Summer 2017

Six Weeks of Creatine-Electrolyte Supplement Effects on Muscle Fatigability

Donnelly R. Miller
Western Washington University, mille419@wwu.edu

Six Weeks of Creatine-Electrolyte Supplement Effects on Muscle Fatigability

By

Donnelly R. Miller

Accepted in Partial Completion of the Requirements for the

Degree of Master of Science

Kathleen L. Kitto, Dean of the Graduate School

ADVISORY COMMITTEE

Chair, Dr. Lorrie R. Brilla

Dr. David N. Suprak

Dr. Jun G. San Juan

MASTER'S THESIS

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Western Washington University, I grant to Western Washington University the non-exclusive royalty-free right to archive, reproduce, distribute, and display the thesis in any and all forms, including electronic format, via any digital library mechanisms maintained by WWU.

I represent and warrant this is my original work and does not infringe or violate any rights of others. I warrant that I have obtained written permissions from the owner of any third party copyrighted material included in thesis files.

I acknowledge that I retain ownership rights to the copyright of this work, including but not limited to the right to use all or part of this work in future works, such as articles or books.

Library users are granted permission for individual, research and non-commercial reproduction of this work for educational purposes only. Any further digital posting of this document requires specific permission from the author.

Any copying or publication of this thesis for commercial purposes, or for financial gain, is not allowed without my written permission.

Donnelly Miller

July, 2017

Six Weeks of Creatine-Electrolyte Supplement Effects on Muscle Fatigability

A Thesis

Presented to

The Faculty of

Western Washington University

In Partial Fulfillment

Of the Requirements of the Degree

Master of Science

By

Donnelly Miller

July 20

Abstract

Creatine supplementation is an ergogenic aid that is often used to enhance resistance training. Electrolytes can help to increase the absorption of creatine. This study examined effects of two differently formulated creatine supplements, creatine monohydrate (CM) or creatine-magnesium chelate (CE), compared to placebo on fatigue, work, and power during knee extensions. Subjects (n=23; 21.9±1.8 years) maintained their regular resistance training program and had not supplemented with creatine in the previous 6 months. Supplementation was 4 g creatine daily for CM and CE, plus 400 mg magnesium in CE. Maximum torque and fatigue of knee extensions at 180 ° sec^{-1} were determined using an isokinetic dynamometer for 2 sets of 30 repetitions each, with 2 minutes rest between sets. Fatigue was calculated by the ratio between the first 1/3 and the last 1/3 of work for each set. Body composition was determined via a three-site skin-folds using standard calipers. Statistical analyses were performed using mixed ANOVA. Fatigue results demonstrated no significant differences (p>0.05). For work and average power, there were no significant interaction effects (p>0.05) in either set 1 or 2. There was a significant time effect for work (1987.49±617.65 J, CM: 1978.55±723.21 J, CE: 2485.57±677.58 J; p = 0.001; η_p^2=0.371) and average power (165.4±70.33 W, CM: 160.59±56.28 W, CE: 186±66.71 W; p = 0.003; η_p^2=0.407) in set 1; with no significant differences in set 2 (p>0.05). There were no significant effects of time or group for body composition (p>0.05). There were no significant differences in these variables for the second set in any group. Supplementation with a creatine-electrolyte formula may help increase total work and average power in resistance-trained individuals.

Acknowledgements

I will begin by giving thanks to the faculty and staff of the College of Humanities and Social Sciences, especially the Kinesiology department. I would especially like to thank my thesis committee, Dr. Lorrie Brilla, Dr. Dave Suprak, and Dr. Jun San Juan for their gracious efforts and guidance in helping me to create, design, and implement my ideas into a thesis project worthy of presentation. Dr. Lorrie Brilla, I thank you for your efforts and helping me to push through and answering my questions, no matter how mundane they have been. With the guidance of my committee I was motivated to perform at my best knowing that I always had assistance when needed. I must also give a huge thanks to Dr. Harsh Buddhadev for helping me out with further understanding of my results stats.

A special thank you goes to Dr. Lorrie Brilla, for her gracious guidance when I declared the Health and Fitness Specialist Kinesiology degree. I cannot thank you enough for helping me get through my major in a timely manner. Thank you for seeing what was best for me by trying to get the biggest of the challenges out of the way first and to help me decrease my worries during my studies.

Thank you to all the resistance trainers at Western Washington University and the community in general who participated. Your time and commitment in participating was very much appreciated. I will also like to give a thank you to those who helped me during my data collection, Eric Hummer, Daniel Crisafulli, and Sam Lyons.

Although separated by thousands of miles, I would finally like to thank my family with their continuous unconditional support and love.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter I

The Problem and Its Scope

Introduction

An individual who exerts a maximal effort utilizes primarily their anaerobic systems, both the phosphagen system and glycolysis. At the onset of physical activity, the body draws from its pool of phosphocreatine to provide this immediate energy and resynthesize adenosine triphosphate (ATP) from adenosine diphosphate (ADP). The primary objective in creatine supplementation is suggested to help increase the amount of phosphocreatine available in the muscle fiber (Lanhers, Pereira, Naughton, Trousselard, Lesage, & Dutheil, 2015).

From recreational fitness enthusiasts to elite level athletes, the use of creatine supplementation has grown in popularity over the last several years. Creatine supplementation experienced a rapid increase in use following the 1992 Summer Olympic Games in Barcelona, Spain when gold medal winners Linford Christie and Sally Gunnel attributed part of their success to creatine supplementation. Many professional athletes including Olympic athletes, National League Football players, and professional baseball players have used creatine supplements (Rawson & Clarkson, 2000). Even as early as 2001, many middle and high school athletes were using creatine supplementation, and the proportion of collegiate athletes approached 28%. Reasons for creatine supplementation included: increased strength, endurance, lean body mass, and improved appearance (Metzl, Small, Levine, & Gershel, 2001). Among nutritional supplements to help increase performance activities related to strength, creatine supplementation is often suggested as an effective ergogenic aid. Despite the increasing amount of research on creatine use, many previous studies examining an athlete's performance in

relation to creatine supplementation have had mixed results with some results showing improved performance and other results showing no change (Lanhers et al., 2015).

A key component of sports performance is the ability of muscle to resist fatigue. Many of the previous studies have not examined how a creatine-electrolyte multi-ingredient supplement affects muscle performance (Lanhers et al., 2015). Fatigue can be measured utilizing the fatigue index (FI). The FI is the decline in peak muscle force output expressed as a percentage of initial values of peak muscle force output (Thorstensson & Karlson, 1976). Isokinetic assessment is a common method of measuring fatigue. The method utilizing isokinetic measurement involves performing multiple muscle contractions at a preset velocity (Corin, Strutton, & McGregor, 2005). Examining the effects of a multi-ingredient creatine-electrolyte supplementation on muscle and how it may relate to decreasing fatigue allowing for continued maximal exertion will enable sports enthusiasts of all levels to better understand the putative benefits. More research is needed in this manner on the specificity of a particular exercise protocol.

Purpose of the Study

The purpose of this study was to determine if a creatine-electrolyte performance supplement increases performance during resistance training following a six-week supplementation phase compared to creatine monohydrate alone or placebo groups. This study attempted to determine if peak muscle force remained near initial peak force during repeated isokinetic knee extensions in subjects already resistance-trained by following a supplementation regimen using a creatine-electrolyte performance supplement.

Hypothesis

The null hypothesis stated that there would be no significant changes in muscle fatigue when comparing three resistance-trained sample groups after 6 weeks of intervention, with one group consuming a placebo (carbohydrate solution), a second group consuming the common monohydrate form of creatine, and the third group consuming the creatine-electrolyte supplement. The null hypothesis also stated that there would be no differences in peak isometric torque, peak isokinetic torque at both 60 and 180 deg/sec, total work, and mean power.

Significance of the Study

Creatine supplementation continues to be researched examining the potential benefits for athletes of all ages and individuals with muscle atrophying diseases (Cooper, Naclerio, Allgrove, & Jimenez, 2013; D'Antona et al., 2014; Smith, Agharkar, & Gonzales, 2014). More importantly, there is limited research on the use of creatine in conjunction with an electrolyte and or other nutrient supplements combined. The use of an electrolyte-creatine supplement may elicit muscle fatigue reduction in resistance-trained individuals by potentially increasing the effects of creatine.

Limitations of the Study

1. Despite randomization in both groups, the pre-test may have had an influence on how participants did on the posttest due to a learning effect. Regardless of having controlled selection by randomization into placebo and experimental groups, the results obtained in this study may only pertain to the specific population sampled in this study.

2. Groups may have experienced participants dropping out, resulting in experimental mortality.
3. Subjects in this study were already on a resistance-training regimen. The strength and fatigue levels in this study may limit the application of results to a more diverse sample.
4. It is possible the subject's training will have resulted in the decreased amount of fatigue, not the supplement. However, subjects were asked to maintain their current training regimen.
5. Both groups were already resistance trained and over the course of the study may have gotten stronger because of their training. The findings may have been influenced by improvements due to training. The placebo group may have helped to control for this factor.
6. Although daily supplement doses were given for consumption, participants may have not taken all the doses given to them.
7. Hydration levels could have affected the total body water measurements. Participants were instructed on the proper procedures to maintain hydration.

Definition of Terms

Anaerobic- Physical effort that does not involve the use of oxygen and activity that relies on phosphocreatine stores, sometimes known as the phosphagen system (Lanhers et al., 2015).

Concentric- A dynamic muscle contraction involving muscle shortening or also known as positive work (Knuttgen & Kraemer, 1987).

Creatine- A molecular compound that can be synthesized in the liver, kidney and pancreas by either certain amino acids or it can be consumed by eating meats and fish (Polyviou et al., 2015).

Creatine monohydrate- A common supplement used by athletes attempting to achieve greater gains in strength, mass, and physical performance (Rawson & Persky, 2007).

Eccentric- A dynamic muscle action involving muscle lengthening or also known as negative work (Knuttgen & Kraemer, 1987)

Electrolytes- Any fluid or mineral carrying an electric charge. Sodium, potassium, magnesium, chloride, and calcium are examples of minerals with an electric charge (National Institutes of Health, 2013).

Fatigue- The intense use of muscle over a period of time leading to a decline in performance (reduction in force) with a return to maximal force generation after a period of rest (Allen, Lamb, & Westerblad, 2008).

Isokinetic- Muscle activity in which a certain anatomical body part moves at a constant velocity that is controlled by an ergometer and can be either be done by either of the dynamic muscle contractions (Knuttgen & Kraemer, 1987).

Isokinetic testing- An assessment method often using a dynamometer in which participants apply force during a predetermined velocity that can measure eccentric and concentric peak torque, total work, and average power of muscle action (Li, Wu, Maffulli, Chan, & Chan, 1996).

Maximal voluntary contraction- The intentional maximal force output by the recruitment of as many muscle fibers as possible (Knuttgen &Kraemer, 1987).

Phosphocreatine- Free form creatine in the body combined with a phosphate molecule (McBreairty et al., 2015).

Power- The product of force times distance divided by a time component or more simply stated as force times velocity that is measured in watts (W) (Knuttgen & Kraemer, 1987).

Torque- The product of force and the perpendicular distance from the axis of rotation to the line in which the force is being applied (Rothstein, Lamb, & Mayhew, 1987).

Wingate test- A 30 second test measuring peak anaerobic power and capacity measured using a cycling ergometer (Smith & Hill, 1991).

Work- Force times distance measured in joules (J) (Knuttgen & Kraemer, 1987).

Work:rest ratio- A method helping to standardize a rest interval as in such example a work:rest ratio of 1:2 would be indicative of a work bout lasting 30 seconds with a 60-second rest interval (Blazquez, Warren, O'Hanlon, & Silvestri, 2013).

Chapter II

Review of the Literature

Introduction

The purpose of this study was to analyze the effects of using an electrolyte enriched creatine supplement compared to creatine monohydrate or placebo over a six-week interval on muscle fatigue. There is a robust amount of research on creatine supplementation. There are various forms of creatine individuals can consume (Cooper, Naclerio, Allgrove, & Jimenez, 2012). However, most of the research has focused on examining the outcomes of using creatine monohydrate. Increases in strength, muscle hypertrophy along with an increase in lean body mass have been associated with creatine supplementation. Creatine benefits appear to decline with longer duration exercise (Cooper et al., 2012). Research has also examined the use of creatine in clinical settings with some studies showing improvements in patients with various muscular disorders (Alves et al., 2013; Hass, Collins, & Juncos, 2007; Tarnopolsky & Martin, 1999). If athletes are to gain any advantage with creatine use, more research should be conducted regarding the effects of creatine and other nutrients combined on muscle fatigability.

For this review, previous research is organized into three major sections. The first section discusses creatine in the body and natural food sources containing creatine. The second section gives an overview on creatine supplementation including: possible health risks related to creatine supplements, the bioavailability of creatine supplements, dosage protocols used in existing research, effects on strength and torque, and effect on anaerobic and aerobic performance. The third section provides an overview on muscle fatigue, common methods to measure fatigue, and creatine's effect on muscle fatigue. The physiological processes leading to muscle fatigue are

examined along with how creatine supplementation may help delay the onset of muscle fatigue thus decrease the loss of force production, particularly during resistance training.

Review of the Pertinent Literature

Creatine. At around the year 1847, a new organic compound was discovered in the meat from various animals. This discovery was made by a French scientist who had observed that creatine levels were significantly elevated in wild foxes in comparison to non-active animals and concluded that creatine is involved with muscle physiology (Balsom, Söderlund, & Ekblom, 1994). Creatine in the body plays an important role in the physiology involving the synthesizing of adenosine triphosphate (ATP), which is the body's energy currency (Balsom et al., 1994; McBreairty, Robinson, Furlong, Brunton, & Bertolo, 2015; Polyviou et al., 2015; Raluca-Ioana & Rahel, 2003). Natural creatine is synthesized within the liver, pancreas, and kidneys (Balsom et al., 1994).

Glycine, arginine, and S-adenosyl-methionine are the three amino acids that help in the synthesizing of creatine (Snow & Murphy, 2001). The physiological process of creatine formation primarily happens in the liver and pancreas (Snow & Murphy, 2001). Once creatine has been synthesized, 95 % is transferred by blood to skeletal muscle. The heart muscle, brain, and testis is where the remaining five percent of the creatine resides (Balsom et al., 1994; Snow & Murphy, 2001). Creatine can also be consumed be eating a variety of meats and fish (Polyviou et al., 2015). Plant sources contain minimal amounts of creatine; therefore, people on meat-restricted diets rely primarily on the creatine made within the body (Balsom et al., 1994).

At the cellular level, creatine helps to synthesize ATP by combining with phosphate to form creatine phosphate or also known as phosphocreatine (PCr). This molecule combines with

adenosine diphosphate (ADP) and is catalyzed by creatine kinase (CK) to resynthesize ATP (McBreairty et al., 2015). Inside the cells, creatine either can exist on its own or can be combined with phosphate making up the total amount of available creatine for high-energy demands of the brain and skeletal muscles. The body has enough stored creatine within the skeletal muscle to perform about 10 seconds of maximal muscle contraction. The short-term buffering system provided by PCr and CK pathway is efficient due to higher diffusion capability of PCr compared to ATP. This buffering system increases the efficiency of energy transfer to various cellular locations (Adhihetty & Beal, 2008). When an individual first exerts maximal force, the predominant form of ATP synthesis comes from the catabolism of phosphocreatine. However, the ability to resynthesize ATP from phosphocreatine rapidly declines within the first few seconds of exercise, much faster than the rate of glycolysis (Volek et al., 1997).

The physiological enhancements of the PCr system, which provides essentially half the energy needed for physical activity involving durations of 10 seconds or less, is one of the original reasons why athletes have used creatine supplementation (Adhihetty & Beal, 2008). The levels of PCr that are found in skeletal muscle are up to 400% greater than the amounts of stored ATP and up to 500% greater than free creatine (Ellington, 1989). During significant energy demands of the muscle, an increase in inorganic phosphate (Pi) occurs at the same time PCr stores are being depleted. During these physiological reactions, the ATP and free ADP ratio remains the same (Ellington, 1989). The mechanisms for keeping the ATP and free ADP ratio consistent is due to the temporary buffering system provided the PCr/creatine phosphokinase (CPK) system (Ellington, 1989). The PCr shuttle is involved in the exchange of creatine between the cytosol and mitochondria (Engelhardt, Neumann, Berbalk, & Reuter, 1998). The adequate concentration of ATP and PCr along with the decreased metabolism of creatine to creatinine is

due to the PCr shuttle. Once creatine is metabolized into creatinine, it exits the muscle fiber where it is transferred to the kidney and excreted from the body (Engelhard et al., 1989).

At maximal efforts lasting one to two minutes, the supply of ATP is primarily from the anaerobic energy systems (Sahlin, 2014). At the same time, hydrogen ions (H^+) and inorganic phosphates ($P_{i)}$ rapidly accumulate in the muscle making muscle contraction more difficult to maintain (Sahlin, 2014). A major limitation to anaerobic capacity is the amount of phosphate storage in the muscle along with the level of protons that can be made. During maximal exercise, PCr stores can easily be depleted providing approximately 70 mmol per kg dry muscle of ATP (Sahlin, 2014). The two energy systems involved during anaerobic activity are the phosphagen and anaerobic glycolysis metabolic pathways. The amount of ATP supplied by either of these metabolic pathways is determined by the intensity and duration of physical activity (Sahlin, 2014). Approximately, for the first three seconds of maximal intensity, the supply of ATP is primarily from PCr stores. As maximal effort continues the rate of PCr utilization declines as glycolysis begins to supply the needed ATP (Gaitanos, Williams, Boobis, & Brooks, 1993; Sahlin, 2014).

Creatine supplementation. Over the years, creatine has been used as a supplement in healthy individuals attempting to enhance performance as well as individuals suffering from neuromuscular disorders. There are numerous studies showing creatine supplementation may possibly be beneficial in sports performance (Cribb, Williams, & Hayes, 2007; Kirksey, Stone, M. H., Warren, Johnson, & Stone, M. E., 1999; Mujika, Padilla, Ibanez, Izquierdo, & Gorostiaga, 2000; Skare, Skadberg, & Wisnes, 2001; Stone et al., 1999). The studies available on the effects of creatine on muscle in relationship to maintaining muscle force production (indicating a reduction in fatigue) seem to be limited. A systematic review by Lanhers et al.

(2015) set out to compare 60 studies on the lower limb during creatine supplementation. Some of the key findings from the review by Lanhers et al. (2015) were that the quadriceps experienced the greatest gains in strength of all lower limb muscles. The review had calculated an average increase of people squatting 8% more weight and leg pressing 3% more weight (Lanhers. Et al., 2015). Creatine supplementation is more beneficial for an untrained individual versus a trained individual with only a 14% increase in performance for a trained athletic person compared to a 31% increase in performance in individuals who have not been training. However, there must be some scrutiny to these findings as the definition of trained versus untrained can vary from study to study. Many studies have focused on younger athletes, particularly males (Lanhers et al., 2015).

Creatine supplementation dosage. Creatine supplementation typically involves two phases: a loading phase and maintenance phase (Buford et al., 2007). Loading phases often last between 5-7 days with an average consumption of 20 g/day. The typical maintenance dosage following the lading phase is between three to five grams a day (Buford et al., 2007). However, various studies have utilized an acute dosage protocol consisting of 20 g/day for 5-7 days (Mujika et al., 2000; Zuniga et al., 2012). Other dosage protocols of longer duration without a loading phase exist (Cooper, Naclerio, Allgrove, & Jimenez, 2012).

A study examining the effects of creatine use during a simulated cycling road race protocol had subjects consume 3 g/day with a placebo or creatine for 28 days. No loading phase was included in this investigation (Hickner, Dyck, Sklar, Hatley, & Byrd, 2010). Prior to supplementation the finishing sprint times at the end of a two hour simulated race were 64.4 ± 13.5 seconds for the creatine group and 69.0 ± 24.8 seconds for the placebo group.

Both the creatine and supplement groups were able to increase their duration of their final sprint time by about 25 seconds. Both the creatine and placebo group had around a 33% increase in power output during the final sprint. Prior to supplementation, the power output was 23,459 ± 6,430 joules for the creatine group and 19,509 ± 2,696 joules for the placebo group. After 28 days of supplementation, the power output for the creatine group was 30,811 ± 10,198 joules and 26,599 ± 3,772 joules for the placebo group. Two other variables that creatine did not have an effect on were hemoglobin and hematocrit levels. At pre and post-testing, hemoglobin and hematocrit were 10% higher than the placebo group. There were significant changes in plasma volume for the creatine group at 90 minutes of cycling. Plasma volume from pre to post-testing was +14.0 ± 6.3% for the creatine group and -10.4 ± 4.4% for the placebo group. It was concluded that 28 days of creatine supplementation did not have any beneficial effects on the final power output or duration of a finishing sprint after two hours of simulated racing.

An investigation on creatine's effect on strength gains in recreational bodybuilders involved subjects consuming 5 g/day of creatine. Participants were randomly assigned to a pre-workout or post-workout consumption group in which the subjects consumed their creatine dosage either before or after their workout. The testing protocol lasted four weeks, with training sessions on five out of the seven days each week. On non-training days, subjects were allowed to consume their creatine dose anytime during the day (Antonio & Ciccone, 2013). After utilizing a magnitude-based inference, it was suggested that using creatine post-workout might be more beneficial than pre-workout consumption in regards to strength and lean body mass increases. During the post-test, the average increase in 1-RM bench press was 7.6 ± 6.2 kg for the post-workout supplement group compared to 6.6 ± 8.2 kg for the pre-workout supplement group. This observation was a potential benefit for using creatine post-workout. Lean body mass

increased by 2.0 ± 1.2 kg and 0.9 ± 1.8 kg for the creatine and placebo groups, respectively. This finding suggested possible benefits in consuming creatine post-workout compared to pre-workout.

After twelve weeks of creatine monohydrate supplementation involving a dosage of six grams daily, a 57.92% increase in myofibrillar protein was observed (Willoughby & Rosene, 2001). There was no loading phase utilized in the study. The subjects were individuals who were not currently on any structured training program. The training protocol consisted of only lower-extremity exercises, mainly the knee extensor muscles. Workouts were done on Monday, Wednesday, and Friday and included three sets of 6-8 repetitions at 85-90% 1-RM. The exercises utilized were bilateral leg press, knee extension, and knee curls. Subjects were split into three groups at random: a control group (placebo plus no resistance training) (CON), a resistance training group plus creatine supplementation (CRT), and a resistance training group consuming a placebo (PLC). There were significant changes in strength for the CRT group compared to both the CON and PLC group ($p<0.05$). To account for variations in absolute muscle strength and body mass between groups at the initiation of the study, relative strength was the variable used instead of absolute strength. The relative strength value was utilized due to its accounting of the differences in body mass between different subjects. For the placebo group, baseline measurements were 2.71 ± 0.41 kg/kg body weight and 2.61 ± 0.49 kg/kg body weight at the end the study. For the PLC group, baseline measurements were 3.18 ± 0.23 kg/kg body weight and 4.10 ± 0.46 kg/kg body weight at post-testing. For the CRT group baseline measurements were 3.23 ± 0.75 kg/kg body weight and 4.98 ± 0.26 kg/kg body weight during post-testing. Both the PLC and CRT groups had increased thigh volume compared to the CON group. However, there was significant increase, $p < 0.05$, in thigh volume in the CRT group compared to the PLC

group. Baseline values for thigh volume were 8.38 ± 2.09 m^3 and 8.93 ± 0.81 m^3 for the PLC and CRT group respectively. At 12 weeks, thigh volume was 9.29 ± 2.25 m^3 and 10.55 ± 0.54 m^3 for the PLC and CRT groups respectively. The increases in myofibrillar protein was 57.92%, 11.62%, and 2.75% for the CRT, PLC, and CON groups, respectively. It was concluded that myosin heavy chain synthesis may result from engaging in a vigorous resistance-training program while on creatine supplementation (Willoughby & Rosene, 2001).

Pearson, Hamby, Russel, & Harris (1999) did not utilize a loading phase in their study examining the long-term effects of creatine use on strength and power in collegiate football players. During a prior pilot, Pearson et al. (1999) had suggested eliminating the loading phase of 20 g/day of creatine monohydrate for five days did not result in limitations to post-supplementation performance. Participants placed into the treatment group consumed five grams of creatine monohydrate daily during the 10-week resistance-training program. After 10 weeks of supplementation, there were observed increases in strength during squats, bench press, and increased power while doing power cleans. Bench press strength in the creatine group when from baseline measurements of 149.12 ± 12.64 kg to 154.22 ± 12.54 kg following supplementation. The placebo group had baseline measurements 130.24 ± 26.73 kg and 128.63 ± 22.09 kg after the study. Squat strength for the creatine group had baseline measurements of 241 ± 12.64 kg and 268.59 ± 56.18 kg at the end of the study. The placebo group had baseline measurements of 221.88 ± 67.95 kg and post study measurements of 232.47 ± 73.43 kg. The increase in power during power cleans went from baseline measurements of 123.32 ± 21.65 kg to 130.97 ± 20.57 kg in the creatine group. For the placebo group baseline measurements in power clean were 111.58 ± 15.42 kg, and measurements following the study were 109.32 ± 29.32 kg. The creatine group also experienced significant increase in body mass, which was suggested to be positive in

nature since there were no changes in body fat after 10 weeks of supplementation compared to baseline measures. Baseline body weight for the creatine group was 106.25 ± 15.61 kg and following 10 weeks of supplementation was 107.67 ± 14.22 kg. Body fat percentage using seven measurement sites was 15.37 ± 5.51 % at baseline and 16.24 ± 6.02 % after 10 weeks (Pearson et al., 1999).

Studies have observed elevated creatine and PCr content in those who use creatine supplementation (Greenhaff, Bodin, Soderlund, & Hultman, 1994; Harris, Söderlund, & Hultman, 1992; Hultman, Soderlund, Timmons, Cederblad, & Greenhaff, 1996). Greenhaff et al. (1994) had subjects consume 20 g/day creatine for 5 days. Prior to supplementation, the mean body weight for the sample group was 80.0 ± 4.7 kg and after five days, supplementation was 81.6 ± 4.8 kg. The total muscle creatine content level at baseline following 120 seconds of intensive isometric contraction electrically induced was 122.1 ± 3.4 mmol/kg dry matter. After five days of creatine supplementation using the same testing protocol, at 120 seconds total muscle creatine content was 143.0 ± 2.2 mmol/kg dry matter (Greenhaff et al., 1994).

Harris et al. (1992) had three different dosage protocols: 20 g/day for 4-5 days, 30 g/day for 4-5 days, or 30 g/day on alternating days for 21 days. The average baseline total muscle creatine content for all subjects in the study was 126.8 ± 11.7 mmol/ kg dry matter. Following supplementation, total muscle creatine content for all subjects was > 140 mmol/kg dry matter with observations of > 150 mmol/kg dry matter in six of the subjects. The average total muscle creatine content following supplementation for all subjects was 148.6 ± 5.0 mmol/kg dry matter.

Hultman et al. (1996) had six subjects consume 20 g/day of creatine for six days (group 1), and another group with nine subjects consuming 20 g/day creatine for six days and then 2

g/day for the following 28 days (group 2). There was not a significant difference between groups for baseline total muscle creatine level. Total muscle creatine content at baseline was 123.4 ± 3.0 mmol/kg dry matter and 119.5 ± 2.5 mmol/kg dry matter for groups 1 and 2, respectively. Total creatine levels for both groups after six days of supplementation increased by about 23 mmol/ kg dry matter. After 35 days, the total creatine content had decreased to near baseline levels in group 1. For group 2, total creatine content in the muscle had remained nearly the same as after the six-day loading phase. For both groups, the majority of the increase in total creatine content was from free creatine. The increase in free creatine for both groups during the first six days was approximately 16 mmol/dg dry matter ($p < 0.05$).

Increases in muscles storage resulting from supplementation of creatine can depend on the amount of creatine that has been stored in muscles prior to supplementing. Individuals consuming a vegetarian diet with little to no fish or meats are more likely to see bigger increases, 20-40%, in muscle creatine stores compared to those who eat more meat and fish. Individuals with higher creatine content prior to supplementation may only increase creatine content by 10-20% with supplementation (Buford et al., 2007). Harris et al. (1992) had made observations that indicated the increases in total muscle creatine content was not dependent on duration or the amount of the dose, but rather on initial total muscle creatine content. This led to the conclusion that there may be an upper limit to the total creatine content a muscle can store. This upper limit was identified to be around 155 mmol/kg dry matter (Harris et al., 1992). A supplementation dosage of 20 g per day for a period of two to six days has indicated a nearly 20% increase in the amount of PCr concentration in the muscle (Greenhaff et al., 1994; Harris et al., 1992). A greater concentration of PCr in the muscle results in the increased re-phosphorylation of ATP. With the

production of ATP via the mechanisms using PCr, it allows the individual to have improvements in repeated exercises involving short and intense intervals (van Loon et al., 2003).

Van Loon et al. investigated the effects creatine had on muscle creatine content, body composition, and muscle and whole body oxidative capacity in individuals who had not been on any regular training schedule. The dosage protocol used in this investigation was a five-day loading phase involving consumption of 20 g/day creatine followed by a 37-day maintenance dosage at 2 g/day. Total muscle creatine content in the supplement group on day six were 158.0 ± 4.4 mmol/kg of dry muscle and on day 42 were 136.6 ± 5.6 mmol/kg of dry muscle. For the placebo group, total creatine muscle content at six days was 128.1 ± 3.9 mmol/kg of dry muscle and at 42 days was 122.7 ± 9.4 mmol/kg of dry muscle. During the study, participants gained about 1.2 kg in weight during the five day 20 g/day loading phase. Body mass for the creatine group was 66.5 ± 1.7 kg at baseline, 67.6 ± 1.6 kg at six days, and 67.5 ± 1.5 kg at 42 days. For the placebo group, body mass was 70.9 ± 3.1 kg at baseline, 71.1 ± 2.9 kg at six days, and 70.7 ± 3.1 kg at 42 days. A sudden increase in body mass during the loading phase is related to the increased water retention in the cells because of the increased osmolarity of the cells (van Loon et al., 2003).

Health risks using creatine supplementation. For the most part, previous research has indicated that creatine supplementation remains adequately safe for human consumption. Other researchers have suggested the potential for renal dysfunction as a result of elevated creatinine levels due to creatine supplementation (Adhihetty & Beal, 2008). The effects of thermoregulation along with hydration while using creatine have also been examined.

Lopez et al. (2009) conducted a systematic review with meta-analysis on 10 different original research articles on thermal regulation and hydration status. Studies included in these meta-analyses were original research in which all subjects were physically active, consumed greater than 2 g/day creatine, and dosage protocols that were at least 5 days long. Creatine dosages used among the ten studies were between 20-25 g/day. The length of creatine supplementation was between five and twenty-eight days. There were no studies in this systematic analysis that involved creatine usage over 28 days. There were no differences in body temperature in relationship to exercising in the heat between the placebo and creatine groups in six out of the ten studies examined. Three studies had observed rectal temperatures that were lower after creatine supplementation compared to the placebo group. One study observed lower rectal temperatures 40 minutes into exercise compared to the placebo group. It was stated these observations of lower rectal temperature were not significant in comparison to the placebo group. The systematic analysis led to the conclusion than an appropriate dosage of creatine supplementation does not hinder the body's thermoregulatory system.

Wright, Grandjean, and Pascoe (2007) utilized a dosage protocol consuming 20 g/day placebo in a flavored drink for six days during the first week of the study. During the second week, the 20 g/day placebo was replaced with creatine monohydrate. The testing protocol was done at the end of each week to compare the results between a placebo and creatine. Ten subjects warmed-up by cycling 30 minutes at 100 W followed by passive recovery. The testing protocol involved six 10-second all out sprints with one-minute recovery between sprints in a 35° C with 60% humidity environment. There were significant decreases in plasma volume (%PV) during the tests. No significant differences between placebo and creatine were observed in relationship to %PV. For creatine, the %PV was -11.16 ± 6.66% versus -11.76 ± 7.67% for the placebo.

There were also no significant changes in average core temperature during the tests. Core temperature during testing following the placebo phase was 38.04 ± 0.56° C and 38.07 ± 0.47° C following the creatine supplementation phase. It was concluded from these results that supplemental use of creatine did not have any impairment on thermoregulatory function or hydration during 30 minutes of low intensity cycling or during a protocol using short sprints during hot or humid conditions (Wright et al., 2007).

The study by Wright et al. was one of the 10 studies included in the meta-analysis by Lopez et al. (2009) that had observed no significant differences in body temperature. Based on these findings, Lopez et al. (2009) concluded creatine supplementation causes no ill effects regarding heat injury during shorter exercise sessions. Some of the side effects of creatine supplementation that have been reported include: renal dysfunction, gastrointestinal discomfort, cardiovascular complications, and muscle damage (Terjung et al., 2000).

There have been two cases involving renal toxicity levels resulting from creatine supplementation (Pline & Smith, 2005). The first case involved a 25-year-old man who had segmental glomerulosclerosis along with relapsing steroid-responsive nephrotic syndrome (Pritchard & Kalra, 1998). The man had suffered from this condition for eight years. Cyclosporin was used to help with his reduce his nephrotic relapses. Upon initiating creatine loading dose of 15 g/day for seven days and then going on a maintenance dose of 2 g/day thereafter for seven weeks, he presented during a clinical exam serum creatinine levels of 180 μmol/L and 54 mL/min of creatinine clearance. While on creatine supplementation, his renal function was declining. His creatinine levels prior to supplementation were 103 μmol/L and a creatinine excretion rate of 93 mL/min. One month after he was advised to stop creatine supplementation, his plasma creatinine was at 128 μmol/L and an excretion rate of 115 mL/min (Pritchard &

Kalra, 1998). The second case involved a 20-year-old man who had consumed 20 g/day pure creatine monohydrate for four weeks (Koshy, Griswold, & Schneeberger, 1999). Upon admission to the hospital after cessation of creatine supplementation, his serum creatinine concentration was 203 μmol/L. Focal interstitial nephritis, tubular injury, effacement of glomerular foot processes, and focal thickening of the basement membrane were discovered during clinical examinations (Kosky et al., 1999). In both of these cases, creatine levels had return to baseline following creatine supplementation cessation (Pline & Smith, 2005).

Renal function complications related to creatine use in young healthy adults is minimal. As long as the recommended dosages of creatine use were followed, creatinine levels would slightly be elevated but with no progression towards renal dysfunction (Pline & Smith, 2005). However, patients consuming any amount of creatine should be monitored for any possible complications in renal function (Pline & Smith, 2005).

There were no reported renal or liver complications in another study lasting three months on cardiac patients using supplemental creatine (Cornelissen et al., 2010). Cardiac patients were subjects in an examination of creatine supplementation's effects while engaged in an endurance and resistance training program lasting three months. Skeletal muscle performance along with cardiorespiratory function were examined. The patients consumed five grams of creatine three times daily for one week. After the loading phase, patients consumed five grams of creatine for three months. The patients exercised three times per week with an average duration of 90 minutes. The muscles tested for muscle strength and endurance were the knee extensors. Peak torque was measured by having patients perform three maximal knee extensions at a constant velocity of 60°/s from 90º to 180º. Muscle endurance was tested by performing two sets of 30 isokinetic knee extensions with 30 seconds rest between intervals. The equation to determine

muscle endurance was: [(mean peak torque of the final five repetitions/mean torque of the first five repetitions) * 100]. There was not any significant difference in muscle endurance between the creatine or placebo groups. For the first set of 30 isokinetic knee extensions during baseline testing, the percentage of strength during the final five repetitions compared to the first five repetitions was 73.9 ± 7.3% and 71.0 ± 8.1% for the placebo and creatine group, respectively. Baseline measures for the second set of 30 repetitions were 62.9 ± 7.9% and 62.9 ± 6.7% for the placebo and creatine group, respectively. Post-test values for the first set of 30 repetitions were 75.5 ± 8.6% and 74.3 ± 7.3% for the placebo and creatine group, respectively. Post-test values for the second set were 69.6 ± 8.3% and 68.8 ± 7.2% for the placebo and creatine group, respectively. Peak isokinetic torque at baseline was 127.7 ± 31.4 Nm and 141.6 ± 32.1 Nm for the placebo and creatine group respectively. Post-test data indicated peak torque values of 147.3 ± 35.0 Nm and 161.0 ± 36.4 Nm for the placebo and creatine group, respectively. The average torque during the second set of knee extensions at baseline was 85.4 ± 19.3 Nm and 93.8 ± 23.0 Nm for the placebo and creatine group, respectively. Post-test average torque values for the second set of knee extensions were 98.9 ± 23.2 Nm and 103.7 ± 25.0 Nm for the placebo and creatine group, respectively.

VO_2 peak at baseline was 21.7 ± 3.8 ml/kg/min and 21.9 ± 6.4 ml/kg/min for the placebo and creatine groups, respectively. Post-test data revealed peak VO_2 values of 26.3 ± 5.3 ml/kg/min and 26.0 ± 7.6 ml/kg/min for the placebo and creatine groups respectively. The findings from the study indicated that creatine dosages benefiting younger healthy individuals did not have any significant effect on patients with coronary artery disease or chronic heart failure (Cornelissen et al., 2010).

Schilling et al. (2001) examined creatine use over a time period of 0.8 to 4.0 years in 26 athletes who were active in strength and power training. Participants in this study consumed creatine for four weeks and then went off the supplement for one to four weeks before resuming supplementation. Average dosage during the loading phase was 13.7 g ± 10.0 g/day. Average maintenance dosage was 9.7 ± 5.7 g/day (Shilling et al., 2001). Long-term usage of creatine did not lead to any decrease in overall health. There were also no indications of increased cramping (Schilling et al., 2001).

Watson et al. (2006) did not observe any increases in heat injury or cramping after 80 minutes of exercise in a dehydrated state in the creatine group versus the placebo group. The subjects had exercised for two hours alternating between walking on treadmill at 6.6 ± 0.32 km/h and cycling at a pace equivalent to the intensity achieved on the treadmill. Switching from cycling to running occurred every 30 minutes. Participants in the study were split evenly into a creatine monohydrate supplemental group or placebo group each consuming 21.6 g/day of the product for nine days. The data from Watson et al. (2006) further indicated that short-term creatine monohydrate use does not negatively affect the thermoregulatory, cardiorespiratory, or metabolic systems.

There are limited studies on the long-term effects of creatine supplementation (Cooper, Naclerio, Allgrove, & Jimenez, 2012). There remains uncertainty as to the positive or negative outcomes of long-term creatine supplementation. Kim, Kim, Carpentier, and Poortsman (2011) suggested that patients with kidney dysfunction, diabetes, hypertension, and reduced glomerular rate should abstain from creatine doses greater than three to five grams per day.

Enhancement of creatine bioavailability. Creatine (N-(aminoiminomethyl)-N-methyl glycine commonly found in various fishes and meats has recently been produced in various forms by manufacturers claiming increased bioavailability, solubility, and chemical components (Jäger, Purpura, Shao, Inoue, & Kreider, 2011). Creatine has a low solubility in water. However, there is a linear relationship between temperature and the solubility of creatine. The hotter the temperature of water the higher the solubility of creatine (Jäger et al., 2011). Another factor increasing the solubility of creatine is a decreased pH solution. Compared to the creatine monohydrate, which dissolves at 14 g/L at 20°C, creatine citrate and creatine pyruvate dissolve at a rate of 29 g/L and 54 g/L respectively at 20°C. Since creatine salts can decrease the pH level of a solution, creatine salts have an enhanced solubility (Jäger et al., 2011).

Absorption rate in the intestines and efficiency of consumption by the body's cells and tissues of creatine make up the two basic components of creatine bioavailability (Jäger et al., 2011). Deldicque et al. (2008) examined the comparisons of creatine consumed in protein or beta-glucan (BG) rich bars compared to consumption in via a liquid solution on creatine plasma kinetics and excretion. The weeklong supplement protocol used by Deldicque et al. (2008) included the following three conditions: two grams powdered creatine consumed with 150 ml of watery solution, a protein enriched bar, or a BG rich food bar. The protein bar consisted the following nutrients: 19 g of carbohydrates, 14.3 g of protein, 1.3 g of fats, and 0.1 g of fiber. The GC bar contained the following: 16.7 g of carbohydrates, 4.1 g of protein, 2.3 g of fats, and 3.2 g of fibers about half of which were beta-glucans. Both of the food bars consisted of two grams of creatine. Subjects consumed their sources of creatine three times daily. Following the subjects first initial two-gram dose of creatine, the amount of creatine excreted within the first 24 hours was 8 ± 1.2% for the BG treatment group which was significantly lower than the protein bar and

liquid groups. Following the weeklong supplement period, there were no significant differences between the treatment groups in the levels of creatine found in the plasma. It was concluded that bioavailability of creatine was not different between the three different treatment groups. Due to the amount of viscous polysaccharides found in the BG bar, carbohydrates, fats, and creatine are more slowly absorbed. This can explain why the urinary output of creatine was less in the BG group during the initial 24 hours after consumption. It was also concluded that creatine has an ample amount of bioavailability due to the near complete absorption of creatine as observed by the lack of creatine found in the subject's feces.

Due to creatine's absorption rate of nearly 100 %, the observations made by Jäger, Harris, Purpura, and Francaux (2007) indicated that various forms of creatine would have minimal to no differences in creatine levels during supplement loading. Jäger et al. (2007) compared 5.0 g of creatine monohydrate (CM), 6.7 g of tri-creatine citrate (CrC), and 7.3 g creatine pyruvate (CrPyr) on creatine concentration and pharmacokinetics. All protocols utilized the dissolving of creatine in 450 ml of water. Out of the three creatine supplement forms, the ingestion of 4.4 g of CrPyr resulted in the highest amounts of creatine found in the plasma eight hours after consumption. The average concentrations were 1.17 times higher in the CrPyr group compared to the CrC and 1.29 times higher compared to CM over an eight-hour period following ingestion. The acidity of a substance will lower the pH level increasing the solubility of creatine associated with that substance. The acidity of pyruvate is greater than citric acid. Jager et al. (2007) observed significant increases in plasma creatine with all three forms of creatine. Despite the different concentrations found within the three different forms of creatine, any bioavailability advantages to one form of creatine over another form of creatine appear minimal because almost 100 % of CM is absorbed by the body.

Creatine effects on muscle strength and torque. Increases in strength, muscle hypertrophy, and increases in fat free mass have been associated with creatine supplementation in conjunction with a resistance-training program over resistance training alone (Cooper et al., 2012). Greenhaff et al. (1993) utilized a creatine dosage regimen of five grams of creatine plus one gram of glucose versus a placebo plus the glucose for five days. The six subjects who consumed the creatine supplement were observed to have higher peak isokinetic torque during five sets of 30 unilateral knee extensions using a constant angular velocity of 180°/s on a Cybex II isokinetic dynamometer (Lumex Inc., Ronkokoma, NY). The greatest significant differences were noted on the second and third sets of leg extensions, $p < 0.01$ and $p < 0.05$ respectively. During baseline measurements for the second set of knee extensions, the placebo group had muscle peak torque of 1855 ± 199 Nm and 1699 ± 248 Nm following the five-day trial. Values for the creatine group were 2359 ± 272 Nm during baseline testing and 2489 ± 290 Nm after the five-day trial. For the third set, the placebo values were 1717 ± 184 Nm at baseline and 1617 ± 192 Nm after five days. The values for the creatine group were 2025 ± 229 Nm at baseline and 2127 ± 241 Nm after the five-day trial. Greenhaff et al. (1993) concluded that elevated muscle creatine content resulting from supplementation attenuated loss of peak torque while performing repeated isokinetic contractions. This is in contrast to the findings observed by Gilliam, Hohzorn, Martin, and Timble et al. (2000).

Gilliam et al. (2000) had found that creatine supplementation over a five-day period did not result in the maintenance of torque in repeated isokinetic contractions in comparison to the placebo group. Subjects had performed five sets of 30 maximal voluntary contractions with one-minute rest between each set. Each repetition included doing both a knee extension and knee curl. The maximum torque had declined by about 50% by the fifth set compared to the first set in

the placebo and creatine group. For the placebo group, the average peak torque at baseline for the first set was 83.90 ± 16.73 Nm and 44.21 ± 10.06 Nm on the 5th set. Post-test torque values were 87.15 ± 17.27 Nm during the first set and 47.48 ± 8.98 Nm for the 5th set. Torque values for the creatine group at baseline were 85.24 ± 13.06 Nm on set one and 37.98 ± 9.79 Nm on the 5th set. Post-test torque values were 86.75 ± 13.74 Nm for the first set and 40.54 ± 8.57 Nm on the fifth set. The average differences in torque between the two groups were: 1.51 Nm, 2.76 Nm, 0.41 Nm, 1.11 Nm, and 2.56 Nm for sets number 1, 2, 3, 4, and 5 respectively. Baseline to post-testing values between group, time, and set were not significant between the placebo and creatine groups (p>0.05). Both groups had similar decreases in maximum torque values across all five sets. The decrease was significant across all sets regardless of the group (p<0.05). The study design and protocol used by Gilliam et al. was nearly identical to the protocol used by Greenhaff et al. (1993).

Zuniga et al. (2012) observed no increased changes in strength compared to a placebo group in 1-RM strength measures using a plate loaded leg extension machine for leg extensions and a free weight bench for the bench press. Subjects in this study were untrained males who did less than four hours per week of physical activity. Subjects were asked to carry on with any physical activity they may have been doing prior to the study. Their 1-RM strength was determined by having each subject progressively lift heavier loads until a load was achieved in which the subjects could not get the full range of motion. Two minutes of rests were given between each lift. Subjects had consumed 20 g/day of creatine monohydrate for one full week. For the placebo group, the 1-RM for leg extension was 126.82 ± 20.91 kg at baseline and 137.40 ± 18.03 kg during the post-test. The bench press 1-RM for the placebo group was 92.61 ± 25.78 kg at baseline and 93.93 ± 24.05 kg during post testing. Leg extension 1-RM for the creatine

group was 115.44 ± 18.66 at baseline and 126.55 ± 19.71 kg during post-testing. Bench press 1-RM for the supplemental group was 91.40 ± 23.66 kg at baseline and 93.44 ± 24.60 kg during post-testing. It was concluded that creatine supplementation did not have any strength benefits for 1-RM upper or lower body strength.

Increases in isometric knee extensor strength by 24% compared to baseline measurements occurred in both male and female subjects after a 14-week strength-training program in conjunction with a supplementation dosage 5 g/day creatine monohydrate (Brose, Parise, & Tarnopolsky, 2003). Increases for both genders combined in knee extensor strength were 46.2 ± 22.5% in the creatine group compared to 22.5 ± 14.4% in the placebo group. For men in the creatine group, the knee extensor isometric strength at baseline was 153 ± 28 Nm and 217 ± 36 Nm after 14 weeks. The male placebo group had baseline values of 156 ± 32 Nm and 180 ± 29 Nm at 14 weeks. The female creatine group had baseline isometric knee extensor strength values of 94 ± 38 Nm and 126 ± 30 Nm at 14 weeks. The female placebo group had baseline measures of 89 ± 17 Nm and 113 ± 25 Nm at 14 weeks. Creatine had no effects on dynamic 1-RM strength measures for either gender in comparison to the placebo group. Increases in strength were due to the training effect ($p < 0.01$). Increases in isometric dorsi-flexion by 18% compared to baseline measurements were observed in the creatine monohydrate group, but only males, 17.8 ± 11.6% and 2.2 ± 5.6%, in the creatine and placebo group, respectively. Isometric dorsi-flexion isometric strength in the male creatine group was 54 ± 14 Nm and 62 ± 15 Nm at baseline and post-testing, respectively. The male placebo values were 52 ± 8 Nm and 52 ± 10 Nm at baseline and post-testing, respectively. This demonstrated a significant increase ($p < 0.05$) in isometric dorsi-flexion strength between the male creatine and placebo groups. Handgrip strength did not show any improvement in either of the sample groups.

Improvements based on using a 1 RM protocol were also observed in the following exercises: upright chest press, leg press, arm flexion, and knee extension but with no differences in these increases between study samples ($p < 0.001$). Increases in strength in these four exercises were related to the effects of training ($p < 0.01$).

Creatine's effects on anaerobic and aerobic performance. Studies examining the effects of creatine on anaerobic performance often utilize Wingate tests (Gotshalk et al., 2002; Okudan, Belviranli, Pepe, & Gökbel, 2015; Okudan & Gokbel, 2005). There are conflicting results on the effectiveness of creatine supplementation on anaerobic performance. A number of studies show benefits related to creatine supplementation (Dabidi Roshan, Babaei, Hosseinzadeh, & Arendt-Nielson, 2013; Eckerson et al., 2004; Gotshalk et al., 2002; Okudan et al., 2015; Okudan & Gokbel, 2005). Some studies show creatine to be ineffective (Aedma, Timpmann, Lätt, & Ööpik, 2015; Reeder, Kazubinski, Foreman, Crauthers, & Lockard, 2013). The enhancement of anaerobic performance observed while on creatine supplementation has been regarded as a result of the elevated stores PCr and free creatine in the muscle (Eckerson et al., 2004). The stored amounts of ATP and PCr are the main contributors of energy supply during maximal contractions (Eckerson et al., 2004).

When comparing anaerobic working capacity (AWC) within moderately to highly active females, a significant increase of 22.1% AWC was observed after five days of creatine supplementation compared to the control group. AWC is the maximal effort an individual can exert and is related to the ATP and phosphocreatine that is stored in the muscle. The dosage protocol utilized five grams of creatine plus 18 g of dextrose consumed four times daily. AWC was measured using an electronically braked cycle ergometer (Eckerson et al., 2004).

Improvements in anaerobic performance consisting of three trials of 30-s Wingate tests separated with five minutes of recovery in between were also observed in subjects who had consumed creatine with water ($Cr.H_2O$ group) compared to a placebo group (Earnest, Snell, Rodriguez, Almada, & Mitchell, 1995). The percentages of increase in anaerobic performance on the Wingate tests after a 14 day dosage protocol consisting of creatine and water were 13%, 18% , and 18% for trials one, two, and three, respectively ($P<0.05$). Baseline Wingate bike test values for the creatine group were 22.65 ± 3.0 kJ, 22.40 ± 2.0 kJ, and 18.54 ± 1.0 kJ for trials 1,2, and 3, respectively. Post-test values during post-testing were 25.98 ± 4.0, 24.49 ± 3.0, and 22.73 ± 2.0 kJ for trials 1, 2, and 3, respectively. Baseline placebo group values were 23. 48 ± 1.0 kJ, 22.08 ± 2.0 kJ, and 21.15 ± 2.0 kJ for trials 1, 2, and 3, respectively. Placebo post-test values were 23.51 ± 1.0 kJ, 22.32 ± 2.0 kJ, and 21.4 ± 2.0 kJ for trials 1, 2, and 3, respectively. This increase in anaerobic performance was related to elevated amounts of PCr in the muscle that have been observed in subjects using creatine.

Another study using a dosage protocol of 20 g/day for four days observed increases in maximum power, but no significant differences in average power or fatigue index in both males and females (Tarnopolsky & MacLennon, 2000). The peak power averaged over two 30-s maximal cycling ergometer trials with four minutes of recovery between each trial was 774 ± 165 W. Maximal average wattage for the placebo group was 746 ± 163 W. The lactate concentration following the two 30-s cycling test was also higher compared to the placebo group. Lactate levels for males who were in the supplement group had lactate concentrations of 12.4 ± 3.2 mmol/L compared to the placebo group which had 10.9 ± 5.3 mmol/L. For females, the lactate concentrations in the supplement group were 13.1 ± 4.0 mmol/L compared to 9.5 ± 2.5 mmol/L for the placebo group.

Chwalbiñska-Moneta (2003) observed a beneficial effect from creatine supplementation on elite rowers. Both endurance and AWC were improved during the weeklong endurance training protocol. The endurance protocol consisted of rowers performing an incremental test. Intensity started at 220 W for three minutes with further increases in workload of 50 W every three minutes until subjects requested to stop. There were 40-second breaks between each workload to enable blood sampling for lactate concentration readings. Subjects had consumed either a placebo or creatine supplementation of 20 g/day for 5 days (Chwalbiñska-Moneta, 2003). One significant finding at the end of the study was the creatine group being able to row 12.1 ± 4.5 s more during the anaerobic rowing test compared to the placebo group which rowed an additional 2.4 ± 8.2 s. The levels of blood lactate decreased for the supplemental group and placebo group during the progressive testing protocol. The decrease in lactate occurred at a lower intensity for the supplemental group compared to the placebo group. For the creatine group, the blood lactate began to show a decrease from baseline values at around 370 W compared to around 420 W for the placebo group. The average amount of lactate at 370 W during baseline was just under 4 mmol/L and at post-testing was around 3 to 3.5 mmol/L for the creatine group. The placebo group lactate values at 370 W during pre and post-testing were at around 4 mmol/L after testing Another finding observed during the graded test was the difference in the mean individual anaerobic threshold (Lat-log) to a greater work intensity post-creatine loading compared to the placebo group (Chwalbiñska-Moneta, 2003) The Lat-log is a measurement from the intersection of two linear segments consisting of the log lactate concentration versus the log exercise load (Beaver, Wasserman, & Whipp, 1985). The Lat-log for the creatine group went from 314.3 ± 5.0 W to 335.6 ± 7.1 W compared to the placebo group which only went from 308.9 ± 6.9 W to 308.9 ± 5.9 W. There were no significant differences between the supplement

group and placebo group after seven days in relation to lactate threshold using a blood lactate concentration of 4 mmol/L. Observations of average blood lactate at the LAT-log were increased a significant amount *(p*<0.02) for the creatine group compared to the placebo group. Chwalbiñska-Moneta (2003) stated that the decreases in heart rate (HR) along with abating of blood lactate levels might have been a result of the training effects, since the subjects were elite rowers. The increase in performance ability at maximal intensities are likely due to the increase PCr after a loading phase since supplementation increases both creatine and PCr content in the muscle.

More recently, lower lactate levels were observed in men, ages 20 to 30 years, following a dosage protocol of 20 g/day of creatine and 60 g/day glucose spread out across four doses over a six-day period (Oliver, Joubert, Martin, & Crouse, 2013). Oliver et al. (2013) performed a study where they instructed individuals to consume five grams of creatine along with 15 grams of glucose four times a day for six days. The subjects were tested on a cycling ergometer starting at 30 watts and increasing the wattage by 30 every three minutes until the subject reached a level of fatigue where he could no longer maintain a cadence of 70-rpm. During the post-test, there was a significantly reduced amount of lactate levels compared to the pre-test as indicated by the observation of a significant condition effect (p = .041) and no interaction effect (p = .498). Lactate levels were decreased throughout the incremental cycling protocol following supplementation. At 180 W the amount of lactate prior to supplementation was around 6.3 mmol/L. After creatine supplementation, the lactate levels at 180 W were closer to 5.6 mmol/L. There was no statistical significance in time it took before participants fatigued (p = .056). The power output at the time of fatigue also showed no significant difference after the six days creatine loading (p = 0.82). However, no other studies to the author's knowledge had observed

significant reduction in lactate using an incremental cycling protocol after a loading phase of an oral creatine supplementation regimen lasting six days (Oliver et al., 2013). The increased PCr content from supplementation is suggested to help with the buffering of the energy needs of the cells. Attenuating reliance on the glycolytic energy pathway along with lowering levels of lactate production during incremental exercise may be due in part to the increased PCr resulting from supplementation (Nelson et al., 2000; Oliver et al., 2013).

Muscle fatigue. Muscle activity that results in a performance decrease over time, with performance returning to or near normal conditions following period of rest, is often termed muscle fatigue (Allen, Lamb, & Westerblad, 2008). Fatigue can also be divided into subcategories: low-frequency fatigue and high-frequency fatigue (Rassier & MacIntosh, 2000). Low-frequency fatigue (LFF) results in a greater loss of force due to the low versus high frequency of stimulation to the muscle. LFF is demonstrated the muscle's reduced force generation capability in response to lower frequency activation (Keeton & Binder-Macleod, 2006). High-frequency fatigue results from the reduced capability to generate maximal force or the ability to respond adequately to the frequencies providing the stimuli to generate maximal force (Rassier & MacIntosh, 2000).

There are a multitude of factors affecting muscle performance which result in muscle fatigue. One of the mechanisms of muscle action which indicates the onset of fatigue is the reduction of shortening velocity. This mechanism results from the increasing time needed for muscle relaxation (Allen et al., 2008). Two major components in the generation of power in muscle are contractile force and shortening velocity (Allen et al., 2008; Sasaki & Ishii, 2005). Muscle force results from actions of the contractile proteins within the sarcomere. The overlap between two major contractile proteins, actin and myosin filaments, contribute to the force-

length relationship (Sasaki & Ishii, 2005). Shortening velocity involves the maximum isometric force and the specific load being applied to the muscle. The faster the rate of muscle shortening, the lesser amount of force or torque that is generated (Fenn & Marsh, 1935; Sasaki & Ishii, 2005). Over time, the decrease in both force and shortening velocity lead to an overall loss of performance. Eventually, there comes a point in time when the intensity of the activity cannot be maintained. Higher intensity activity shows a more obvious sign of fatigue versus a submaximal effort in which fatigue may not present itself as clearly. However, there are differences when it comes to complete exhaustion/fatigue versus muscle injury (Allen et al., 2008).

It can sometimes be difficult to determine the difference between muscle injury and muscle fatigue when it comes to performance. A key point to muscle fatigue is the fact that the decline in muscle performance is reversible with usually a short period of rest (Allen et al., 2008). Low-frequency fatigue can often take up to many days before a there is a return to baseline muscle performance (Keeton & Binder-Macleod, 2006). The rate of muscle fatigue can vary depending on the strength and duration of the contraction (Allen et al., 2008). At times, it can take a number of days of rest to reach the same original intensity or performance following muscle fatigue (Allen et al., 2008). Repeated short muscle actions usually have a fast component of recovery during the first 30 minutes and a slower component that can last for several hours. Sometimes, a small component of weakness may persist beyond 24 hours. Eccentric muscle actions increase the potential for muscle damage. With muscle injury, a decline in performance also occurs; however, the time to be able to achieve the original performance takes a significantly longer time. Decreased force generation in muscle can persist up to several days depending on the intensity of the exercise that causes the muscle damage. The most injury prone actions are those of muscle lengthening (eccentric actions). Muscle injury also indicates an

inflammatory response, structural abnormalities, membrane damage, activation of satellite cells, and regeneration of muscle fibers. The amount of recovery needed for muscle to achieve its maximal force production can take considerably longer when there is muscle damage done. This muscle damage can result from over stretching of muscle. These physiological processes are not typically seen with muscle fatigue (Allen et al., 2008).

A maximal or near maximal force exerted by the muscle or doing a 1-repetition maximum or lifting a heavy object results in rapid fatigue. Recovery time needed to allow the muscle to perform work again can occur within 1-2 seconds following cessation of muscle action (Allen et al., 2008; Edwards, Hill, Jones, & Merton, 1977). Activities including walking, swimming, running, or any other sustained physical activity or activity resulting in repeated short tetani results in a much slower rate of fatigue compared to maximal effort. The recovery time with longer sustained activity can be dependent on various factors. There can be a rapid phase of recovery where muscle can regain most of its potential work capacity after about five to ten minutes of rest. The ability to perform maximal force after a period of sustained activity can be achieved after 30 minutes or more of continuous rest (Allen et al., 2008).

There are two components that can contribute to fatigue: central and peripheral factors. The neuromuscular junction, sarcolemma, and mechanisms involving the contractile proteins, myosin and actin, and regulatory proteins, troponin and tropomyosin, along with other proteins found in the contractile unit of the sarcomere play a role in the peripheral component. The other factor contributing to fatigue comes from a reduced input from the central nervous system. The central factor of fatigue originates from pathways above the neuromuscular junction and can include both the central and peripheral nerves as well as an inability to generate facilitation of the neurons (Schillings, Hoefsloot, Stegeman, & Zwarts, 2003).

Schillings et al. (2003) examined a sample group consisting of thirteen males and seven females the contributing factors of fatigue during a sustained maximal voluntary contraction (MVC) of the biceps brachii muscle. During the first minute of a two-minute MVC, the majority of fatigue resulted from peripheral factors. Force at the beginning of MVC was 214. ± 80.1 N and after two minutes was 79.6 ± 29.8 N, which was 38.2 ± 7.8% of the original force. There were also differences in the duration of force responses from the beginning to the end of muscle contraction. Force responses at the beginning were 125.1 ± 9.6 ms to 211.2 ± 40.8 ms, which was a 169.1 ± 31.7% change over two minutes of muscle contraction. Two factors contributed to this increased duration: reduced maximal contraction and relaxation rates. Maximal contraction went from 1.03 ± 0.21 % m/s to 0.81 ± 0.12 % m/s and relaxation went from 0.60 ± 0.11 % m/s to 0.35 ± 0.07 % m/s. Central activation failure (CAF) also demonstrated a bigger increase during sustained MVC. Two different calculation methods were used to determine CAF. In the first method, CAF had increased from 18.1 ± 15.2% after 15 seconds to 39.8 ± 39.9% after two minutes. Using the second type of calculation CAF values had gone 16.9 ± 13.6% after 15 seconds to 29.0 ± 21.1% after two minutes. The large variations in CAF between subjects was explained by the fact some subjects had a big increase in CAF, and other subjects had either no change or a decrease in CAF.

After the first minute, peripheral factors leveled off while the increase in fatigue became completely due to central fatigue factors. Both peripheral and central factors of fatigue resulted in a loss of MVC in the biceps brachii after two minutes, but the greatest amount of force loss occurred during the first minute. The decrease in voluntary force as a percentage of MVC went from 100% at the onset of the contraction down to about 75% at 30 seconds and 60% at 60 seconds. At 120 seconds, the voluntary force was at 40% of MVC. Muscle fiber conduction

velocity (MFCV) also decreased within the first minute but had minimal changes during the second minute. AT 30 seconds, the MFCV was at 75% of the maximum MFCV. At 60 seconds, it had dropped to 60% of maximum MFCV. At 120 seconds, MFCV was at 62.5% of the maximum amount. It was also noted that central activation varies between different muscle groups and that studies can only be compared with other studies if the same muscle was utilized. It was concluded that peripheral factors play a key role in the initial decrease in force because the exertion of the muscle is at its highest at the beginning of a MVC. Peripheral factors had contributed to 89.0% of the voluntary force loss. The increased metabolic demand plus the occluded blood flow to the muscle are also increasing the demand on the muscle at the beginning of muscle action. If an MVC continues for a prolonged period then it was demonstrated there is the probability of an increased challenge in having the continuation of neurons firing possibly resulting from central activation failure (Schillings et al., 2003).

Measuring muscle fatigue. According to Thorstensson and Karlsson (1976), fatigue was indicated by a decrease in the amount of maximal force production in 50 subsequent muscle contractions involving the vastus lateralis muscle in comparison to the initial contraction. The apparatus utilized in this study was an isokinetic dynamometer (Cbyex II, Lumex Inc. N.Y.). Thorstenssson and Karlsson (1976) was one of the first studies to examine the effects on rapid voluntary isokinetic muscle action. Since that time, many studies have utilized isokinetic dynamometers for strength tests, peak torque, and rate of muscle fatigue (Bosquet et al., 2010; Gautrey, Mitchell, & Watson, 2013; Gleeson & Mercer, 1996). A factor considered when doing isokinetic testing is the rest interval between tests (Bottaro, Russo, & de Oliveira, 2005).

There is not a clear consensus as to the appropriate rest interval between sets when conducting isokinetic muscle testing (Bottaro et al., 2005). One study had indicated that rest

intervals greater than three minutes should be the protocol when three sets of knee extensions consisting of 10 repetitions are performed during testing (Woods, Bridge, Nelson, Risse, & Pincivero, 2004). Another study had observed similar peak torque production with rest periods of 30, 60, or 90 seconds during two sets of four repetitions with each repetition lasting six seconds in elderly individuals (Bottaro et al., 2005). A recovery period of 60 seconds was suggested to be sufficient for healthy subjects performing four sets of knee extensions (Parcell, Sawyer, Tricoli, & Chinevere, 2002).

Creatine and fatigue. Some studies have demonstrated the ability for muscle to maintain contraction for longer periods of time along with an increase in lean body mass resulting from creatine supplementation (Adhihetty & Beal, 2008; van Loon et al., 2003). There is an enormous body of literature on the effects of creatine supplementation related to sports performance. Creatine supplementation has regularly been demonstrated to improve strength, increase hypertrophy, and increase fat free mass in individuals. These improvements on the performance parameters listed are enhanced when an individual uses creatine while actively engaged in a heavy resistance-training program (Cooper et al., 2012). Previous studies have suggested an increase in muscle performance (Cribb et al., 2007; Deldicque et al., 2008). However, Baker, Candow, and Farthing (2015) observed no performance enhancements utilizing an acute pre-exercise creatine supplementation protocol.

A study examined muscle fatigue while doing chest press and leg press until muscle failure had observed no benefits in consuming 20 g of creatine over a placebo three hours prior to exercise. Participants in this study had done three sets at 70 % of 1-RM for both the chest press and leg press with each set consisting of as many reps the participant could do. The amount of repetitions in subsequent sets decreased identically in both the creatine and placebo group

indicating equal progression of muscle fatigue between the two groups. The number of leg press repetitions for the first set were around 33 for both groups. Leg press repetitions for the second was around 18 with the placebo group performing a slightly higher amount of reps compared to the creatine group. The number of leg press repetitions for the 3rd set was around 15 for both groups. For the chest press, the number of repetitions was around 13 for both groups. Both groups performed about seven repetitions of chest press for the 2nd set. Both groups did around five chest press repetitions for the 3rd set with the placebo group performing only slightly greater repetitions. It was concluded that ingesting a bolus of creatine three hours prior to exercise had no effects on increasing leg press or chest press performance on healthy adult males aged 54 ± 4.3 years (Baker et al., 2015).

A similar study done involving 14 active men showed a decrease in fatigue with consuming 25 g of creatine over a period of one week. In this particular study, the subjects were instructed to do five sets of bench press exercises until muscle failure in each set. The amount of weight that was used was the subject's 10-rep maximum as determined during the pretests (Volek et al., 1997). The other exercise utilized was the jump squat at 30% of the subject's 1-RM. The 30% value was chosen because previous research had indicated this was the percentage where mechanical power is maximized. Subjects performed five sets of 10 continuous jump squats with an emphasis to perform at maximal effort each rep. The rep with the highest recorded amount of power was the peak power for that particular set. For both exercises, two minutes of rest were given (Volek et al., 1997). Both, the amount of reps performed on the bench press and peak power during each set of jump squats, were higher in the creatine group compared to the placebo group. Peak power output had increased in all five sets of jump squats as a result of creatine supplementation. In the creatine group, there was an average increase of 2.3 repetitions

in the first set of bench press exercises. This is similar to a previous study where after 28 days of creatine supplementation, there was a four-repetition increase at 70 % of 1-RM in resistance-trained men (Volek et al., 1997).

de Salles Painelli et al. (2014) examined the effects of concurrent exercise sessions involving both aerobic and strength exercises while using creatine supplementation. The study utilized a loading phase of 20 g/day of creatine for 7 days followed by a maintenance dosage of 5 g/day. Four testing sessions with 72 hours of recovery between each session were initiated after the seven-day loading phase. The protocol used for continuous aerobic exercise was a five-kilometer treadmill run at 90 % of the subject's anaerobic threshold. Intermittent aerobic exercise utilized a one-minute effort at the subject's maximum VO_2 with one minute of recovery between running bouts. An endurance strength assessment consisting of subjects performing four sets of leg-press and bench press exercises to failure at 80 % of 1-RM was utilized. The 1-RM and the endurance strength assessment were performed 10 minutes after the aerobic exercise session. The four concurrent exercise testing protocols used were: continuous aerobic exercise followed by 1-RM in, intermittent aerobic exercise followed by 1-RM, continuous aerobic exercise followed by endurance strength assessment, and intermittent aerobic exercise followed by the endurance strength assessment. In comparing 1-RM maximal dynamic strength in both the leg press and bench press, a significant increase ($p = 0.04$) was observed in the leg-press following continuous aerobic exercise in comparison to the control group. A significant increase in the 1-RM bench-press was also noted in the creatine supplementation group after doing intermittent or continuous aerobic exercise in comparison to the control group. The increase in 1-RM bench-press in the creatine group compared to the placebo group was 1.98% ($p = 0.001$) following continuous exercise. The increase in 1-RM bench-press following intermittent aerobic exercise

for the creatine group was 0.72% ($p = 0.03$) more than the placebo group. There was also a statistically significant decrease in the number of leg-press repetitions in the placebo group that had done intermittent aerobic exercise prior to the muscle endurance testing. The number of repetitions were 20.31% ($p = 0.02$) lower compared to the creatine group having done continuous aerobic exercise prior to the strength endurance testing and 21.69% ($p = 0.04$) less repetitions compared to the creatine group. When comparing the number of leg-press repetitions in the creatine group following either continuous or intermittent aerobic activity, there were no significant differences ($p>0.05$). The number of leg press repetitions for the creatine group were 37 and 33 following continuous and intermittent exercise, respectively. The number of leg-press repetitions for the placebo group were 35 and 27 following continuous and intermittent exercise, respectively. The number of bench-press repetitions after either continuous or intermittent aerobic exercise was 26 compared to 23 repetitions performed by the placebo group (de Salles Painelli et al., 2014). A key finding in the study was observing the decreased acute strength losses while doing concurrent physical activity session involving intermittent high-intensity aerobic efforts in recreationally strength trained males. The data from de Salles Painelli et al. (2014) along with previous research suggests that creatine loading has a positive influence on attenuating fatigue. As stated by Lanhers et al. (2015), creatine supplementation can be beneficial in the lower-limb strength, particularly in bouts lasting three minutes or less.

Summary

Many athletes attempting to increase strength gains, lean body mass, and athletic performance use creatine supplements. There are many studies that have observed increases within these athletic domains (Rawson & Persky, 2007). However, there are also some studies

that indicate that oral creatine supplementation has no beneficial effect in increasing muscle performance (Baker et al., 2015; Aedma et al., 2015).

Results may be dependent to some extent on short-term versus- long-term supplementation. Study protocols have ranged from as little as 5-7 days, and other lasing up to 12 weeks. The dosage protocols also vary within existing research. Some studies have utilized a loading dose phase lasting up to seven days. Other studies that have extended several days to weeks have not used a loading phase. It is also important to note that many studies have examined exercise that typically lasts under three minutes, which utilize more of the glycolytic and creatine phosphate systems. These energy pathways can rely more on creatine, especially during the first seconds of muscle action.

Creatine's effects on muscle fatigue have also been examined through previous research. Improvements in maintaining muscle performance relating to fatigue reduction have been observed. Such observations have included the increased number of reps or maintenance of peak torque on subsequent sets following creatine supplementation (Volek et al., 1997). Creatine has also shown been shown to have beneficial effects in attenuating fatigue on individuals who had done prior exercise before performing 1-RM strength measures (de Salles Painelli et al., 2014). Not all studies have demonstrated such benefits in fatigue reduction as observed by Baker et al. (2015). However, participants only consumed either 20 g of a placebo or creatine three hours prior to exercise on two separate occasions separated by 72 hours.

More research is needed on enhanced creatine supplement in relationship to peak power output on subsequent sets. Previous research has indicated minimal differences in the bioavailability of various forms of creatine since the absorption rate of creatine is near 100%.

Rates of absorption may depend on the acidity of the creatine formula (Jäger et al., 2011). Results from this study may provide information on the effects of a creatine-electrolyte performance supplement on fatigability of muscle compared to standard creatine monohydrate or placebo.

Chapter III

Methods and Procedures

Introduction

This study was designed to examine the effects of a six-week creatine-electrolyte supplementation compared to creatine monohydrate and placebo on two sets of 30 maximal isokinetic knee extensions. The total work performed, mean power, and the degradation of power from the first 10 repetitions to the last 10 repetitions was analyzed for both sets of knee extensions. This study provided data about the effectiveness two different creatine supplementation formulas; creatine monohydrate and a creatine-electrolyte supplement.

Description of Study Subjects

The study included 24 subjects recruited from the university and local gyms around the Bellingham area. The subjects had been on a resistance training program for at least six months prior the study. There were no specific training regimens that needed to be followed. The subjects were asked to maintain their current training program. Participants were excluded from the study if they had consumed creatine within six months prior to the experiment. Additional exclusionary criteria included having any current or previous kidney, liver, or endocrine disease that could result in adverse effects relating to proper fluid balance or the homeostasis of cellular creatine levels in the body.

Design of the Study

This study utilized a pretest and post-test experimental design in which subjects were assigned to two different supplementation groups or the placebo group. The study also utilized a

double blind format in which neither the subjects nor experimenter who interacted with the subjects knew who was in which group. Only the lead experimenter knew the group assignments. Subjects were randomly assigned to the placebo, creatine monohydrate (CM), or creatine-electrolyte (CE) groups. Randomization was carried out by giving a box of supplementation that had been given a numbered code to match one of the three possible supplementation formulas. In order have an equivalent number of participants in each group, each supplement package based on each code was given sequentially.

Supplementation Protocol

Following random assignment into the placebo, CM, or CE groups, each subject was provided with their supplemental package containing their supplement. The CE group consumed four grams of an electrolyte formula consisting of 286 mg magnesium chloride, 171 mg potassium chloride, and 171 mg calcium chloride, and 114 mg sodium chloride once daily. The CM group consumed four grams of a standard creatine monohydrate formula per day. The placebo consumed four grams of maltodextrin, carbohydrate solution daily. The supplementation period lasted six weeks to allow for adequate saturation of the supplement into the tissues. All supplemental formulas had identical appearances. Subjects were instructed to orally consume their respected supplement for the duration of the study with approximately 500 ml or 16 fluid oz. of water. Orange Crush (The Jel Sert Company, West Chicago, IL) packages were given to each subject as an option to help make the consumption of the supplement more palatable. Subjects were dropped from the study if they reported not consuming the supplement for more than three days. The administration of these solutions were done using a double-blind method. Only the lead researcher, not involved with subject testing, was aware of the group assignments.

Data Collection Procedures

Instrumentation. Maximum torque and fatigue assessments were completed in the Applied Neuromechanics Laboratory at Western Washington University using a Biodex System 4 (Biodex Medical Systems Inc., Shirley, NY) isokinetic dynamometer. The dominant leg was used for all tests. Settings for seat height and fore aft were recorded according to the length of the subject's leg and shank to ensure consistency across measures. Proper adjustments were made on the chair so that the subject's lateral femoral epicondyle of the dominant legs were in alignment with the center of rotation of the shaft of the dynamometer. Adjustments were made so that the back of the seat was in a position where the length of the dynamometer's arm was properly fitted to the subject's shank. The shank pad was positioned on the distal portion of the tibia about one centimeter above the lateral malleolus of the ankle joint, considered the force point, and was secured with a Velcro strap (Lee, Kim, & Park, 2013). The hip angle of the subject while sitting was 80 degrees. To help reduce excessive movement of the body, shoulder, waist, and thigh straps were utilized in accordance with manufacturer instructions. The range of motion of the subject's leg was set to 20 to 100 degrees of knee flexion.

Measurement techniques and procedures. The researcher explained the experimental procedure to each individual prior to performing the tests. Subjects were informed on the amount of time the experiment would take along with other testing procedures and were provided with an informed consent form. The informed consent was completed and understood by all participants prior to being included in the study. After completion, the participants signed and dated the consent form. Participants were allowed to address any additional questions they had

about the experiment. Baseline and post-testing measurements were done on the following: height, weight, a three-day diet analysis, body water, and body composition. The subjects' physical activity levels were also noted.

A three-day diet analysis was utilized on two separate occasions during the study. Each subject was asked to record his or her dietary intake during these three-day intervals. Subjects were asked to maintain their dietary habits throughout the study. The data were then analyzed using Nutritionist Pro software (Ayxxya Systems, Stafford, TX). The nutrient and energy levels were determined using the dietary analysis.

Body water measurements including total body water (TBW), intracellular fluid compartments (IFC), and extracellular fluid compartments (ECF) were analyzed via the RJL Quantum X bioimpedance unit (RJL Systems Inc., Clinton, MI). The sites of electrode placement were the wrist and the third metacarpal for the right upper extremity and the ankle and third metatarsal for the right lower extremity following the placement of the electrodes, the body composition analyzer unit was connected to the electrodes. An alternating current (50 KHz) was utilized to measure and record each subject's resistance and reactance. Calculations for total body, intra-cellular and extra-cellular were determined via an online calculator provided by the Quantum X Bioelectrical Body Composition Analyzer manufacturing company ("Interactive Online BIA," n.d.). The subjects were instructed to avoid any exercise during the 12 hours prior to the analysis. The tests for all subjects were completed at the same time of day for each subject.

Body composition consisting of percent body fat, fat free mass, and fat mass was assessed utilizing the three-site skinfolds measurement technique (Pescatello, 2014, Box 4.3, p. 69). The same researcher, to ensure intrarater reliability, performed all skinfold assessments. An

estimate of the subject's body composition was assessed by measuring skinfold thickness at the following locations for males: chest, triceps, and subscapular. For females, the skin fold measurement sites were triceps, suprailiac, and abdomen. The sum of the three-skin fold measurement along with age and race were entered into an equation (Siri) to estimate body composition based on body density. Body fat percentage was first calculated by determining body density using the Siri equation matching the appropriate three-site formula to determine body density (Pescatello, 2014, Box 4.3, p. 69). The Siri model, where the percentage of body fat was equal to 495 and divided by body density and then subtracted by 450, was utilized to determine the subject's body fat percentage (Pescatello, 2014, p. 70).

Prior to conducting the isometric and 1-RM isokinetic testing, the subjects did two sets of 10 knee-extensor exercises as a task specific warm-up. Due to the participants having done a five-minute self-selected warm-up on a cycle ergometer prior to performing bench press and squat cluster sets prior to testing done on the dynamometer, no further warm-up was warranted. Maximal isokinetic knee extension torque measurement was determined at angular velocities of 60 °/s and 180 °/s. Isometric maximal voluntary contraction torque for both knee extension and flexion was collected at 60 degrees of knee flexion. Three trials for each of the given conditions listed above were performed. A two-minute rest period was allowed between trials. Peak isokinetic and isometric torques in Newton-meters (Nm) were determined during the maximal isokinetic knee extension test and during a subsequent test of maximal isometric muscle action. Torques were normalized by dividing by body mass. Rest intervals were allowed until the subject indicated that he/she was fully recovered. After completion of these tests, the subjects cooled down for five minutes on a cycle ergometer at an easy pace with no resistance added.

The testing procedures to determine fatigability involved having each subject do a task specific warm-up using the dynamometer followed by 30 maximal isokinetic knee extension repetitions at 180 °/s. The absolute torque reduction through the trial, from peak maximal torque to subsequent minimum peak torque was recorded in Nm. The total work done during the fatigue trial, integrated torque with respect to angular displacement, was determined ensuring that no greater than 30 repetitions were included in the analysis. The subjects had two minutes of rest before performing a second set of 30 repetitions. The subjects then performed a cool down for five minutes on a cycle ergometer at an easy pace, without resistance. Fatigue was determined by calculating the absolute reduction of torque throughout the trial, which was used to determine the fatigue index. The fatigue index was calculated by dividing the total work performed during the last 10 repetitions from the total work performed during the first 10 repetitions.

Data Analysis

Statistical analysis was performed using a 3 x 2 mixed ANOVA at an alpha level of $p \leq 0.05$ to determine the effects of a creatine supplement or placebo on muscle fatigability between groups across testing times. Statistical analysis was also performed to determine peak isometric torque, peak isokinetic torque, dietary variables, physical activity level expenditure, body composition, and body water composition between groups from pre to post-test. An effect size analysis was used. Excel (Microsoft Corporation, Redmond, WA) along with SPSS (IBM Corporation, Armonk, NY) was used to complete the data analysis.

Chapter IV

Results and Discussion

Introduction

This study tested the null hypothesis that there would be no significant difference in peak isokinetic force, peak isometric force, and muscle fatigue from pre-test to post-test when comparing three different supplement groups: CE, CM, and placebo. Each subject attended two data collection sessions, pre-testing and post-testing, separated by six weeks of supplement intervention. Total body water, extracellular water, and intracellular measurements were determined by using the Quantum X bioimpedence unit. Body composition was measured using the three-site skin-fold caliper test. Total work, mean power, and peak torque measurements were obtained by using an isokinetic dynamometer. Peak isokinetic force was tested by having the subjects perform three sets of one repetition maximal exertion knee extensor exercise at 60 °/s and 180 °/s with two minutes of recovery between sets. Peak isometric torque was tested at 60 degrees of knee flexion by having the subjects perform five-second maximal contractions for both knee extension and knee flexion. There was a two-minute rest period between maximal contractions of extensor and flexor muscles of the knee. Following peak isokinetic force and isometric force measurements, the subjects then spun at a self-selected cadence on Monark ergometer for five minutes before commencing the fatigue protocol. Muscle fatigue was measured by having the subjects perform 30 repetitions of knee extensions at maximal effort for two sets separated by a two-minute recovery period. Fatigue was calculated by the ratio between the first 1/3 and the last 1/3 of work for each set. The three-site skin-folds test was utilized to measure body composition. Total body, intracellular, and extracellular water were analyzed with

the Quantum X Bioelectrical Body Composition Analyzer in accordance with the manufacturer's recommended procedures. Statistical analysis was performed by using mixed ANOVA.

Results

For this study, resistance-trained individuals were recruited for the six-week creatine supplementation experiment. The subjects (n = 24; 17 male, 7 female) were randomly assigned to one of three groups: placebo, CM, or CE. All 24 subjects completed post-testing for the dietary variables and physical activity level expenditure, body composition, and body water analysis. One subject did not complete post-testing for fatigue, work, or power.

Subject characteristics. Subject demographics for each group are displayed in Table 1. No significant differences were observed between groups. Data for dietary variables and physical activity demonstrated the only statistical significance was kilocalories out, with the placebo group expending more kilocalories than either of the creatine groups at both pre and post-testing ($p < 0.05$). Detailed data is presented in Table 2.

Table 1. Subject demographics (mean ± SD)

	All Subjects		Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
n	24		8		9		7	
Age (yr)	21.9±3.9	21.9±1.8	22±2.1	22±2.1	22.4±2.1	22.3±1.8	21.7±1.1	21.9±1.1
Height (m)	1.69±0.09	1.71±0.1	1.71±0.1	1.73±0.1	1.67±0.1	1.68±0.1	1.72±0.1	1.72±0.1
Mass (kg)	72.5±9.3	73.2±9.5	74.9±12.7	75.4±12.5	70.1±7.5	71.3±8.6	72.9±7.1	72.9±8.2

Table 2. Dietary Variables and Physical Activity Level Energy Expenditure (mean ± SD)

	Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Energy Expended ($Kcal \cdot d^{-1}$)	3991.6±1201.6*	3937.3±1115.0*	3299.98±335.29	3084.99±554.31	3520.06±417.32	3559.11±439.06
Dietary Energy ($Kcal \cdot d^{-1}$)	4035.86±205.29	4089.00±198.06	3715.16±65.13	3524.72±277.60	3802.55±292.50	3631.07±305.85
Dietary CHO ($g \cdot d^{-1}$)	407.25±148.99	423.75±148.74	397.12±82.62	347.70±93.71	354.95±19.40	365.30±45.21
Dietary Fat ($g \cdot d^{-1}$)	199.03±124.81	211.55±115.61	187.78±38.22	202.08±49.75	175.58±46.49	183.73±33.61
Dietary Protein ($g \cdot d^{-1}$)	213.15±48.42	219.33±51.34	175.60±24.06	185.20±45.03	179.65±43.82	161.40±40.88

Energy expenditure was greatest for the placebo group compared to both the creatine-monohydrate and placebo groups during both pre-testing and post-testing, $p<0.05$*.

Body Composition. Data for body fat percentage demonstrated no interaction between time and supplement ($F[2,21] = 0.466$, $p = 0.634$, $\eta_p^2 = 0.43$). There was also no main effect for time for body fat percentage ($F[1, 21] = 2.489$, $p = 0.130$, $\eta_p^2 = .106$), nor was there any main effect for supplement ($F[2, 21] = 0.960$, $p = 0.399$, $\eta_p^2 = 0.084$). No interaction between time and supplement was observed for lean body mass ($F[2,21] = 0.608$, $p = 0.554$, $\eta_p^2 = 0.055$). Lean body also demonstrated no main effect for time ($F[1, 21] = 0.471$, $p = 0.500$, $\eta_p^2 = 0.022$), nor was there any main effect for supplement ($F[2, 21] = 0.756$, $p = 0.482$, $\eta_p^2 = 0.067$). Fat mass also demonstrated no statistical significance as there was no interaction between time and supplement ($F[2, 21] = 0.577$, $p = 0.570$, $\eta_p^2 = 0.052$). There was also no significance for the main effect of time in lean body mass ($F[1, 21] = 2.347$, $p = 0.140$, $\eta_p^2 = 0.101$ or main effect for supplement ($F[2,21] = 0.923$, $p = 0.413$, $\eta_p^2 = 0.081$) A medium effect size of time for both fat

mass and body fat percentage ($\eta_p^2 = 0.10$ and $\eta_p^2 = 0.11$, respectively) were observed. Detailed body composition results are displayed in Table 3, Figure 1, and Figure 2.

Table 3. Body Composition (mean ± SD)

	Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Body Fat (%)	14.75±5.79	15.19±8.32	16.06±8.98	17.53±10.11	11.11±6.26	11.61±6.07
Lean Body Mass (kg)	63.63±10.57	63.94±11.91	60.14±8.32	58.72±8.59	65±8.85	64.71±9.34
Fat Mass (kg)	11.16±4.88	11.46±6.25	11.48±6.77	12.7±8.23	7.97±4.12	8.33±3.93

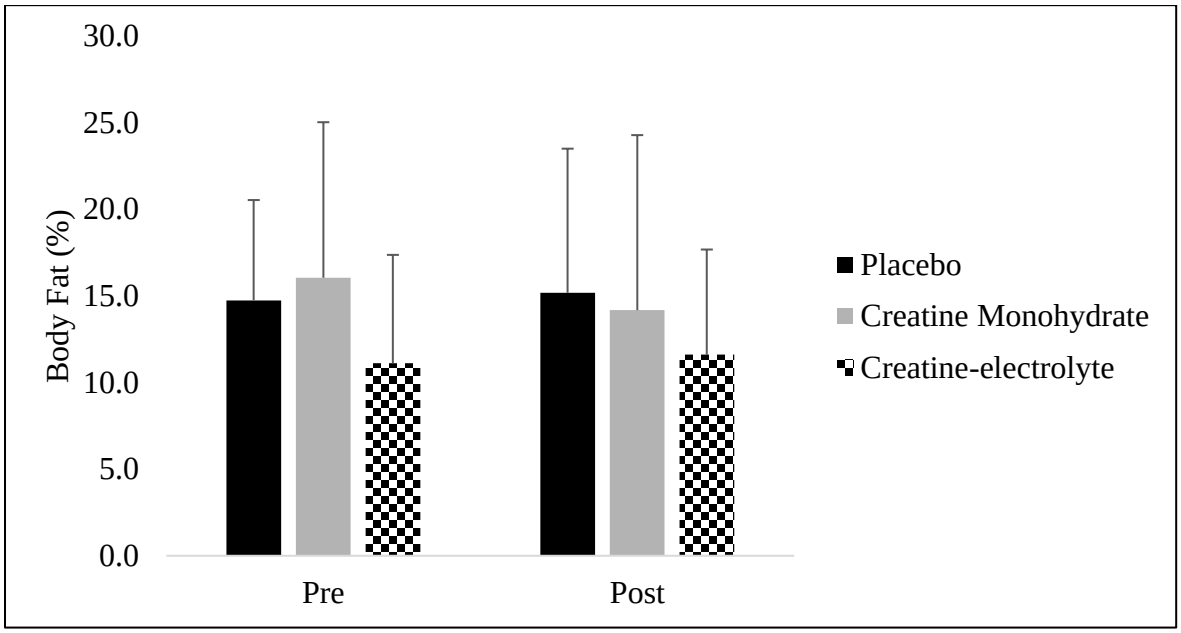

Figure 1. Graphical representation of body fat percentage at pre-test and post-test (mean ± SD).

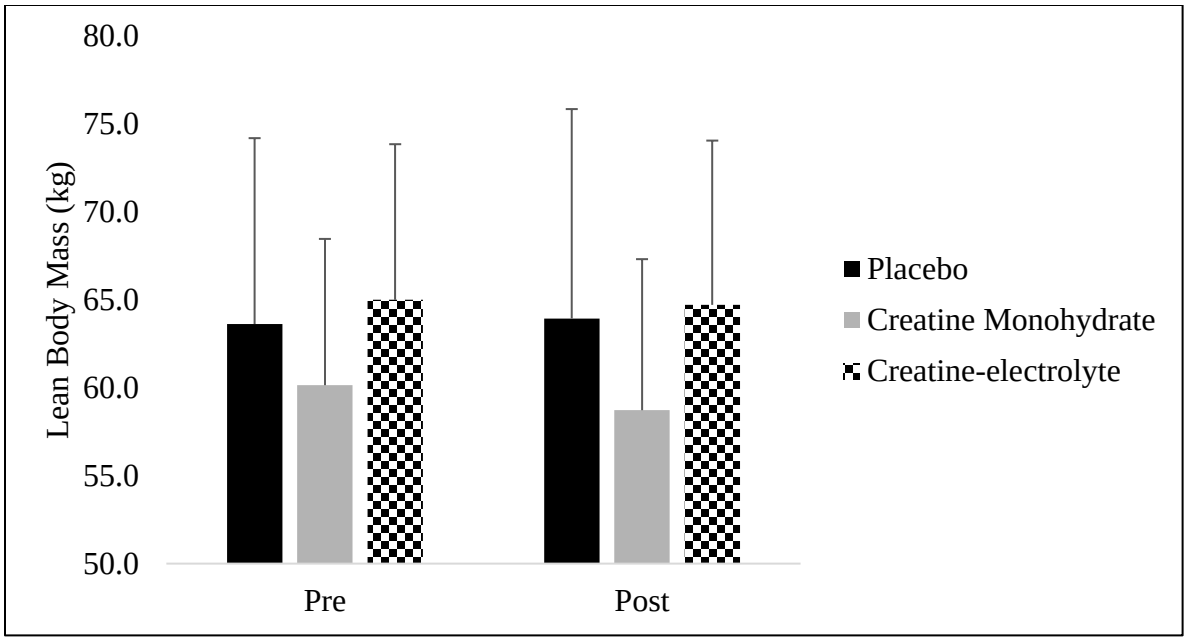

Figure 2. Graphical representation of lean body mass at pre-test and post-test (mean ± SD).

Body water analysis.

Interactions for total body water or intra-cellular water demonstrated no significant effect (F[2, 16] = 0.400, p = 0.677, η_p^2 = 0.048) and (F[2, 16] = 0.361, p = 0.703, η_p^2 = 0.043) for total body water and intracellular water, respectively. A significant interaction in group and time for extra-cellular water (F[2, 16] = 4.395, p = 0.03, η_p^2 = 0.35) was observed and data is displayed in Figure 3. The extra-cellular water in the placebo group increased from 16.8 ± 3.92 to 17.63 ± 3.31 L and decreased from 17.27 ± 2.23 to 16.7 ± 2.75 L in the creatine-electrolyte group (t(5) = -2.515, p = 0.053 and t(5) = 1.19, p = 0.287, respectively). Extra-cellular water remained relatively stable from pre-testing to post-testing in the creatine monohydrate group. Body water analysis data is displayed in Table 4. Graphical display of these water variables are displayed in Figures 4 through 6.

Table 4. Total Body Water, Intra-Cellular Water, and Extra-Cellular Water (mean ± SD)

	Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Total Body Water (L)	42.26±7.73	40.51±8.49	36.01±6.20	36.57±5.91	40.5±6.44	40.05±6.20
Intra-Cellular Water (L)	24±4.76	22.88±5.50	19.91±4.84	20.1±4.36	23.25±4.32	23.33±3.44
Extra-Cellular Water (L)	16.8±3.92	17.63±3.31	16.07±1.75	16.46±1.94	17.27±2.23	16.7±2.75

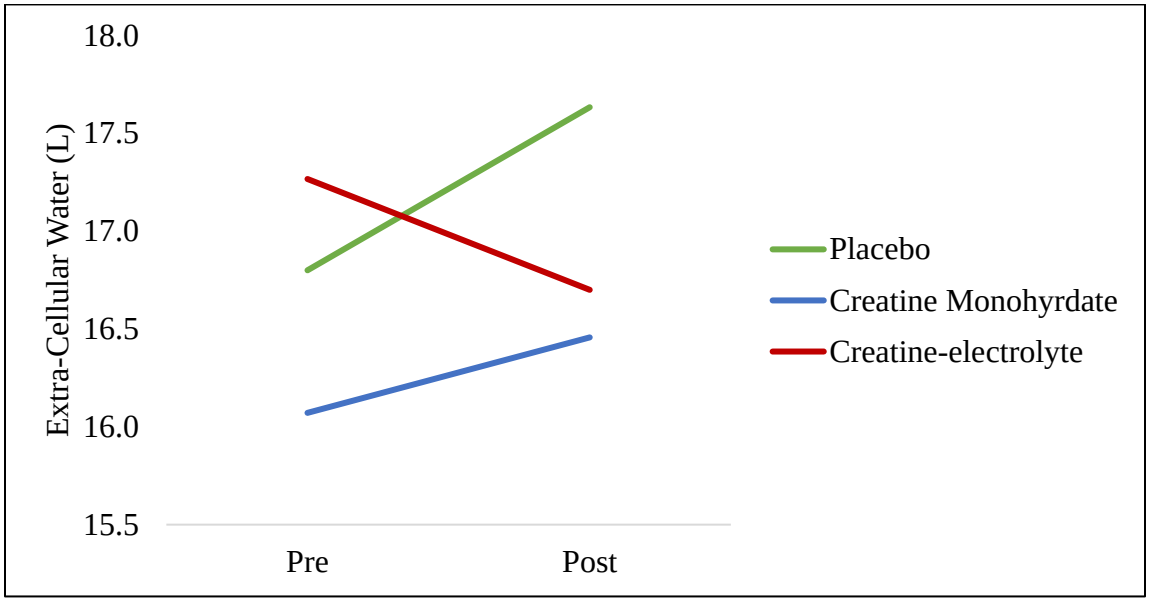

Figure 3. Interaction effect of group and time on extra-cellular body water

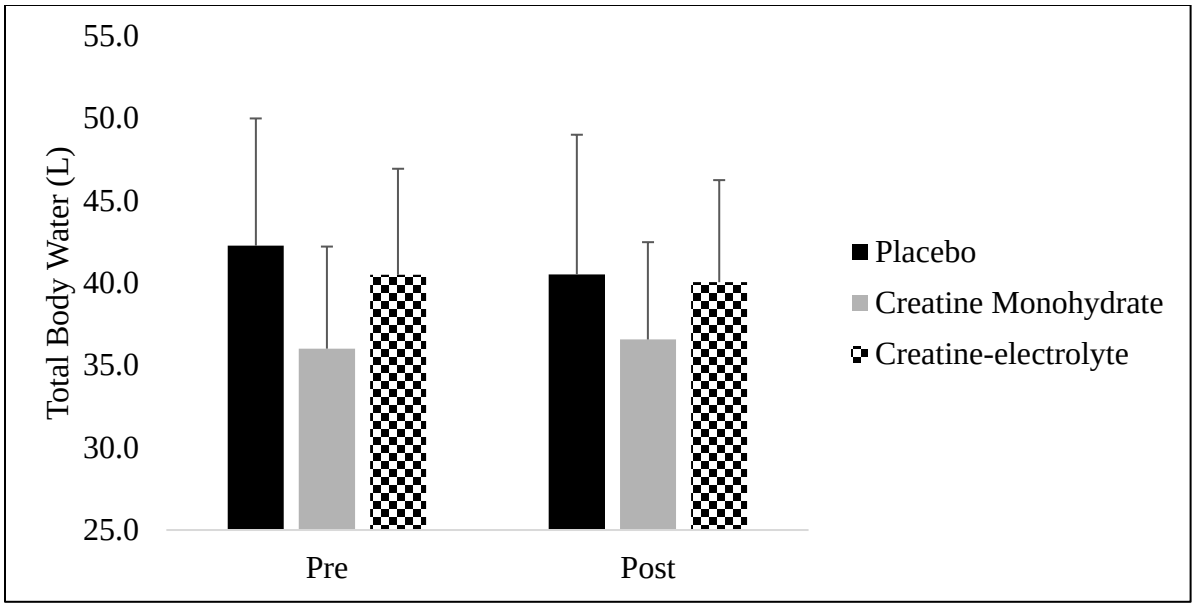

Figure 4. Graphical representation of total body water at pre-test and post-test (mean ± SD)

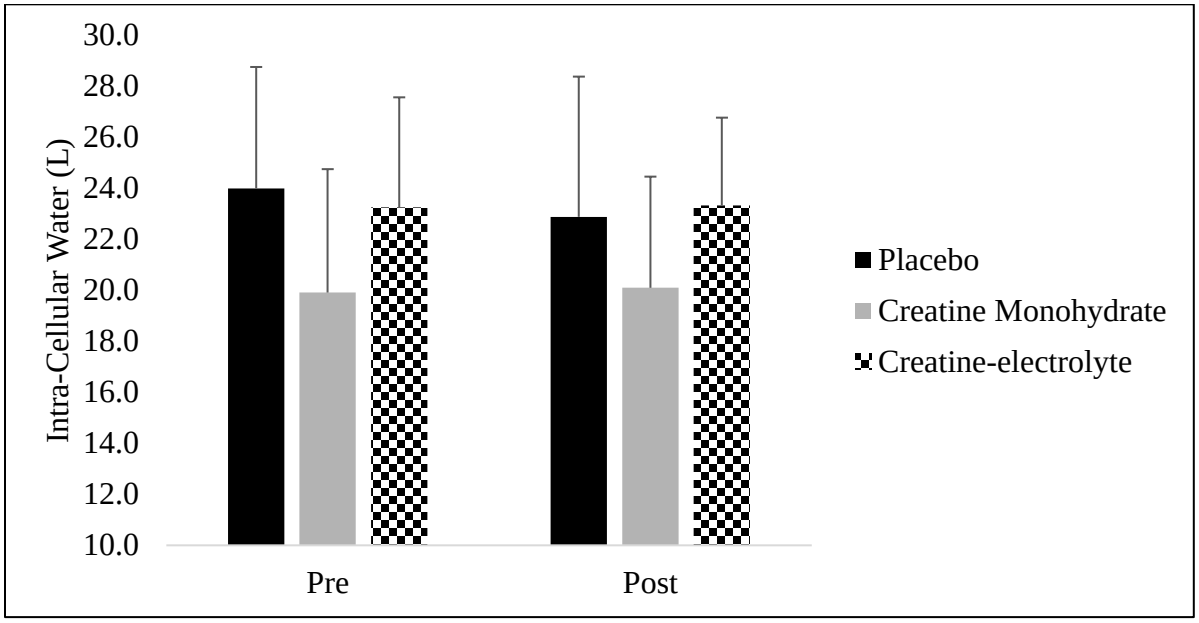

Figure 5. Graphical representation of intra-cellular water at pre-test and post-test (mean ± SD)

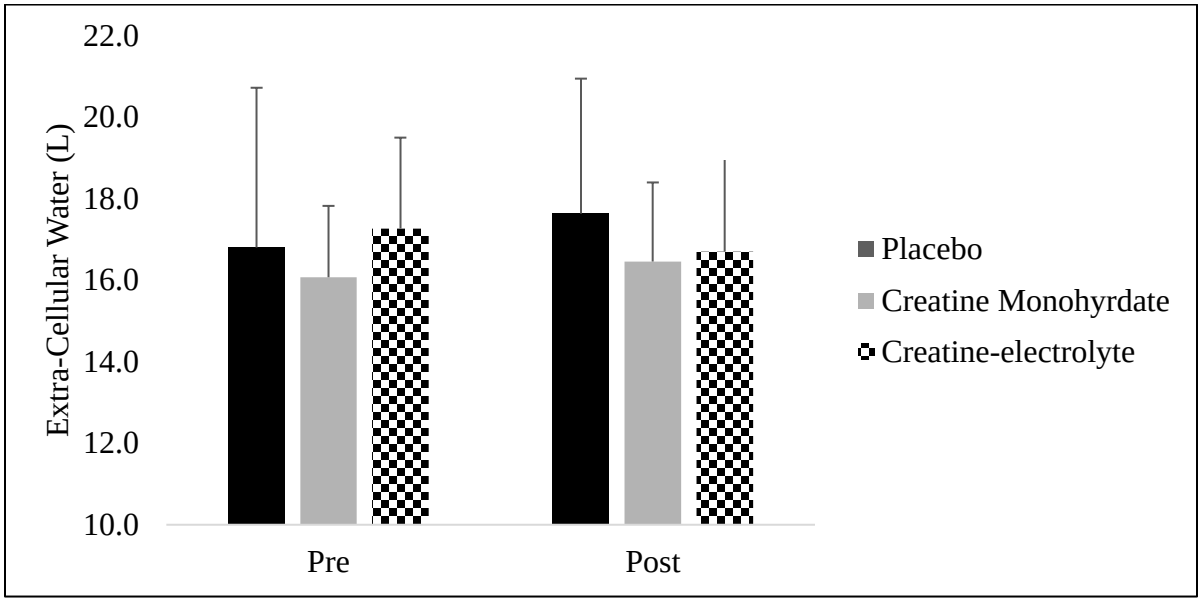

Figure 6. Graphical representation of extra-cellular water at pre-test and post-test for all three groups (mean ± SD)

Peak torques. Results for normalized peak isometric torque indicated no significant interaction between time and group (F[2, 20] = 1.042, p = 0.371, η_p^2 = .091). There were no significant main effects for the CE (F[1,20] = 0.390, p = 0.539, η_p^2 = 0.019), CM (F[1, 20] = 0.142, p = 0.710, η_p^2 = 0.007), and placebo (F[1, 20] = 2.770, p = 0.112, η_p^2 = 0.122). There were no significant main effects for normalized peak isokinetic torque at 60 deg/sec for the CE (F[1, 20] = 3.021, p = 0.098, η_p^2 = 0.131), CM (F[1, 20] = 2.220, p = 0.152, η_p^2 = 0.100) and placebo (F[1, 20] = 0.199, p = 0.660, η_p^2 = 0.010). Normalized peak isokinetic torque at 60 deg/sec also demonstrated no significant interaction between time and group (F[2, 20] = 2.704, p = 0.91 η_p^2 = 0.213). Although normalized peak isokinetic torque at 180 deg/sec approached significance between subjects (F[2, 20] = 1.662, p = 0.075, η_p^2=0.150), the results were not statistically

significantly different. However, main effects demonstrated statistical significance for CE for normalized isokinetic torque at 180 deg/sec (F[1, 20] = 4.890, p = 0.039, η_p^2=0.196). No significant main effects were observed for CM (F[1, 20] = 0.080, p = 0.781, η_p^2 0.004) or the placebo (F[1, 20] = 1.550, p = 0.228, η_p^2 = 0.072). Descriptive data are presented in Table 5 and data are displayed in Figures 7 through 9.

Table 5. Isometric and isokinetic peak torques (mean ± SD) * p<0.05

	Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Isometric torque	307.48±43.54	331.19±48.87	331.97±78.67	326.61±81.95	313.12±85.31	322.63±76.82
Isokinetic torque (60º/s)	278.15±31.28	271.63±47.76	281.05±94.40	259.29±78.45	252.98±67.60	280.12±51.63
Isokinetic torque (180º/s)	164.65±45.52	181.85±40.13	172.58±69.25	168.68±54.58	164.04±37.62	196.69±39.52*

A significant (p<0.05) difference in the amount of torque produced in the CE group from pre-supplementation testing.

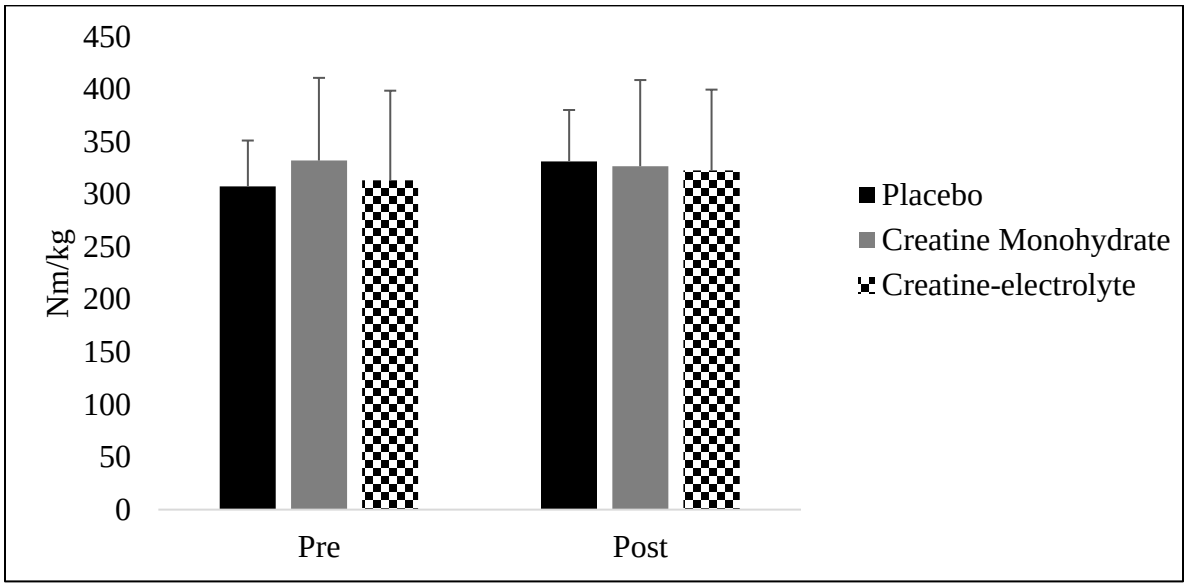

Figure 7. Graphical representation of peak isometric torque at pre-test and post-test (mean ± SD)

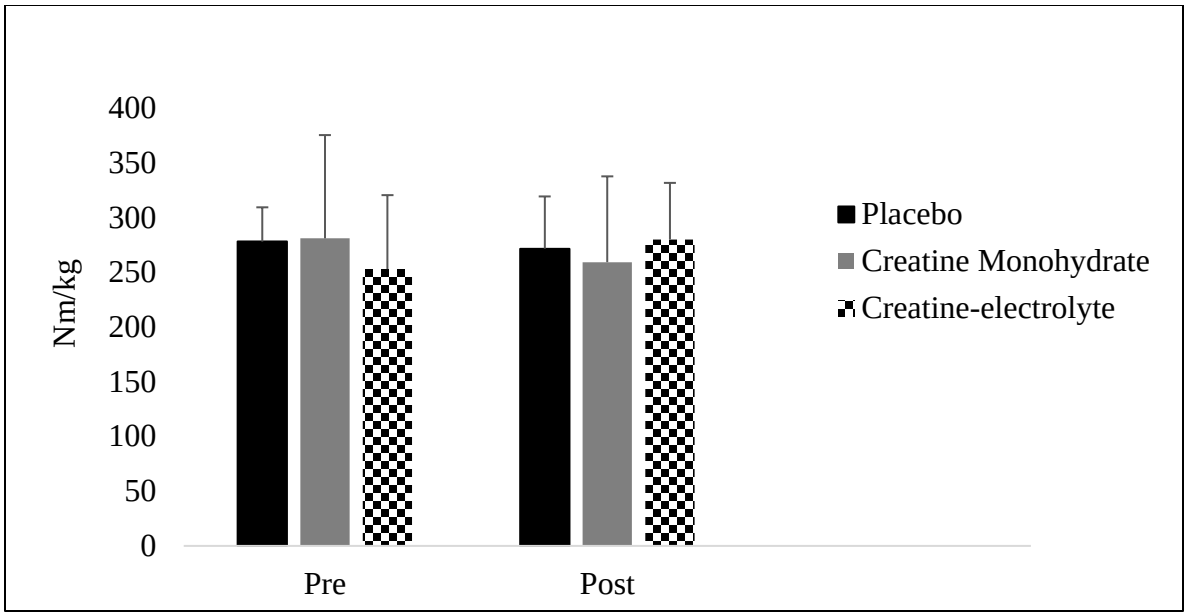

Figure 8. Graphical representation of peak isokinetic torque 60 °/sec at pre-test and post-test (mean ± SD)

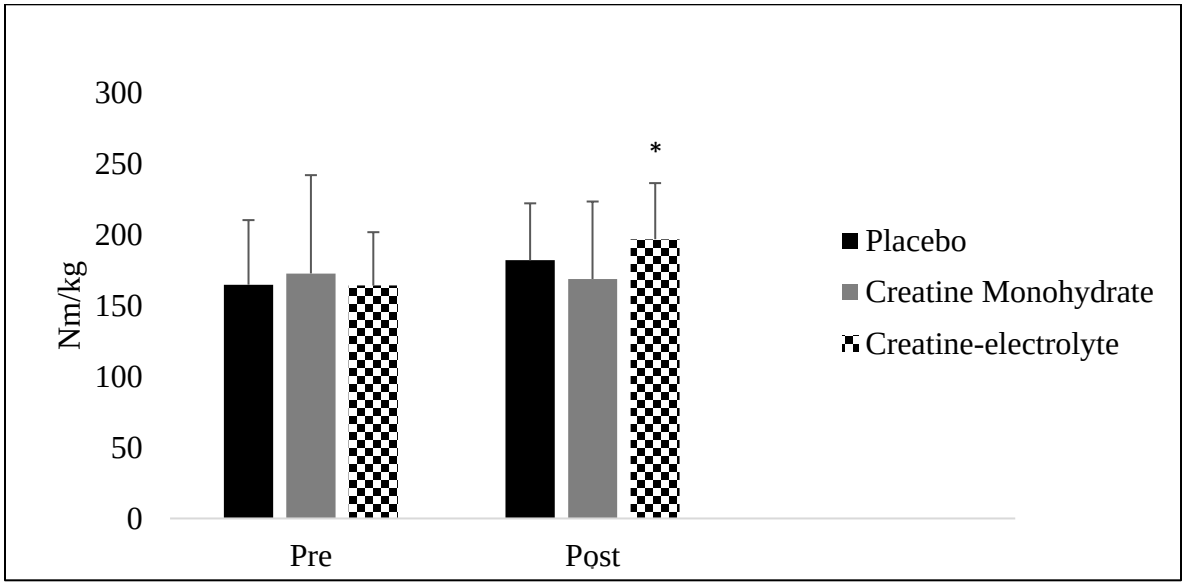

Figure 9. Graphical representation of peak isokinetic torque 180 °/sec at pre-test and post-test (mean ± SD); *p <0.05, time effect

Fatigue, power, and work for repeated sets at maximal effort. Results for the fatigue index during two sets consisting of 30 maximal isokinetic knee extensions at 180 deg/sec, with two minute rests between sets, demonstrated no significant group or time interaction in set one (F[2,20) = 1.847, p = 0.184, η_p^2 = 0.156) or set two (F[2,20] = 0.925, p = 0.413, η_p^2 = 0.085). The data demonstrated no significant main effects for the CE (F[1, 20] = 2.202, p = 0.153, η_p^2 = 0.099), CM (F[1, 20) = 0.558, p = 0.464, η_p^2 = 0.027), and placebo (F[1, 20] = 2.795, p = 0.110, η_p^2 = 0.123) in the first set, nor were there any significant main effects in the second set for the CE (F[1, 20] = 0.287, p = 0.598, η_p^2 = 0.014), CM (F[1, 20] = 3.276, p = 0.085, η_p^2 = 0.141) or placebo (F[1, 20] = 0.008, p = 0.931, η_p^2 = 0.001).

No significant group and time interactions for total work were demonstrated in set one (F[2, 20] = 0.398, p = 0.677, η_p^2 = 0.038) nor in set two (F[2, 20] = 0.187, p = 0.831, η_p^2 = 0.018). There was a significant main effect for total work for CE observed in set one (F[1, 20] = 6.516, p = 0.019, η_p^2 = 0.246) and for placebo (F[1, 20] = 5.580, p = 0.028, η_p^2 = 0.218). No significant main effects were observed for total work for CM in the first set (F[1, 20] = 2.171, p = 0.156, η_p^2 = 0.098). No significant main effects in total work performed in set two were observed for CE (F[1, 20] = 0.667, p = 0.424, η_p^2 = 0.032), CM (F[1, 20] = 0.394, p = 0.537, η_p^2 = 0.019), and placebo (F[1, 20] = 2.165, p = 0.157, η_p^2 = 0.098).

There was also no significant group and time interactions for mean power in set one (F[2, 20] = 0.398, p = 0.677, η_p^2 = 0.038) nor in set two (F[2, 20] = 0.736, p = 0.492, η_p^2 = 0.069). In set 1 during the post-test, there was statistically significant time effect for work (F[1, 20] = 13.712, p = 0.001 η_p^2= 0.407) for CE. There was also a significant time effect for mean power in set 1 during the post-test (F[1, 20] = 11.790, p = 0.003, η_p^2= 0.371) for CE.

There was no significant time effect for total work or mean power in set two following the six-week supplementation period (F[1, 20] = 2.810, p = 0.109, η_p^2 = 0.123) and (F[1, 20] = 1.554, p = 0.227, η_p^2 = 0.072), respectively. Data demonstrated significant main effects for mean power in set one for CE (F[1, 20] = 6.317, p = 0.021, η_p^2 = 0.240). No significant main effects for mean power in set one were observed for the CM (F[1, 20] = 1.908, p = 0.182, η_p^2 = 0.087) or placebo (F[1, 20] = 4.076, p = 0.057, η_p^2 = 0.169). No significant main effects were observed for mean power during the second set in CE (F[1, 20] = 2.739, p = 0.114, η_p^2 = 0.120), CM (F[1, 20] = 0.086, p = 0.772, η_p^2 = 0.004, and placebo (F[1, 20] = 0.021, p = 0.885, η_p^2 = 0.001). Descriptive data in Table 6 demonstrates the creatine-electrolyte group had significant increases in power and work. Table 7 lists the descriptive data for the second set of 30 maximal knee extensions. Graphical representations for work ratios, total work, and average power for each set during the pre-test and post-test are displayed in Figures 10 through 15.

Table 6. Normalized power, work, and fatigue index during 30 maximal knee extensions in set 1 (mean ± SD).

Set 1	**Placebo**		**Creatine Monohydrate**		**Creatine-electrolyte**	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Power (W)	144.3±68.9	164.4±70.3	146.1±53.7	160.6±56.3	157.9±39.7	186±66.7*
Work (J)	1721.5±619.9	1987.5±617.7	1812.6±612.3	1978.6±723.2	2178.3±488.1	2485±677.6*
Fatigue Index	1.5±0.6	1.7±0.5	1.8±0.2	1.7±0.3	1.7±0.0	1.9±0.4

(p<0.05); CE vs. CM, placebo

Table 7. Normalized power, work, and fatigue index during 30 maximal knee extensions in set 2 (mean ± SD).

Set 2	Placebo		Creatine Monohydrate		Creatine-electrolyte	
	Pre-Test	**Post-Test**	**Pre-Test**	**Post-Test**	**Pre-Test**	**Post-Test**
Power (W)	132.7±61.7	134±54.5	121.4±35.2	123.9±27.8	130.9±35.5	145.7±49.4
Work (J)	1494.4±501.8	1652.2±589.3	1466.1 ±401.2	1533.5±388.6	1702.5 ±363.4	1796.2±450.5
Fatigue Index	1.9 ±0.5	1.9 ±0.3	2.3 ±0.4	2.0±0.6	2.2 ±0.4	2.1 ±0.2

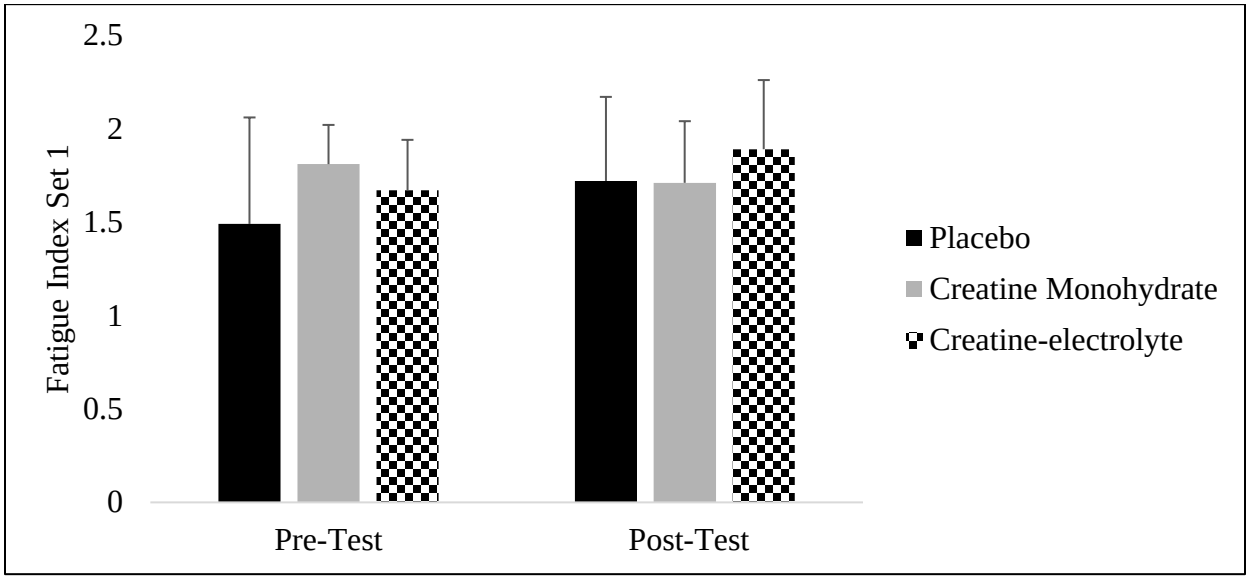

Figure 10. Graphical representation of fatigue index for set 1 of 30 maximal knee extensions during pre-test and post-test (mean ± SD)

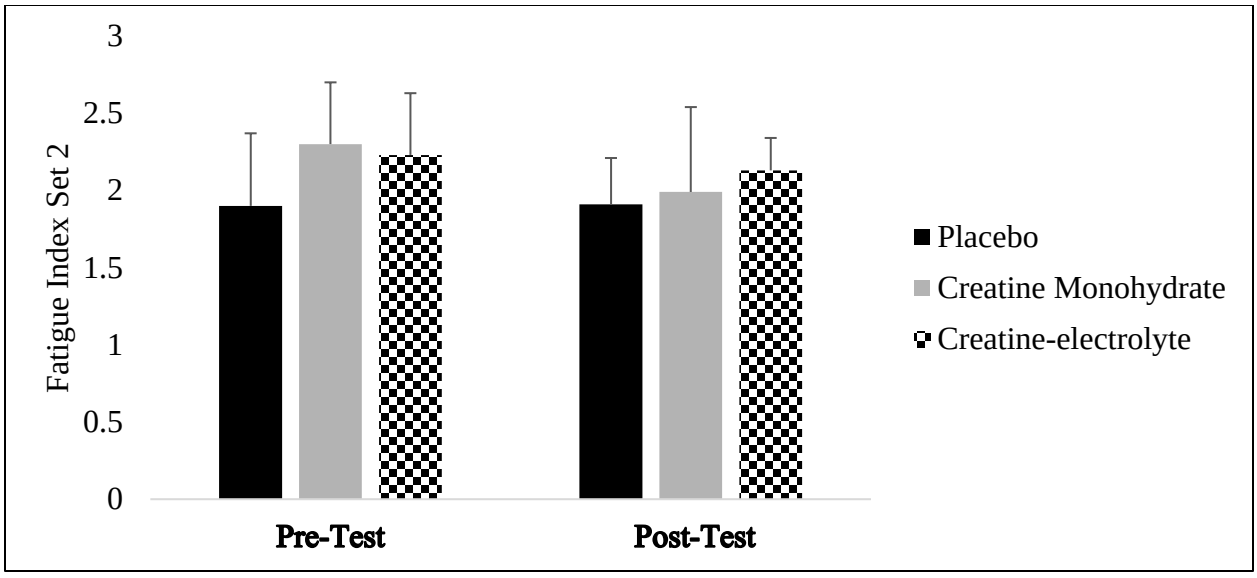

Figure 11. Graphical representation of fatigue index for set 2 of 30 maximal knee extensions during pre-test and post-test (mean ± SD)

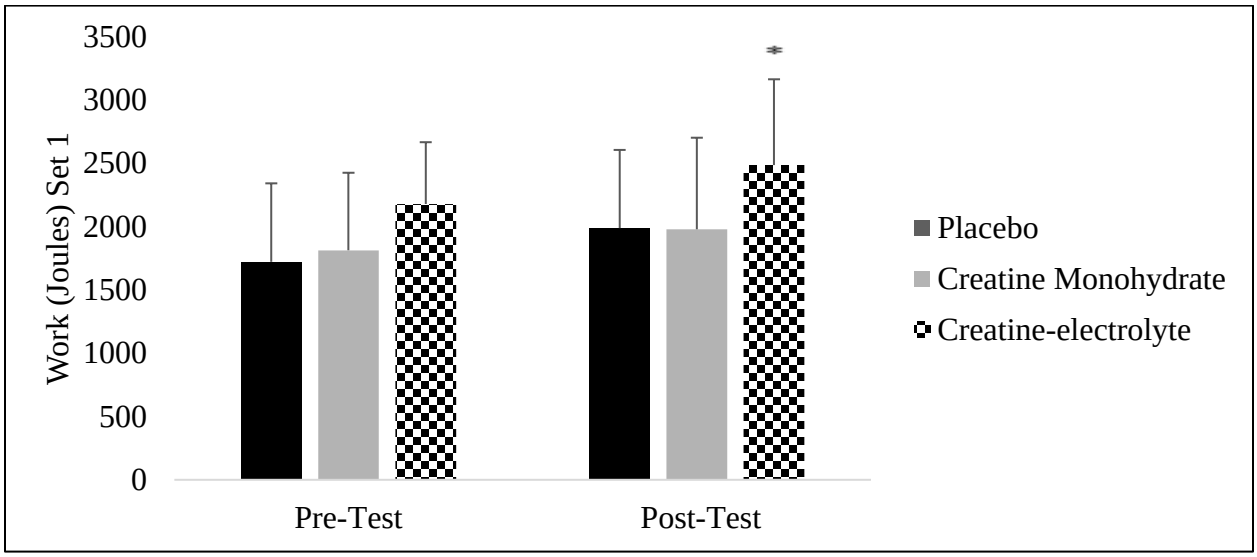

Figure 12. Graphical representation of total work for set 1 of 30 maximal knee extensions during pre-test and post-test (mean ± SD) *p <0.05

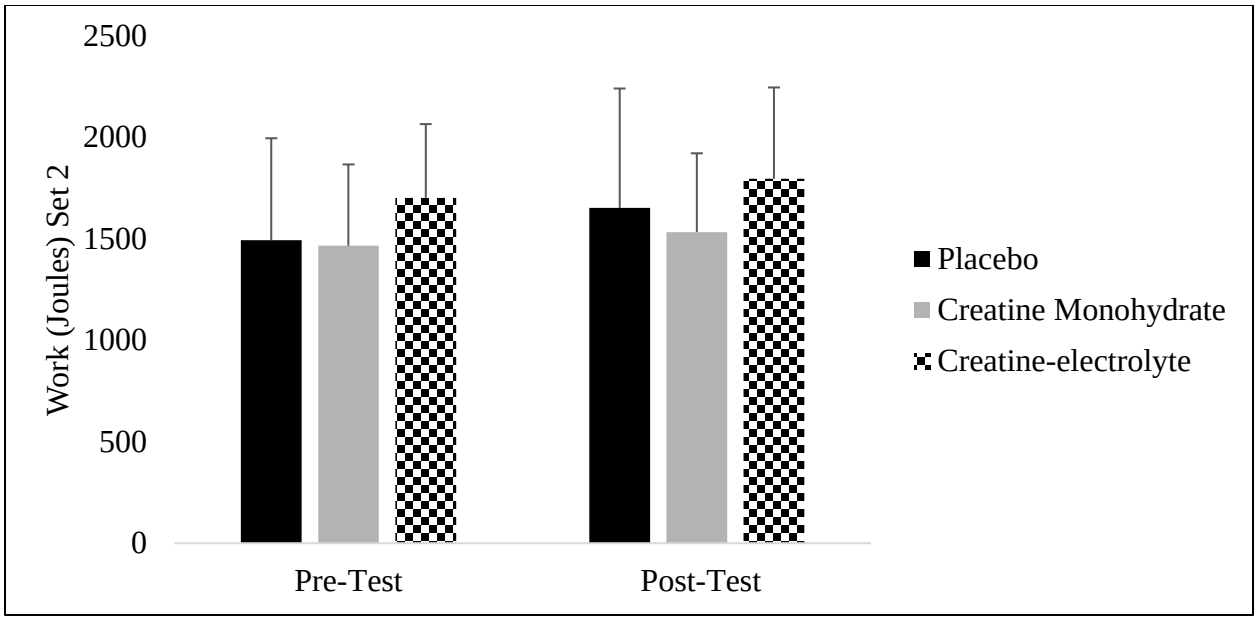

Figure 13. Graphical representation of total work for set 2 of 30 maximal knee extensions at pre-test and post-test (mean ± SD)

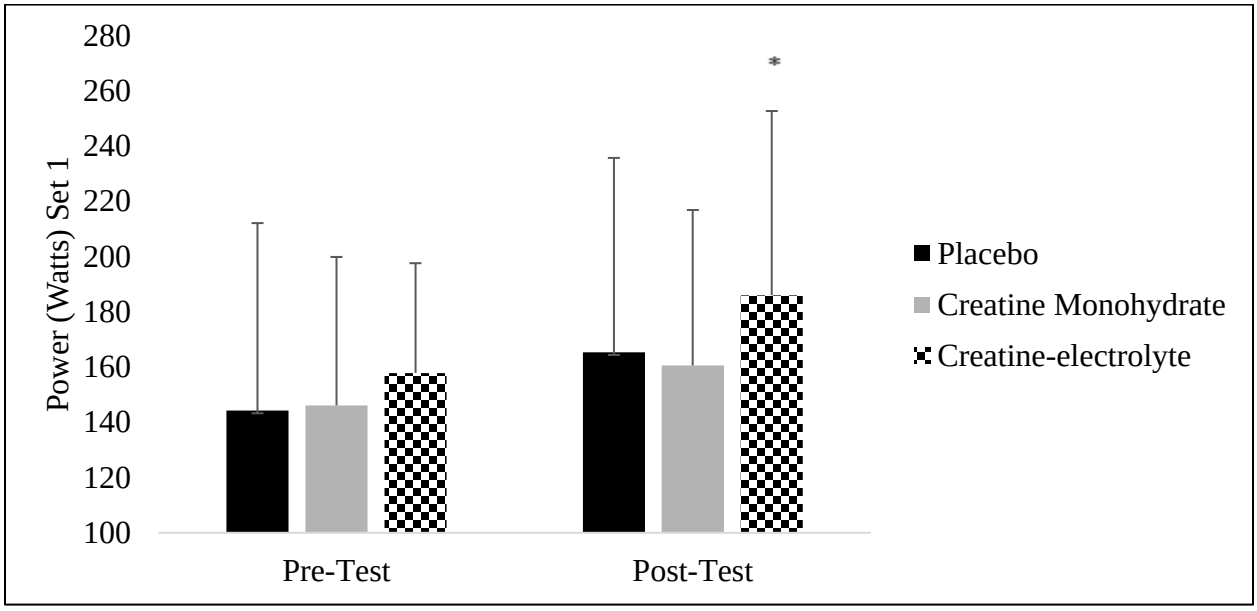

Figure 14. Graphical representation of average power for set 1 of 30 maximal knee extensions at pre-test and post-test (mean ± SD); *p<0.05

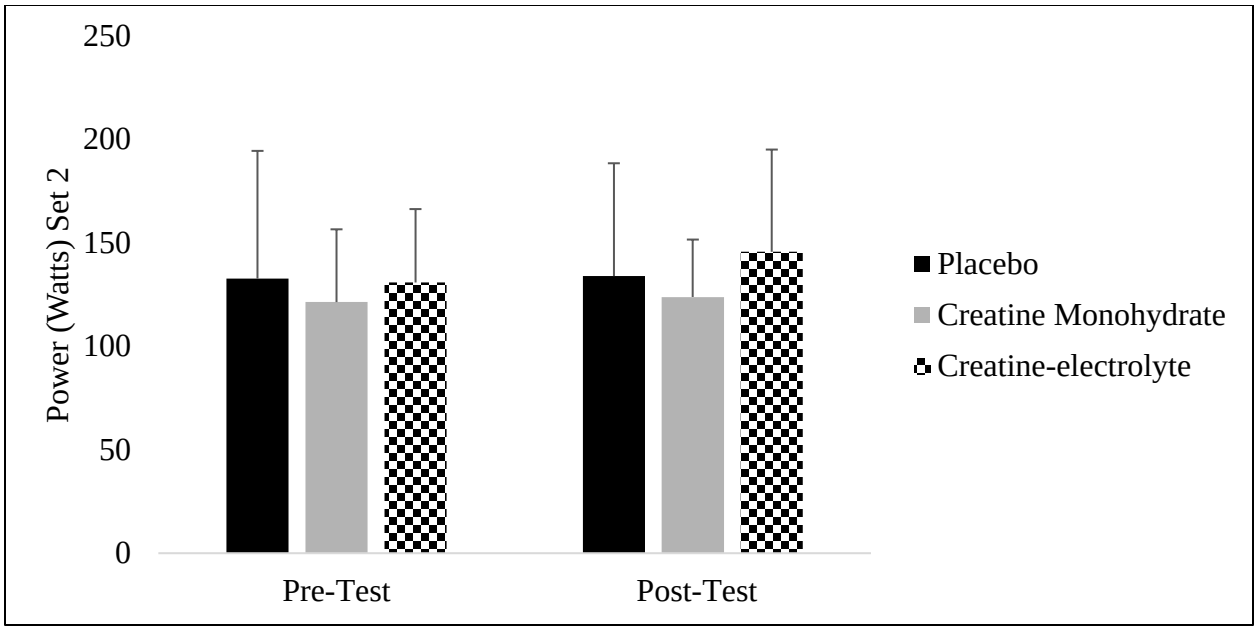

Figure 15. Graphical representation of average power for set 2 of 30 maximal knee extensions at pre-test and post-test (mean ± SD)

Discussion

The purpose of this study was to examine if a six-week CE supplementation protocol would increase peak isometric power, peak isokinetic power, and improve the fatigue index after performing two sets of 30 maximal knee extensions compared to CM and a placebo. The results demonstrating a significant time effect for work and mean power did not support the null hypothesis that there would be no significant changes in muscle functions following six-weeks of supplementation between three different supplement groups. Pairwise comparisons also demonstrated a significant difference between the CE group and CM group for normalized peak isokinetic torque at 180 deg/sec. Both the placebo and CE group demonstrated increases in peak isokinetic torque from pre-testing to post-testing, with the CM group demonstrating a decrease in torque from pre-testing to post-testing. A medium to large effect was observed based on partial

η_p^2 data. The results for the remaining variables examined in the study supported the null hypothesis. Based on the results, the CE supplement was useful in promoting greater torque-generating capabilities for knee extensions at 180 deg/sec. The CE supplement was also beneficial for increasing the total amount of work along with increasing the average power during the first set of 30 maximal knee extensions at 180 deg/sec. A significant interaction for time and group was also observed with extra-cellular water content. Possibly due to the small sample sizes in each group, simple effects statistical analysis tests were unable to reveal where the interactions took place.

Although there was a significant time effect for both total work and mean power in the first set of 30 maximal knee extensions, there was no significance for time effect of these variables in the second set nor was there any significant interaction for time and group during either set of knee extensions in the attenuation of fatigue. The absence of any attenuation of fatigue in the current study differed from the observations by Greenhaff et al. (1993) who observed the decrement in fatigue following a creatine supplementation protocol that consisted of 20 g/day for five days. Compared to the placebo group, the reduction in fatigue from pre-to post testing in the CM group was greater than that in the placebo group across all five sets of 30 maximal knee extensions at 180 deg/sec with one minute of recovery between sets. In the current study, the maximum amount of creatine supplementation consumed in one day was 4 g/day. The results observed by Greenhaff et al. (1993) may have been in part be due to the greater increase in total muscle creatine storage that followed the much larger consumption of creatine on a daily basis. The subjects were also described as physically active but not highly trained. Some of the subjects in the current study were highly resistance trained which may have had an influence on the results. Current training status may elicit different effects on the performance outcome

following creatine supplementation. However, Gilliam et al. (2000), utilizing an identical supplementation and exercise testing protocol as Greenhaff et al. (1993), observed no significant effects from pre to post-testing in the attenuation of fatigue in either the creatine or placebo group. Without performing muscle biopsies to determine the effectiveness of creatine uptake of the muscle following supplementation, it cannot be assured if creatine loading is taking place and thus affecting the results.

The absence of any significant gains in 1-RM torque at 60 deg/sec and 180 deg/sec in the CM group in the current study is similar to those observed by Zuniga et al. (2012). There was no effect on either 1-RM leg extension strength or bench press strength following the seven-day 20 g/day supplementation protocol (Zuniga et al., 2012). Both study by Zuniga et al. (2012) and the current study included a two-minute rest period between each 1-RM set; however, the leg extensions were performed on a plate-loaded leg extension resistance-training machine which is different from the isokinetic dynamometer that was used in the current study. Zuniga et al. (2012) observed a 5.4% increase in mean power but no differences in peak power during two 30-second Wingate tests separated by seven minutes in the CM group from pre-post testing. It could be concluded from Zuniga et al. (2012) and the current study that CM may not always beneficial for increasing peak power or 1-RM strength.

The use of creatine supplementation by athletes helps to increase the amount of creatine and phosphocreatine (PCr) found inside the muscles. The elevated muscular creatine is used during quick bouts of anaerobic activity (Allen, 2012; Greenhaff et al., 1994). Phosphocreatine stores along with re-synthesis of creatine are elevated during creatine supplementation (Greenhaff et al., 1994). The increase athletic performance in the CE group during post-testing for the first set of 30 maximal repetitions concurs with previous research (Burke et al., 2003;

Izquierdo, Ibañez, González-Badillo, & Gorostiaga, 2002). Contrary to previous research, the CM group did not experience any increase in athletic performance.

Although all humans share similar anatomical and physiological characteristics, there can be biological variability in the initial levels of cellular creatine and phosphorylated creatine (Syrotuik & Bell, 2004). Greenhaff et al. (1994) observed the greatest muscle uptake of creatine in recreationally active male subjects who had muscle creatine concentrations of less than 120 mmol/ kg dry matter prior to consuming creatine monohydrate. It was also demonstrated that greatest increases in total creatine concentration in the muscle following five days of consuming 20 g/day creatine monohydrate supplementation occurred in individuals who had lower pre-feeding levels of creatine concentration. With the combination of pre-feeding levels of creatine and supplementation, total creatine concentration did not exceed 155 mmol/ dry matter in any of the eight male subjects with supplementation (Greenhaff et al., 1994). Variations in total resting muscle creatine monohydrate and phosphorylated creatine were observed after a five-day supplementation of 0.3 g/kg a day in 11 recreationally resistance-trained men (Syrotuik & Bell, 2004).

Measurements of resting muscle creatine were obtained from muscle biopsies of the right vastus lateralis (Syrotuik & Bell, 2004). To distinguish responders from non-responders following the supplementation period, the following amounts of resting muscle phosphorylated creatine plus creatine-monohydrate were used to categorize each subject: $\geq$ 20 mmol/kg dry weight (dw), 10-20 mmol/kg dw, < 10 mmol/kg dw for responders, quasi responders, and non-responders, respectively. Of the eleven subjects, three were considered responders, five were quasi responders, and three were non-responders. The average increase in total resting muscle creatine and phosphorylated creatine was 29.5, 14.9, and 5.1 mmol/kg dw for the responders,

quasi responders, and non-responders, respectively. The large increases in total resting muscle creatine after supplementation in responders was suggested to be influenced by the lower levels of total creatine content at baseline compared to the baseline mean concentrations of total resting muscle creatine for all subjects. Observations from the investigation suggested that individuals with lower levels of total resting muscle creatine content prior to supplementation would benefit more than individuals with higher levels of total resting creatine content (Syrotuik & Bell, 2004). It cannot be inferred as to who were and were not responders in the current study due to not performing any muscle biopsies on any of the subjects. Muscle biopsies could potentially be an avenue for future research to determine if responsiveness to creatine supplementation can have an effect on physical performance outcome measures.

Another physiological factor potentially affecting an individual's response to creatine supplementation is muscle fiber type (Casey, Constantin-Teodosiu, Howell, Hultman, & Greenhaff, 1996; Syrotuik & Bell, 2004). A positive correlation between the changes in phosphorylated creatine in type II muscle fibers and the decline in muscle phosphorylated creatine during exercise, along with greater increase in total work production, following supplementation was observed in subjects who trained in various activities five to six days a week (Casey et al., 1996). Previous authors have observed that resting phosphorylated creatine concentration in type II muscle fibers is around 12% greater than in type I muscle fibers (Greenhaff et al., 1994; Söderlund, Greenhaff, & Hultman, 1992). The decline in phosphorylated creatine during 30 seconds exercise at maximal intensity was 10-25% greater in type II muscle fibers (Greenhaff et al., 1994.)

Casey et al. (1996) observed that baseline levels of phosphorylated creatine concentration in the nine male subjects were 66.6 ± 4.2 mmol/kg dry matter in type I muscle fibers and 79.3 ±

1.5 mmol/kg dry matter in type II muscle fibers. After five days of creatine supplementation of 20 g/day, phosphorylated creatine concentration was 77.6 ± 3.2 mmol/kg dry matter in type I muscle fibers and 91.0 ± 5.8 mmol/kg dry matter in type II muscle fibers. After 30 seconds of maximal isokinetic cycling at 80 revolutions per minute (rpm), phosphorylated creatine concentrations were 29.9 ± 6.0 mmol/kg dry matter in type I fibers and 17.9 ± 9.8 mmol/kg dry matter in type II fibers. Following four minutes of recovery, concentrations were 69.6 ± 3.9 mmol/kg dry matter in type I fibers and 67.2 ± 4.1 mmol/kg dry matter in type II fibers. After another 30-second bout of maximal intensity isokinetic cycling at 80 rpm, phosphorylated creatine concentrations were 12.8 ± 3.7 mmol/kg dry matter in type I fibers and 7.4 ± 2.8 mmol/kg dry matter in type II fibers (Casey et al., 1996). Degradation of phosphorylated creatine after maximal intensity exercise was observed to be greater in type II muscle fibers versus type I muscle fibers (Casey et al., 1994; Greenhaff et., 1994). Despite the greater decreases in phosphorylated creatine concentration seen in type II muscle fibers, supplementation was suggested to induce an ergogenic effect by being able to resynthesize ATP due to an increased phosphorylated creatine pool in type II muscle fibers (Casey et al., 1996).

The potential variables consisting of baseline total muscle creatine levels and muscle fiber type composition cannot be dismissed as potential reasons why no significant effects were observed between the CM group and placebo groups from pre-testing to post-testing in the current study. Since no muscle biopsies were taken from the subjects during the study, attributing the absence of any significant effects in peak isokinetic torque, isometric torque, peak power, workload, and fatigue index between the CM and placebo groups due to the subjects' total resting creatine concentration and muscle fiber type cannot be confirmed

It has been suggested that creatine alone has limited potential in maximizing the activation of the creatine transporter (Spillane et al., 2009). The significant increase seen in both the amount of work performed and average power in during the first set of 30 maximal knee extension in the CE but not in the CM group in comparison to the placebo group may be related to the improved activation of the creatine transporter along with the increased cellular absorption of using a creatine and electrolyte combination formula. Attempts at improving cellular absorption and transport of creatine to maximize total intramuscular creatine concentration have been made by developing various creatine formulas consisting of carbohydrates, electrolytes, and esterified alcohol (Spillane et at., 2009). The CE formula used in the current study consisted of magnesium chloride, potassium chloride, calcium chloride, sodium chloride. Some of these different creatine formulations were suggested to help increase creatine-reuptake by increased up-regulation or bypassing the creatine transporter (Spillane et al., 2009). It has also been suggested that by combining a cation to creatine, this may enable the molecule to enter through a second pathway via the ligand-gated cation channel that is located on the sarcolemma under the innervating motor neuron (Selsby, DiSilvestro, & Devor, 2004).

However, not all creatine formulas have demonstrated beneficial effects. Spillane et al. (2009) observed no significant increases in anaerobic or strength gains in supplementing with creatine ethyl ester (CEE) compared to CM or a placebo. The increases in both peak and mean anaerobic power observed during a Wingate tests and 1-RM leg press and bench press strength were suggested to be due to the four-day per week training protocol for the duration of the study since the CEE, CM and placebo group had demonstrated roughly the same increases in performance measures. The training protocol involved training both upper and lower extremities. This is different from the protocol used in the current study in that the subjects were asked to

maintain their current resistance training regimens. In both the current study and the study done by Spillane et al. (2009), there is the possibility that the subject's training regimen may have had a bigger impact than the supplementation itself. The daily maintenance dosage was also slightly different with 4 g/day in the current study compared to Spillane et al. (2009) having subjects consume 5 g/day.

It could also be speculated that the significantly greater calorie expenditure in the placebo group during both pre-testing and post-testing compared to that of the CM and CE groups may have affected the results. The placebo group consumed a larger amount of protein compared to the supplementation groups. It could be suggested that the placebo group may have consumed protein rich foods such as red meat and fish which contain dietary creatine. It cannot be assumed that a diet rich in protein resulted from eating meats and fish. Consumption of such foods provides about half of the body's daily need of creatine (Syrotuik & Bell, 2004). When comparing non-responders to responders using creatine supplementation, Syrotuik and Bell (2004) did not observe any effects relating to protein consumption since both groups had consumed high amounts of protein prior to supplementation. It may be important to consider the sources of protein, plant versus meat, instead of total protein consumption in future analysis comparing different formulations of creatine supplementation. A protein diet primarily from foods rich in creatine could potentially blunt the effects of creatine-supplementation.

A study investigating the effects of creatine supplementation on total amount of work performed during pre-test and post-test conditions was with vegans versus non-vegan subjects (Burke et al., 2003). Like the current study, Burke et al. (2003) utilized a protocol involving knee extensions on an isokinetic dynamometer at 180 deg/sec. However, the total number of repetitions performed was 50. Subjects for the study were recreationally active individuals with

at least one year of resistance training but less than 5 years. The loading phase consisted of ingesting 0.0625 g/kg per kilogram of lean body tissue mass (LTM) four times daily for one week. The dosage was reduced to 0.0625 g/kg per LTM once daily for 49 more days. All subjects performed the same high volume eight-week upper and lower body training program utilizing a resistance of greater than 70% of 1-RM. Results demonstrated a significant increase ($p < 0.05$) in total work performed in both the non-vegans and vegans consuming creatine supplementation compared to the non-vegan and vegan placebo groups. The results are congruent to the findings observed with the creatine-electrolyte group in the current study which demonstrated a greater amount of total work performed in set 1 compared to the creatine monohydrate and placebo groups with a large effect size ($\eta_p^2 = 0.407$). The average total work done by the vegans who supplemented with creatine went from approximately 5200 J to approximately 6500 J at post-testing. Non-vegans who supplemented with creatine demonstrated an increase from approximately 5300 J to approximately 5900 J at post-testing. The larger workloads observed by Burke et al. (2003) were most likely due to the greater number of repetitions performed, 50 repetitions, versus 30 repetitions in the current study. The fact that subjects had only performed three 1-RM leg press and bench press exercises each along with having 10 minutes of rest prior to conducing the 50 knee extensions may also have potentially contributed to the results observed by Burke et al. (2003). In the current study, a shorter rest period coupled with having performed squat and bench press cluster sets along with having performed 1-RM isokinetic knee extensions may have affected the results in the current study.

An increase in power during 10 repetitions of half-squats followed by a set of completing set of half-squats to exhaustion was observed in male handball players following a five-day creatine supplementation period (Izquierdo et al., 2002). Similar to the current study, participants

were resistance trained. Supplementation involved consuming five grams of creatine monohydrate or a maltodextrin placebo four times daily, which was different from the supplementation protocol of four grams per day in the current study. A significant increase ($p < 0.01$) in the average power during 10 repetitions was demonstrated with 557 ± 107 W and 605 ± 123 W during pre-testing and post-testing, respectively, in the CM group. This increase in mean power was congruent with the increase in mean power in the CE group during 30 repetitions in the current study (157 ± 87 W and 186 ± 66.71 W from pre-testing to post-testing, respectively). No significant differences in power output were observed in the placebo between pre-testing and post-testing (Izquierdo et al., 2002).

Congruent to the current study where there were no significant differences in peak isokinetic torque at 60 deg/sec, no significant differences were observed in knee extension torque in 24 resistance-trained males following six weeks of supplementation with a multi-ingredient performance supplement (MIPS) (Ormsbee et al., 2012). Subjects in the MIPS group consumed supplementation consisting of whey protein, casein protein, branched-chain amino acids, beta alanine, caffeine, and creatine before and after workouts, and once daily on non-training days. However, subjects were required to adhere to a progressive resistance-training program utilizing 1-RM rep ranges from 70-90%. Subjects in the current study were asked to maintain their current resistance training habits.

There are limitations to the current study which could have affected the results and implications for the use of a creatine-electrolyte supplement. Although subjects were asked to continue with their resistance-training program, it is possible that some subjects may not have adhered to their resistance-training program due to outside circumstances. There is the possibility that some subjects may have detrained during the six-week study. It should also be noted that all

subjects in the current study had participated in doing bench press and barbell squat cluster-sets as part of the study protocol prior to performing the peak isometric torque, peak isokinetic torque, and a fatigue protocol test during both pre-testing and post-testing conditions. Due to the time frame of the testing protocols, there may not have been enough time for the subject to fully recover following the performance of cluster-sets involving squats. A third limitation is that there were a small number of subjects in each of the groups. Having a small number of subjects can reduce the statistical power of results that are obtained. This is especially relevant where the effect size was large but the p-value did not reach significance, as for the Fatigue Index in set one.

Summary

Six weeks of supplementation involving the combination of a creatine formula with electrolytes may be beneficial for increasing some aspects of athletic performance. The creatine-electrolyte group demonstrated an increase in peak isokinetic torque for knee extensions at 180 deg/sec from pre-testing to post-testing (164.04 ± 37.6 W and 196.69 ± 39.5 W, respectively). Likewise, an increase in the amount of work during the first set of 30 maximal knee extensor exercises from pre-testing to post-testing (157.9 ± 39.7 W and 186.0 ± 66.7 W, respectively) was performed, along with a greater amount of mean power from pre-testing to post-testing (2178.3 ± 488.1 W and 2485 ± 677.6 J) in the creatine-electrolyte group. The results from the current study are similar to some previous research that found similar results. The use of a creatine-electrolyte supplement may be beneficial for individuals who want to increase performance in activities involving short bouts of effort.

Chapter V

Summary, Conclusions, and Recommendations

Summary

This study investigated the effects of a creatine-electrolyte supplement on resistance training performance. The following dependent variables were examined: isometric knee extension and flexion torque, isokinetic knee extension torque at 60 deg/sec and 180 deg/sec, total work, mean power, and fatigue index. Subjects were randomly assigned to one of three groups: placebo, CM, or CE group. Subjects reported to the lab on two occasions for testing. Baseline measurements included the testing of body composition through skinfold measurements, body water analysis, diet analysis, isometric testing of both the knee flexors and extensors, isokinetic testing at 60 and 180 deg/sec for the knee extensors, and two sets of 30 maximal knee extensors separated with two minutes of recovery. There was a significant difference between the creatine monohydrate group and the creatine-electrolyte group for isokinetic torque of the knee extensors at 180 deg/sec during post-testing. There was a relatively larger increase for torque in the creatine-electrolyte group over the placebo group, with a slight decline in torque seen in the creatine monohydrate group. There was also a significant time effect for work and mean power for the creatine-electrolyte group during the first set of 30 maximal knee extension exercises. Another significant difference observed was the number of kilocalories expended for the placebo group compared to both the creatine monohydrate and creatine-electrolyte groups during both the pre-testing and post-testing. There was also a significant interaction with an increase in the amount of extra-cellular water in both the placebo group and creatine monohydrate group with a decrement in extra-cellular water in the creatine-electrolyte

group. No significant differences or interactions were observed in body composition, total body water, intra-cellular water, peak isometric knee extensor/flexor torque, peak knee extensor isokinetic torque at 60 deg/sec, fatigue index for both sets of 30 maximal knee extension along with total work done and power in the second set of maximal knee extensions.

Conclusions

Supplementation with a creatine-electrolyte substance may be beneficial for increasing performance in short duration activities lasting 10 seconds or less in resistance-trained individuals. Resistance-trained male and female athletes can use a creatine-electrolyte supplement to increase the amount of work along with increasing power for lower body exercises such as knee extensions. Since only leg extensions were examined in the current study, the results may not universally pertain to all lower body exercises. The fact that there were no significant improvements in total work done, mean power, and fatigue index during the second set of 30 maximal repetitions is indicative that future research should reexamine the effects of a creatine-electrolyte supplement on muscle fatigue along with other attributes of athletic performance.

Recommendations

Future research. The results from the current study suggests that a creatine-electrolyte supplement may be beneficial for certain aspects of athletic performance. Due to the limitations encountered in the current study along with no significant findings in many of the isometric and peak isokinetic torque variables, future research should consider re-examining the effects of a creatine-electrolyte supplement in a much larger sample. Future research could also focus on the effects of a creatine-electrolyte supplement in more diverse samples such as untrained

individuals, elderly, and individuals with certain pathologies to examine the potential benefits. With a larger sample group, along with controlling for the type of training subjects do during a supplementation period, the effects of creatine with an electrolyte component on strength, power, and fatigue index can be reexamined on both upper and lower body exercises across multiple sets.

Practical applications. Results from the current study suggested that a creatine supplement formulated with electrolytes may improve sports performance activities of durations of less than 10 seconds, particularly for the quadriceps muscle group, for resistance-trained individuals. Individuals, particularly those who are doing high volume sets of knee extensor exercise could take the supplement on a daily basis over a six-week period and monitor their results.

References

Adhihetty, P. J., Beal, M. F. (2008). Creatine and its potential therapeutic value for targeting cellular energy impairment in neurodegenerative diseases. *Neuromuscular Medicine, 10*(4), 275-290. doi:10.1007/s12017-008-8053-y

Aedma, M. Timpmann, S., Lätt, E., & Ööpik, V. (2015). Short-term creatine supplementation has no impact on upper-body anaerobic power in trained wrestlers. *Journal of the International Society of Sports Nutrition, 12*(1), 1-9. doi: 10.1186/s12970-015-0107-6

Allen, P. J. (2012). Creatine metabolism and psychiatric disorders: Does creatine supplementation have therapeutic value? *Neurscience and Biobehavioral Reviews, 36*(5), 1442-1462. doi:10.1016/j.neubiorev.2012.03.005

Allen, D. G., Lamb, G. D., & Westerblad, H. (2008). Skeletal muscle fatigue: Cellular mechanisms. *Physiological Reviews, 88*(1), 287-332. doi:10.1152/physrev.00015.2007

Alves, C. R., Santiago, B. M., Lima, F. R., Otaduy, M. C., Calich, A. L., Tritto, A. C., . . . Gualano, B. (2013). Creatine supplementation in fibromyalgia: A randomized, double-blind, placebo-controlled trial. *Arthritis Care & Research, 65*(9), 1449-1459. doi:10.1002/acr.22020

Antonio, J., & Ciccone, V. (2013). The effects of pre versus post workout supplementation of creatine monohydrate on body composition an strength. *Journal of the International Society of Sports Nutrition, 10*: 36. doi:10.1186/1550-2783-10-36

Baker, T., Candow, D. G., & Farthing, J. P. (2015). Effect of pre-exercise creatine ingestion on muscle performance in healthy aging males. *Journal of Strength & Conditioning Research.* Advance online publication. doi:10.1519/JSC.0000000000001254

Balsom, P., Söderlund, K., & Ekblom, B. (1994). Creatine in humans with special reference to creatine supplementation. *Sports Medicine, 18*(4), 268-280. doi:10.2165/00007256-199418040-00005

Beaver, W. L., Wasserman, K., & Whipp, B. J. (1985). Improved detection of lactate threshold during exercise using a log-log transformation. *Journal of Applied Physiology, 59*(6), 1936-1940.

Bosquet, L., Maquet, D., Forthomme, B., Nowak, N., Lehance., C., & Croisier, J. L. (2010). Effect of the lengthening of the protocol on the reliability of muscle fatigue indicators. *International Journal of Sports Medicine, 31*(2), 82-88. doi:10.1055/s-0029-1243168

Bottaro, M., Russo, A. F., & de Oliveira, R. J. (2005). The effects of rest interval on quadriceps torque during an isokinetic testing protocol in elderly. *Journal of Sports Science & Medicine, 4*(3), 285-290. doi:10.1249/00005768-200505001-01358

Brose, A., Parise, G., Tarnopolsky, M. A. (2003). Creatine supplementation enhances isometric strength and body composition improvements following strength exercise training in older adults. *Journals of Gerontology Series A: Biological Sciences & Medical, 58A*(1), B11. doi:10.1093/gerona/58.1.B11

Buford, T., Kreider, R., Stout, J., Greenwood, M., Campbell, B., Spano, M., . . . Antonio, J. (2007). International Society of Sports Nutrition position stand: Creatine supplementation

and exercise. *Journal of the International Society of Sports Nutrtion, 4*:6. doi:10.1186/1550-2783-4-6

Burke, D. G., Chilibeck, P. D., Parise, G., Candow, D. G., Mahoney, D., & Tarnopolsky, M. (2003). Effect of creatine and weight training on muscle creatine and performance in vegetarians. *Medicine and science in sports and exercise*, *35*(11), 1946-1955.

Casey, A., Constantin-Teodosiu, D., Howell, S., Hultman, E., Greenhaff, P. L. (1996). Creatine ingestion favorably affects performance and muscle metabolism during maximal exercise in humans. *American Journal of Physiology – Endocrinology and Metabolism, 271*(1), E31-E37.

Chwalbiñska-Moneta, J. (2003). Effect of creatine supplementation on aerobic performance and anaerobic capacity in elite rowers in the course of endurance training. *International Journal of Sports Nutrition and Exercise Metabolism, 13*(2), 173-183.

Cooper, R., Naclerio, F., Allgrove, J., & Jimenez. (2012). Creatine supplementation with specific view to exercise/sports performance: An update. *Journal of the International Society of Sports Nutrition, 9*(1):33. doi:10.1186/1550-2783-9-33

Corin, G., Strutton, P. H., & McGregor, A. H. (2005). Establishment of a protocol to test fatigue of the trunk muscles. *British Journal of Sports Medicine, 39*, 731-735. doi:10.1136/bjsm.2004.015537

Cornelissen, V. A., Defoor, J. G., Stevens, A., Schepers, D., Hespel, P., Decramer, M., . . . Vanhees, L. (2010). Effect of creatine supplementation as a potential adjunct therapy to

exercise training in cardiac patients: A randomized controlled trial. *Clinical Rehabilitation, 24*(11), 988-999. doi:10.1177/0269215510367995

Cribb, P. J., Williams, A. D., & Hayes, A. (2007). A creatine-protein-carbohydrate supplement enhances responses to resistance training. *Medicine & Science in Sports & Exercise, 39*(11), 1960-1968. doi:10.1249/mss.0b013e31814fb52a

Dabidi Roshan, V., Babaei, H., Hosseinzadeh, M., & Arendt-Nielson, L. (2013). The effect of creatine supplementation on muscle fatigue and physiological indices following intermittent swimming bouts. *Journal of Sports Medicine and Physical Fitness, 53*(3), 232-239.

D'Antona, G., Nabavi, S. M., Micheletti, P., Di Lorenzo, A., Aquilani, R., Nisoli, E., Rondanelli, M., & Daglia, M. (2014). Creatine, L-carnitine, and ω3 polyunsaturated fatty acid supplementation from healthy to diseased skeletal muscle. *BioMed Research International, 2014*, 613890. doi:10.1155/2014/613890

Deldicque, L., Décombaz, J., Zbinden Foncea, H., Vuichoud, J., Poortmans, J. R., & Francaux, M. (2008). Kinetics of creatine ingested as a food ingredient. *Europlean Journal of Applied Physiology, 102*(2), 133-143. doi:10.1007/s00421-007-0558-9

de Salles Painelli, V., Alves, V. T., Ugrinowitsch, C., Benatti, F. B., Artioli, G. G., Lancha Jr, A. H., . . . Roschel, H. (2014). Creatine supplementation prevents acute strength loss induced by concurrent exercise. *European Journal of Applied Physiology, 114*(8), 1749-1755. doi:10.1007/s00421-014-2903-0

Earnest, C. P., Snell, P. G., Rodriguez, R., Almada, A. L., & Mitchell, T. L. (1995). The effect of creatine monohydrate ingestion on anaerobic power indices, muscular strength and body

composition. *Acta Physiologica Scandinavica, 153*(2), 207-209. doi:10.1111/j.1748-1716.1995.tb09854.x

Eckerson, J. M., Stout, J. R., Moore, G. A., Stone, N. J., Nishimura, K., & Tamura, K. (2004). Effect of two and five days of creatine loading on anaerobic working capacity in women. *The Journal of Strength & Conditioning Research, 18*(1), 168-173. doi:10.1519/00124278-200402000-00025

Ellington, W. R. (1989). Phosphocreatine represents a thermodynamic and functional improvement over other muscle phosphagens. *Journal of Experimental Biology, 143*, 177-194.

Englehardt, M., Neumann, G., Berbalk, A., & Reuter, I. (1998). Creatine supplementation in endurance sports. *Medicine & Science in Sports & Exercise, 30*(7), 1123-1129.

Fenn, W. O., & Marsh, B. S. (1935). Muscular force at different speeds of shortening. *The Journal of Physiology, 85*(3), 277-297. doi:10.1113/jphysiol.1935.sp003318

Gaitanos, G. C., Williams, C., Boobis, L. H., & Brooks, S. (1993). Human muscle metabolism during intermittent maximal exercise. *Journal of Applied Physiology, 75*(2), 712-719.

Gautrey, C., Mitchell, A., & Watson, T. (2013). The effect of isokinetic testing speed on the reliability of muscle fatigue indicators during a hip abductor-adductor fatigue protocol. *International Journal of Sports Medicine, 34*(7), 646-653. doi:10.1055/s-0032-1321801

Gilliam, J. D., Hohzorn, C., Martin, D., & Trimble, M. H. (2000). Effect of oral creatine supplementation on isokinetic torque production. *Medicine & Science in Sports & Exercise, 32*(5), 993-996. doi:10.1097/00005768-200005000-00017

Gleeson, N. P., & Mercer, T. H. (1996). The utility of isokinetic dynamometry in the assessment of human muscle function. *Sports Medicine, 21*(1), 18-34. doi:10.2165/00007256-199621010-00003

Gotshalk, L. A., Volek, J. S., Staron, R. S., Denegar, C. R., Hagerman, F. C., & Kraemer, W. J. (2002). Creatine supplementation improves muscular performance in older men. *Medicine and Science in Sports and Exercise, 34*(3), 537-543. doi:10.1097/00005768-200203000-00023

Greenhaff, P. L., Bodin, K., Soderlund, K., & Hultman, E. (1994). Effect of oral creatine supplementation on skeletal muscle phosphocreatine resynthesis. *American Journal of Physiology – Endocrinology and Metabolism, 266*(5), E725-E730.

Greenhaff, P. L., Casey, A., Short, A. H., Harris, R., Soderlund, K., & Hultman, E. (1993). Influence of oral creatine supplementation of muscle torque during repeated bouts of maximal voluntary exercise in man. *Clinical Science, 84*(5), 565-571. doi:10.1042/cs0840565

Greenhaff, P. L., Nevill, M. E., Soderlund, K., Bodin, K., Boobis, L. H., Williams, C., & Hultman, E. (1994). The metabolic responses of human type I and II muscle fibres during maximal treadmill sprinting. *The Journal of Physiology*, *478*(Pt 1), 149–155.

Harris, R. C., Söderlund, K., & Hultman, E. (1992). Elevation of creatine in resting and exercised muscle of normal subjects by creatine supplementation. *Clinical Science, 83*(3), 367-374. doi:10.1042/cs0830367

Hass, C. J., Collins, M. A., & Juncos, J. L. (2007). Resistance training with creatine monohydrate improves upper-body strength in patients with Parkinson disease: A randomized trial. *Neurorehabilitation and Neural Repair, 21*,2, 107-115. doi:10.1177/1545968306293449

Hickner, R. C., Dyck, D. J, Sklar, J., Hatley, H., & Byrd, P. (2010). Effect of 28 days of creatine ingestion on muscle metabolism and performance of a simulated cycling road race. *Journal of the International Society of Sport Nutrition, 7*: 26. doi:10.1186/1550-2783-7-26

Hultman, E., Soderlund, K., Timmons, J. A., Cederblad, G., & Greenhaff, P. L. (1996). Muscle creatine loading in men. *Journal of Applied Physiology, 81*(1), 232-237.

Interactive Online BIA (n.d.). Retrieved from http://www.rjlsystems.com/interactive-online-bia/

Izquierdo, M., Ibañez, J., González-Badillo, J. J., & Gorostiaga E. M. (2002). Effects of creatine supplementation on muscle power, endurance, and sprint performance. *Medicine and Science in Sports and Exercise. 34*(2), 332-343.

Jäger, R., Harris, R. C., Purpura, M., & Francaux, M. (2007). Comparison of new forms of creatine in raising plasma creatine levels. *Journal of the International Society of Sports Nutrition, 4*(1):17. doi:10.1186/1550-2783-4-17

Jäger, R., Purpura, M, Shao, A., Inoue, T., & Kreider, R. B. (2011). Analysis of the efficacy, safety, and regulatory status of novel forms of creatine. *Amino Acids, 40*(5), 1369-1383. doi:10.1007/s00726-011-0874-6

Keeton, B. R., & Binder-Macleod, S. A. (2006). Low-frequency fatigue. *Physical Therapy, 86*(8), 1146-1150.

Kim, H. J., Kim, C. K., Carpentier, A., & Poortmans, J. R. (2011). Studies on the safety of creatine supplementation. *Amino Acids, 40*(5), 1409-1418. doi:10.1007/s00726-011-0878-2

Kirksey, B., Stone, M. H., Warren, B. J., Johnson, R. L., & Stone, M. E. (1999). The effects of 6 weeks of creatine monohydrate supplementation on performance measures and body composition in collegiate track and field athletes. *Journal of Strength and Conditioning Research, 13*(2), 148-156. doi:10.1519/1533-4287(1999)013%3C0148:TEOWOC%3E2.0.CO;2

Knuttgen, H., Kraemer, W. J. (1987). Terminology and measurement in exercise performance. *The Journal of Strength and Conditioning Research, 1*(10), 1-10. doi:10.1519/00124278-198702000-00001

Koshy, K. M., Griswold, E., & Schneeberger, E. E. (1999). Interstitial nephritis in a patient taking creatine. *The New England Journal of Medicine, 340*, 814-815. doi:10.1056/NEJM199903113401017

Lanhers, C., Pereira, B., Naughton, G., Trousselard, M., Lesage, F., & Dutheil, . (2015). Creatine supplementation and lower limb strength performance: A systematic review and meta-analysis. *Sports Medicine, 45*(9), 1285-1294. doi:10.1007/s40279-015-0337-4

Lee, J. C., Kim, J. Y., & Park, G. D. (2013). Effect of 12 weeks of accelerated rehabilitation exercise on muscle function of patients with ACL reconstruction of the knee joint. *Journal of Physical Therapy Science, 25*(12), 1595-1599. doi:10.1589/jpts.25.1595

Li, R. C., Wu, Y., Maffulli, N., Chan, K. M., & Chan, J. L. (1996). Eccentric and concentric isokinetic knee flexion and extension: A reliability study using the Cybex 6000 dynamometer. *British Journal of Sports Medicine, 30*, 156-160. doi:10.1136/bjsm.30.2.156

Lopez, R. M., Casa, D. J., McDermott, B. P., Ganio, M. S., Armstrong, L. E., & Maresh, C. M. (2009). Does creatine supplementation hinder exercise heat tolerance or hydration status? A systematic review with meta-analyses. *Journal of Athletic Training, 44*(2), 215-223. doi:10.4085/1062-6050-44.2.215

McBreairty, L. E., Robinson, J. L., Furlong, K. R., Brunton, J. A., & Bertolo, R. F. (2015). Guanidinoacetate is more effective than creatine at enhancing tissue creatine stores while consequently limiting methionine availability in yucatan miniature pigs. *PLoS ONE, 10*(6), 1-11. doi:10.1371/journal.pone.0131563

Metzl, J. D., Small, E., Levine, S. R., & Gershel, J. C. (2001). Creatine use among young athletes. *Pediatrics, 108*(2), 421-425. doi:10.1542/peds.108.2.421

Mujika, I., Padilla S., Ibanez, J., Izquierdo, M., & Gorostiaga, E. (2000). Creatine supplementation and sprint performance in soccer players. *Medicine & Science in Sports & Exercise, 32*(2), 518-525. doi:10.1097/00005768-200002000-00039

National Institutes of Health, U.S. National Library of Medicine, MedlinePlus. (2013). *Electrolytes.* Retrieved February 18, 2016, from https://www.nlm.nih.gov/medlineplus/ency/article/002350.htm

Nelson, A. G., Day, R., Glickman-Weiss, E. L., Hegsted, M., Kokkonen, J., & Sampson, B. (2000). Creatine supplementation alters the response to a graded cycle ergometer test. *European Journal of Applied Physiology, 83*(1), 89-94. doi:10.1007/s004210000244

Okudan, N, Belviranli, M., Pepe, H, & Gökbel, H. (2015). The effects of beta alanine plus creatine administration on performance during repeated bouts of supramaximal exercise in sedentary men. *The Journal of Sports Medicine and Physical Fitness, 55*(11), 1322-1328.

Okudan, N., & Gokbel, H. (2005). The effects of creatine supplementation on performance during the repeated bouts of supramaximal exercise. *The Journal of Sports Medicine and Physical Fitness, 45*(4), 507-511.

Oliver, J. M., Joubert, D. P., Martin, S. E., & Crouse, S. F. (2012). Oral creatine supplementation's decrease of blood lactate during exhaustive, incremental cycling. *International Journal of Sport Nutrition and Exercise Metabolism, 23*(3), 252-258.

Ormsbee, M. J., Mandler, W. K., Thomas, D. D., Ward, E. G., Kinsey, A. W., Simonavice, E., . . . Kim, J. S. (2012). The effects of six weeks supplementation with multi-ingredient performance supplements and resistance training on anabolic hormones, body composition, strength, and power in resistance-trained men. *Journal of the International Society of sports Nutrition, 9*(1), 49. doi:10.1186/1550-2783-9-49.

Parcell, A. C., Sawyer, R. D., Tricoli, V. A., & Chinevere, T. D. (2002). Minimum rest period for strength recovery during a common isokinetic testing protocol. *Medicine & Science in Sports & Exercise, 34*(6), 1018-1022. doi:10.1097/00005768-200206000-00018

Pearson, D. R., Hamby, D. G., Russel, W., & Harris, T. (1999). Long-term effects of creatine monohydrate on strength and power. *Journal of Strength and Conditioning Research, 13*(3), 187-192. doi:10.1519/00124278-199908000-00001

Pescatello, L. S. (2014). ACSM's Guidlines for Exercise Testing and Prescription (9th ed.). Baltimore: Wolters Kluwer/Lippincott Williams & Wilkins.

Pline, K., & Smith, C. (2005). The effect of creatine intake on renal function. *Annals of Pharacotherapy, 39*(6), 1093-1096. doi:10.1345/aph.1E628

Polyviou, T. P., Pitsiladis, Y. P., Celis-Morales, C., Brown, B., Speakman, J. R., & Malkova, D. (2015). The effects of hyperhydrating supplements containing creatine and glucose on plasma lipids and insulin sensitivity in endurance-trained athletes. *Journal of Amino Acids, 2015*, 1-8. doi:10.1155/2015/352458

Pritchard, N. R., & Kalra, P. A. (1998). Renal dysfunction accompanying oral creatine supplements. *Lancet, 351*(9111), 1252-1253. doi:0.1016/S0140-6736(05)79319-3

Raluca-loana, S., & Rahel, B. (2003). Determination of creatine and creatinine using a diamond paste based electrode. *Instrumentation Science & Technology, 31*(2), 183-188.

Rassier, D. E., & Macintosh, B. R. (2000). Coexistence of potentiation and fatigue in skeletal muscle. *Brazilian Journal of Medical and Biological Research, 33*(5), 499-508. doi:10.1590/S0100-879X2000000500003

Rawson, E. S., & Clarkson, P. M. (2000). Creatine supplementation: The athlete's friend or foe? *International Sportmed Journal 1*(1), 1-4.

Rawson, E. S., & Persky, A. M. (2007). Mechanisms of muscular adaptations to creatine supplementation. *International SportMed Journal, 8*(2), 43-53.

Reeder, J. R., Kazubinski, K., Foreman, A., Crauthers, M., & Lockard, M. (2013). Effect of creatine supplementation on time to fatigue in the anaerobic Wingate test. *International Journal of Exercise Science: Conference Proceedings, 8*(1), 13.

Rothstein, J. M., Lamb, R. L., & Mayhew, T. P. (1987). Clinical uses of isokinetic measurments. Critical issues. *Physical Therapy, 67*(12), 1840-1844.

Sahlin, K. (2014). Muscle energetics during explosive activities and potential effects of nutrition and training. *Sports Medicine, 44*(Suppl 2), 167-173. doi:10.1007/s40279-014-0256-9

Sasaki, K., & Ishii, N. (2005). Shortening velocity of human triceps surae muscle measured with the slack test in vivo. *The Journal of Physilogy, 567*(Pt 3), 1047-1056. doi:10.1113/jphysiol.2005.091124

Schilling, B., Stone, M., Utter, A., Kearney, J., Johnson, M., Coglianese, R., . . . Stone, M. E. (2001). Creatine supplementation and health variables: A retrospective study. *Medicine & Science in Sports & Exercise, 33*(2), 183-188. doi:10.1097/00005768-200102000-00002

Schillings, M. L., Hoefsloot, W., Stegeman, D. F., & Zwarts, M. J. (2003). Relative contributions of central and peripheral factors to fatigue during a maximal sustained effort. *European Journal of Applied Physiology, 90*(5), 562-568. doi:10.1007/s00421-003-0913-4

Selsby, J. T., DiSilvestro, R. A., & Devor, S. T. (2004). Mg2+- creatine chelate and low-dose creatine supplementation regimen improve exercise performance. *Journal of Strength and Conditioning Research, 18*(2), 311-315. doi:10.1519/R-13072.1

Skare, O. C., Skadberg, Ø, & Wisnes, A. R. (2001). Creatine supplementation improves sprint performance in male sprinters. *Scandinavian Journal of Medicine & Science in Sports, 11*, 96-102. doi:10.1034/j.1600-0838.2001.011002096.x

Smith, R. N., Agharkar, A. S., & Gonzales, E. B. (2014). A review of creatine supplementation in age-related diseases: More than a supplement for athletes. *F1000 Research, 3*, 222. doi:10.12688/f1000research.5218.1

Smith, J. C., & Hill, D. W. (1991). Contribution of energy systems during a Wingate power test. *British Journal of Sports Medicine, 25*(4), 196-199. doi:10.1136/bjsm.25.4.196

Snow, R. J., & Murphy, R. M. (2001). Creatine and the creatine transporter: A review. *Molecular and Cellular Biochemistry, 224*, 169-181.

Söderlund, K., Greenhaff, P. L., & Hultman, E. (1992). Energy metabolism in type I and type II human muscle fibres during short term electrical stimulation at different frequencies. *Acta Physiologica, Scandinavica, 144*(1), 15-22. doi:10.1111/j.1748-1716.1992.tb09262.x

Spillane, M., Schoch, R., Cooke, M., Harvey, T., Greenwood, M., Kreider, R., & Willoughby, D. S. (2009). The effects of creatine ethyl ester supplementation combined with heavy resistance training on body composition, muscle performance, and serum and muscle creatine levels. *Journal of the International Society of Sports Nutrition, 6*, 6. doi:10.1186/1550-2783-6-6

Stone, M. H., Sanborn, K., Smith, L. L., O'Bryant, H. S., Hoke, T., Utter, A. C., . . . Garner, B. (1999). Effects of in-season (5 weeks) creatine and pyruvate supplementation on anaerobic

performance and body composition in American football players. *International Journal of Sports Nutrition, 9*(2), 146-165.

Syrotuik, D. G., & Bell G. J. (2004) Acute creatine monohydrate supplementation: A descriptive physiological profile of responders vs. nonresponders. *The Journal of Strength & Conditioning Research 18*(3), 610-617.

Tarnopolsky, M. A., MacLennan, D. P. (2000). Creatine monohydrate supplementation enhances high-intensity exercise performance in males and females. *International Journal of Sports Nutrition and Exercise Metabolism, 10*(4), 452-463.

Tarnopolsky, M., & Martin, J. (1999). Creatine monohydrate increases strength in patients with neuromuscular disease. *Neurology, 52*(4), 854-857. doi:10.1212/WNL.52.4.854

Terjung, R. L, Clarkson, P., Eichner, E. R., Greenhaff, P. L., Hespel, P. J., Israel, R. G., . . . Williams, M. H. (2000). American College of Sports Medicine roundtable. The physiological and health effects of oral creatine supplementation. *Medicine & Science in Sports & Exercise, 32*(3), 706-717.

Thorstensson, A., & Karlsson, J. (1976). Fatiguability and fibre composition of human skeletal muscle. *Acta Physiologica Scandinavica, 98*(3), 318-322. doi:10.1111/j.1748-1716.1976.tb10316.x

van Loon, L. J., Oosterlaar, A. M., Hartgens, F., Hesselink, M. K., Snow, R. J., & Wagenmakers, A. J. (2003). Effects of creatine loading and prolonged creatine supplementation on body composition, fuel selection, sprint and endurance performance in humans. *Clinical Science, 104*(2), 153-162. doi:10.1042/cs1040153

Volek, J. S., Kraemer, W. J., Bush, J. A., Boetes, M., Incledon, T., Clark, K. L., & Lynch, J. M. (1997). Creatine supplementation enhances muscular performance during high-intensity resistance exercise. *Journal of the American Dietetic Association, 97*(7), 765-770. doi:10.1016/S0002-8223(97)00189-2

Watson, G., Casa, D. J., Fiala, K. A., Hile, A., Roti, M. W., Healey, J. C., . . . Maresh, C. M. (2006). Creatine use and exercise heat tolerance in dehydrated men. *Journal of Athletic Training, 41*(1), 18-29.

Willoughby, D. S., & Rosene, J. (2001). Effects of oral creatine and resistance training on myosin heavy chain expression. *Medicine & Science in Sports & Exercise, 33*(10), 1674-1681. doi:10.1097/00005768-200110000-00010

Woods, S., Bridge, T., Nelson, D., Risse, K., & Pincivero, D. M. (2004). The effects of rest interval length on ratings of perceived exertion during dynamic knee extension exercise. *Journal of Strength and Conditioning Research, 18*(3), 540-545. doi:10.1519/00124278-200408000-00026

Wright, G. A., Grandjean, W. P., & Pascoe, D. D. (2007). The effects of creatine loading on thermoregulation and intermittent sprint exercise performance in a hot humid environment. *Journal of Strength and Conditioning Research, 21*(3), 655-660. doi:10.1519/00124278-200708000-00002

Zuniga, J. M., Housh, T. J., Camic, C. L., Hendrix, C. R., Mielke, M., Johnson, G. O., . . . Schmidt, R. J. (2012). The effects of creatine monohydrate loading on anaerobic performance and one-repetition maximum strength. *Journal of Strength and Conditioning Research, 26*(6), 1651-1656. doi:10.1519/JSC.0b013e318234eba1

Appendix A

Informed Consent

Western Washington University
Health and Human Development Department

Consent to Take Part in a Research Study

Project: Effect of a Multi-ingredient Performance Supplement (MIPS) and Simple Creatine on Fatigue and Cluster-Set Velocity in Resistance-Trained Subjects

You are invited to participate in a study investigating the effects of a multi-ingredient performance supplement (MIPS), containing creatine and electrolytes (like those in a sports drink), standard creatine monohydrate (most common creatine form used) and placebo on fatigue and lift velocity in weight-trained subjects. To improve upon past studies, this analysis aims to objectively evaluate a soluble creatine supplement versus creatine or placebo on fatigue and lift velocity in an athletic population. The results of this study will enhance our understanding of this supplement and how it may affect physical performance.

I UNDERSTAND THAT:

1. This experiment will begin with measurement of height, weight, body fat by skinfold assessment, and body water determination using a bio-impedance unit. Height will be measured with a stadiometer and weight with a standard physician's balance beam scale. Body composition assessment will be completed using skinfold measurements taken at three anatomical locations. The three sites used for male subjects will be on the chest, back of the arm, and upper back. Female subjects will have skinfold measurements taken on the back of the arm, over the hip, and abdomen. For determining total body water, an impedance device is used. For this test, you will lie on a table and have electrodes attached to your wrists and ankles. It takes less than a minute, and then the electrodes are removed. My participation for these tests will be approximately 30 minutes. Height, weight, total body water, and body composition will be determined during pre- and post-testing.

2. Supplementation will be either treatments (creatine and electrolytes, like those in a sports drink or creatine monohydrate, the standard creatine used by consumers) or placebo (sugar, specifically maltodextran) for 6 weeks in a blinded fashion. Blinded is that neither the subject nor the researcher providing the numbered supplement will know whether the supplement is the treatment or placebo until the end of the 6-week period. Each week, the packet for that week will be picked up at the lab. For this study, consistent dietary and exercise programs should be maintained. During the first and sixth week of supplementation, I will keep a 3-day diet record and 3-day physical activity record that will be submitted for analysis.

3. All subjects will undergo pre- and post-supplementation testing sessions to assess muscle fatigue and lift velocity during a cluster set protocol, which allows determined rest

intervals within the set of repetitions. Maximum torque and a fatigue protocol results will be determined using a Biodex System 4 (Biodex Medical Systems Inc., Shirley, NY) isokinetic dynamometer. A general warm-up will be performed for 5 minutes using a cycle ergometer with no resistance added. All tests on the Biodex will be performed with the dominant leg. You will sit on the dynamometer's chair as proper adjustments are made, the back of the seat will be adjusted and the length of the dynamometer's arm will be properly fitted to the length of the shank (area between knee and ankle).

Your body will be stabilized with two shoulder straps, a waist strap, and a thigh strap, to reduce extraneous movements. Once in proper position, you will be instructed to perform a task-specific warm-up, consisting of a concentric/concentric knee extension/flexion, followed by a 30 second rest at the original starting position.

Maximal knee extension isokinetic torque measurement will determined. Isometric maximal voluntary contraction torque for both knee extension and flexion will be collected. Three trials for a given condition will be performed. A two minute resting period will be allowed between trials. Peak torques will be determined during this test and during a subsequent test of maximal isometric muscle action. Rest intervals will be allowed until you indicate that you are fully recovered. After the completion of three attempts for each of the conditions, you will perform a cool down for 5 minutes on cycle ergometer, at an easy pace, with no resistance added.

The fatigue test will require you to perform 30 maximal isokinetic knee extension repetitions. The absolute torque reduction through the trial, from peak maximal torque to subsequent minimum peak torque. The total work done during fatigue trial will be determined. There will be 2 minutes of rest before performing a second set of 30 repetitions. You will then perform a cool down for 5 minutes on cycle ergometer, at an easy pace, with no resistance added.

On a separate day, estimated one repetition maximums (1RM) for the squat and bench press will be determined according to the National Strength and Conditioning Association (NSCA) testing procedures. A three repetition maximum will be determined, than the O'Conner formula used to estimate the 1RM. You will perform a pre and post cluster set test for both the parallel back squat and bench press exercises. The load for each exercise will be 80% of the 1RM. The test includes four total clusters, with each cluster being comprised of two sets of five repetitions. Rest provided will be 1.5 minutes between clusters and 30 seconds between each sub-set. Average velocity for each repetition will be measured using an arm band accelerometer (PUSH, Toronto, Canada) placed on the right forearm. Data is transmitted and collected with the PUSH Assist application (PUSH, Toronto, Canada). The outcome measure will be the change in average mean velocities (m/s).

4. There may be risks during the fatigue and velocity tests but this will be minimized with a spotter. I understand that exercise can lead to muscular soreness, cramping, pain, and

fatigue. During testing, there is a risk of experiencing muscle soreness that should disappear after a period of rest. I understand that if exercise testing is painful, I can stop at any time. In addition, I am aware that I could experience delayed onset muscle soreness (DOMS) after the session that could last for 24-72 hours. The safeguards that will be used minimize potential muscle soreness include a warm-up, acclimation, and cool down period. If I feel like I cannot or should not perform any of these tasks, I could opt out from the participation in this study.

5. Possible benefits include that subjects may be have performance benefits associated with supplementation. The results of this study may aid in future research.

6. There is twenty dollars ($20) compensation for my participation in the complete project: supplementation, pre- and post-testing. My participation is voluntary, I may choose to withdraw my consent and discontinue participation without penalty.

7. All information collected is confidential. My signed consent form will be kept in a locked cabinet separate from the data collection forms for the project data. My name will not be associated with any of my data collected throughout the study.

8. My signature on this form does not waive my legal rights of protection.

9. Any questions you may have regarding the study procedures will be answered by the primary researchers (Dave Suprak, Lorrie Brilla,) who can be contacted at Dave.Suprak@wwu.edu (360-650-2586) or Lorrie.Brilla@wwu.edu (360-650-3056). Any questions about your rights as a research subject should be directed to Janai Symons, the WWU Research Compliance Officer (RCO), 360-650-3082. If any injury or adverse effect of this research is experienced you should contact Lorrie Brilla, Dave Suprak, or the RCO.

♦♦

I have read the above descriptions and agree to participate in this study.

______________________________________ ____________________

Participant's Signature Date

____

Participant's PRINTED NAME

Appendix B

Human Subjects Activity Review Form

Human Subjects Activity Review

1. What is your research question, or the specific hypothesis?

The hypothesis is that there will be a difference in fatigue, total work, and average velocity of movement in repeated bout activities between the multi-ingredient supplement (creatine and electrolytes), standard creatine monohydrate supplement (creatine monohydrate), and placebo (carbohydrate solution) condition. It is specifically hypothesized that the supplementation conditions will result in a greater difference in:

- the rate of fatigue and total work on an isokinetic dynamometer for two sets of 30 repetitions with 2 minutes rest between sets;
- for bench press and squat, and total work performed at 80% 1RM average velocity for each repetition when comparing four total clusters, with each cluster being comprised of two sets of five repetitions, and rest provided for 1.5 minutes between clusters and 30 seconds between each sub-set.

2. What are the potential benefits of the proposed research to the field?

Fifty years ago, Gatorade, an original multi-ingredient performance supplement was developed, a combination of carbohydrate and electrolytes. The standard sports drinks contain 4–8% carbohydrate, 10–30 mmol/L sodium, and 3–5 mmol/L potassium [1]. Other electrolytes or protein may also be included in sports drinks formulations. Sports drinks were the original prototype of multi-ingredient performance supplements (MIPS). Much recent research has been reported with various combinations of MIPS, complex mixes of nutrients with the common factor being creatine [2-8].

One of the most popular and widely researched natural supplements is creatine, which has been extensively studied since the 1990's for performance enhancement and has been quite well supported. Creatine has been assigned group A level of supporting evidence by the Australian Institute of Sport [1]. Many aspects of creatine supplementation have been reported [9-24]. Increases in body weight, both lean body mass [9- 13, 15, 17, 18] and body water [17, 21], are common findings. Training and supplementation elicits improvements in muscle strength [9, 11, 12, 14-17, 19, 23] and power [13-17, 20]. When effect size was calculated in a meta-analysis on creatine supplementation, there were greater effects for upper body, repetitive-bout laboratory-based exercise tasks lasting < 30 seconds versus lower body, single-bout, field studies, or longer duration physical activity [10]. There were no effects between males and females nor training status.

The benefits of creatine supplementation are well documented, particularly during repeated bouts of high-intensity muscular activity. However, most research evaluating the effects of creatine involves use of Wingate testing for determining anaerobic peak and mean power plus rate of fatigue [25-33]. The Wingate test shows mixed results in response to short-term creatine supplementation, but is mostly positive, especially in rate of fatigue and repeated bouts. It has been suggested that the mixed results may be an artifact due to not accounting for flywheel inertia [28]. When corrected, non-significant results became statistically significant. Some research has observed outcomes with graded exercise testing, including maximal oxygen consumption and anaerobic threshold [34-39]. The main outcomes were no changes in maximal oxygen consumption. However, creatine supplementation can alter the contributions of the different metabolic systems. Thus, the body is able to perform the sub-maximal workloads at a lower oxygen cost with a concomitant reduction in the work performed by the cardiovascular system. Ventilatory anaerobic threshold does show improvement [35, 38, 39]. Newer technology may allow assessment of cycling propulsive power. Instrumented bicycle pedals

for dynamic measurement of propulsive cycling loads are available that may give the sensitivity necessary to determine changes in power [40-42].

The mechanism best supporting creatine effects is the increased intramuscular creatine concentration and restoration. The ergogenic effect is related to an increase in temporal and spatial buffering of ATP and to increased muscle buffer capacity [24]. Different formulations of creatine supplementation have been studied, with no appreciable differences in outcomes [15-17]. Recently, formulations have been developed to improve aqueous solubility, gastrointestinal permeability, and ultimately the outcomes associated with creatine [43]. Permeability was improved across Caco-2 human epithelial cell monolayers. This type of formulation has potential for improved oral absorption of creatine, and may enhance bioavailability, and therefore performance outcomes.

The purpose of this project is to assess performance outcomes in response to six weeks of a multi-ingredient performance supplement, which includes creatine and electrolytes. The project will determine effects in resistance trained subjects during typical weight training and power activities: weight lifting and countermovement vertical jump. Additionally, body composition and total body water will be appraised.

3. What are the potential benefits, if any, of the proposed research to the subjects?

The benefit of this research is that subjects' supplementation may positively impact physical performance. The results of this study may aid in directing future research.

4. Answer a), then answer either b) or c) as appropriate.

a. Describe how you will identify the subject population, and how you will contact key individuals who will allow you access to that subject population or database.

The sample will consist of men and women volunteers from Western Washington University, with no musculoskeletal impairment or injury, and who have been weight training regularly for the past six months. Flyers will be posted in Wade King Student Rec Center and in Ridgeway Lounge (current location of strength equipment for Athletics). We will obtain consent to post flyers. This method of recruitment has been used frequently in the past.

b. Describe how you will recruit a sample from your subject population, including possible use of compensation, and the number of subjects to be recruited.

For this study, 54 women and men will be recruited to participate. The first 54 will be invited to participate, with the remainder on a waitlist, if needed. Inclusion for this study demands that subjects be free of any musculoskeletal impairment or injury, and who have been weight training regularly for the past six months. Participants in this study will be compensated twenty dollars for their full participation.

OR

c. Describe how you will access preexisting data about the subjects.

N/A

5. Briefly describe the research methodology. Attach copies of all test instruments/questionnaires that will be used.

Description of the Study Population

The study sample will consist of fifty-four apparently healthy, recreationally active participants for standard creatine supplementation (Cr), multi-ingredient performance supplementation (MIP) and placebo (P), a carbohydrate solution. The multi-ingredient performance supplement contains creatine and electrolytes, sodium, potassium, calcium, and magnesium. Subjects will have weight training experience for the last 6 months. Subjects will be chosen randomly based on their volunteer responses to flyers posted around Western Washington University (WWU) campus. Subjects will be randomly assigned to three groups, placebo, Cr, and a multi-ingredient performance supplement, which includes creatine. Prerequisite to participation, each subject receives an informed consent form previously approved by the institution's Human Subjects Committee. Subjects who had supplemented creatine in their habitual diet within the 60 days prior to orientation or any who were suffering from any kidney, liver, or endocrine disease or any disorder that might affect normal cellular levels of creatine or fluid balance (or both) will be excluded. The medical history questionnaire will filter any subjects taking any substance classified as a diuretic other than caffeine in their habitual diet. Subjects will be instructed to keep exercise regimens consistent throughout the study with continued participation in their weight training. Training logs will be maintained to confirm compliance. If a subject misses more than three supplement days, they will be dropped from the study.

Procedures and Instrumentation

The baseline and posttest data included: height, measured by stadiometer, weight, using a balance beam scale, body water by bioelectrical impedance (BIA), body composition with air displacement plethysmography (ADP), physical activity profile, and specific tests described below. These measures will be repeated at the end of the study.

Diet and Supplementation: The diet analysis aids in description of the study sample. Two separate 3-day diet records will be kept by the subjects and the records will be analyzed using Nutritionist Pro software (Axxya Systems, Stafford, TX). From this data, nutrient and energy levels will be determined. Supplementation will be given orally and provided by the manufacturer, with placebo appearance identical. Subjects will be randomly assigned to groups (treatment, hence supplemented [S] with creatine and electrolytes similar to a sports drink and placebo [P] which is a carbohydrate solution), and these will be administered in a double blind fashion. The treatment period will be six weeks to allow for tissue saturation.

Body Water: Total body water (TBW) and both intracellular and extracellular fluid compartments (ICF and ECF) will be determined with an RJL Quantum X bioimpedance unit. Electrodes will be placed on the right upper and lower extremities, at approximately the wrist and the third metacarpal plus the ankle and third metatarsal, respectively. This tool has been used to assess TBW and volume of body water compartments, with good reliability and validity [44-46]. The subjects will refrain from exercise for at least 12 hours prior to testing. For a full twenty four hours before body water testing, subjects will maintain hydration. All tests will be completed at the same time of day for each subject.

Body Composition: Body composition (i.e. percent body fat, fat free mass, and fat mass) will be assessed using a three-site skinfolds measurement technique. The measurement of skinfold thickness

is a valid and reliable method for assessing body composition [67]. The same investigator will conduct all skinfold measurements. Male and female subjects will be assessed by use of a three site skinfold test, which will provide the researchers with an estimate of the subject's body density. The three sites used for male subjects will be the chest, triceps, and subscapular skinfolds. Female subjects will have skinfold measurements taken at the triceps, suprailiac, and abdomen. The sum of the three skinfold measurements will be entered into an age and race appropriate equation to estimate body density [68]. Once the subject's body density has been estimated, a subsequent equation (Siri) will be used to estimate body composition based on body density [68].

Exercise Protocols: Subjects will maintain their training throughout the course of the study. A physical activity log will be completed for each participant to assess the caloric expenditures of each subject during the two three-day diet log periods. This activity log is assigned a kilocalorie expenditure value per kilogram body weight in fifteen minute intervals to corresponding exertion levels of categorized physical activities, ranging in intensities from one to nine, with one being activities such as sleep and nine being activities such as heavy resistance exercise. This assessment is referred to as the 3-day the Bouchard method [47].

MIPS and Simple Creatine on Fatigue and Cluster-Set Velocity in Resistance-Trained Subjects

This stage will have three groups; a creatine monohydrate [C] group in addition to the creatine and electrolytes [M] and placebo [P] groups described previously. The testing battery will focus on fatigue or repeated bout outcomes.

Maximum torque and a fatigue protocol results will be determined using a Biodex System 4 (Biodex Medical Systems Inc., Shirley, NY) isokinetic dynamometer. Each subject will perform a general warm-up for 5 minutes using a cycle ergometer with no resistance added. All tests will be performed with the dominant leg. Subjects will be acclimated and settings will be recorded for their body segments on the dynamometer to ensure consistency across measures. The subject will sit on the dynamometer's chair as proper adjustments are made, ensuring the center of rotation of the shaft of the dynamometer is in alignment with the lateral femoral epicondyle of the dominant leg. For that purpose, the back of the seat will be adjusted and the length of the dynamometer's arm will be properly fitted to the length of the participant's shank. The shank pad will be positioned on the distal portion of the tibia. The subject will be positioned sitting with a hip angle at about 80°. The range of motion will be from 20° to 80° of knee flexion The participant will be stabilized with two shoulder straps, a waist strap, and a thigh strap, to reduce extraneous movements. Once in proper position, each subject will be instructed to perform a task-specific warm-up, consisting of with a concentric/concentric knee extension/flexion at 60 $°\cdot sec^{-1}$ angular velocity, followed by a 30 second rest at the original starting position of 50° of knee flexion.

Maximal knee extension isokinetic torque measurement will determined at an angular velocity of 60 $°\cdot sec^{-1}$ and of 180 $°\cdot sec^{-1}$. Isometric maximal voluntary contraction torque for both knee extension and flexion will be collected at 60 degrees of knee flexion. Three trials for a given condition will be performed. A two minute resting period will be allowed between trials. Peak torques will be determined during this test and during a subsequent test of maximal isometric muscle action. Rest intervals will be allowed until subject indicates they are fully recovered. After the completion of three attempts for each of the conditions, subjects will perform a cool down for 5 minutes on cycle ergometer, at an easy pace, with no resistance added.

The fatigue test will require subjects to perform a task-specific warm-up on the dynamometer followed by 30 maximal isokinetic knee extension repetitions. The absolute torque reduction through

the trial, from peak maximal torque to subsequent minimum peak torque, will be recorded in Nm. The total work done during fatigue trial, integrated torque with respect to time, will be determined ensuring that no more than 30 repetitions were included in the analysis. The subject will have 2 minutes of rest before performing a second set of 30 repetitions. Subjects will perform a cool down for 5 minutes on cycle ergometer, at an easy pace, with no resistance added.

Subjects will perform a pre and post cluster set test for both the parallel back squat and bench press exercises. The load for each exercise will be 80% of their one repetition maximum [48]. The test includes four total clusters, with each cluster being comprised of two sets of five repetitions. Rest provided will be 1.5 minutes between clusters and 30 seconds between each sub-set. Average velocity for each repetition will be measured using an arm band accelerometer (PUSH, Toronto, Canada) placed on the subject's right forearm. Data is transmitted and collected with the PUSH Assist application (PUSH, Toronto, Canada). The outcome measure will be the change in average mean velocities (m/s). The average mean velocity (m/s) of the first cluster will serve as a baseline to measure the change in velocity throughout the test. Average mean velocity (m/s) of each cluster thereafter will then be calculated and subtracted from the baseline value to determine the change in velocity. These three values will be averaged to determine the overall change in velocity in the cluster set test. Data will then be averaged for subjects within their predetermined group. Values of zero represent no change in average velocity (m/s). Positive values represent a relative decrease in average velocity (m/s). Negative values represent an increase in average velocity (m/s).

6. Give specific examples (with literature citations) for the use of your test instruments/questionnaires, or similar ones, in previous similar studies in your field.

Sports drinks were the original prototype of multi-ingredient performance supplements (MIPS). Much recent research has been reported with various combinations of MIPS, complex mixes of nutrients with the common factor being creatine [2-8]. Creatine is a widely used supplement deemed safe by the International Sports Nutrition Society.

It is common in studies on creatine effects to evaluate fatigue, power, and velocity of movement. Some studies related to this project's focus would be repeated exercise bouts and fatigue. A systematic review and meta-analyses demonstrated creatine supplementation is effective in lower extremity physical performance for exercise duration of less than 3 minutes, independent of sample characteristic, training protocols, and supplementation doses and duration [54]. Physical tests at high intensity and repetitive sets have been used to assess creatine effects. Repeat sets have included the Wingate Anaerobic Test (WAnT) [55, 56] and swimming sprints [57]. In a study similar to this proposed study, muscle fatigue (five sets of 30 concentric knee extensions at 180 degrees/s) was evaluated after ingesting a low dose (≈2.3 g/d; 0.03 g/kg/d) of creatine for 6 weeks [58]. Significantly increased plasma creatine concentration and enhanced resistance to fatigue during repeated bouts of high-intensity contractions were reported.

A more recent type of resistance training uses the concept of cluster sets to elicit better performance outcomes [59-65]. There are variable rest intervals sued within a set, in contrast to traditional resistance training with no within-set rest. Mechanical variables have been measured [60-62, 64, 65] with specific attention given to velocity and power in different types of lifts [60-62, 64]. Lower lactates are demonstrated in cluster-set protocols [59] and lower perceived exertion reported [63]. These cluster-set findings are similar to ones reported for creatine supplementation. No studies have yet reported on a combination of a creatine containing supplement and cluster-set protocol on performance outcomes.

7. **Describe how your study design is appropriate to examine your question or specific hypothesis. Include a description of controls used, if any.**

This study will follow a double blind, three-group format analyzed for a 6-week treatment period. These groups will consist of two separate supplementation and one placebo assignments. Supplementation will be a creatine-electrolyte multi-ingredient performance supplement, standard creatine monohydrate, or placebo (carbohydrate solution). Comparisons will between baseline and after 6-weeks of, between and within groups, for the selected variables. Testing procedures will be conducted at the same time of day, as much as possible, to avoid confounding factors.

8. **Give specific examples (with literature citations) for the use of your study design, or similar ones, in previous similar studies in your field.**

A blinded, repeated measures design type is common in sports nutrition research. It has long been a recommended design [52] in this area of research.

9. **Describe the potential risks to the human subjects involved.**

When conducting any physical activity there are risks of muscle, tendon, or ligament injury present. This possibility also exists for the resistance exercises in this project.

10. **If the research involves potential risks, describe the safeguards that will be used to minimize such risks.**

Only subjects who have been weight training for a minimum of the past 6 months will be entered into the study. To ensure safety of subjects, an introduction to the movements utilized will be conducted. The warm–up and trials will be monitored diligently by multiple lab assistants familiar with weight training protocols to ensure proper form. To reduce the chance of fatigue resulting in an injury, rest periods are given to allow for recovery. The supplementation of creatine and electrolyte solutions has been deemed safe with minimal known risks as documented in the International Society for Sports Nutrition position stand [53] and Australian Institute of Sports Supplement Framework [1].

Describe how you will address privacy and /or confidentiality.

Any and all data collected will be kept completely confidential and will be stored and analyzed by subject number only. Only the primary researchers will have access to the records. The data will be stored separately from the informed consents to keep the identity anonymous. A locked cabinet will be used for hard copy and electronic data.

11. **If your research involves the use of schools (pre-kindergarten to university level) or other organizations (e.g., community clubs, companies), please attach a clearance letter from an administrator from your research site indicating that you have been given permission to conduct this research. For pre-kindergarten to grade 12 level schools, an administrator (e.g. principal or higher) should issue the permission. For post-secondary level schools the class instructor may grant permission. For Western Washington University, this requirement of a clearance letter is waived if you are recruiting subjects from a scheduled class. If you are**

recruiting subjects from a campus group (not a class) at Western Washington University, you are required to obtain a clearance letter from a leader or coordinator of the group.

N/A

12. If your research involves the use of schools (pre-kindergarten to university level)or other organizations (e.g., community clubs, companies), and you plan to take still or video pictures as part of your research, please complete

a) To d) below:

a. Who have you contacted at the school district or organization involved, to determine the policy on the use of photography in the school or organization?

N/A

b. Explain how your research plan conforms to the policy on the use of photography in the school or organization.

N/A

c. Attach a copy of the school district or organization policy on the use of photography at the schools or organization.

N/A

d. Explain how you will ensure that the only people recorded in your pictures will be the ones that have signed a consent form.

N/A

In addition, please attach the following information:

1. A bibliography relevant to the subject matter of the proposed research.

See below

2. A copy of the informed consent form (a checklist is attached for you to use as a guide)

See below

3. A current curriculum vitae.

See below

4. A copy of the certificate of completion for Human Subjects Training from the online human subjects training module, for each person involved in the research who will have any contact with the subjects or their data.

See below

5. If your subjects are required to turn in a physical clearance from prior to participation include a copy of the blank form.

N/A

1.) Bibliography relevant to the subject matter of the proposed research:

1. AIS Sports Supplement Framework http://www.ausport.gov.au/ais/nutrition/supplements/groupa 2014.
2. Lowery RP, Joy JM, Dudeck JE, Oliveira de Souza E, McCleary SA, Wells S, Wildman R, Wilson JM. Effects of 8 weeks of Xpand® 2X pre workout supplementation on skeletal muscle hypertrophy, lean body mass, and strength in resistance trained males. J Int Soc Sports Nutr. 2013 Oct 9;10(1):44. doi: 10.1186/1550-2783-10-44.
3. Ormsbee MJ, Mandler WK, Thomas DD, Ward EG, Kinsey AW, Simonavice E, Panton LB, Kim JS. The effects of six weeks of supplementation with multi-ingredient performance supplements and resistance training on anabolic hormones, body composition, strength, and power in resistance-trained men. J Int Soc Sports Nutr. 2012 Nov 15;9(1):49. doi: 10.1186/1550-2783-9-49.
4. Ormsbee MJ, Thomas DD, Mandler WK, Ward EG, Kinsey AW, Panton LB, Scheett TP, Hooshmand S, Simonavice E, Kim JS. The effects of pre- and post-exercise consumption of multi-ingredient performance supplements on cardiovascular health and body fat in trained men after six weeks of resistance training: a stratified, randomized, double-blind study. Nutr Metab (Lond). 2013 May 16;10(1):39. doi: 10.1186/1743-7075-10-39.
5. Ormsbee MJ, Ward EG, Bach CW, Arciero PJ, McKune AJ, Panton LB. The impact of a pre-loaded multi-ingredient performance supplement on muscle soreness and performance following downhill running. J Int Soc Sports Nutr. 2015 Jan 21;12(1):2. doi: 10.1186/s12970-014-0063-6.
6. Outlaw JJ, Wilborn CD, Smith-Ryan AE, Hayward SE, Urbina SL, Taylor LW, Foster CA. Acute effects of a commercially-available pre-workout supplement on markers of training: a double-blind study. J Int Soc Sports Nutr. 2014 Aug 15;11:40. doi: 10.1186/s12970-014-0040-0.
7. Smith AE, Fukuda DH, Kendall KL, Stout JR. The effects of a pre-workout supplement containing caffeine, creatine, and amino acids during three weeks of high-intensity exercise on aerobic and anaerobic performance. J Int Soc Sports Nutr. 2010 Feb 15;7:10. doi: 10.1186/1550-2783-7-10.
8. Spillane M, Schwarz N, Willoughby DS. Heavy resistance training and peri-exercise ingestion of a multi-ingredient ergogenic nutritional supplement in males: effects on body composition, muscle performance and markers of muscle protein synthesis. J Sports Sci Med. 2014 Dec 1;13(4):894-903.
9. Antonio J, Ciccone V. The effects of pre versus post workout supplementation of creatine monohydrate on body composition and strength. J Int Soc Sports Nutr. 2013 Aug 6;10:36. doi: 10.1186/1550-2783-10-36.
10. Branch JD. Effect of creatine supplementation on body composition and performance: a meta-analysis. Int J Sport Nutr Exerc Metab. 2003 Jun;13(2):198-226.

11. Cooke MB, Rybalka E, Williams AD, Cribb PJ, Hayes A. Creatine supplementation enhances muscle force recovery after eccentrically-induced muscle damage in healthy individuals. J Int Soc Sports Nutr. 2009 Jun 2;6:13. doi: 10.1186/1550-2783-6-13.

12. Cooper R, Naclerio F, Allgrove J, Jimenez A. Creatine supplementation with specific view to exercise/sports performance: an update. J Int Soc Sports Nutr. 2012 Jul 20;9(1):33. doi: 10.1186/1550-2783-9-33.

13. Eckerson JM, Stout JR, Moore GA, Stone NJ, Iwan KA, Gebauer AN, Ginsberg R. Effect of creatine phosphate supplementation on anaerobic working capacity and body weight after two and six days of loading in men and women. J Strength Cond Res. 2005 Nov;19(4):756-63.

14. Izquierdo M, Ibañez J, González-Badillo JJ, Gorostiaga EM. Effects of creatine supplementation on muscle power, endurance, and sprint performance. Med Sci Sports Exerc. 2002 Feb;34(2):332-43.

15. Jäger R, Metzger J, Lautmann K, Shushakov V, Purpura M, Geiss KR, Maassen N. The effects of creatine pyruvate and creatine citrate on performance during high intensity exercise. J Int Soc Sports Nutr. 2008 Feb 13;5:4. doi: 10.1186/1550-2783-5-4.

16. Jäger R, Purpura M, Shao A, Inoue T, Kreider RB. Analysis of the efficacy, safety, and regulatory status of novel forms of creatine. Amino Acids. 2011 May;40(5):1369-83. doi: 10.1007/s00726-011-0874-6.

17. Jagim AR, Oliver JM, Sanchez A, Galvan E, Fluckey J, Riechman S, Greenwood M, Kelly K, Meininger C, Rasmussen C, Kreider RB. A buffered form of creatine does not promote greater changes in muscle creatine content, body composition, or training adaptations than creatine monohydrate. J Int Soc Sports Nutr. 2012 Sep 13;9(1):43. doi: 10.1186/1550-2783-9-43.

18. Kilduff LP, Vidakovic P, Cooney G, Twycross-Lewis R, Amuna P, Parker M, Paul L, Pitsiladis YP. Effects of creatine on isometric bench-press performance in resistance-trained humans. Med Sci Sports Exerc. 2002 Jul;34(7):1176-83.

19. Lanhers C, Pereira B, Naughton G, Trousselard M, Lesage FX, Dutheil F. Creatine supplementation and lower limb strength performance: A systematic review and meta-analyses. Sports Med. 2015 May 7.

20. Mendez-Villanueva A, Edge J, Suriano R, Hamer P, Bishop D. The recovery of repeated-sprint exercise is associated with PCr resynthesis, while muscle pH and EMG amplitude remain depressed. PLoS One. 2012;7(12):e51977. doi: 10.1371/journal.pone.0051977.

21. Powers ME, Arnold BL, Weltman AL, Perrin DH, Mistry D, Kahler DM, Kraemer W, Volek J. Creatine supplementation increases total body water without altering fluid distribution. J Athl Train. 2003 Mar;38(1):44-50.

22. Preen D, Dawson B, Goodman C, Beilby J, Ching S. Creatine supplementation: a comparison of loading and maintenance protocols on creatine uptake by human skeletal muscle. Int J Sport Nutr Exerc Metab. 2003 Mar;13(1):97-111.

23. Rosene J, Matthews T, Ryan C, Belmore K, Bergsten A, Blaisdell J, Gaylord J, Love R, Marrone M, Ward K, Wilson E. Short and longer-term effects of creatine supplementation on exercise induced muscle damage. J Sports Sci Med. 2009 Mar 1;8(1):89-96. eCollection 2009.

24. Sahlin K. Muscle energetics during explosive activities and potential effects of nutrition and training. Sports Med. 2014 Nov;44 Suppl 2:S167-73. doi: 10.1007/s40279-014-0256-9.

25. Barros MP, Ganini D, Lorenço-Lima L, Soares CO, Pereira B, Bechara EJ, Silveira LR, Curi R, Souza-Junior TP. Effects of acute creatine supplementation on iron homeostasis and uric acid-

based antioxidant capacity of plasma after wingate test. J Int Soc Sports Nutr. 2012 Jun 12;9(1):25. doi: 10.1186/1550-2783-9-25.

26. Chromiak JA, Smedley B, Carpenter W, Brown R, Koh YS, Lamberth JG, Joe LA, Abadie BR, Altorfer G. Effect of a 10-week strength training program and recovery drink on body composition, muscular strength and endurance, and anaerobic power and capacity. Nutrition. 2004 May;20(5):420-7.
27. Green JM, McLester JR, Smith JE, Mansfield ER. The effects of creatine supplementation on repeated upper- and lower-body Wingate performance. J Strength Cond Res. 2001 Feb;15(1):36-41.
28. Havenetidis K, Cooke CB, Butterly R, King RF. Incorrect calculation of power outputs masks the ergogenic capacity of creatine supplementation. Appl Physiol Nutr Metab. 2006 Oct;31(5):635-42.
29. Havenetidis K, Matsouka O, Cooke CB, Theodorou A. The use of varying creatine regimens on sprint cycling. J Sports Sci Med. 2003 Sep 1;2(3):88-97.
30. Herda TJ, Beck TW, Ryan ED, Smith AE, Walter AA, Hartman MJ, Stout JR, Cramer JT. Effects of creatine monohydrate and polyethylene glycosylated creatine supplementation on muscular strength, endurance, and power output. J Strength Cond Res. 2009 May;23(3):818-26. doi: 10.1519/JSC.0b013e3181a2ed11.
31. Hoffman JR, Stout JR, Falvo MJ, Kang J, Ratamess NA. Effect of low-dose, short-duration creatine supplementation on anaerobic exercise performance. J Strength Cond Res. 2005 May;19(2):260-4.
32. Koçak S, Karli U. Effects of high dose oral creatine supplementation on anaerobic capacity of elite wrestlers. J Sports Med Phys Fitness. 2003 Dec;43(4):488-92.
33. Okudan N, Gokbel H. The effects of creatine supplementation on performance during the repeated bouts of supramaximal exercise. J Sports Med Phys Fitness. 2005 Dec;45(4):507-11.
34. de Andrade Nemezio KM1, Bertuzzi R, Correia-Oliveira CR, Gualano B, Bishop DJ, Lima-Silva AE. Effect of creatine loading on oxygen uptake during a 1-km cycling time trial. Med Sci Sports Exerc. 2015 Jun 16. [Epub ahead of print]
35. Graef JL, Smith AE, Kendall KL, Fukuda DH, Moon JR, Beck TW, Cramer JT, Stout JR. The effects of four weeks of creatine supplementation and high-intensity interval training on cardiorespiratory fitness: a randomized controlled trial. J Int Soc Sports Nutr. 2009 Nov 12;6:18. doi: 10.1186/1550-2783-6-18.
36. Hickner RC, Dyck DJ, Sklar J, Hatley H, Byrd P. Effect of 28 days of creatine ingestion on muscle metabolism and performance of a simulated cycling road race. J Int Soc Sports Nutr. 2010 Jul 7;7:26. doi: 10.1186/1550-2783-7-26.
37. Murphy AJ, Watsford ML, Coutts AJ, Richards DA. Effects of creatine supplementation on aerobic power and cardiovascular structure and function. J Sci Med Sport. 2005 Sep;8(3):305-13.
38. Nelson AG, Day R, Glickman-Weiss EL, Hegsted M, Kokkonen J, Sampson B. Creatine supplementation alters the response to a graded cycle ergometer test. Eur J Appl Physiol. 2000 Sep;83(1):89-94.
39. Oliver JM, Joubert DP, Martin SE, Crouse SF. Oral creatine supplementation's decrease of blood lactate during exhaustive, incremental cycling. Int J Sport Nutr Exerc Metab. 2013 Jun;23(3):252-8.

40. Candotti CT, Ribeiro J, Soares DP, De Oliveira AR, Loss JF, Guimarães AC. Effective force and economy of triathletes and cyclists. Sports Biomech. 2007 Jan;6(1):31-43.

41. Gurgel J, Porto F, Russomano T, Cambraia R, de Azevedo DF, Glock FS, Beck JC, Helegda S. Development and calibration of a pedal with force and moment sensors. Conf Proc IEEE Eng Med Biol Soc. 2006;1:4144-6.

42. Martin JC, Davidson CJ, Pardyjak ER. Understanding sprint-cycling performance: the integration of muscle power, resistance, and modeling. Int J Sports Physiol Perform. 2007 Mar;2(1):5-21.

43. Gufford BT, Ezell EL, Robinson DH, Miller DW, Miller NJ, Gu X, Vennerstrom JL. pH-dependent stability of creatine ethyl ester: relevance to oral absorption. J Diet Suppl. 2013 Sep;10(3):241-51. doi: 10.3109/19390211.2013.822453.

44. Johnson H, Virk S, Mayelin P, Barbieri T. Predicting total body water and extracellular fluid volumes from bioelectrical measurements of the human body. J Am Coll Nutr. 1992;11: 539-47.

45. Patel, R, Matthie J, Withers P, Peterson E, Zarowitz B. Estimation of total body and extracellular water using single- and multiple-frequency bioimpedance. Annals Pharmacologicaltherapy. 1994;28:565-69.

46. Ritz, P. Bioelectrical impedance analysis estimation of water compartments in elderly diseased patients. J Gerontol Series A: Biological Sci Med Sci. 2001;56: M344-48.

47. Bouchard C. Bouchard three-day physical activity record. A collection of physical activity questionnaires for health-related research. Med Sci Sports Exerc. 1997; 29(6):Supplement:19-24.

48. Oliver JM, Kreutzer A, Jenke S, Phillips MD, Mitchell JB, Jones MT. Acute response to cluster sets in trained and untrained men. Eur J Appl Physiol. 2015 http://doi.org/10.1007/s00421-015-3216-7.

49. González-Badillo JJ, Rodríguez-Rosell D, Sánchez-Medina L, Gorostiaga EM, Pareja-Blanco F. Maximal intended velocity training induces greater gains in bench press performance than deliberately slower half-velocity training. Eur J Sport Sci. 2014;14(8):772-81. doi: 10.1080/17461391.2014.905987.

50. Richards JG. The measurement of human motion: a comparison of commercially available systems. Human Movement Sci 1999; 18(5): 589-602.

51. Komi PV, Bosco C. Utilization of stored elastic energy in leg extensor muscles by men and women. Med Sci Sports. 1978;10(4):261–265.

52. Hopkins WG, Hawley JA, Burke LM. Design and analysis of research on sport performance enhancement. Med Sci Sports Exerc. 1999;31(3):472-85.

53. Cooper R, Naclerio F, Allgrove J, Jimenez A. Creatine supplementation with specific view to exercise/sports performance: an update. J Int Soc Sports Nutr. 2012 Jul 20;9(1):33. doi: 10.1186/1550-2783-9-33.

54. Lanhers C, Pereira B, Naughton G, Trousselard M, Lesage FX, Dutheil F. Creatine supplementation and lower limb strength performance: A systematic review and meta-analyses. Sports Med. 2015 Sep;45(9):1285-94. doi: 10.1007/s40279-015-0337-4.

55. Okudan N, Belviranli M, Pepe H, Gökbel H. The effects of beta alanine plus creatine administration on performance during repeated bouts of supramaximal exercise in sedentary men. J Sports Med Phys Fitness. 2015 Nov;55(11):1322-8.

56. Okudan N, Gokbel H. The effects of creatine supplementation on performance during the repeated bouts of supramaximal exercise. J Sports Med Phys Fitness. 2005 Dec;45(4):507-11.
57. Dabidi Roshan V, Babaei H, Hosseinzadeh M, Arendt-Nielsen L. The effect of creatine supplementation on muscle fatigue and physiological indices following intermittent swimming bouts. J Sports Med Phys Fitness. 2013 Jun;53(3):232-9.
58. Rawson ES, Stec MJ, Frederickson SJ, Miles MP. Low-dose creatine supplementation enhances fatigue resistance in the absence of weight gain. Nutrition. 2011 Apr;27(4):451-5. doi: 10.1016/j.nut.2010.04.001.
59. Girman JC, Jones MT, Matthews TD, Wood RJ. Acute effects of a cluster-set protocol on hormonal, metabolic and performance measures in resistance-trained males. Eur J Sport Sci. 2014;14(2):151-9. doi: 10.1080/17461391.2013.775351.
60. Haff GG, Whitley A, McCoy LB, O'Bryant HS, Kilgore JL, Haff EE, Pierce K, Stone MH. Effects of different set configurations on barbell velocity and displacement during a clean pull. J Strength Cond Res. 2003 Feb;17(1):95-103.
61. Hansen KT, Cronin JB, Newton MJ. The effect of cluster loading on force, velocity, and power during ballistic jump squat training. Int J Sports Physiol Perform. 2011 Dec;6(4):455-68.
62. Hardee JP, Lawrence MM, Zwetsloot KA, Triplett NT, Utter AC, McBride JM. Effect of cluster set configurations on power clean technique. J Sports Sci. 2013;31(5):488-96. doi: 10.1080/02640414.2012.736633.
63. Mayo X, Iglesias-Soler E, Fernández-Del-Olmo M. Effects of set configuration of resistance exercise on perceived exertion. Percept Mot Skills. 2014 Dec;119(3):825-37. doi: 10.2466/25.29.PMS.119c30z3.
64. Moir GL, Graham BW, Davis SE, Guers JJ, Witmer CA. Effect of cluster set configurations on mechanical variables during the deadlift exercise. J Hum Kinet. 2013 Dec 31;39:15-23. doi: 10.2478/hukin-2013-0064. eCollection 2013.
65. Moreno SD, Brown LE, Coburn JW, Judelson DA. Effect of cluster sets on plyometric jump power. J Strength Cond Res. 2014 Sep;28(9):2424-8. doi: 10.1519/JSC.0000000000000585.

Appendix C

Food Diary Completion Form

FOOD DIARY PLEASE FOLLOW THESE INSTRUCTIONS CAREFULLY IN COMPLETING THIS DIARY

Beginning with midnight on _____, write down everything you eat or drink and all vitamin and mineral supplements

Write only one food item or beverage on a line. For example, if you eat oatmeal with sugar and milk, write oatmeal on a line, sugar on the next, and milk on the next.

Keep this record with you so all information can be recorded at the time food and drink are ingested.

Measure and record the amounts of food served in portion sizes of cups, ounces, tablespoons, teaspoons, slices, and inches.

Indicate how the food was prepared fried, steamed, baked, raw etc

Be sure to measure and record all those little extras.... gravies, salad dressings, taco sauce, pickles, jelly, sugar, margarine, etc. Indicate amounts.

Consider the following points as you are recording different types of foods:

Beverages -record amount in cups or ounces

-list type of milk, such as whole, nonfat, 2%, evaporated

-indicate type of beverage type, such as fresh, fruit drink,etc.

Fruits & Vegetables indicate whether fresh, frozen, dried, canned

-record as portion of cup, piece, number eaten, and size

-record preparation method

Breads & Cereals -indicate whether whole wheat, white, sourdough, rye, etc.

-record portions

-record anything added to the bread or cereal....jam, sugar, etc.

Meats-record in ounces or approximate measurement after cooking

-record preparation method

Desserts

-record portion size and number

If you have any questions, please call 360-650-2851

Appendix D

Background Information Form

BACKGROUND INFORMATION FORM

Name:_____Date:_____

Height in inches: ____ Weight in lbs.: ____

Age:_____ Sex:___ Birth date:_____

Street Address:_____

City:_____ State:_____ Zip:_____

Phone: _____

In case of emergency notify: Name:_____

Phone Number: _____ Relationship: _____

Have you had a physical examination within the past two years? _____

Name of your physician:_____ Phone Number:_____

Do you have a family history of heart disease? _____

If so, describe?_____

Do you have any renal problems?_____

Do you experience any uncomfortable sensations while exercising?_____

_____

How active are you? What type of exercise do you engage in and how many times a week do you exercise?_____

_____

Do you drink alcohol?_____ If so, how much?_____

Please list everything not already included on this questionnaire that might cause you problems in a strength or jump test:

_____

_____

_____

_____

Appendix E

Raw Data

Subject supplment grouping	
ASF_001	2
ASF_002	3
ASF_003	2
ASF_004	1
ASF_005	2
ASF_006	1
ASF_007	2
ASF_008	3
ASF_009	2
ASF_010	1
ASF_011	3
ASF_012	1
ASF_013	3
ASF_014	1
ASF_015	1
ASF_016	3
ASF_017	2
ASF_018	2
ASF_019	2
ASF_020	1
ASF_021	1
ASF_022	2
ASF_023	3
ASF_024	3
ASF_025	1
ASF_026	1
ASF_027	3
ASF_028	1
ASF_029	2
ASF_030	3
Codes reference ending numbers	
Lot #1 = 106	Placebo of maltodextrin
Lot #2 = 105	Creatine monohydrate (4 mg creatine)
Lot #3 = 102	Creatine-electrolyte (4 mg creatine)

Subject #	Gender	Supp #		Age	Height (In)	Height (m)	Weight (lbs)	Weight (kg)	Dominant Limb		Age	Height (In)	Height (m)	Weight (lbs)	Weight (kg)	Dominant Limb
							PRE-TEST				133					
ASF_001	Male	2		22	62.6	1.5768262	128	58.18181818	Right		22	62	1.561712846	133	60.45454545	Right
ASF_002	Female	3		22	66.9	1.68513854	149	67.72727273	Right		22	66.9	1.685138539	142	64.54545455	Right
ASF_003	Female	2		19	65.748	1.65612091	150	68.18181818	Right		19	65.75	1.656171285	148	67.27272727	Right
ASF_004	Male	1		23	62.99	1.58664987	131	59.54545455	Right		23	63	1.586901763	131	59.54545455	Right
ASF_005	Female	2		22	65	1.6372796	143	65	Right		22	65	1.637279597	146.5	66.59090909	Right
ASF_006	Male	1		23	68.897	1.73544081	157	71.36363636	Right		23	69	1.738035264	159	72.27272727	Right
ASF_007	Male	2		22	64.86	1.63375315	152.1	69.13636364	Right		22	64.86	1.633753149	152	69.09090909	Right
ASF_008	Male	3		20	70	1.76322418	180	81.81818182	Right		20	70	1.763224181	185	84.09090909	Right
ASF_009	Male	2		26	72.0472	1.81479093	162.2	73.72727273	Right		25	72	1.813602015	175	79.54545455	Right
ASF_010	Male	1		26	66.14	1.66599496	173	78.63636364	Right		26	66	1.662468514	171	77.72727273	Right
ASF_011	Male	3		23	65.55	1.6511335	139	63.18181818	Right		23	66	1.662468514	137.5	62.5	Right
ASF_012	Male	1		20	70.886	1.78554156	178	80.90909091	Left		20	7.86	0.197984887	177	80.45454545	Left
ASF_013	Male	3			72.5		167		Right							
ASF_014	Male	1		22	72	1.81360202	171	77.72727273	Right		22	72	1.813602015	174	79.09090909	Right
ASF_015	Male	2		18	68.5039	1.72553904	158	71.81818182	Right		19	68.5	1.725440806	159	72.27272727	Right
ASF_016	Male	3		22	67.5	1.70025189	167	75.90909091	Right		22	67.5	1.700251889	167	75.90909091	Right
ASF_017	Female	2	0	24	67	1.68765743	142	64.54545455	Right		24	67	1.687657431	143	65	Right
ASF_018	Female	2		21	61.75	1.55541562	185	84.09090909	Right		21	67	1.687657431	189	85.90909091	Right
ASF_019	Male	2			68		174		Right							
ASF_020	Female	1		22	65	1.6372796	154	70	Right		22	65	1.637279597	154	70	Right
ASF_021	Male	1		19	75	1.88916877	219.5	99.77272727	Right		19	75	1.889168766	221	100.4545455	Right
ASF_022	Male	2		23	70.75	1.78211587	167	75.90909091	Right		23	70	1.763224181	169	76.81818182	right
ASF_023	Male	3		21	76	1.91435768	160	72.72727273	Right		22	76	1.914357683	162	73.63636364	Right
ASF_024	Male	3		21	65	1.6372796	150	68.18181818	Right		21	66	1.662468514	151	68.63636364	Right
ASF_025	Female	1		21	62	1.56171285	135	61.36363636	Right		21	62	1.561712846	140	63.63636364	Right
ASF_026		1														
ASF_027	Male	3		23	66	1.66246851	179	81.36363636	Right		23	66.25	1.668765743	179	81.36363636	Right

Subject #	Supp #		Resistance	Reactants	Total Body Water (	Intra-celluar	Extra-cellular		Resistance	Reactants	Total Body Water (	Intra-celluar	Extra-cellular
			PRE-TEST						POST-TEST				
ASF_001	2		443	61.3	37.7	22.8	14.8		432	59.2	38	22.9	15.1
ASF_002	3		688	81	29.3	15.2	14.1		698.6	88.6	28.4	16.8	11.6
ASF_003	2		616.3	67.6	31.3	16.2	15.1		608.2	69.9	31.6	16.5	15.1
ASF_004	1		485.4	56.8	35.2	20.9	14.2		431.9	60.2	39.1	23.6	15.4
ASF_005	2		569	65	32.7	17.3	15.4		574.4	71.7	32.5	17.3	15.2
ASF_006	1		495.4	63.5	41.3	24.2	17.2		492.4	66.3	42.8	25.1	17.7
ASF_007	2		510.1	72.8	36.1	21.4	14.7						
ASF_008	3		446.5	55.8	47.3	27.1	20.2		482.4	66	44.4	25.5	18.9
ASF_009	2		499	98.1	49	29.1	19.9		460.5	54.1	48.3	27.6	20.6
ASF_010	1		419.3	63.3	45.1	26.4	18.6						
ASF_011	3		484.6	56.7	38.1	22.5	15.6		475.9	55.3	39.1	23.1	16
ASF_012	1		452	60.5	47.8	27.6	20.2						
ASF_013	3		401	54.3	55.1	32.3	22.8						
ASF_014	1		483.1	57.3	46.1	26.5	19.6		492.5	60.1	45.4	26.1	19.4
ASF_015	2		547.6	66.3	36.4	21.1	15.3		521.7	63.9	39.1	22.7	16.4
ASF_016	3		464.6	62.3	42.5	24.7	17.8		484.5	65.3	41	23.8	17.2
ASF_017	2		590.1	60.5	33.3	17.4	15.9		579.9	59.1	33.9	17.7	16.2
ASF_018	2		660.3	70.9	31.7	15.5	16.1		635.4	68.9	32.6	16	16.6
ASF_019	2		417.4	55.1	47.6	27.6	20						
ASF_020	1		601.3	63.9	31.5	16.1	15.3		579.4	53.6	32.5	16.4	16.1
ASF_021	1		479.6	67.8	51.4	28.7	22.7		462.3	64.7	53.1	29.9	23.2
ASF_022	2		483.4	60.5	33.5	19.2	14.3						
ASF_023	3		541.9	69.2	45.6	26.6	19		539.4	67.3	45.8	26.6	19.1
ASF_024	3		535.5	74.5	34.6	20.5	14.1						
ASF_025	1		578.3	74.3	48.1	27.6	11.8		565.3	76.2	30.2	16.2	14
ASF_027	3		477.2	73.1	40.2	23.4	16.9		463.2	70.9	41.6	24.2	17.4
ASF_028	1												

Subject #	Gender	Supp #		Site #1	Site #2	Site #3	Sum	Body Fat %	Lean Body Mass (lbs)	Fat Mass (lbs)		Site #1	Site #2	Site #3	Sum	% BF	Lean Body Mass (lbs)	Fat Mass (lbs)
				PRE-TEST								POST-TEST						
ASF_001	Male	2		4	7	8	19	4.7	68.9	3.4		3	9.5	9	21.5	5.5	57.1	3.3
ASF_002	Female	3		18.5	11.5	31.5	61.5	24.1	51.4	16.3		16.5	11	33.5	61	24	49.1	15.5
ASF_003	Female	2		21	15.5	24	60.5	23.6	52.1	16.1		21.5	18	25.5	65	25.1	50.4	16.9
ASF_004	Male	1		6	8.5	10.5	25	6.7	55.5	4		4.5	11	10.5	26	7	55.4	4.2
ASF_005	Female	2		22.5	14	31	67.5	26	48.1	16.9		24	14.5	27.5	66	25.6	49.6	17
ASF_006	Male	1		3.5	16.5	19	39	11	63.5	7.9		4	10.5	16.5	31	8.6	66.1	6.2
ASF_007	Male	2		8.5	22.5	12	43	12.1	60.8	8.4		5	19.5	17.5	42	11.9	60.8	8.3
ASF_008	Male	3		6.5	16	15.5	38	10.4	73.3	8.5		5.75	18	18.5	42.25	11.7	74.3	9.8
ASF_009	Male	2		8	13	6.5	27.5	7.8	67.9	5.8		8.5	13	8	29.5	8.4	72.9	6.6
ASF_010	Male	1		13	22.5	15	50.5	14.8	66.2	11.5		10.5	21	1.5	33	13	67.6	10.1
ASF_011	Male	3		10	18	11.5	39.5	11.2	56.1	7.1		5.5	19	10	34.5	9.7	56.5	6
ASF_012	Male	1		9.5	14.5	13	37	10.1	72.7	8.2		8.5	14	12.5	35	9.5	72.8	7.6
ASF_013	Male	3		8	11.5	7	26.5								0			
ASF_014	Male	1		9.5	17	7.5	34	12.4	68.1	9.7		5	16	16.5	37.5	10.5	70.8	8.3
ASF_015	Male	2		19.5	26	20.5	66	18.2	58.7	13.1		17.5	25.5	20	63	17.5	59.6	12.7
ASF_016	Male	3		6.5	14	12	32.5	9	69.1	6.8		4.5	11.5	13	29	7.9	70.4	6
ASF_017	Female	2		18	9	20.5	47.5	18.9	52.3	12.2		15.5	11	26.5	53	21.5	51	14
ASF_018	Female	2		28	27.5	48.5	104	28.1	60.4	23.6		26	30	44	100	35.2	55.7	30.2
ASF_019	Male	2		6.5	15	13.5	35								0			
ASF_020	Female	1		23.5	24	37.5	85	23.7	53.4	16.6		21.5	24.5	26	72	30.4	48.7	21.3
ASF_021	Male	1		13	29	27	69	19.2	80.6	19.1		13.5	33	21.5	68	18.9	81.5	19
ASF_022	Male	2		4	9.5	6.25	19.75	5.1	72.1	3.8		5	12	9	26	7.1	71.4	5.4
ASF_023	Male	3		3	6.75	6	15.75	3.6	70.1	2.6		3	8	7.5	18.5	4.6	70.3	3.4
ASF_024	Male	3		5.5	21	11	37.5	10.4	61.1	7.1		4	21.5	14	39.5	11	61.1	7.5
ASF_025	Female	1		14	14.5	21	49.5	20.1	49	12.3		17	19	24	60	23.6	48.6	15
ASF_026		1					0								0			
ASF_027	Male	3		8	8	14.75	30.75	9.1	73.9	7.4		10	19.5	14	43.5	12.4	71.3	10.1
ASF_028		1					0								0			
ASF_029		2					0								0			
ASF_030		3					0								0			
ASF_031		3					0								0			
ASF_032		2					0								0			

						Peak Torque (Nm)					Peak Torque/Body Weight (Nm/kg)			
		Mass (kg)				Pre		Post			Pre		Post	
Supplement Group		Pre	Post			Set 1	Set 2	Set 1	Set 2		Set 1	Set 2	Set 1	Set 2
Creatine-electrolyte	ASF_002	67.72727	64.54545			101.1305	104.4793	104.4793	94.41916		149.3201	154.2648	161.8694	146.2832
Creatine-electrolyte	ASF_008	81.81818	84.09091			191.7262	179.3747	232.6448	234.8412		234.332	219.2358	276.6587	279.2706
Creatine-electrolyte	ASF_011	63.18182	62.5			138.2528	108.3705	133.7243	115.1903		218.8173	171.5217	213.9589	184.3045
Creatine-electrolyte	ASF_016	75.90909	75.90909			180.6627	172.4058	213.6362	159.051		237.9988	227.1214	281.437	209.5283
Creatine-electrolyte	ASF_023	72.72727	73.63636			150.7534	152.2448	158.9832	129.0061		207.2859	209.3366	215.9031	175.1934
Creatine-electrolyte	ASF_024	68.18182	68.63636			144.0557	143.7574	152.882	137.3579		211.2816	210.8442	222.742	200.1241
Creatine-electrolyte	ASF_027	81.36364	81.36364			141.6423	114.2412	177.7884	160.3797		174.0855	140.4082	218.5109	197.1147
Creatine Mono	ASF_001	58.18182	60.45455			155.8242	133.6565	148.8417	120.2746		267.8228	229.7222	246.2043	198.9505
Creatine Mono	ASF_003	68.18182	67.27273			106.4588	112.3702	94.48695	91.77532		156.1396	164.8096	140.4536	136.4228
Creatine Mono	ASF_005	65	66.59091			92.48034	99.34078	120.8169	102.7981		142.2774	152.832	181.4316	154.3726
Creatine Mono	ASF_007	69.13636	69.09091			160.3797	142.144	158.5087	140.3543		231.9759	205.5994	229.4205	203.1443
Creatine Mono	ASF_009	73.72727	79.54545			180.3645	152.2855	189.1637	125.9284		244.6374	206.5524	237.8058	158.31
Creatine Mono	ASF_017	64.54545	65			110.6212	94.74456	110.7432	106.1199		171.3849	146.7873	170.3742	163.2613
Creatine Mono	ASF_018	84.09091	85.90909			104.6556	106.3232	94.48695	99.15097		124.4553	126.4385	109.9848	115.4138
Creatine Mono	ASF_022	75.90909	76.81818			186.4656	153.3295	176.5275	151.2144		245.6434	201.9909	229.7991	196.8471
Placebo	ASF_004	59.54545	59.54545			137.4664	133.643	139.012	118.8646		230.8596	224.4386	233.4553	199.6199
Placebo	ASF_006	71.36364	72.27273			91.43636	78.50186	111.6516	115.8275		128.1274	110.0026	154.4865	160.2645
Placebo	ASF_010	78.63636	77.72727			175.1988	167.3079	192.7024	158.8612		222.7962	212.7615	247.9212	204.3828
Placebo	ASF_012	80.90909	80.45455			150.3873	138.185	154.1836	135.0666		185.872	170.7904	191.6407	167.8794
Placebo	ASF_014	77.72727	79.09091			194.0989	186.4656	177.2325	166.5758		249.7179	239.8973	224.0871	210.6131
Placebo	ASF_015	71.81818	72.27273			181.4084	180.2153	175.7547	159.4849		252.594	250.9327	243.1826	220.6709
Placebo	ASF_020	70	70			113.5904	95.61228	94.47339	68.92978		162.272	136.589	134.962	98.47112
Placebo	ASF_025	61.36364	63.63636			106.5537	95.34112	113.6447	113.6447		173.6431	155.3707	178.5845	178.5845

					Work (Joules)																	
					Work (Joules)				Post				Ratio				Power (W)					
		Mass (kg)			Set 1		Set 2		Set 1		Set 2		Pre		Post		Pre		Post			
Supplement Group		Pre	Post		WKF1/3	WKL1/3	WKF1/3	WKL1/3	WKF1/3	WKL1/3	WKF1/3	WKL1/3	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2		
Creatine-electrolyte	ASF_002	67.72727	64.54545		580.8	381.6	672.9	311.4	548.7	383.3	537.9	308.2	1.522013	2.160886	1.431516	1.745295	100	92.8	80.5	84.6		
Creatine-electrolyte	ASF_008	81.81818	84.09091		1234.4	705.7	942.1	458.1	1455.4	831.4	1218.4	546	1.749185	2.056538	1.750541	2.231502	223	187.3	299.3	243.6		
Creatine-electrolyte	ASF_011	63.18182	62.5		835.6	420.8	672.1	289.6	885.5	504.4	663.8	334.7	1.985741	2.320787	1.755551	1.983269	155.4	116.2	167.8	124.9		
Creatine-electrolyte	ASF_016	75.90909	75.90909		1041.9	544.1	1071.8	413	1463.6	614.5	957.5	411.2	1.914905	2.595157	2.381774	2.328551	173.9	154.7	227.1	157.5		
Creatine-electrolyte	ASF_023	72.72727	73.63636		826.8	572	960.4	417	1129.1	484.5	782	374.4	1.445455	2.303118	2.330444	2.088675	149.9	135.5	159.5	118		
Creatine-electrolyte	ASF_024	68.18182	68.63636		730.1	397.3	659.9	246.1	859.8	427.7	665.4	296.5	1.837654	2.68143	2.010288	2.244182	178.6	143.1	185.5	143.5		
Creatine-electrolyte	ASF_027	81.36364	81.36364		797.7	632.3	545.4	373.2	1076.3	689.7	907.2	400.5	1.261585	1.461415	1.560534	2.265169	124.3	86.5	182.3	147.7		
Creatine Mono	ASF_001	58.18182	60.45455		614.1	273.3	448	189.8	655.1	320	508	205.1	2.246981	2.360379	2.047188	2.476841	133.3	100.9	153	111.6		
Creatine Mono	ASF_003	68.18182	67.27273		627.5	394.6	658.4	329.1	444.4	410.1	460.6	388.9	1.590218	2.000608	1.083638	1.184366	106.2	105.1	103.4	101		
Creatine Mono	ASF_005	65	66.59091		462.7	270.4	541.5	311.9	744.7	400.5	614.4	343.8	1.711169	1.736133	1.859426	1.787086	92.7	108	132.4	113.6		
Creatine Mono	ASF_007	69.13636	69.09091		901.1	532.3	792.3	295.6	903.3	632.7	744	618.1	1.692842	2.680311	1.427691	1.203689	159.6	120.6	157.8	131.7		
Creatine Mono	ASF_009	73.72727	79.54545		1189.3	662.7	1052.6	415	1399.1	810.2	860.7	389.9	1.794628	2.536386	1.726858	2.207489	207.8	157.7	247.1	129.8		
Creatine Mono	ASF_017	64.54545	65		615.4	311.8	589.5	202	732.4	346.8	658.6	262	1.973701	2.918317	2.11188	2.51374	115.3	89	135.9	112.3		
Creatine Mono	ASF_018	84.09091	85.90909		617.7	336.9	605.2	271.4	560.2	323.3	570.4	233.2	1.833482	2.229919	1.732756	2.445969	110.9	98.4	109.1	103.8		
Creatine Mono	ASF_022	75.90909	76.81818		925.2	564.1	802.8	413.4	1061.7	630.3	918.6	441.4	1.640135	1.941945	1.684436	2.081106	243.2	191.4	246	187		
Placebo	ASF_004	59.54545	59.54545		838.3	473.9	742.8	365.7	953.7	533.6	727.9	449.5	1.768939	2.031173	1.787294	1.619355	164.4	141.7	161.9	137.4		
Placebo	ASF_006	71.36364	72.27273		128.8	204.9	216.7	209.9	422.6	458.8	531.5	289.4	0.628599	1.032396	0.921099	1.836558	22.7	27.2	81.8	72.3		
Placebo	ASF_010	78.63636	77.72727		956.4	427.3	884.2	334.5	967.1	468.7	1062.6	447.1	2.23824	2.643348	2.063367	2.37665	208	196.9	284	210.8		
Placebo	ASF_012	80.90909	80.45455		848.2	486.4	701.7	402.8	750.7	460.9	611.8	396.9	1.743832	1.742056	1.62877	1.541446	183.9	152.6	177.7	152.9		
Placebo	ASF_014	77.72727	79.09091		925.6	552.2	852.1	449.8	1120.4	705.4	1018.5	578.3	1.676204	1.894398	1.588319	1.761197	218.4	193	205.4	179.4		
Placebo	ASF_015	71.81818	72.27273		436.7	681.9	866.7	395.8	980.7	628.3	879.9	379.7	0.640416	2.189742	1.560879	2.317356	160.6	176.8	201.6	150.1		
Placebo	ASF_020	70	70		493.6	341.4	428.8	271.4	396.9	157.7	243.6	122.8	1.445811	1.579956	2.516804	1.983713	71.7	62.7	64.8	42.5		
Placebo	ASF_025	61.36364	63.63636		572	319.5	502.6	245.1	648.1	386.4	550.6	297.9	1.790297	2.050592	1.677277	1.848271	124.4	111	146	126.3		

		Mass (kg)		Peak Torque 60 deg/s (Nm)			Peak Torque 60 deg/s (Nm/Kg)			Peak Torque 180 deg/s (Nm)			Peak Torque 180 deg/s (Nm/Kg)		
Supplement Group		Pre	Post	Pre	Post		Pre	Post		Pre	Post		Pre	Post	
Creatine-electroly	ASF_002	67.72727	64.54545	129.75	122.57		191.58	189.89		85.55	82.30		126.32	127.50	
Creatine-electroly	ASF_008	81.81818	84.09091	297.20	259.91		363.24	309.08		153.61	182.36		187.75	216.86	
Creatine-electroly	ASF_011	63.18182	62.5	139.11	180.87		220.17	289.39		80.40	135.04		127.25	216.06	
Creatine-electroly	ASF_016	75.90909	75.90909	253.81	271.03		334.36	357.04		175.31	186.15		230.94	245.23	
Creatine-electroly	ASF_023	72.72727	73.63636	159.04	217.07		218.68	294.78		109.82	160.26		151.00	217.63	
Creatine-electroly	ASF_024	68.18182	68.63636	162.97	180.19		239.02	262.53		121.62	128.40		178.37	187.07	
Creatine-electroly	ASF_027	81.36364	81.36364	165.82	210.02		203.80	258.12		119.31	135.45		146.64	166.47	
						0.087964			0.082499			0.01539			0.0190727
				186.81	205.95		252.98	280.12		120.80	144.28		164.04	196.69	
				58.53624	47.10587		62.58326	47.79659155		31.72606	33.20085		34.83152	36.5857	
Creatine Mono	ASF_001	58.18182	60.45455	238.8951	226.5572		410.601	374.7562362		146.2928	137.8867		251.4407	228.0832	
Creatine Mono	ASF_003	68.18182	67.27273	138.9713	114.431		203.8246	170.1001869		102.6354	62.09646		150.5319	92.30555	
Creatine Mono	ASF_005	65	66.59091	186.2894	198.8985		286.5991	298.6871568		106.4317	107.7875		163.7411	161.8652	
Creatine Mono	ASF_007	69.13636	69.09091	164.054	180.0526		237.2904	260.6024814		118.3629	123.2439		171.2021	178.3793	
Creatine Mono	ASF_009	73.72727	79.54545	221.4051	223.9811		300.3028	281.5762715		161.0712	154.8344		218.4689	194.649	
Creatine Mono	ASF_017	64.54545	65	134.0904	124.0573		207.7457	190.8574496		26.70961	89.48398		41.38109	137.6677	
Creatine Mono	ASF_018	84.09091	85.90909	148.1909	139.7848		176.227	162.7125011		112.6685	93.8226		133.9841	109.2115	
Creatine Mono	ASF_022	75.90909	76.81818	323.227	257.3342		425.808	334.9913269		189.6789	189.9501		249.8764	247.2723	
				194.3904	183.1371		281.0498	259.2854513		120.4814	119.8882		172.5783	168.6792	
				60.35003	49.25324		88.30334	73.38147664		45.38255	38.00535		64.777	51.05356	
Placebo	ASF_004	59.54545	59.54545	206.0843	183.4422		346.0958	308.0708172		141.0051	133.0057		236.8024	223.3684	
Placebo	ASF_006	71.36364	72.27273	198.7629	202.8304		278.5213	280.6457881		74.16324	111.3127		103.923	154.0175	
Placebo	ASF_010	78.63636	77.72727	223.9811	280.2476		284.8315	360.5524291		144.3946	189.2722		183.6232	243.5081	
Placebo	ASF_012	80.90909	80.45455	231.9805	178.0189		286.7174	221.2664252		155.6479	110.3636		192.3738	137.1751	
Placebo	ASF_014	77.72727	79.09091	210.2874	220.1848		270.5451	278.3946187		150.767	173.0024		193.9692	218.7386	
Placebo	ASF_015	71.81818	72.27273	177.2054	164.8675		246.7417	228.1185016		113.3464	120.2611		157.8241	166.3989	
Placebo	ASF_020	70	70	174.7649	189.6789		249.6642	270.9699014		95.99191	111.3127		137.1313	159.0181	
Placebo	ASF_025	61.36364	63.63636	160.8	143.1744		262.0445	224.9883041		68.46881	97.07657		111.5788	152.5489	
				197.9833	195.3056		278.1452	271.6258482		117.9731	130.7009		164.6532	181.8467	
				23.45935	38.7397		29.26166	44.67633548		32.78329	30.8835		42.57694	37.54223	

		Mass (kg)			Peak Isometric TQ (Nm)				Peak Isometric TQ (Nm/kg)		
Supplment Group		Pre	Post		Pre	Post			Pre	Post	
Creatine-electrolyte	ASF_002	67.72727	64.54545		180.595	142.2253			266.65	220.35	
Creatine-electrolyte	ASF_008	81.81818	84.09091		270.0789	259.5036			330.10	308.60	
Creatine-electrolyte	ASF_011	63.18182	62.5		204.0506	216.5241			322.96	346.44	
Creatine-electrolyte	ASF_016	75.90909	75.90909		309.2621	340.0391			407.41	447.96	
Creatine-electrolyte	ASF_023	72.72727	73.63636		312.516	283.5015			429.71	385.00	
Creatine-electrolyte	ASF_024	68.18182	68.63636		139.2425	185.0691			204.22	269.64	
Creatine-electrolyte	ASF_027	81.36364	81.36364		187.7808	228.1842			230.79	280.45	
											0.303486
									313.12	322.63	
									78.98	71.12	
Creatine Mono	ASF_001	58.18182	60.45455		253.1312	270.8924			435.07	448.09	
Creatine Mono	ASF_003	68.18182	67.27273		195.2378	150.4958			286.35	223.71	
Creatine Mono	ASF_005	65	66.59091		209.2027	245.403			321.85	368.52	
Creatine Mono	ASF_007	69.13636	69.09091		185.4759	174.087			268.28	251.97	
Creatine Mono	ASF_009	73.72727	79.54545		267.2317	285.942			362.46	359.47	
Creatine Mono	ASF_017	64.54545	65		164.4607	206.8978			254.80	318.30	
Creatine Mono	ASF_018	84.09091	85.90909		226.8283	206.4911			269.74	240.36	
Creatine Mono	ASF_022	75.90909	76.81818		347.0894	309.1265			457.24	402.41	
											0.373036
									331.97	326.61	
									73.59	76.66	
Placebo	ASF_004	59.54545	59.54545		225.2014	212.3211			378.20	356.57	
Placebo	ASF_006	71.36364	72.27273		230.6246	244.3184			323.17	338.05	
Placebo	ASF_010	78.63636	77.72727		271.5703	314.6853			345.35	404.86	
Placebo	ASF_012	80.90909	80.45455		222.4897	228.7265			274.99	284.29	
Placebo	ASF_014	77.72727	79.09091		230.0823	272.5194			296.01	344.56	
Placebo	ASF_015	71.81818	72.27273		185.6115	186.425			258.45	257.95	
Placebo	ASF_020	70	70		179.5103	205.6776			256.44	293.83	
Placebo	ASF_025	61.36364	63.63636		200.7966	235.0988			327.22	369.44	
											0.022878
									307.48	331.19	
									40.72	45.72	

Appendix F

Statistical Output

Between-Subjects Factors

		N
Supplement	1.00	8
	2.00	9
	3.00	7

Within-Subjects Factors

Measure: Bodyfat

time	Dependent Variable
1	BFPre
2	BFPost

Descriptive Statistics

	Supplement	Mean	Std. Deviation	N
BFPre	1.00	14.7500	5.78841	8
	2.00	16.0556	8.98848	9
	3.00	11.1143	6.25365	7
	Total	14.1792	7.26989	24
BFPost	1.00	15.1875	8.32817	8
	2.00	17.5333	10.11793	9
	3.00	11.6143	6.06999	7
	Total	15.0250	8.50531	24

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
time	Pillai's Trace	.106	2.489[b]	1.000	21.000	.130	.106	2.489	.325
	Wilks' Lambda	.894	2.489[b]	1.000	21.000	.130	.106	2.489	.325
	Hotelling's Trace	.119	2.489[b]	1.000	21.000	.130	.106	2.489	.325
	Roy's Largest Root	.119	2.489[b]	1.000	21.000	.130	.106	2.489	.325
time * Supplement	Pillai's Trace	.043	.466[b]	2.000	21.000	.634	.043	.932	.116
	Wilks' Lambda	.957	.466[b]	2.000	21.000	.634	.043	.932	.116
	Hotelling's Trace	.044	.466[b]	2.000	21.000	.634	.043	.932	.116
	Roy's Largest Root	.044	.466[b]	2.000	21.000	.634	.043	.932	.116

a. Design: Intercept + Supplement

Within Subjects Design: time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Bodyfat

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Bodyfat

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	7.697	1	7.697	2.489	.130	.106	2.489	.325
	Greenhouse-Geisser	7.697	1.000	7.697	2.489	.130	.106	2.489	.325
	Huynh-Feldt	7.697	1.000	7.697	2.489	.130	.106	2.489	.325
	Lower-bound	7.697	1.000	7.697	2.489	.130	.106	2.489	.325
time * Supplement	Sphericity Assumed	2.883	2	1.441	.466	.634	.043	.932	.116
	Greenhouse-Geisser	2.883	2.000	1.441	.466	.634	.043	.932	.116
	Huynh-Feldt	2.883	2.000	1.441	.466	.634	.043	.932	.116
	Lower-bound	2.883	2.000	1.441	.466	.634	.043	.932	.116
Error(time)	Sphericity Assumed	64.937	21	3.092					
	Greenhouse-Geisser	64.937	21.000	3.092					
	Huynh-Feldt	64.937	21.000	3.092					
	Lower-bound	64.937	21.000	3.092					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Bodyfat

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	7.697	1	7.697	2.489	.130	.106	2.489	.325
time * Supplement	Linear	2.883	2	1.441	.466	.634	.043	.932	.116
Error(time)	Linear	64.937	21	3.092					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: Bodyfat

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	9816.018	1	9816.018	80.017	.000	.792	80.017	1.000
Supplement	235.434	2	117.717	.960	.399	.084	1.919	.194
Error	2576.151	21	122.674					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Bodyfat

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
14.376	1.607	11.034	17.718

2. Supplement

Estimates

Measure: Bodyfat

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.00	14.969	2.769	9.210	20.727
2.00	16.794	2.611	11.365	22.223
3.00	11.364	2.960	5.208	17.520

Pairwise Comparisons

Measure: Bodyfat

(I) Supplement	(J) Supplement	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1.00	2.00	-1.826	3.806	1.000	-11.725	8.074
	3.00	3.604	4.053	1.000	-6.940	14.149
2.00	1.00	1.826	3.806	1.000	-8.074	11.725
	3.00	5.430	3.947	.550	-4.837	15.697
3.00	1.00	-3.604	4.053	1.000	-14.149	6.940
	2.00	-5.430	3.947	.550	-15.697	4.837

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: Bodyfat

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	117.717	2	58.858	.960	.399	.084	1.919	.194
Error	1288.075	21	61.337					

The F tests the effect of Supplement. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

3. time

Estimates

Measure: Bodyfat

time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	13.973	1.496	10.863	17.084
2	14.778	1.749	11.141	18.416

Pairwise Comparisons

Measure: Bodyfat

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1	2	-.805	.510	.130	-1.866	.256
2	1	.805	.510	.130	-.256	1.866

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.106	2.489[a]	1.000	21.000	.130	.106	2.489	.325
Wilks' lambda	.894	2.489[a]	1.000	21.000	.130	.106	2.489	.325
Hotelling's trace	.119	2.489[a]	1.000	21.000	.130	.106	2.489	.325
Roy's largest root	.119	2.489[a]	1.000	21.000	.130	.106	2.489	.325

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

4. Supplement * time

Measure: Bodyfat

Supplement	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1.00	1	14.750	2.577	9.391	20.109
	2	15.188	3.013	8.921	21.454
2.00	1	16.056	2.429	11.003	21.108
	2	17.533	2.841	11.625	23.442
3.00	1	11.114	2.755	5.385	16.843
	2	11.614	3.221	4.915	18.314

Post Hoc Tests

Supplement

Multiple Comparisons

Measure: Bodyfat

Bonferroni

(I) Supplement	(J) Supplement	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-1.8257	3.80557	1.000	-11.7253	8.0739
	3.00	3.6045	4.05334	1.000	-6.9397	14.1486
2.00	1.00	1.8257	3.80557	1.000	-8.0739	11.7253
	3.00	5.4302	3.94685	.550	-4.8370	15.6973
3.00	1.00	-3.6045	4.05334	1.000	-14.1486	6.9397
	2.00	-5.4302	3.94685	.550	-15.6973	4.8370

Based on observed means.

The error term is Mean Square(Error) = 61.337.

General Linear Model

Within-Subjects Factors

Measure: LeanMass

time	Dependent Variable
1	LeanPre
2	LeanPost

Between-Subjects Factors

		N
Supplement	1.00	8
	2.00	9
	3.00	7

Descriptive Statistics

	Supplement	Mean	Std. Deviation	N
LeanPre	1.00	63.6250	10.56703	8
	2.00	60.1444	8.31897	9
	3.00	65.0000	8.85344	7
	Total	62.7208	9.10857	24
LeanPost	1.00	63.9375	11.90725	8
	2.00	58.7222	8.59284	9
	3.00	64.7143	9.33746	7
	Total	62.2083	9.96419	24

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
time	Pillai's Trace	.022	.471[b]	1.000	21.000	.500	.022	.471	.101
	Wilks' Lambda	.978	.471[b]	1.000	21.000	.500	.022	.471	.101
	Hotelling's Trace	.022	.471[b]	1.000	21.000	.500	.022	.471	.101
	Roy's Largest Root	.022	.471[b]	1.000	21.000	.500	.022	.471	.101
time * Supplement	Pillai's Trace	.055	.608[b]	2.000	21.000	.554	.055	1.216	.138
	Wilks' Lambda	.945	.608[b]	2.000	21.000	.554	.055	1.216	.138
	Hotelling's Trace	.058	.608[b]	2.000	21.000	.554	.055	1.216	.138
	Roy's Largest Root	.058	.608[b]	2.000	21.000	.554	.055	1.216	.138

a. Design: Intercept + Supplement

Within Subjects Design: time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: LeanMass

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: LeanMass

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	2.569	1	2.569	.471	.500	.022	.471	.101
	Greenhouse-Geisser	2.569	1.000	2.569	.471	.500	.022	.471	.101
	Huynh-Feldt	2.569	1.000	2.569	.471	.500	.022	.471	.101
	Lower-bound	2.569	1.000	2.569	.471	.500	.022	.471	.101
time * Supplement	Sphericity Assumed	6.627	2	3.313	.608	.554	.055	1.216	.138
	Greenhouse-Geisser	6.627	2.000	3.313	.608	.554	.055	1.216	.138
	Huynh-Feldt	6.627	2.000	3.313	.608	.554	.055	1.216	.138
	Lower-bound	6.627	2.000	3.313	.608	.554	.055	1.216	.138
Error(time)	Sphericity Assumed	114.466	21	5.451					

	Greenhouse-Geisser	114.466	21.000	5.451					
	Huynh-Feldt	114.466	21.000	5.451					
	Lower-bound	114.466	21.000	5.451					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: LeanMass

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	2.569	1	2.569	.471	.500	.022	.471	.101
time * Supplement	Linear	6.627	2	3.313	.608	.554	.055	1.216	.138
Error(time)	Linear	114.466	21	5.451					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: LeanMass

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	186669.853	1	186669.853	1032.299	.000	.980	1032.299	1.000
Supplement	273.271	2	136.636	.756	.482	.067	1.511	.161
Error	3797.414	21	180.829					

a. Computed using alpha = .05

1. Grand Mean

Measure: LeanMass

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
62.691	1.951	58.633	66.748

Estimates

Measure: LeanMass

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.00	63.781	3.362	56.790	70.773
2.00	59.433	3.170	52.842	66.025
3.00	64.857	3.594	57.383	72.331

Pairwise Comparisons

Measure: LeanMass

(I) Supplement	(J) Supplement	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1.00	2.00	4.348	4.620	1.000	-7.671	16.367
	3.00	-1.076	4.921	1.000	-13.878	11.726
2.00	1.00	-4.348	4.620	1.000	-16.367	7.671
	3.00	-5.424	4.792	.811	-17.889	7.042
3.00	1.00	1.076	4.921	1.000	-11.726	13.878
	2.00	5.424	4.792	.811	-7.042	17.889

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.022	.471[a]	1.000	21.000	.500	.022	.471	.101
Wilks' lambda	.978	.471[a]	1.000	21.000	.500	.022	.471	.101
Hotelling's trace	.022	.471[a]	1.000	21.000	.500	.022	.471	.101
Roy's largest root	.022	.471[a]	1.000	21.000	.500	.022	.471	.101

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

4. Supplement * time

Measure: LeanMass

				95% Confidence Interval	
Supplement	time	Mean	Std. Error	Lower Bound	Upper Bound
1.00	1	63.625	3.278	56.807	70.443
	2	63.938	3.541	56.574	71.301
2.00	1	60.144	3.091	53.717	66.572
	2	58.722	3.338	51.780	65.665
3.00	1	65.000	3.505	57.712	72.288
	2	64.714	3.785	56.842	72.586

Within-Subjects Factors

Measure: Fatmass

time	Dependent Variable
1	FMPre
2	FMPost

Between-Subjects Factors

		N
Supplement	1.00	8
	2.00	9
	3.00	7

Descriptive Statistics

	Supplement	Mean	Std. Deviation	N
FMPre	1.00	11.1625	4.88202	8
	2.00	11.4778	6.77104	9
	3.00	7.9714	4.11733	7
	Total	10.3500	5.48381	24
FMPost	1.00	11.4625	6.24864	8
	2.00	12.7111	8.23323	9
	3.00	8.3286	3.92756	7
	Total	11.0167	6.54806	24

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
time	Pillai's Trace	.101	2.347[b]	1.000	21.000	.140	.101	2.347	.310
	Wilks' Lambda	.899	2.347[b]	1.000	21.000	.140	.101	2.347	.310
	Hotelling's Trace	.112	2.347[b]	1.000	21.000	.140	.101	2.347	.310
	Roy's Largest Root	.112	2.347[b]	1.000	21.000	.140	.101	2.347	.310
time * Supplement	Pillai's Trace	.052	.577[b]	2.000	21.000	.570	.052	1.154	.133
	Wilks' Lambda	.948	.577[b]	2.000	21.000	.570	.052	1.154	.133
	Hotelling's Trace	.055	.577[b]	2.000	21.000	.570	.052	1.154	.133
	Roy's Largest Root	.055	.577[b]	2.000	21.000	.570	.052	1.154	.133

a. Design: Intercept + Supplement

Within Subjects Design: time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Fatmass

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Fatmass

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	4.715	1	4.715	2.347	.140	.101	2.347	.310
	Greenhouse-Geisser	4.715	1.000	4.715	2.347	.140	.101	2.347	.310
	Huynh-Feldt	4.715	1.000	4.715	2.347	.140	.101	2.347	.310
	Lower-bound	4.715	1.000	4.715	2.347	.140	.101	2.347	.310
time * Supplement	Sphericity Assumed	2.318	2	1.159	.577	.570	.052	1.154	.133
	Greenhouse-Geisser	2.318	2.000	1.159	.577	.570	.052	1.154	.133
	Huynh-Feldt	2.318	2.000	1.159	.577	.570	.052	1.154	.133
	Lower-bound	2.318	2.000	1.159	.577	.570	.052	1.154	.133

Error(time)	Sphericity Assumed	42.199	21	2.009					
	Greenhouse-Geisser	42.199	21.000	2.009					
	Huynh-Feldt	42.199	21.000	2.009					
	Lower-bound	42.199	21.000	2.009					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Fatmass

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	4.715	1	4.715	2.347	.140	.101	2.347	.310
time * Supplement	Linear	2.318	2	1.159	.577	.570	.052	1.154	.133
Error(time)	Linear	42.199	21	2.009					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: Fatmass

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	5255.536	1	5255.536	73.514	.000	.778	73.514	1.000
Supplement	132.025	2	66.012	.923	.413	.081	1.847	.188
Error	1501.292	21	71.490					

a. Computed using alpha = .05

1. Grand Mean

Measure: Fatmass

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
10.519	1.227	7.968	13.070

2. Supplement

Estimates

Measure: Fatmass

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.00	11.313	2.114	6.917	15.708
2.00	12.094	1.993	7.950	16.239
3.00	8.150	2.260	3.451	12.849

Pairwise Comparisons

Measure: Fatmass

(I) Supplement	(J) Supplement	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
1.00	2.00	-.782	2.905	1.000	-8.339	6.775
	3.00	3.162	3.094	.955	-4.887	11.212
2.00	1.00	.782	2.905	1.000	-6.775	8.339
	3.00	3.944	3.013	.614	-3.893	11.782
3.00	1.00	-3.162	3.094	.955	-11.212	4.887
	2.00	-3.944	3.013	.614	-11.782	3.893

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Univariate Tests

Measure: Fatmass

	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Contrast	66.012	2	33.006	.923	.413	.081	1.847	.188
Error	750.646	21	35.745					

The F tests the effect of Supplement. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Computed using alpha = .05

Estimates

Measure: Fatmass

			95% Confidence Interval	
time	Mean	Std. Error	Lower Bound	Upper Bound
1	10.204	1.129	7.857	12.551
2	10.834	1.349	8.028	13.640

Pairwise Comparisons

Measure: Fatmass

					95% Confidence Interval for Difference[a]	
(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]	Lower Bound	Upper Bound
1	2	-.630	.411	.140	-1.486	.225
2	1	.630	.411	.140	-.225	1.486

Based on estimated marginal means

a. Adjustment for multiple comparisons: Bonferroni.

Multivariate Tests

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Pillai's trace	.101	2.347[a]	1.000	21.000	.140	.101	2.347	.310
Wilks' lambda	.899	2.347[a]	1.000	21.000	.140	.101	2.347	.310
Hotelling's trace	.112	2.347[a]	1.000	21.000	.140	.101	2.347	.310
Roy's largest root	.112	2.347[a]	1.000	21.000	.140	.101	2.347	.310

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

4. Supplement * time

Measure: Fatmass

Supplement	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1.00	1	11.163	1.945	7.118	15.207
	2	11.462	2.325	6.627	16.298
2.00	1	11.478	1.833	7.665	15.291
	2	12.711	2.192	8.152	17.270
3.00	1	7.971	2.079	3.648	12.295
	2	8.329	2.486	3.160	13.498

General Linear Model

Within-Subjects Factors

Measure: TBW

time	Dependent Variable
1	TBWPre
2	TBWPost

Between-Subjects Factors

		N
Supplement	1.00	6
	2.00	7
	3.00	6

Descriptive Statistics

	Supplement	Mean	Std. Deviation	N
TBWPre	1.00	42.2667	7.73218	6
	2.00	36.0143	6.20227	7
	3.00	40.5000	6.44267	6
	Total	39.4053	6.96854	19
TBWPost	1.00	40.5167	8.48656	6
	2.00	36.5714	5.91882	7
	3.00	40.0500	6.19540	6
	Total	38.9158	6.76505	19

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
time	Pillai's Trace	.016	.264[b]	1.000	16.000	.615	.016	.264	.077
	Wilks' Lambda	.984	.264[b]	1.000	16.000	.615	.016	.264	.077
	Hotelling's Trace	.016	.264[b]	1.000	16.000	.615	.016	.264	.077
	Roy's Largest Root	.016	.264[b]	1.000	16.000	.615	.016	.264	.077
	Pillai's Trace	.048	.400[b]	2.000	16.000	.677	.048	.800	.104

time * Supplement	Wilks' Lambda	.952	.400[b]	2.000	16.000	.677	.048	.800	.104
	Hotelling's Trace	.050	.400[b]	2.000	16.000	.677	.048	.800	.104
	Roy's Largest Root	.050	.400[b]	2.000	16.000	.677	.048	.800	.104

a. Design: Intercept + Supplement

Within Subjects Design: time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: TBW

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: TBW

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	2.834	1	2.834	.264	.615	.016	.264	.077
	Greenhouse-Geisser	2.834	1.000	2.834	.264	.615	.016	.264	.077
	Huynh-Feldt	2.834	1.000	2.834	.264	.615	.016	.264	.077
	Lower-bound	2.834	1.000	2.834	.264	.615	.016	.264	.077

time * Supplement	Sphericity Assumed	8.605	2	4.303	.400	.677	.048	.800	.104
	Greenhouse-Geisser	8.605	2.000	4.303	.400	.677	.048	.800	.104
	Huynh-Feldt	8.605	2.000	4.303	.400	.677	.048	.800	.104
	Lower-bound	8.605	2.000	4.303	.400	.677	.048	.800	.104
Error(time)	Sphericity Assumed	172.064	16	10.754					
	Greenhouse-Geisser	172.064	16.000	10.754					
	Huynh-Feldt	172.064	16.000	10.754					
	Lower-bound	172.064	16.000	10.754					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: TBW

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Linear	2.834	1	2.834	.264	.615	.016	.264	.077
time * Supplement	Linear	8.605	2	4.303	.400	.677	.048	.800	.104
Error(time)	Linear	172.064	16	10.754					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: TBW

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]

Intercept	58440.687	1	58440.687	704.404	.000	.978	704.404	1.000
Supplement	189.770	2	94.885	1.144	.343	.125	2.287	.216
Error	1327.436	16	82.965					

a. Computed using alpha = .05

General Linear Model

Within-Subjects Factors

Measure: Intra

time	Dependent Variable
1	IntraPre
2	IntraPost

Between-Subjects Factors

		N
Supplement	1.00	6
	2.00	7
	3.00	6

Descriptive Statistics

	Supplement	Mean	Std. Deviation	N
IntraPre	1.00	24.0000	4.76151	6
	2.00	19.9143	4.83991	7
	3.00	23.2500	4.32516	6
	Total	22.2579	4.77264	19
IntraPost	1.00	22.8833	5.50833	6

2.00	20.1000	4.36310	7
3.00	23.3333	3.43725	6
Total	22.0000	4.50691	19

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
time	Pillai's Trace	.010	.167[b]	1.000	16.000	.688	.010	.167	.067
	Wilks' Lambda	.990	.167[b]	1.000	16.000	.688	.010	.167	.067
	Hotelling's Trace	.010	.167[b]	1.000	16.000	.688	.010	.167	.067
	Roy's Largest Root	.010	.167[b]	1.000	16.000	.688	.010	.167	.067
time * Supplement	Pillai's Trace	.043	.361[b]	2.000	16.000	.703	.043	.722	.098
	Wilks' Lambda	.957	.361[b]	2.000	16.000	.703	.043	.722	.098
	Hotelling's Trace	.045	.361[b]	2.000	16.000	.703	.043	.722	.098
	Roy's Largest Root	.045	.361[b]	2.000	16.000	.703	.043	.722	.098

a. Design: Intercept + Supplement

Within Subjects Design: time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Intra

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Intra

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
time	Sphericity Assumed	.754	1	.754	.167	.688	.010	.167	.067
	Greenhouse-Geisser	.754	1.000	.754	.167	.688	.010	.167	.067
	Huynh-Feldt	.754	1.000	.754	.167	.688	.010	.167	.067
	Lower-bound	.754	1.000	.754	.167	.688	.010	.167	.067
time * Supplement	Sphericity Assumed	3.251	2	1.625	.361	.703	.043	.722	.098
	Greenhouse-Geisser	3.251	2.000	1.625	.361	.703	.043	.722	.098
	Huynh-Feldt	3.251	2.000	1.625	.361	.703	.043	.722	.098
	Lower-bound	3.251	2.000	1.625	.361	.703	.043	.722	.098
Error(time)	Sphericity Assumed	72.083	16	4.505					
	Greenhouse-Geisser	72.083	16.000	4.505					
	Huynh-Feldt	72.083	16.000	4.505					
	Lower-bound	72.083	16.000	4.505					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Intra

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]

time	Linear	.754	1	.754	.167	.688	.010	.167	.067
time * Supplement	Linear	3.251	2	1.625	.361	.703	.043	.722	.098
Error(time)	Linear	72.083	16	4.505					

a. Computed using alpha = .05

Tests of Between-Subjects Effects

Measure: Intra

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	18708.023	1	18708.023	498.579	.000	.969	498.579	1.000
Supplement	99.931	2	49.965	1.332	.292	.143	2.663	.246
Error	600.363	16	37.523					

a. Computed using alpha = .05

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	ExtraPre
2	ExtraPost

Between-Subjects Factors

		N
Group	1	6
	2	7
	3	6

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
time	Pillai's Trace	.074	1.275[b]	1.000	16.000	.275
	Wilks' Lambda	.926	1.275[b]	1.000	16.000	.275
	Hotelling's Trace	.080	1.275[b]	1.000	16.000	.275
	Roy's Largest Root	.080	1.275[b]	1.000	16.000	.275
time * Group	Pillai's Trace	.355	4.395[b]	2.000	16.000	.030
	Wilks' Lambda	.645	4.395[b]	2.000	16.000	.030
	Hotelling's Trace	.549	4.395[b]	2.000	16.000	.030
	Roy's Largest Root	.549	4.395[b]	2.000	16.000	.030

a. Design: Intercept + Group

Within Subjects Design: time

b. Exact statistic

Mauchly's Test of Sphericity[a]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	.000	0	.	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Group

Within Subjects Design: time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
time	Sphericity Assumed	.447	1	.447	1.275	.275
	Greenhouse-Geisser	.447	1.000	.447	1.275	.275
	Huynh-Feldt	.447	1.000	.447	1.275	.275
	Lower-bound	.447	1.000	.447	1.275	.275
time * Group	Sphericity Assumed	3.081	2	1.540	4.395	.030
	Greenhouse-Geisser	3.081	2.000	1.540	4.395	.030
	Huynh-Feldt	3.081	2.000	1.540	4.395	.030
	Lower-bound	3.081	2.000	1.540	4.395	.030
Error(time)	Sphericity Assumed	5.608	16	.350		
	Greenhouse-Geisser	5.608	16.000	.350		
	Huynh-Feldt	5.608	16.000	.350		
	Lower-bound	5.608	16.000	.350		

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F	Sig.
time	Linear	.447	1	.447	1.275	.275
time * Group	Linear	3.081	2	1.540	4.395	.030
Error(time)	Linear	5.608	16	.350		

Tests of Between-Subjects Effects

Measure: MEASURE_1

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	10695.905	1	10695.905	746.170	.000

Group	6.502	2	3.251	.227	.800
Error	229.350	16	14.334		

Within-Subjects Factors

Measure: IsometricTQ_Norm

Time	Dependent Variable
1	Pre_IsometricTQ_Norm
2	Post_IsomericTQ_Norm

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_IsometricTQ_Norm	MagnaPower	313.1199	85.30822	7
	Creatine Monohydrate	331.9734	78.66844	8
	Placebo	307.4790	43.53621	8
	Total	317.7156	68.37937	23
Post_IsomericTQ_Norm	MagnaPower	322.6330	76.82159	7
	Creatine Monohydrate	326.6052	81.94821	8
	Placebo	331.1936	48.87351	8
	Total	326.9923	67.22205	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	5.041
F	.717
df1	6
df2	8714.141
Sig.	.636

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.057	1.216[b]	1.000	20.000	.283	.057	1.216	.183
	Wilks' Lambda	.943	1.216[b]	1.000	20.000	.283	.057	1.216	.183
	Hotelling's Trace	.061	1.216[b]	1.000	20.000	.283	.057	1.216	.183
	Roy's Largest Root	.061	1.216[b]	1.000	20.000	.283	.057	1.216	.183
Time * Supplement	Pillai's Trace	.094	1.042[b]	2.000	20.000	.371	.094	2.083	.206
	Wilks' Lambda	.906	1.042[b]	2.000	20.000	.371	.094	2.083	.206
	Hotelling's Trace	.104	1.042[b]	2.000	20.000	.371	.094	2.083	.206
	Roy's Largest Root	.104	1.042[b]	2.000	20.000	.371	.094	2.083	.206

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: IsometricTQ_Norm

Within Subjects Effect	Mauchly's W		df	Sig.	Epsilon[b]

		Approx. Chi-Square			Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: IsometricTQ_Norm

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	987.831	1	987.831	1.216	.283	.057	1.216	.183
	Greenhouse-Geisser	987.831	1.000	987.831	1.216	.283	.057	1.216	.183
	Huynh-Feldt	987.831	1.000	987.831	1.216	.283	.057	1.216	.183
	Lower-bound	987.831	1.000	987.831	1.216	.283	.057	1.216	.183
Time * Supplement	Sphericity Assumed	1691.902	2	845.951	1.042	.371	.094	2.083	.206
	Greenhouse-Geisser	1691.902	2.000	845.951	1.042	.371	.094	2.083	.206
	Huynh-Feldt	1691.902	2.000	845.951	1.042	.371	.094	2.083	.206
	Lower-bound	1691.902	2.000	845.951	1.042	.371	.094	2.083	.206
Error(Time)	Sphericity Assumed	16242.746	20	812.137					
	Greenhouse-Geisser	16242.746	20.000	812.137					
	Huynh-Feldt	16242.746	20.000	812.137					
	Lower-bound	16242.746	20.000	812.137					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: IsometricTQ_Norm

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	987.831	1	987.831	1.216	.283	.057	1.216	.183
Time * Supplement	Linear	1691.902	2	845.951	1.042	.371	.094	2.083	.206
Error(Time)	Linear	16242.746	20	812.137					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_IsometricTQ_Norm	1.991	2	20	.163
Post_IsomericTQ_Norm	1.449	2	20	.258

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: IsometricTQ_Norm
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	4755552.090	1	4755552.090	519.309	.000	.963	519.309	1.000
Supplement	1195.950	2	597.975	.065	.937	.006	.131	.059
Error	183149.333	20	9157.467					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: IsometricTQ_Norm

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
322.167	14.137	292.677	351.657

2. Supplement

Measure: IsometricTQ_Norm

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	317.876	25.575	264.527	371.226
Creatine Monohydrate	329.289	23.924	279.385	379.193
Placebo	319.336	23.924	269.432	369.240

3. Time

Measure: IsometricTQ_Norm

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	317.524	14.792	286.668	348.380
2	326.811	14.710	296.127	357.494

4. Supplement * Time

Estimates

Measure: IsometricTQ_Norm

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	313.120	26.760	257.300	368.940
	2	322.633	26.611	267.124	378.142
Creatine Monohydrate	1	331.973	25.032	279.758	384.189
	2	326.605	24.892	274.681	378.529
Placebo	1	307.479	25.032	255.264	359.694
	2	331.194	24.892	279.270	383.118

Pairwise Comparisons

Measure: IsometricTQ_Norm

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-9.513	15.233	.539	-41.288	22.262
	2	1	9.513	15.233	.539	-22.262	41.288
Creatine Monohydrate	1	2	5.368	14.249	.710	-24.355	35.091
	2	1	-5.368	14.249	.710	-35.091	24.355
Placebo	1	2	-23.715	14.249	.112	-53.438	6.008
	2	1	23.715	14.249	.112	-6.008	53.438

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.019	.390[a]	1.000	20.000	.539	.019	.390	.091
	Wilks' lambda	.981	.390[a]	1.000	20.000	.539	.019	.390	.091
	Hotelling's trace	.020	.390[a]	1.000	20.000	.539	.019	.390	.091
	Roy's largest root	.020	.390[a]	1.000	20.000	.539	.019	.390	.091

Creatine Monohydrate	Pillai's trace	.007	.142[a]	1.000	20.000	.710	.007	.142	.065
	Wilks' lambda	.993	.142[a]	1.000	20.000	.710	.007	.142	.065
	Hotelling's trace	.007	.142[a]	1.000	20.000	.710	.007	.142	.065
	Roy's largest root	.007	.142[a]	1.000	20.000	.710	.007	.142	.065
Placebo	Pillai's trace	.122	2.770[a]	1.000	20.000	.112	.122	2.770	.354
	Wilks' lambda	.878	2.770[a]	1.000	20.000	.112	.122	2.770	.354
	Hotelling's trace	.138	2.770[a]	1.000	20.000	.112	.122	2.770	.354
	Roy's largest root	.138	2.770[a]	1.000	20.000	.112	.122	2.770	.354

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

General Linear Model

[DataSet0] U:\Thesis_Data.sav

Within-Subjects Factors

Measure: Iso_TQ_60_Deg_Normalized

Time	Dependent Variable
1	Pre_Iso_TQ_60_Deg_Normalized
2	Post_Iso_TQ_60_Deg_Normalized

Between-Subjects Factors

		Value Label	N
Supplement	1.00	Creatine-elec	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement	Mean	Std. Deviation	N
Creatine-Electrolyte	252.9774	67.59765	7

	Creatine Monohydrate	281.0498	94.40025	8
Pre_Iso_TQ_60_Deg_Normalized	Placebo	278.1452	31.28203	8
	Total	271.4957	67.46410	23
Post_Iso_TQ_60_Deg_Normalized	Creatine-Electrolyte	280.1186	51.62622	7
	Creatine Monohydrate	259.2855	78.44810	8
	Placebo	271.6258	47.76101	8
	Total	269.9183	59.04322	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	9.200
F	1.309
df1	6
df2	8714.141
Sig.	.249

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.000	.002[b]	1.000	20.000	.965	.000	.002	.050
	Wilks' Lambda	1.000	.002[b]	1.000	20.000	.965	.000	.002	.050
	Hotelling's Trace	.000	.002[b]	1.000	20.000	.965	.000	.002	.050
	Roy's Largest Root	.000	.002[b]	1.000	20.000	.965	.000	.002	.050
Time * Supplement	Pillai's Trace	.213	2.704[b]	2.000	20.000	.091	.213	5.408	.474
	Wilks' Lambda	.787	2.704[b]	2.000	20.000	.091	.213	5.408	.474
	Hotelling's Trace	.270	2.704[b]	2.000	20.000	.091	.213	5.408	.474
	Roy's Largest Root	.270	2.704[b]	2.000	20.000	.091	.213	5.408	.474

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Iso_TQ_60_Deg_Normalized

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Iso_TQ_60_Deg_Normalized

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	1.662	1	1.662	.002	.965	.000	.002	.050
	Greenhouse-Geisser	1.662	1.000	1.662	.002	.965	.000	.002	.050
	Huynh-Feldt	1.662	1.000	1.662	.002	.965	.000	.002	.050
	Lower-bound	1.662	1.000	1.662	.002	.965	.000	.002	.050
Time * Supplement	Sphericity Assumed	4614.388	2	2307.194	2.704	.091	.213	5.408	.474
	Greenhouse-Geisser	4614.388	2.000	2307.194	2.704	.091	.213	5.408	.474
	Huynh-Feldt	4614.388	2.000	2307.194	2.704	.091	.213	5.408	.474
	Lower-bound	4614.388	2.000	2307.194	2.704	.091	.213	5.408	.474
Error(Time)	Sphericity Assumed	17066.053	20	853.303					
	Greenhouse-Geisser	17066.053	20.000	853.303					
	Huynh-Feldt	17066.053	20.000	853.303					
	Lower-bound	17066.053	20.000	853.303					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Iso_TQ_60_Deg_Normalized

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]

Time	Linear	1.662	1	1.662	.002	.965	.000	.002	.050
Time * Supplement	Linear	4614.388	2	2307.194	2.704	.091	.213	5.408	.474
Error(Time)	Linear	17066.053	20	853.303					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Iso_TQ_60_Deg_Normalized	4.318	2	20	.028
Post_Iso_TQ_60_Deg_Normalized	1.700	2	20	.208

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Iso_TQ_60_Deg_Normalized
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	3353363.739	1	3353363.739	433.760	.000	.956	433.760	1.000
Supplement	526.176	2	263.088	.034	.967	.003	.068	.054
Error	154618.531	20	7730.927					

a. Computed using alpha = .05

Estimated Marginal Means

1. Time

Measure: Iso_TQ_60_Deg_Normalized

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	270.724	14.524	240.428	301.020
2	270.343	12.797	243.648	297.038

2. Supplement * Time

Estimates

Measure: Iso_TQ_60_Deg_Normalized

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	252.977	26.274	198.170	307.784
	2	280.119	23.151	231.826	328.412
Creatine Monohydrate	1	281.050	24.577	229.783	332.317
	2	259.285	21.656	214.112	304.459
Placebo	1	278.145	24.577	226.878	329.412
	2	271.626	21.656	226.452	316.800

Pairwise Comparisons

Measure: Iso_TQ_60_Deg_Normalized

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-27.141	15.614	.098	-59.712	5.429
	2	1	27.141	15.614	.098	-5.429	59.712
Creatine Monohydrate	1	2	21.764	14.606	.152	-8.703	52.231
	2	1	-21.764	14.606	.152	-52.231	8.703
Placebo	1	2	6.519	14.606	.660	-23.948	36.986
	2	1	-6.519	14.606	.660	-36.986	23.948

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.131	3.021[a]	1.000	20.000	.098	.131	3.021	.380
	Wilks' lambda	.869	3.021[a]	1.000	20.000	.098	.131	3.021	.380
	Hotelling's trace	.151	3.021[a]	1.000	20.000	.098	.131	3.021	.380
	Roy's largest root	.151	3.021[a]	1.000	20.000	.098	.131	3.021	.380
Creatine Monohydrate	Pillai's trace	.100	2.220[a]	1.000	20.000	.152	.100	2.220	.295
	Wilks' lambda	.900	2.220[a]	1.000	20.000	.152	.100	2.220	.295
	Hotelling's trace	.111	2.220[a]	1.000	20.000	.152	.100	2.220	.295
	Roy's largest root	.111	2.220[a]	1.000	20.000	.152	.100	2.220	.295
Placebo	Pillai's trace	.010	.199[a]	1.000	20.000	.660	.010	.199	.071
	Wilks' lambda	.990	.199[a]	1.000	20.000	.660	.010	.199	.071
	Hotelling's trace	.010	.199[a]	1.000	20.000	.660	.010	.199	.071
	Roy's largest root	.010	.199[a]	1.000	20.000	.660	.010	.199	.071

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

3. Grand Mean

Measure: Iso_TQ_60_Deg_Normalized

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
270.534	12.990	243.438	297.630

4. Supplement

Measure: Iso_TQ_60_Deg_Normalized

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	266.548	23.499	217.530	315.566
Creatine Monohydrate	270.168	21.981	224.315	316.020
Placebo	274.886	21.981	229.033	320.738

Within-Subjects Factors

Measure: Peak_Iso_TQ_180DEG_Norm

Time	Dependent Variable
1	Pre_Iso_TQ_180DEG_Norm
2	Post_Iso_TQ_180Deg_Norm

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7

	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_Iso_TQ_180DEG_Norm	MagnaPower	164.0401	37.62234	7
	Creatine Monohydrate	172.5783	69.24952	8
	Placebo	164.6532	45.51666	8
	Total	167.2232	50.86375	23
Post_Iso_TQ_180Deg_Norm	MagnaPower	196.6898	39.51707	7
	Creatine Monohydrate	168.6792	54.57855	8
	Placebo	181.8467	40.13433	8
	Total	181.7842	44.93726	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	2.915
F	.415
df1	6
df2	8714.141
Sig.	.870

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.150	3.521[b]	1.000	20.000	.075	.150	3.521	.431

	Wilks' Lambda	.850	3.521[b]	1.000	20.000	.075	.150	3.521	.431
	Hotelling's Trace	.176	3.521[b]	1.000	20.000	.075	.150	3.521	.431
	Roy's Largest Root	.176	3.521[b]	1.000	20.000	.075	.150	3.521	.431
Time * Supplement	Pillai's Trace	.143	1.662[b]	2.000	20.000	.215	.143	3.324	.308
	Wilks' Lambda	.857	1.662[b]	2.000	20.000	.215	.143	3.324	.308
	Hotelling's Trace	.166	1.662[b]	2.000	20.000	.215	.143	3.324	.308
	Roy's Largest Root	.166	1.662[b]	2.000	20.000	.215	.143	3.324	.308

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Peak_Iso_TQ_180DEG_Norm

					Epsilon[b]		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Peak_Iso_TQ_180DEG_Norm

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	2686.546	1	2686.546	3.521	.075	.150	3.521	.431
	Greenhouse-Geisser	2686.546	1.000	2686.546	3.521	.075	.150	3.521	.431
	Huynh-Feldt	2686.546	1.000	2686.546	3.521	.075	.150	3.521	.431
	Lower-bound	2686.546	1.000	2686.546	3.521	.075	.150	3.521	.431
Time * Supplement	Sphericity Assumed	2536.019	2	1268.010	1.662	.215	.143	3.324	.308
	Greenhouse-Geisser	2536.019	2.000	1268.010	1.662	.215	.143	3.324	.308
	Huynh-Feldt	2536.019	2.000	1268.010	1.662	.215	.143	3.324	.308
	Lower-bound	2536.019	2.000	1268.010	1.662	.215	.143	3.324	.308
Error(Time)	Sphericity Assumed	15258.783	20	762.939					
	Greenhouse-Geisser	15258.783	20.000	762.939					
	Huynh-Feldt	15258.783	20.000	762.939					
	Lower-bound	15258.783	20.000	762.939					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Peak_Iso_TQ_180DEG_Norm

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	2686.546	1	2686.546	3.521	.075	.150	3.521	.431
Time * Supplement	Linear	2536.019	2	1268.010	1.662	.215	.143	3.324	.308
Error(Time)	Linear	15258.783	20	762.939					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Iso_TQ_180DEG_Norm	.875	2	20	.432
Post_Iso_TQ_180Deg_Norm	.610	2	20	.553

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Peak_Iso_TQ_180DEG_Norm
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	1399141.793	1	1399141.793	337.951	.000	.944	337.951	1.000
Supplement	746.352	2	373.176	.090	.914	.009	.180	.062
Error	82801.374	20	4140.069					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Peak_Iso_TQ_180DEG_Norm

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
174.748	9.506	154.919	194.576

2. Supplement

Measure: Peak_Iso_TQ_180DEG_Norm

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	180.365	17.196	144.494	216.236
Creatine Monohydrate	170.629	16.086	137.074	204.183
Placebo	173.250	16.086	139.695	206.804

3. Time

Measure: Peak_Iso_TQ_180DEG_Norm

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	167.091	11.111	143.914	190.267
2	182.405	9.517	162.554	202.257

4. Supplement * Time

Estimates

Measure: Peak_Iso_TQ_180DEG_Norm

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	164.040	20.100	122.111	205.969
	2	196.690	17.216	160.777	232.603
Creatine Monohydrate	1	172.578	18.802	133.358	211.799
	2	168.679	16.104	135.086	202.273
Placebo	1	164.653	18.802	125.433	203.874
	2	181.847	16.104	148.253	215.440

Pairwise Comparisons

Measure: Peak_Iso_TQ_180DEG_Norm

Supplement			Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-32.650*	14.764	.039	-63.447	-1.852
	2	1	32.650*	14.764	.039	1.852	63.447
Creatine Monohydrate	1	2	3.899	13.811	.781	-24.909	32.708
	2	1	-3.899	13.811	.781	-32.708	24.909
Placebo	1	2	-17.193	13.811	.228	-46.002	11.615

2	1	17.193	13.811	.228	-11.615	46.002

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.196	4.890[a]	1.000	20.000	.039	.196	4.890	.558
	Wilks' lambda	.804	4.890[a]	1.000	20.000	.039	.196	4.890	.558
	Hotelling's trace	.245	4.890[a]	1.000	20.000	.039	.196	4.890	.558
	Roy's largest root	.245	4.890[a]	1.000	20.000	.039	.196	4.890	.558
Creatine Monohydrate	Pillai's trace	.004	.080[a]	1.000	20.000	.781	.004	.080	.058
	Wilks' lambda	.996	.080[a]	1.000	20.000	.781	.004	.080	.058
	Hotelling's trace	.004	.080[a]	1.000	20.000	.781	.004	.080	.058
	Roy's largest root	.004	.080[a]	1.000	20.000	.781	.004	.080	.058
Placebo	Pillai's trace	.072	1.550[a]	1.000	20.000	.228	.072	1.550	.220
	Wilks' lambda	.928	1.550[a]	1.000	20.000	.228	.072	1.550	.220
	Hotelling's trace	.077	1.550[a]	1.000	20.000	.228	.072	1.550	.220
	Roy's largest root	.077	1.550[a]	1.000	20.000	.228	.072	1.550	.220

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: WLRatio_Set1

Time	Dependent Variable
1	Pre_WLRatio_Set1
2	Post_WLRatio_Set1

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7

	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_WLRatio_Set1	MagnaPower	1.6738	.26866	7
	Creatine Monohydrate	1.8104	.21354	8
	Placebo	1.4915	.57230	8
	Total	1.6579	.39624	23
Post_WLRatio_Set1	MagnaPower	1.8887	.36664	7
	Creatine Monohydrate	1.7092	.33188	8
	Placebo	1.7180	.45487	8
	Total	1.7669	.37992	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	11.146
F	1.586
df1	6
df2	8714.141
Sig.	.147

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.091	2.007[b]	1.000	20.000	.172	.091	2.007	.271

	Wilks' Lambda	.909	2.007[b]	1.000	20.000	.172	.091	2.007	.271
	Hotelling's Trace	.100	2.007[b]	1.000	20.000	.172	.091	2.007	.271
	Roy's Largest Root	.100	2.007[b]	1.000	20.000	.172	.091	2.007	.271
Time * Supplement	Pillai's Trace	.156	1.847[b]	2.000	20.000	.184	.156	3.694	.339
	Wilks' Lambda	.844	1.847[b]	2.000	20.000	.184	.156	3.694	.339
	Hotelling's Trace	.185	1.847[b]	2.000	20.000	.184	.156	3.694	.339
	Roy's Largest Root	.185	1.847[b]	2.000	20.000	.184	.156	3.694	.339

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: WLRatio_Set1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: WLRatio_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	.147	1	.147	2.007	.172	.091	2.007	.271
	Greenhouse-Geisser	.147	1.000	.147	2.007	.172	.091	2.007	.271
	Huynh-Feldt	.147	1.000	.147	2.007	.172	.091	2.007	.271
	Lower-bound	.147	1.000	.147	2.007	.172	.091	2.007	.271
Time * Supplement	Sphericity Assumed	.271	2	.136	1.847	.184	.156	3.694	.339
	Greenhouse-Geisser	.271	2.000	.136	1.847	.184	.156	3.694	.339
	Huynh-Feldt	.271	2.000	.136	1.847	.184	.156	3.694	.339
	Lower-bound	.271	2.000	.136	1.847	.184	.156	3.694	.339
Error(Time)	Sphericity Assumed	1.468	20	.073					
	Greenhouse-Geisser	1.468	20.000	.073					
	Huynh-Feldt	1.468	20.000	.073					
	Lower-bound	1.468	20.000	.073					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: WLRatio_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	.147	1	.147	2.007	.172	.091	2.007	.271
Time * Supplement	Linear	.271	2	.136	1.847	.184	.156	3.694	.339
Error(Time)	Linear	1.468	20	.073					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_WLRatio_Set1	3.687	2	20	.043
Post_WLRatio_Set1	.208	2	20	.814

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: WLRatio_Set1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	134.804	1	134.804	585.698	.000	.967	585.698	1.000
Supplement	.288	2	.144	.625	.545	.059	1.250	.140
Error	4.603	20	.230					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: WLRatio_Set1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
1.715	.071	1.567	1.863

2. Supplement

Measure: WLRatio_Set1

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	1.781	.128	1.514	2.049
Creatine Monohydrate	1.760	.120	1.510	2.010
Placebo	1.605	.120	1.355	1.855

3. Time

Measure: WLRatio_Set1

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	1.659	.082	1.489	1.829
2	1.772	.081	1.602	1.941

4. Supplement * Time

Estimates

Measure: WLRatio_Set1

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	1.674	.147	1.366	1.981
	2	1.889	.147	1.582	2.195
Creatine Monohydrate	1	1.810	.138	1.523	2.098
	2	1.709	.138	1.422	1.996
Placebo	1	1.492	.138	1.204	1.779
	2	1.718	.138	1.431	2.005

Pairwise Comparisons

Measure: WLRatio_Set1

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-.215	.145	.153	-.517	.087
	2	1	.215	.145	.153	-.087	.517
Creatine Monohydrate	1	2	.101	.135	.464	-.181	.384
	2	1	-.101	.135	.464	-.384	.181
Placebo	1	2	-.226	.135	.110	-.509	.056
	2	1	.226	.135	.110	-.056	.509

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.099	2.202[a]	1.000	20.000	.153	.099	2.202	.293
	Wilks' lambda	.901	2.202[a]	1.000	20.000	.153	.099	2.202	.293
	Hotelling's trace	.110	2.202[a]	1.000	20.000	.153	.099	2.202	.293
	Roy's largest root	.110	2.202[a]	1.000	20.000	.153	.099	2.202	.293
Creatine Monohydrate	Pillai's trace	.027	.558[a]	1.000	20.000	.464	.027	.558	.110
	Wilks' lambda	.973	.558[a]	1.000	20.000	.464	.027	.558	.110
	Hotelling's trace	.028	.558[a]	1.000	20.000	.464	.027	.558	.110
	Roy's largest root	.028	.558[a]	1.000	20.000	.464	.027	.558	.110
Placebo	Pillai's trace	.123	2.795[a]	1.000	20.000	.110	.123	2.795	.357
	Wilks' lambda	.877	2.795[a]	1.000	20.000	.110	.123	2.795	.357
	Hotelling's trace	.140	2.795[a]	1.000	20.000	.110	.123	2.795	.357
	Roy's largest root	.140	2.795[a]	1.000	20.000	.110	.123	2.795	.357

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: WLRatio_Set2

Time	Dependent Variable
1	Pre_WLRatio_Set2
2	Post_WLRatio_Set2

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_WLRatio_Set2	MagnaPower	2.2256	.40336	7
	Creatine Monohydrate	2.3005	.40128	8
	Placebo	1.8955	.47153	8
	Total	2.1368	.44697	23
Post_WLRatio_Set2	MagnaPower	2.1267	.20502	7
	Creatine Monohydrate	1.9875	.54554	8
	Placebo	1.9106	.30256	8
	Total	2.0031	.37861	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	7.402
F	1.054
df1	6
df2	8714.141
Sig.	.388

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.077	1.676[b]	1.000	20.000	.210	.077	1.676	.234
	Wilks' Lambda	.923	1.676[b]	1.000	20.000	.210	.077	1.676	.234
	Hotelling's Trace	.084	1.676[b]	1.000	20.000	.210	.077	1.676	.234
	Roy's Largest Root	.084	1.676[b]	1.000	20.000	.210	.077	1.676	.234
Time * Supplement	Pillai's Trace	.085	.925[b]	2.000	20.000	.413	.085	1.851	.187
	Wilks' Lambda	.915	.925[b]	2.000	20.000	.413	.085	1.851	.187

	Hotelling's Trace	.093	.925[b]	2.000	20.000	.413	.085	1.851	.187
	Roy's Largest Root	.093	.925[b]	2.000	20.000	.413	.085	1.851	.187

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: WLRatio_Set2

					Epsilon[b]		
Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: WLRatio_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	.200	1	.200	1.676	.210	.077	1.676	.234
	Greenhouse-Geisser	.200	1.000	.200	1.676	.210	.077	1.676	.234
	Huynh-Feldt	.200	1.000	.200	1.676	.210	.077	1.676	.234
	Lower-bound	.200	1.000	.200	1.676	.210	.077	1.676	.234
Time * Supplement	Sphericity Assumed	.221	2	.111	.925	.413	.085	1.851	.187
	Greenhouse-Geisser	.221	2.000	.111	.925	.413	.085	1.851	.187
	Huynh-Feldt	.221	2.000	.111	.925	.413	.085	1.851	.187
	Lower-bound	.221	2.000	.111	.925	.413	.085	1.851	.187
Error(Time)	Sphericity Assumed	2.392	20	.120					
	Greenhouse-Geisser	2.392	20.000	.120					
	Huynh-Feldt	2.392	20.000	.120					
	Lower-bound	2.392	20.000	.120					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: WLRatio_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	.200	1	.200	1.676	.210	.077	1.676	.234
Time * Supplement	Linear	.221	2	.111	.925	.413	.085	1.851	.187
Error(Time)	Linear	2.392	20	.120					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_WLRatio_Set2	.069	2	20	.933
Post_WLRatio_Set2	4.483	2	20	.025

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: WLRatio_Set2
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	197.160	1	197.160	929.119	.000	.979	929.119	1.000
Supplement	.692	2	.346	1.629	.221	.140	3.259	.303
Error	4.244	20	.212					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: WLRatio_Set2

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
2.074	.068	1.932	2.216

2. Supplement

Measure: WLRatio_Set2

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	2.176	.123	1.919	2.433
Creatine Monohydrate	2.144	.115	1.904	2.384

Placebo	1.903	.115	1.663	2.143

3. Time

Measure: WLRatio_Set2

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	2.141	.089	1.954	2.327
2	2.008	.081	1.840	2.176

4. Supplement * Time

Estimates

Measure: WLRatio_Set2

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	2.226	.162	1.888	2.563
	2	2.127	.146	1.823	2.431
Creatine Monohydrate	1	2.300	.151	1.985	2.616
	2	1.988	.136	1.703	2.272
Placebo	1	1.895	.151	1.580	2.211
	2	1.911	.136	1.626	2.195

Pairwise Comparisons

Measure: WLRatio_Set2

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	.099	.185	.598	-.287	.485
	2	1	-.099	.185	.598	-.485	.287
Creatine Monohydrate	1	2	.313	.173	.085	-.048	.674
	2	1	-.313	.173	.085	-.674	.048
Placebo	1	2	-.015	.173	.931	-.376	.346
	2	1	.015	.173	.931	-.346	.376

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]

MagnaPower	Pillai's trace	.014	.287[a]	1.000	20.000	.598	.014	.287	.080
	Wilks' lambda	.986	.287[a]	1.000	20.000	.598	.014	.287	.080
	Hotelling's trace	.014	.287[a]	1.000	20.000	.598	.014	.287	.080
	Roy's largest root	.014	.287[a]	1.000	20.000	.598	.014	.287	.080
Creatine Monohydrate	Pillai's trace	.141	3.276[a]	1.000	20.000	.085	.141	3.276	.406
	Wilks' lambda	.859	3.276[a]	1.000	20.000	.085	.141	3.276	.406
	Hotelling's trace	.164	3.276[a]	1.000	20.000	.085	.141	3.276	.406
	Roy's largest root	.164	3.276[a]	1.000	20.000	.085	.141	3.276	.406
Placebo	Pillai's trace	.000	.008[a]	1.000	20.000	.931	.000	.008	.051
	Wilks' lambda	1.000	.008[a]	1.000	20.000	.931	.000	.008	.051
	Hotelling's trace	.000	.008[a]	1.000	20.000	.931	.000	.008	.051
	Roy's largest root	.000	.008[a]	1.000	20.000	.931	.000	.008	.051

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: Workload_Set1

Time	Dependent Variable
1	Pre_Workload_Set 1
2	Post_Workload_Set 1

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_Workload_Set 1	MagnaPower	2178.3143	488.07486	7
	Creatine Monohydrate	1812.6375	612.31062	8
	Placebo	1721.5000	619.93139	8

	Total	1892.2304	587.78305	23
Post_Workload_Set 1	MagnaPower	2485.5714	677.57840	7
	Creatine Monohydrate	1978.5500	723.21383	8
	Placebo	1987.4875	617.65494	8
	Total	2135.9696	684.78925	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	8.778
F	1.249
df1	6
df2	8714.141
Sig.	.278

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.407	13.712[b]	1.000	20.000	.001	.407	13.712	.941
	Wilks' Lambda	.593	13.712[b]	1.000	20.000	.001	.407	13.712	.941
	Hotelling's Trace	.686	13.712[b]	1.000	20.000	.001	.407	13.712	.941
	Roy's Largest Root	.686	13.712[b]	1.000	20.000	.001	.407	13.712	.941
Time * Supplement	Pillai's Trace	.038	.398[b]	2.000	20.000	.677	.038	.795	.105
	Wilks' Lambda	.962	.398[b]	2.000	20.000	.677	.038	.795	.105
	Hotelling's Trace	.040	.398[b]	2.000	20.000	.677	.038	.795	.105
	Roy's Largest Root	.040	.398[b]	2.000	20.000	.677	.038	.795	.105

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Workload_Set1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Workload_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	695358.722	1	695358.722	13.712	.001	.407	13.712	.941
	Greenhouse-Geisser	695358.722	1.000	695358.722	13.712	.001	.407	13.712	.941
	Huynh-Feldt	695358.722	1.000	695358.722	13.712	.001	.407	13.712	.941
	Lower-bound	695358.722	1.000	695358.722	13.712	.001	.407	13.712	.941
Time * Supplement	Sphericity Assumed	40328.780	2	20164.390	.398	.677	.038	.795	.105
	Greenhouse-Geisser	40328.780	2.000	20164.390	.398	.677	.038	.795	.105
	Huynh-Feldt	40328.780	2.000	20164.390	.398	.677	.038	.795	.105
	Lower-bound	40328.780	2.000	20164.390	.398	.677	.038	.795	.105
Error(Time)	Sphericity Assumed	1014261.197	20	50713.060					
	Greenhouse-Geisser	1014261.197	20.000	50713.060					
	Huynh-Feldt	1014261.197	20.000	50713.060					
	Lower-bound	1014261.197	20.000	50713.060					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Workload_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	695358.722	1	695358.722	13.712	.001	.407	13.712	.941
Time * Supplement	Linear	40328.780	2	20164.390	.398	.677	.038	.795	.105

Error(Time)	Linear	1014261.197	20	50713.060					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Workload_Set1	.482	2	20	.624
Post_Workload_Set1	.115	2	20	.892

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Workload_Set1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	188318292.987	1	188318292.987	254.207	.000	.927	254.207	1.000
Supplement	2046623.327	2	1023311.663	1.381	.274	.121	2.763	.262
Error	14816141.833	20	740807.092					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Workload_Set1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
2027.343	127.155	1762.103	2292.584

2. Supplement

Measure: Workload_Set1

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	2331.943	230.032	1852.104	2811.782
Creatine Monohydrate	1895.594	215.175	1446.746	2344.442
Placebo	1854.494	215.175	1405.646	2303.342

3. Time

Measure: Workload_Set1

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	1904.151	121.322	1651.078	2157.224
2	2150.536	140.824	1856.782	2444.291

4. Supplement * Time

Estimates

Measure: Workload_Set1

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	2178.314	219.480	1720.488	2636.141
	2	2485.571	254.761	1954.150	3016.993
Creatine Monohydrate	1	1812.638	205.304	1384.380	2240.895
	2	1978.550	238.307	1481.451	2475.649
Placebo	1	1721.500	205.304	1293.243	2149.757
	2	1987.488	238.307	1490.388	2484.587

Pairwise Comparisons

Measure: Workload_Set1

Supplement			Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-307.257*	120.372	.019	-558.349	-56.165
	2	1	307.257*	120.372	.019	56.165	558.349
Creatine Monohydrate	1	2	-165.913	112.598	.156	-400.787	68.962
	2	1	165.913	112.598	.156	-68.962	400.787
Placebo	1	2	-265.987*	112.598	.028	-500.862	-31.113
	2	1	265.987*	112.598	.028	31.113	500.862

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.246	6.516[a]	1.000	20.000	.019	.246	6.516	.680
	Wilks' lambda	.754	6.516[a]	1.000	20.000	.019	.246	6.516	.680

	Hotelling's trace	.326	6.516[a]	1.000	20.000	.019	.246	6.516	.680
	Roy's largest root	.326	6.516[a]	1.000	20.000	.019	.246	6.516	.680
Creatine Monohydrate	Pillai's trace	.098	2.171[a]	1.000	20.000	.156	.098	2.171	.289
	Wilks' lambda	.902	2.171[a]	1.000	20.000	.156	.098	2.171	.289
	Hotelling's trace	.109	2.171[a]	1.000	20.000	.156	.098	2.171	.289
	Roy's largest root	.109	2.171[a]	1.000	20.000	.156	.098	2.171	.289
Placebo	Pillai's trace	.218	5.580[a]	1.000	20.000	.028	.218	5.580	.613
	Wilks' lambda	.782	5.580[a]	1.000	20.000	.028	.218	5.580	.613
	Hotelling's trace	.279	5.580[a]	1.000	20.000	.028	.218	5.580	.613
	Roy's largest root	.279	5.580[a]	1.000	20.000	.028	.218	5.580	.613

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: Workload_Set2

Time	Dependent Variable
1	Pre_Workload_Set 2
2	Post_Workload_Set 2

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_Workload_Set 2	MagnaPower	1702.5429	363.41779	7
	Creatine Monohydrate	1466.1375	401.15449	8
	Placebo	1494.4000	501.76841	8
	Total	1547.9174	422.38984	23
	MagnaPower	1796.1857	450.49496	7

	Creatine Monohydrate	1533.4500	388.59367	8
Post_Workload_Set 2	Placebo	1652.2125	589.26232	8
	Total	1654.7217	474.96935	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	2.861
F	.407
df1	6
df2	8714.141
Sig.	.875

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.123	2.810[b]	1.000	20.000	.109	.123	2.810	.358
	Wilks' Lambda	.877	2.810[b]	1.000	20.000	.109	.123	2.810	.358
	Hotelling's Trace	.141	2.810[b]	1.000	20.000	.109	.123	2.810	.358
	Roy's Largest Root	.141	2.810[b]	1.000	20.000	.109	.123	2.810	.358
Time * Supplement	Pillai's Trace	.018	.187[b]	2.000	20.000	.831	.018	.375	.075
	Wilks' Lambda	.982	.187[b]	2.000	20.000	.831	.018	.375	.075
	Hotelling's Trace	.019	.187[b]	2.000	20.000	.831	.018	.375	.075
	Roy's Largest Root	.019	.187[b]	2.000	20.000	.831	.018	.375	.075

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Workload_Set2

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Workload_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	129325.569	1	129325.569	2.810	.109	.123	2.810	.358
	Greenhouse-Geisser	129325.569	1.000	129325.569	2.810	.109	.123	2.810	.358
	Huynh-Feldt	129325.569	1.000	129325.569	2.810	.109	.123	2.810	.358
	Lower-bound	129325.569	1.000	129325.569	2.810	.109	.123	2.810	.358
Time * Supplement	Sphericity Assumed	17252.037	2	8626.019	.187	.831	.018	.375	.075
	Greenhouse-Geisser	17252.037	2.000	8626.019	.187	.831	.018	.375	.075
	Huynh-Feldt	17252.037	2.000	8626.019	.187	.831	.018	.375	.075
	Lower-bound	17252.037	2.000	8626.019	.187	.831	.018	.375	.075
Error(Time)	Sphericity Assumed	920410.057	20	46020.503					
	Greenhouse-Geisser	920410.057	20.000	46020.503					
	Huynh-Feldt	920410.057	20.000	46020.503					
	Lower-bound	920410.057	20.000	46020.503					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Workload_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	129325.569	1	129325.569	2.810	.109	.123	2.810	.358
Time * Supplement	Linear	17252.037	2	8626.019	.187	.831	.018	.375	.075
Error(Time)	Linear	920410.057	20	46020.503					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Workload_Set2	.701	2	20	.508
Post_Workload_Set2	.575	2	20	.572

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Workload_Set2
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	118395005.461	1	118395005.461	317.148	.000	.941	317.148	1.000
Supplement	484317.141	2	242158.571	.649	.533	.061	1.297	.143
Error	7466220.176	20	373311.009					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Workload_Set2

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
1607.488	90.264	1419.200	1795.776

2. Supplement

Measure: Workload_Set2

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	1749.364	163.294	1408.738	2089.991
Creatine Monohydrate	1499.794	152.748	1181.167	1818.420
Placebo	1573.306	152.748	1254.680	1891.933

3. Time

Measure: Workload_Set2

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound

1	1554.360	89.636	1367.383	1741.337
2	1660.616	101.339	1449.227	1872.005

4. Supplement * Time

Estimates

Measure: Workload_Set2

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	1702.543	162.158	1364.288	2040.798
	2	1796.186	183.329	1413.769	2178.603
Creatine Monohydrate	1	1466.138	151.685	1149.729	1782.546
	2	1533.450	171.488	1175.732	1891.168
Placebo	1	1494.400	151.685	1177.992	1810.808
	2	1652.213	171.488	1294.494	2009.931

Pairwise Comparisons

Measure: Workload_Set2

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-93.643	114.668	.424	-332.836	145.550
	2	1	93.643	114.668	.424	-145.550	332.836
Creatine Monohydrate	1	2	-67.313	107.262	.537	-291.057	156.432
	2	1	67.313	107.262	.537	-156.432	291.057
Placebo	1	2	-157.813	107.262	.157	-381.557	65.932
	2	1	157.813	107.262	.157	-65.932	381.557

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.032	.667[a]	1.000	20.000	.424	.032	.667	.122
	Wilks' lambda	.968	.667[a]	1.000	20.000	.424	.032	.667	.122
	Hotelling's trace	.033	.667[a]	1.000	20.000	.424	.032	.667	.122
	Roy's largest root	.033	.667[a]	1.000	20.000	.424	.032	.667	.122
Creatine Monohydrate	Pillai's trace	.019	.394[a]	1.000	20.000	.537	.019	.394	.092
	Wilks' lambda	.981	.394[a]	1.000	20.000	.537	.019	.394	.092

	Hotelling's trace	.020	.394[a]	1.000	20.000	.537	.019	.394	.092
	Roy's largest root	.020	.394[a]	1.000	20.000	.537	.019	.394	.092
Placebo	Pillai's trace	.098	2.165[a]	1.000	20.000	.157	.098	2.165	.288
	Wilks' lambda	.902	2.165[a]	1.000	20.000	.157	.098	2.165	.288
	Hotelling's trace	.108	2.165[a]	1.000	20.000	.157	.098	2.165	.288
	Roy's largest root	.108	2.165[a]	1.000	20.000	.157	.098	2.165	.288

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: Power_Set1

Time	Dependent Variable
1	Pre_Power_Set1
2	Post_Power_Set1

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_Power_Set1	MagnaPower	157.8714	39.73687	7
	Creatine Monohydrate	146.1250	53.73564	8
	Placebo	144.2625	67.86507	8
	Total	149.0522	53.39516	23
Post_Power_Set1	MagnaPower	186.0000	66.71304	7
	Creatine Monohydrate	160.5875	56.27792	8
	Placebo	165.4000	70.33148	8
	Total	169.9957	62.58444	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	7.859
F	1.119
df1	6
df2	8714.141
Sig.	.348

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.371	11.790[b]	1.000	20.000	.003	.371	11.790	.904
	Wilks' Lambda	.629	11.790[b]	1.000	20.000	.003	.371	11.790	.904
	Hotelling's Trace	.590	11.790[b]	1.000	20.000	.003	.371	11.790	.904
	Roy's Largest Root	.590	11.790[b]	1.000	20.000	.003	.371	11.790	.904
Time * Supplement	Pillai's Trace	.038	.398[b]	2.000	20.000	.677	.038	.796	.105
	Wilks' Lambda	.962	.398[b]	2.000	20.000	.677	.038	.796	.105
	Hotelling's Trace	.040	.398[b]	2.000	20.000	.677	.038	.796	.105
	Roy's Largest Root	.040	.398[b]	2.000	20.000	.677	.038	.796	.105

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Power_Set1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon[b]		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Power_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	5168.966	1	5168.966	11.790	.003	.371	11.790	.904
	Greenhouse-Geisser	5168.966	1.000	5168.966	11.790	.003	.371	11.790	.904
	Huynh-Feldt	5168.966	1.000	5168.966	11.790	.003	.371	11.790	.904
	Lower-bound	5168.966	1.000	5168.966	11.790	.003	.371	11.790	.904
Time * Supplement	Sphericity Assumed	348.852	2	174.426	.398	.677	.038	.796	.105
	Greenhouse-Geisser	348.852	2.000	174.426	.398	.677	.038	.796	.105
	Huynh-Feldt	348.852	2.000	174.426	.398	.677	.038	.796	.105
	Lower-bound	348.852	2.000	174.426	.398	.677	.038	.796	.105
Error(Time)	Sphericity Assumed	8768.196	20	438.410					
	Greenhouse-Geisser	8768.196	20.000	438.410					
	Huynh-Feldt	8768.196	20.000	438.410					
	Lower-bound	8768.196	20.000	438.410					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Power_Set1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	5168.966	1	5168.966	11.790	.003	.371	11.790	.904
Time * Supplement	Linear	348.852	2	174.426	.398	.677	.038	.796	.105
Error(Time)	Linear	8768.196	20	438.410					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Power_Set1	1.218	2	20	.317

Post_Power_Set1	.107	2	20	.899

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Power_Set1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	1173547.714	1	1173547.714	171.750	.000	.896	171.750	1.000
Supplement	3117.718	2	1558.859	.228	.798	.022	.456	.081
Error	136658.061	20	6832.903					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Power_Set1

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
160.041	12.212	134.567	185.515

2. Supplement

Measure: Power_Set1

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	171.936	22.092	125.852	218.019
Creatine Monohydrate	153.356	20.665	110.249	196.463
Placebo	154.831	20.665	111.724	197.938

3. Time

Measure: Power_Set1

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	149.420	11.626	125.169	173.670
2	170.663	13.500	142.503	198.822

4. Supplement * Time

Estimates

Measure: Power_Set1

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	157.871	21.032	114.000	201.743
	2	186.000	24.422	135.057	236.943
Creatine Monohydrate	1	146.125	19.673	105.087	187.163
	2	160.588	22.845	112.935	208.240
Placebo	1	144.263	19.673	103.225	185.300
	2	165.400	22.845	117.747	213.053

Pairwise Comparisons

Measure: Power_Set1

Supplement			Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-28.129*	11.192	.021	-51.475	-4.783
	2	1	28.129*	11.192	.021	4.783	51.475
Creatine Monohydrate	1	2	-14.463	10.469	.182	-36.301	7.376
	2	1	14.463	10.469	.182	-7.376	36.301
Placebo	1	2	-21.138	10.469	.057	-42.976	.701
	2	1	21.138	10.469	.057	-.701	42.976

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.240	6.317[a]	1.000	20.000	.021	.240	6.317	.667
	Wilks' lambda	.760	6.317[a]	1.000	20.000	.021	.240	6.317	.667
	Hotelling's trace	.316	6.317[a]	1.000	20.000	.021	.240	6.317	.667
	Roy's largest root	.316	6.317[a]	1.000	20.000	.021	.240	6.317	.667
Creatine Monohydrate	Pillai's trace	.087	1.908[a]	1.000	20.000	.182	.087	1.908	.260
	Wilks' lambda	.913	1.908[a]	1.000	20.000	.182	.087	1.908	.260
	Hotelling's trace	.095	1.908[a]	1.000	20.000	.182	.087	1.908	.260
	Roy's largest root	.095	1.908[a]	1.000	20.000	.182	.087	1.908	.260
Placebo	Pillai's trace	.169	4.076[a]	1.000	20.000	.057	.169	4.076	.485

	Wilks' lambda	.831	4.076[a]	1.000	20.000	.057	.169	4.076	.485
	Hotelling's trace	.204	4.076[a]	1.000	20.000	.057	.169	4.076	.485
	Roy's largest root	.204	4.076[a]	1.000	20.000	.057	.169	4.076	.485

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05

Within-Subjects Factors

Measure: Power_Set2

Time	Dependent Variable
1	Pre_Power_Set2
2	Post_Power_Set2

Between-Subjects Factors

		Value Label	N
Supplement	1.00	MagnaPower	7
	2.00	Creatine Monohydrate	8
	3.00	Placebo	8

Descriptive Statistics

Supplement		Mean	Std. Deviation	N
Pre_Power_Set2	MagnaPower	130.8714	35.48815	7
	Creatine Monohydrate	121.3875	35.17830	8
	Placebo	132.7375	61.73755	8
	Total	128.2217	44.45920	23
Post_Power_Set2	MagnaPower	145.6857	49.43957	7
	Creatine Monohydrate	123.8500	27.76843	8
	Placebo	133.9625	54.54461	8
	Total	134.0130	44.03981	23

Box's Test of Equality of Covariance Matrices[a]

Box's M	10.116
F	1.440
df1	6
df2	8714.141
Sig.	.195

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Pillai's Trace	.072	1.554[b]	1.000	20.000	.227	.072	1.554	.221
	Wilks' Lambda	.928	1.554[b]	1.000	20.000	.227	.072	1.554	.221
	Hotelling's Trace	.078	1.554[b]	1.000	20.000	.227	.072	1.554	.221
	Roy's Largest Root	.078	1.554[b]	1.000	20.000	.227	.072	1.554	.221
Time * Supplement	Pillai's Trace	.069	.736[b]	2.000	20.000	.492	.069	1.472	.157
	Wilks' Lambda	.931	.736[b]	2.000	20.000	.492	.069	1.472	.157
	Hotelling's Trace	.074	.736[b]	2.000	20.000	.492	.069	1.472	.157
	Roy's Largest Root	.074	.736[b]	2.000	20.000	.492	.069	1.472	.157

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. Exact statistic

c. Computed using alpha = .05

Mauchly's Test of Sphericity[a]

Measure: Power_Set2

	Mauchly's W		df	Sig.	Epsilon[b]

Within Subjects Effect		Approx. Chi-Square			Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Time	1.000	0.000	0		1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. Design: Intercept + Supplement
Within Subjects Design: Time

b. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

Tests of Within-Subjects Effects

Measure: Power_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Sphericity Assumed	435.675	1	435.675	1.554	.227	.072	1.554	.221
	Greenhouse-Geisser	435.675	1.000	435.675	1.554	.227	.072	1.554	.221
	Huynh-Feldt	435.675	1.000	435.675	1.554	.227	.072	1.554	.221
	Lower-bound	435.675	1.000	435.675	1.554	.227	.072	1.554	.221
Time * Supplement	Sphericity Assumed	412.678	2	206.339	.736	.492	.069	1.472	.157
	Greenhouse-Geisser	412.678	2.000	206.339	.736	.492	.069	1.472	.157
	Huynh-Feldt	412.678	2.000	206.339	.736	.492	.069	1.472	.157
	Lower-bound	412.678	2.000	206.339	.736	.492	.069	1.472	.157
Error(Time)	Sphericity Assumed	5608.511	20	280.426					
	Greenhouse-Geisser	5608.511	20.000	280.426					
	Huynh-Feldt	5608.511	20.000	280.426					
	Lower-bound	5608.511	20.000	280.426					

a. Computed using alpha = .05

Tests of Within-Subjects Contrasts

Measure: Power_Set2

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Time	Linear	435.675	1	435.675	1.554	.227	.072	1.554	.221
Time * Supplement	Linear	412.678	2	206.339	.736	.492	.069	1.472	.157
Error(Time)	Linear	5608.511	20	280.426					

a. Computed using alpha = .05

Levene's Test of Equality of Error Variances[a]

	F	df1	df2	Sig.
Pre_Power_Set2	2.080	2	20	.151
Post_Power_Set2	.997	2	20	.387

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Supplement
Within Subjects Design: Time

Tests of Between-Subjects Effects

Measure: Power_Set2
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Intercept	791284.839	1	791284.839	202.426	.000	.910	202.426	1.000
Supplement	1953.338	2	976.669	.250	.781	.024	.500	.084
Error	78180.238	20	3909.012					

a. Computed using alpha = .05

Estimated Marginal Means

1. Grand Mean

Measure: Power_Set2

Mean	Std. Error	95% Confidence Interval	
		Lower Bound	Upper Bound
131.416	9.237	112.148	150.683

2. Supplement

Measure: Power_Set2

Supplement	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
MagnaPower	138.279	16.710	103.423	173.134
Creatine Monohydrate	122.619	15.631	90.014	155.223
Placebo	133.350	15.631	100.745	165.955

3. Time

Measure: Power_Set2

Time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	128.332	9.676	108.148	148.517
2	134.499	9.447	114.794	154.205

4. Supplement * Time

Estimates

Measure: Power_Set2

Supplement		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
MagnaPower	1	130.871	17.505	94.357	167.386
	2	145.686	17.090	110.037	181.335
Creatine Monohydrate	1	121.388	16.374	87.231	155.544
	2	123.850	15.986	90.504	157.196
Placebo	1	132.738	16.374	98.581	166.894
	2	133.963	15.986	100.616	167.309

Pairwise Comparisons

Measure: Power_Set2

Supplement			Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
						Lower Bound	Upper Bound
MagnaPower	1	2	-14.814	8.951	.114	-33.486	3.857
	2	1	14.814	8.951	.114	-3.857	33.486
Creatine Monohydrate	1	2	-2.463	8.373	.772	-19.928	15.003
	2	1	2.463	8.373	.772	-15.003	19.928
Placebo	1	2	-1.225	8.373	.885	-18.691	16.241
	2	1	1.225	8.373	.885	-16.241	18.691

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

Supplement		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
MagnaPower	Pillai's trace	.120	2.739[a]	1.000	20.000	.114	.120	2.739	.351
	Wilks' lambda	.880	2.739[a]	1.000	20.000	.114	.120	2.739	.351
	Hotelling's trace	.137	2.739[a]	1.000	20.000	.114	.120	2.739	.351
	Roy's largest root	.137	2.739[a]	1.000	20.000	.114	.120	2.739	.351
Creatine Monohydrate	Pillai's trace	.004	.086[a]	1.000	20.000	.772	.004	.086	.059
	Wilks' lambda	.996	.086[a]	1.000	20.000	.772	.004	.086	.059
	Hotelling's trace	.004	.086[a]	1.000	20.000	.772	.004	.086	.059
	Roy's largest root	.004	.086[a]	1.000	20.000	.772	.004	.086	.059
Placebo	Pillai's trace	.001	.021[a]	1.000	20.000	.885	.001	.021	.052
	Wilks' lambda	.999	.021[a]	1.000	20.000	.885	.001	.021	.052
	Hotelling's trace	.001	.021[a]	1.000	20.000	.885	.001	.021	.052

Roy's largest root	.001	.021[a]	1.000	20.000	.885	.001	.021	.052

Each F tests the multivariate simple effects of Time within each level combination of the other effects shown. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

b. Computed using alpha = .05