do NOT use the following for measurements: glass, bowl, spoon, handful, or bag as these are not standardized measurements. It may be helpful to refer to food packaging for portion sizes. Estimate to the best of your ability.
2. Please do not "diet" or make changes to your normal eating or drinking during this time. Choose a day that is normal for you (e.g., do not choose a day when you are sick).
3. Please be as honest and accurate as possible. No one will be "grading" your eating or drinking habits. Please record all snacks, candy, night time eating and alcohol consumption.
4. Carry your Food Diary with you throughout the day, rather than trying to remember everything at the end of the night.
5. Do not forget condiments, sandwich toppings, salad dressings, coffee creamer/additions.
6. If you eat out, please list the restaurant and describe the food as accurately as possible.
7. For combinations foods (e.g., sandwiches, casseroles, soups), list the amounts of all ingredients as best as you can.
8. Whole pieces of meat should be estimated using "ounces" (3 oz = size of deck of playing cards) and chopped or ground meat can be estimated using "cups".
9. Please record any ergogenic aids, such as protein supplements/powers, creatine, etc. and how they were consumed (e.g., mixed with 8 fl. oz. of water, milk, etc.).
10. Water intake can be totaled as a daily total amount and recorded at the top of the food diary.

POOR description		**GOOD description**	
Description	**Amount**	**Description**	**Amount**
Toast with jelly	2 slices	100% whole wheat toast (Sara Lee)	2 slices
		Strawberry jelly (Smucker's)	2 tablespoons
Strawberry yogurt	1 container	Chobani Greek Yogurt (fat-free, strawberry flavor)	6 oz.
Oatmeal	1 bowl	Quaker oats instant oatmeal (Apples and Cinnamon, made with water)	1 packet, with 2/3 cup water
Coffee	1 cup*	Coffee, brewed	16 fluid ounces
		Sugar, white	1 teaspoon

		Whole milk	2 tablespoons
Clam chowder	1 bowl	New England clam chowder (Campbell's Chunky)	1 - 10.75 ounce can
Pizza	2	Pepperoni pizza, Papa John's, thin crust	2 slices from a large pizza (14" diameter)
Mac and cheese	1 serving	Kraft Mac and Cheese-Original (cooked in water, margarine and milk)	1/5 of box 1 tsp Parkay margarine 2 tsp skim milk
Green beans	½ cup	Green beans, no salt added-canned (Del Monte)	½ cup
cake	1 piece	Cake, white (no frosting), homemade	one 2" x 2" square
Hot chocolate	1 mug	Swiss Miss hot chocolate, made with 2% milk	10 fluid ounces

* 1 cup = 8 fluid ounces; Drinking cups and glasses come in all sizes; therefore only record "1 cup" for liquids if you truly consumed 1 cup or 8 fluid ounces; Additionally, 1 glass is NOT an acceptable measurement.

Example Food Diary

Food Diary Day 1 Date: **8/23/14** Check one: ☐Weekday ☒ Weekend day
Vitamin/mineral/herbal supplements (name and amount)*: **Centrum Ultra Men's, 1 pill/day**
Amount of water consumed (in cups or mL): ☐none 5 ☒cups ☐mL

Time of day	**Food/beverage (name of food, preparation, brand name, etc.)**	**Amount consumed (include units or size)[1]**
7:45 am	Tropicana orange juice, with pulp, fortified with vitamin D and calcium	6 fl. oz.
	Honey nut cheerios	1 cup
	2% milk	1 cup
	Toasted plain bagel (Thomas brand)	1 (4 inch diameter)
	Strawberry cream cheese (fat-free, Philadelphia brand)	1 Tbsp
1:45 pm	Diet coke with ice (McDonald's)	Medium, 22 fl. oz.
	Quarter Pounder with cheese (McDonald's)	1 sandwich
	French fries (McDonald's)	1 large
4:00 pm	Banana	1 medium (7 inches)
	Jif crunch peanut butter (reduced fat)	1 Tbsp
6:15 pm	2% milk	8 fl. oz.
	Tossed salad (3 cups iceberg lettuce, 2 T chopped tomatoes, ¼ c shredded carrots)	See description for amounts
	Hidden Valley Ranch (regular—not reduced/fat-free)	3 Tbsp

* If multivitamin, indicate brand name; if single vitamin/mineral supplement, indicate vitamin/mineral name and amount.

[2] Examples of units: cups, tablespoons (Tbsp), teaspoons (tsp), grams, ounces, mL, fluid ounces (fl. oz.), etc.

Food Diary Day 1 Date: ____________________ Check one: ☐Weekday ☐ Weekend day

Vitamin/mineral/herbal supplements (name and amount)*: ☐ none taken

____

Amount of water consumed (in cups or mL): ☐ none __________☐cups ☐mL ☐ oz

Time of day	**Food/beverage (name of food, preparation, brand name, etc.)**	**Amount consumed (include units or size)[1]**

* If multivitamin, indicate brand name; if single vitamin/mineral supplement, indicate vitamin/mineral name and amount.
[2] Examples of units: cups, tablespoons (Tbsp), teaspoons (tsp), grams, ounces, mL, fluid ounces (fl. oz.), etc.

Food Diary Day 2 Date: ____________________ Check one: ☐Weekday ☐ Weekend day

Vitamin/mineral/herbal supplements (name and amount)*: ☐ none taken

____

Amount of water consumed (in cups or mL): ☐ none __________☐cups ☐mL ☐ oz

Time of day	**Food/beverage (name of food, preparation, brand name, etc.)**	**Amount consumed (include units or size)[1]**

* If multivitamin, indicate brand name; if single vitamin/mineral supplement, indicate vitamin/mineral name and amount.
[2] Examples of units: cups, tablespoons (Tbsp), teaspoons (tsp), grams, ounces, mL, fluid ounces (fl. oz.), etc.

Food Diary Day 3 Date: ____________________ Check one: ☐Weekday ☐ Weekend day

Vitamin/mineral/herbal supplements (name and amount)*: ☐ none taken

____

Amount of water consumed (in cups or mL): ☐ none __________☐cups ☐mL ☐ oz

Time of day	**Food/beverage (name of food, preparation, brand name, etc.)**	**Amount consumed (include units or size)[1]**

* If multivitamin, indicate brand name; if single vitamin/mineral supplement, indicate vitamin/mineral name and amount.

[2] Examples of units: cups, tablespoons (Tbsp), teaspoons (tsp), grams, ounces, mL, fluid ounces (fl. oz.), etc.

Appendix E

Data Collection

Data Sheet

Anthropometric characteristics
Subject:____ Group:___________ Time Point:________ Date:____________

Age:__________(years) Height:______(cm) Weight_______(kg) Gender : __________ (M/F)
RHR:________Blood pressure: __________

VO2 Max_________(ml/kg/min.) Max HR___________

	Skin fold (mm)			Average
Subscapular				
Chest				
Side				
Suprailium				
Abdomen				
Triceps				
Thigh				

%BF = ____________
Sum = ____________

		Baseline	Post-Test
Vertical Jump			
1rm back squat			
1rm deadlift			
HR			
BP			
Vo2 max			
BF %			
ANAM	Mood State		
	Anger		
	Anxiety		
	Depression		
	Fatigue		
	Happiness		
	Restless		
	Vigor		
	SCWT		
	Interference A		
	Word A		
	Color A		
	Word-Color A		
	RMCPT		
	Mean RT		
	% Correct		
	TP Score		

Squat: 3 minutes' rest:
Squat 1RM_____________
Squat 85% of 1RM____________
RHR=
RBP=

1st warmup set___________10 reps
REST: 1minute rest

2nd warmup set: increase 10-20% lbs___________5 reps
REST: 2 minutes' rest

3rd warmup set: increase 10-20%lbs___________2-3 reps
Squat Set 1_________reps___________lbs
REST: 3 minutes
HR=
BP=

Squat Set 2_________reps_________lbs
REST: 3 minutes
HR=
BP=

Squat Set 3_________reps_________lbs
HR=
BP=

REST 10 MIN
HR=
BP=

Squat: 90 Seconds rest:
Squat 1RM_____________
Squat 85% of 1RM____________
RHR=
RBP=

1st warmup set___________ 10 reps
REST: 1minute rest

2nd warmup set: increase 10-20% lbs___________5 reps
REST: 2 minutes' rest

3rd warmup set: increase 10-20%lbs___________2-3 reps
Squat Set 1_________reps___________lbs
REST: 90 Seconds
HR=
BP=

Squat Set 2_________reps_________lbs
REST: 90 Seconds
HR=
BP=

Squat Set 3_________reps_________lbs
HR=
BP=

REST 10 MIN
HR=
BP=

Deadlift: 3 minutes' rest
Deadlift 1RM______________
Deadlift 85% of 1RM_____________
RHR=
RBP=

1st warmup set____________10 reps
REST: 1minute rest

2nd warmup set: increase 10-20% lbs____________5 reps
REST: 2 minutes' rest

3rd warmup set: increase 10-20%lbs____________2-3 reps
Deadlift Set 1__________reps____________lbs
REST: 3 minutes

HR=
BP=

Deadlift Set 2_________reps_________lbs
REST: 3 minutes
HR=
BP=

Deadlift Set 3_________reps_________lbs
HR=
BP=

REST 10 MIN
HR=
BP=

Deadlift: 90 seconds rest
Deadlift 1RM_____________
Deadlift 85% of 1RM____________
RHR=
RBP=

1st warmup set___________10 reps
REST: 1minute rest

2nd warmup set: increase 10-20% lbs___________5 reps
REST: 2 minutes' rest

3rd warmup set: increase 10-20%lbs___________2-3 reps
Deadlift Set 1_________reps___________lbs
REST: 90 seconds

HR=
BP=

Deadlift Set 2_________reps_________lbs
REST: 90 seconds

HR=
BP=

Deadlift Set 3_________reps_________lbs
HR=
BP=

REST 10 MIN
HR=
BP=