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The Effects on Acute Power Production Enhancement and Maintenance due to Pre-workout Supplementation in Recreationally trained College Aged Males.

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By

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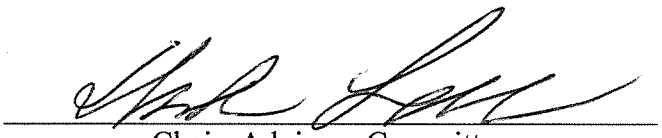

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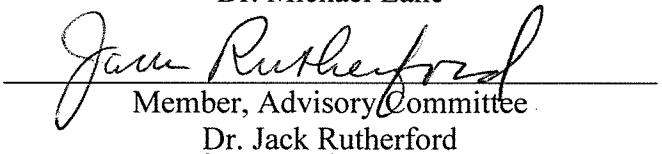

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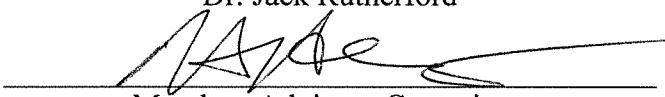

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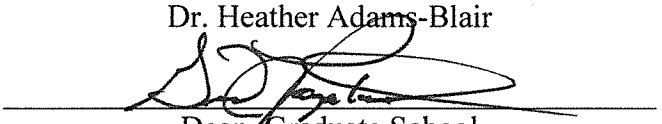

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THE EFFECTS ON ACUTE POWER PRODUCTION ENHANCEMENT AND MAINTENANCE DUE TO PRE-WORKOUT SUPPLEMENTATION IN RECREATIONALLY TRAINED COLLEGE AGED MALES

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Submitted to the Faculty of the Graduate School of
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DEDICATION

This thesis is dedicated to my wife
Celeste Byrd
for her unwavering support.

"But man is not made for defeat. A man can be destroyed but not defeated."

-Ernest Hemingway

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I would like to thank my major professor, Dr. Michael Lane, for his guidance, patience and the many, many editing sessions. I would also like to thank the other committee members, Dr. Jack Rutherford and Dr. Heather Adams-Blair, for their comments and assistance over the past year of this journey. I would like to express my thanks to my wife, Celeste, for her understanding and encouragement. This could not have been accomplished without her. I would also like to thank Tyler Hurley for all or his help, pep talks and recruitment help during this research study.

Abstract

Introduction: The current research in power production has shown the use of pre-workout supplements to increase peak power production, but the current research has not yet been able to delve in to the effectiveness of pre-workout supplementation on maintaining power production.

Purpose: The purpose of this study was to examine the effects on acute power production enhancement and maintenance due to supplementation in recreationally trained college aged individuals.

Methods: Data was collected from 13 recreationally trained, college-aged males in a double-blind crossover study. After a familiarization sessions subjects participated in three testing sessions utilizing a cross over double blind design (Supplement, Placebo+Caffeine and Placebo). Subjects arrived and ingested their beverage and after waiting 20 minutes performed a warm up and then vertical jump testing (5 jumps). Subjects then performed ten bike sprints utilizing a Monark ergo bike, with each subject's resistance being 7.5% of their body weight in kg. Each sprint last 5 seconds with a 55 second recovery. Subjects then performed another round of vertical jumps utilizing a Vertec. Blood lactate samples were taken both before the Wingate protocol and after. Each subject's perceived level of energy, focus, fatigue and anxiety/restlessness was self reported on a visual analog scale (VAS) once upon arrival, 20 minutes after ingestion of the treatment, and after the completion of the Wingate protocol.

Results: Age: 23.3±4.2 (years), Height, 69±2.9 (inches); Weight, 199.6±33.9 (pounds); Body Fat, 21.6±8.9 (%); Fat Free Mass, 155.2±23.5 (pounds); and Reach, 87.2±4.5 (inches). The supplement treatment resulted in the highest average maximum (Supp: 783.1±155.7, PL+Caff: 769.8±166.5, PL: 778.2±165.8) and mean (Supp: 705±143.7, PL+Caff: 694.6±157.2, PL: 702.1±153.6) power outputs during the Wingate protocol. The results from the lactate test were $F(1, 36) = 121.942$ $p<0.0001$, post hoc utilizing LSD resulted in significance ($P=0.029$), in that the placebo + caffeine treatment showed an higher increase in pre to post Wingate lactate compared to the other two treatments. VAS results showed the supplement treatment resulted in a higher average level of perceived energy and focus, as well as a lower average level of perceived fatigue both 20 minutes after ingestion of the treatments and after the Wingate bike test compared to the subject's arrival for testing.

Discussion: The results suggest the pre-workout supplement, Assault Black, may increase an individual's average maximum and average mean power production during acute, high intensity physical activity. The results also suggest the supplement provides an increase in an individual's average feeling of energy and focus as well as lowers the individual's average level of fatigue. Even though the increases are not statistical significant during this acute study, these increases in performance, even though small, can possibly accumulate over time, adding up to larger performance increases with time.

TABLE OF CONTENTS

LIST OF TABLES

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

Chapter 1 – Introduction

With sport becoming increasingly popular and forever engrained into our society, so has the desire of the athlete to want to be better than the next. This desire has prompted many athletes to search out effective ways to gain that competitive edge over their opponent, one avenue being performance-enhancing supplementation. In a survey conducted using male and female Division I college athletes 89 percent of the subjects reported either previously or currently using supplements (Froiland, Koszewski, Hingst & Kopecky, 2004). Increased use of performance-enhancing supplement has been observed not only in athletes, but also in the general populations to increase the benefits of the individual's chosen fitness program. From this knowledge a simple question arises; do supplements enhance performance and if they do, to what degree?

Before examining the pre-workout "cocktail" supplements, the individual supplements that make up most of the pre-workout "cocktail" supplements must be examined. An individual supplement that has been shown to increase performance is creatine, which is probably the most studied performance supplement used today. Creatine aids in the production of adenosine triphosphate (ATP), which is used for energy in the cell when work is performed. Creatine has been shown to increase growth hormone and testosterone concentrations during exercise (Rahimi, Faraji, Vatani & Qaderi, 2010). It has also been shown to decrease lactate levels while increasing power output during incremental physical activity (Oliver, Joubert, Martin, & Crouse, 2013).

Another common supplement in many pre-workout "cocktails" are Branched-Chain Amino Acids (BCAAs). Many studies involving the importance of BCAAs, show that BCAAs help increase the rate of protein synthesis in resting human muscle. Study results suggest this is done by the BCAAs activating the mechanistic target of Rapamycin signaling pathway (mTOR) and p70 S6 kinase in the muscle during the recovery period after muscle resistance exercise (Blomstrand, Eliasson, Karlsson & Kohnke, 2006). Chronic activation of this pathway has been correlated to increases in muscle size (Baar & Esser 1999).

Even though caffeine has no nutritional value, it is found in many pre-workout supplements and has been shown to be of benefit during exercise. Studies have shown when subjects were tested on such exercises as the bench press and leg press, the supplementation of caffeine caused a delay in fatigue, which would allow higher number of repetitions to be achieved during resistance training (Green, et al, 2007). Studies have also shown caffeine to aid in an improvements of endurance running performance (Ping, Keong, & Bandyopadhyay, 2009).

Another common ingredient found in most pre-workout supplements are nitrates. Nitrates have been shown to lower VO2 and improve cycle trail times in trained endurance cyclist (Cermak, Gibala, & Loon, 2012). Nitrates within the blood of the body can be converted into Nitric Oxide (NO), a vasodilator, which aids in pathway communication between cells. It has been suggested that an increase in nitric oxide production could improve tolerance to physical activity by enhancing oxygen and

nutrient delivery to the muscles being used during exercise (Bescos, Sureda, Tur & Pons, 2012).

Many of the pre-workout "cocktail" supplements used are a combination of the individual supplements mentioned above. These supplements are combined into one pre-workout "cocktail" with the theory they will play off each other and provide the most "bang for the buck". In a study involving a pre-workout supplement given to subjects before a resistance-training test, the results showed an increase in the number of successful repetitions, as well as a greater peak in power production (Gonzalez, et al, 2011).

A study on the effects of a pre-workout supplement containing caffeine, creatine, amino acids, B-vitamins and beta-alanine was examined to see if there were any effects on muscular endurance, aerobic and anaerobic capacity, as well as choice reaction time (improved reflexes). The results showed an improvement in the subject's choice reaction time, lower body muscular endurance, as well as an increase in perceived energy, alertness, focus and reduced fatigue (Spradley, et al, 2012). This result could suggest maintenance of muscular power could occur, but must be further examined.

The current research shows how the use of a pre-workout, performance-enhancing supplement may improve peak power production, such as the study performed by Gonzalez, et al (2011). However the previous studies do not mention how or if this improvement of peak power was maintain during testing.

Problem

The current research in this area has shown the use of pre-workout supplements to increase peak power production, but the current research has not yet been able to delve in to the effectiveness of pre-workout supplementation on maintaining power production, or what effects pre-workout supplementation has on repeated bouts or physical activity. Perhaps utilization of this pre-workout, supplement "cocktail", in reality leads to the same average performance, but increases the initial performances at the expense of the final bouts. As the benefits of being able to maintain power production for longer periods of time, will have a profoundly positive affect on an individual's performance during physical activity.

Purpose

The purpose of this study is to examine the effects on acute power production enhancement and maintenance due to supplementation in recreationally trained college aged individuals.

Hypothesis

1) Use of the pre-workout, performance-enhancing supplement will have a positive relationship with the ability to maintain power outputs during the interval Wingate exercise performance on the ergonomic bike.
2) Use of the pre-workout, performance-enhancing supplement will have a positive relationship on the subject's ability to maintain vertical jump height performance, after completion of the Wingate fatigue protocol.

Definitions

Independent Variables

The pre-workout supplement, placebo + caffeine, and placebo treatments.

Dependent Variables

These will be the described as the subject's power output during the Wingate fatigue test. The measure of the subject's vertical jump height, both before and after the completion of the Wingate fatigue protocol. The measure of the subject's perceived level of energy, fatigue, focus and anxiety/restlessness will be included under these variables.

Population

Recreationally trained – subjects participate in some form of physical activity most days of week, utilizing either resistance training and/or some aerobic activity. Final judgment will be reserved for the research team.

Performance-enhancing supplement

Nutritional substances ingested into the body, derived from sources other than an individuals regular diet, which improves the bodies physiological processes during physical activity.

Power

The rate of doing work during an all-out, short-term physical effort. Measured in Watts.

Wingate Test

An anaerobic bike test, used to measure peak anaerobic power.

Assumptions

The researcher assumes all subjects will give their best effort for each testing session and will attend all four testing sessions. The subjects will only be ingesting the chosen supplement during the testing sessions and reframe from using other supplements in between each testing session. The equipment being use will be properly calibrated and provide accurate and reliable results. The subjects will not have participated in intense exercise at least 24 hours before each testing session.

Limitations

The subjects will be recreationally trained and volunteers. The subjects will have greatly varied fitness levels and will have varying levels of motivation for participating in the test. The subject's will also be expected to take time off from training before participating in the testing seasons and will not have had a hard training session at least 48 hours before testing begins to help limit the diminishing of their testing performance.

Delimitations

For the study, only male subjects will be recruited to participate, which will prevent any possible potential complications in the results being affected possibly due to hormonal change effects on the pre-workout supplement as well as blood loss due to the female menstrual cycle. The subjects will perform each of their testing sessions during the same time of day and each testing session will be spaced out so that the negative effects of accumulated fatigue from the testing itself will not be a factor. The subjects will not train hard within 24 hours before each of their testing sessions. Also, the delivery of the treated beverages will be double blind to prevent any bias of the researchers.

Chapter 2 – Review of Literature

The most common individual supplements will be discussed, as to their importance within the human body and their benefits during physical activity. These supplements are beta alanine, branched-chain amino acids, B-vitamins, caffeine, creatine, nitric oxide, citrulline malate and agmatine sulfate. These individual supplements each have their own benefits in enhancing physical activity performance and are the common supplements used in creating what is know as a "pre-workout" supplement.

Beta Alanine

One of the most interesting supplements being examined in research fields today is beta alanine, which is also being placed in many of the pre-workout "cocktail" supplements. Beta alanine aids in the production of carnosine, which acts as a lacate acid buffer in the body (Baguet et al., 2009). This can allow for increase durations of exercise. Studies have also shown beta alanine to cause increase performance in runners (Ducker, Dawson & Wallman, 2013). Other studies have shown Beta Alanine supplementation to increase the jumping power of elite athletes (Gross, et al, 2014).

Branched-Chain Amino Acids

Branched-Chain Amino Acids (BCAAs) are obtained from food, such as meats and dairy that are essential nutrients our bodies need to function properly. Many studies have been conducted involving the importance of BCAAs, which are leucine, isoleucine, and valine for physical activity. According to Blomstrand, et al, (2006) BCAAs have an

"anabolic effects on protein metabolism by increasing the rate of protein synthesis and decreasing the rate of protein degradation in resting human muscle". This can be due to signal pathway changes during protein synthesis, in the mTOR pathway under favorable cell growth conditions. The intake of BCAAs after resistance training has been shown to have a positive impact on protein synthesis within the body, by causing a positive protein balance (Blomstrand, 2006).

Out of the three BCAAs, research shows leucine to be the most important marker of initiating protein synthesis (Wilkinson et al, 2013). In trained rats, Leucine supplement research has been shown to improve performance and sparing muscle glycogen stores (Campos-Ferraz, Bozza, Nicastro, and Lancha, 2013). With muscle glycogen stores staying available for longer periods, this will have a positive affect on delaying the onset of fatigue.

In a study where subjects were given either a BCAA supplement drink or a placebo drink over a period of 7 days. On the seventh day, the subjects performed an incremental loading exercise test with a cycle ergometer until exhaustion in order to measure the lactate threshold. Results from the study showed subject's who ingested the BCAA supplement drink had higher VO2 and workload levels at lactate threshold point, thereby suggesting BCAA's may be beneficial at increasing the endurance exercise capacity (Matsumoto et al, 2009).

B-Vitamins

There is little literature on the benefits of B-Vitamins when it comes to performance enhancement in physical activity. However, B-Vitamins are a vital piece of

the puzzle in energy metabolism and cell regeneration in the body. Each B-vitamin is involved in many functions of the physiological process of the body. Athletes who may not be getting enough of these vitamins through food intake may see the benefit or need for supplementation of these vitamins. The lack of these vitamins can lead to a decrease in performance during high intensity bouts of physical activity. According to Woolf, et al, (2006) "The B-vitamins (thiamin, riboflavin, and vitamin B-6) are necessary in the energy- producing pathways of the body, while folate and vitamin B-12 are required for the synthesis of new cells, such as the red blood cells, and for the repair of damaged cells". There is currently a lack of research on the effects of acute supplementation with B-vitamins on physical activity performance.

Caffeine

Caffeine has been the subject of many studies over the years. It has been shown to increase alertness, reaction time, force production and even decrease sensitivity to pain, which could allow longer bouts of physical activity. Caffeine is found naturally in items such as coffee beans and tealeaves. It has no nutritional value, but is found in many products today, such as soft drinks, energy drinks, and even certain alcoholic beverages. According to Sokmen, et al, (2008): "Caffeine has global effects on the central nervous system (CNS) and on hormonal, metabolic, muscular, cardiovascular, pulmonary, and renal functions during rest and exercise. It stimulates bronchodilation of alveoli, vasodilation of blood vessels, neural activation of muscle contraction, blood nitration in the kidneys, catecholamine secretion, and lipolysis".

When caffeine is used as a supplement, many factors need to be taken into consideration; such as age, body size, and level of tolerance. When it comes to a person's gender in dealing with the use of caffeine, Graham (2001) said, "It appears that male and female athletes have similar caffeine pharmacokinetics, i.e., for a given dose of caffeine, the time course and absolute plasma concentrations of caffeine and its metabolites are the same". According to Attwood, Higgs and Terry (2007), "High caffeine consumers are more likely than moderate consumers to perceive broadly positive effects of caffeine, and this may contribute to their levels of use".

When it comes to endurance activities, the use of caffeine supplements have been linked to increase work output and time to exhaustion. In the examination of forty double blind studies by Doherty and Smith (2004), caffeine improved an endurance test outcome by 12.3%. In a study by Green, et al, (2007), subjects were tested on the bench press and leg press to examine the number of repetitions to failure, along with the perceived rate of exertion. With the results showing caffeine can be beneficial in resistance training by possibly delaying fatigue, thereby allowing higher number of repetitions to be achieved.

Creatine

Creatine is arguably the most studied exercise performance supplement used today. "Creatine is an amino-acid derivative synthesized from arginine, glycine, and methionine in the liver, kidney and pancreas" (Ratamess, et al, 2007). Creatine can be attained from the consumption of red meats. Creatine aids in the production of adenosine triphosphate (ATP), which is used for energy in the cell when work is performed. There has been numerous studies showing the positives of creatine supplementation, however

not every study has a conclusion showing the benefit of creatine supplementation. Such as a study examining the effects of creatine on sprint exercise performance and skeletal muscle anaerobic metabolism done by Snow, et al, (1998), which the results showed no effect on performance, only that the supplement increased the amount of creatine in the muscles. In a more recent study, creatine supplementation was shown to have an acute strength endurance performance effect on leg press and bench press exercises performed after the completion of a concurrent aerobic physical activity (Painelli et al, 2014)

Nitrates

Nitric Oxide (NO) is naturally produced within the body from the breakdown of certain amino acids. NO is also found within many of the foods consumed by humans, such as green leafy vegetables. NO plays a major role in pathway communication between cells. NO is also a vasodilator, which can increase the blood flow to the area it is released in. In theory, this is of benefit because with increased blood flow, then more nutrients are carried to the muscles being used to help with repair and growth. According to Bescos, et al, (2012), "In relation with exercise physiology, it has been suggested that an increase in NO production may enhance oxygen and nutrient delivery to active muscles, thus improving tolerance to physical exercise and recovery mechanisms".

In a double-blind crossover study in which 12 male, trained cyclists where given nitrate supplementation to examine the effects on time trail, the supplementation of nitrates resulted in an increase in power output as well as time trail improvements. (Cermak, Gibana, & Loon, 2012).

The effects of NO supplementation vary, as Bescos, et al, (2012), pointed out "training status of the subjects seem to be an important factor linked to the ergogenic effect of NO supplementation". In a study involving higher-level trained cyclists, the researchers performed another nitrate supplementation study looking for performance improvements in which the results showed no improvements (Wilkerson et al, 2012). This study would further elaborate on Bescos et al (2012), suggestion that nitrates may not have the same effects on different training levels of the subjects, with untrained subjects showing the greatest benefit from this type of supplementation.

Citrulline Malate

Citrulline is an amino acid, which plays a role in NO synthesis within the body. Citrulline has been shown to promote fatigue and lactate recovery during endurance exercise (Lopez-Cabral, et al, 2012). Some research has shown citrulline supplementation to have the feeling of soreness decrease by as much as 40% after pectoral training exercise (Pérez-Guisado & Jakeman, 2010). The supplement's effect on fatigue could potentially allow an athlete to be more productive during their training sessions.

Agmatine Sulfate

This is a fairly new supplement being utilized within the aspect of physical activity performance and there is very limited research on this supplement's provided benefits within physical activity performance enhancement. Agmatine is derived from the amino acid arginine and has mainly been involved in studies on its effect on nitric

oxide production (Lowery et al, 2013). Studies performed on neonatal rats have also shown agmatine to protect neurons with in the cerebral cortex (Abe, Abe & Saito, 2000).

Pre-Workout Supplement

Many of the pre-workout supplements on the market are a combination or "cocktail" of the individual supplements previously discussed and more. They are combined under the guise that they will synergistically work with each other and provide the most "bang for the buck". In a study performed by Gonzalez, et al, (2011), in which college age, resistance trained males were given a pre-workout supplement 10 minutes prior to their multi-joint resistance training test, the results showed an increase in a the number of successful repetitions the subjects were able to complete, as well as a greater peak in power production..

Another study performed by Hoffman, et al, (2009) was performed, again on male athletes, in which a pre-workout supplement was administered to subject before a series of Wingate test were performed. The results of this study showed no anaerobic power measurement, however, subjects did have an increase in the feeling of energy and focus.

Smith, et al, (2010), implemented a study in which a moderately-trained athletes where giving a pre-workout supplement before each testing session and examined over a 3 week time period involving high-intensity interval training (HIIT). The results had a positive influence on performance. The researcher states "These results demonstrated improvements in VO2 max, critical velocity (CV) and lean body mass (LBM)…" (Smith, et al, 2010).

In a study by Spradley, et al, (2012), the effects of a pre-workout supplement containing caffeine, creatine, amino acids, B-vitamins and beta-alanine was examined to see if there were any effects on muscular endurance, aerobic and anaerobic capacity, as well as choice reaction time. Before the testing with the supplement use began, a baseline determined for the subject on their 1RM for the bench and leg press, VO2 max, along with base lines for choice reaction times and velocity familiarization. On the following visit, the subjects (recreational trained males) ingested the supplement 20 minutes prior to testing. There results were recorded and on the next visit the subjects were given the supplement crossover. According to Spradley, et al (2012), "Ingesting the supplement before exercise significantly improved agility choice reaction performance and lower body muscular endurance, while increasing perceived energy and reducing subjective fatigue".

Chapter 3 – Methods

To determine the effect of a pre-workout, performance-enhancing supplement has on the production and maintenance of power, this research study analyzed a series of Wingate tests. The Wingate test was utilized because it has been shown to induce fatigue, which allowed for the researcher to examine how the subjects were able to maintain power output throughout the length of the testing protocol as fatigue accumulated. As the subject became fatigued, the subject's power output performance decreased, this allowed the researcher to test if the ingestion of a pre-workout, performance-enhancing supplement causes any change in the performance results compared to the other treatments.

Participants

After being approved by the Institutional Review Board, research was conducted using recreationally trained, college age male subjects during the investigation period. The subject's status of being considered "recreationally trained" was based on the number of hours the participants spends exercising or participating in physical activity and at the researcher's discretion. All subjects signed an informed consent form before the start of the beginning of the research. Subjects were asked to continue with the same weekly exercise/physical activity schedule as before the research testing began, but to abstain from intense training (heavy resistance training or long bouts of aerobic activity) 24 hours before each testing session.

Instruments/Apparatus

During this investigational research, the BodPod (COSMED USA, INC, Concord, CA) was used to measure the baseline of the subject's body composition. For the Wingate test portion of the research investigation, the Monark (Monark Exercise AB, Vansbro, Sweden, model 894E rope-braked cycle ergometer was used. Data generated from the Wingate test was recorded and gathered using the Monark Anaerobic Test Software, version 2.24.2 (Monark Exercise AB, Vansbro, Sweden). A Vertec (Sports Imports, Columbus, OH) scale was used in the vertical jump portion of the test.

Supplement

The supplement, Assault Black (MusclePharm, Denver, Colorado, USA) was used during this investigation. The supplement contains Branch-Chain Amino Acids (BCAAs), Creatine, Beta Alanine, Nitrates, B-vitamins, Citrulline Malate, Agmatine Sulfate, and Caffeine. The complete nutritional facts for the supplement are listed in Appendix A. The caffeine mixture was matched to the amount in the respective supplement for Assault Black (300mg), with added sucralose and appropriate coloring to match that of Assault Black. The placebo being used was of same flavor and color. Both the supplement and placebo was administered in 500ml of water.

Procedures/Study Design

This study was a double blind crossover design. Subjects came to the first session for baseline testing and familiarization. During this time the subjects were screened for general health and drug/supplement consumption (done by a health history questionnaire), along with blood pressure, and resting heart rate values. Subjects that had any major health conditions, high blood pressure or high resting heart rates (HR >90bpm,

BP >140/90), chronically consume supplements, and/or have any orthopedic issues were excluded from the remained of the study. A bod pod scan was performed to measure body composition of each subject.

Warm-Up - Subjects rode the cycle ergometer for five minutes at a self-selected pace. After this they performed stretching as needed before starting the familiarization portion of the session.

Vertical jump familiarization – A standing reach was taken by having the subjects extend their hands middle finger over middle finger with bare feet flat on the floor. The reach was measured with a tape measure mounted on a wall. The subjects then were instructed to jump and touch as high as possible with their dominant hand on the Vertec without taking a step approach. They were given 4 trials with a one- minute rest period between each jump.

Wingate familiarization – The subject were properly fitted to the Monark 894E ergometer bike so they would be able to given optimal performance with their limb length differences. The subject then begin the warm-up by pedaling at a rate of at least 70rpms for 2-minutes. Upon the completion of the 2-minute warm-up the subject then gave a max effort sprint, under load for 5 seconds. The subject's load was determined by using 7.5% of the subject's weight in kilograms. The subject then pedal at a normal pace (of at least 70rpms) for 55-seconds. At the end of the 55-seconds of normal pace, the subject gave another max effort sprint, under for 5-seconds. The subject repeated the normal pace and max effort sprint sections until the subject performed 5 max effort

sprints (half of the actual testing protocol), then the subject pedaled at normal pace of at least 70 rpms for 1-minutes as a cool down.

Subjects then scheduled their first experimental session, which was controlled for the same time of day and day of the week and was told to abstain from physical exertion 24 hours before the testing.

Experimental sessions - Each session the subjects came in at the same time of day within 30 minutes of the first session. There were at least 3 and no more than 9 days between each testing session.

Visual Analog Scale – Subjects performed a visual analog scale test set at a distance of 10cm apart for energy, focus, fatigue, and anxiety/restlessness. The scales were counter weighted for low being 1 and high being 10 for the energy and focus, the inverse for fatigue and anxiety/restlessness. Subjects rated their performance on a RPE scale. These tests were given directly before ingestion of the supplement condition, before the initial vertical jump performance and after the Wingate test.

Upon arrival the subjects were given their condition beverage to consume. The subjects consumed the entire treatment and then waited 20 minutes before they began the exercise testing. During the 20-minute wait, the subject's lactate level was tested for baseline comparisons.

Supplement conditions – There were three different supplement conditions, one was a placebo of food coloring and sucralose to match the taste and texture of the other trials, the second was caffeine (matched to the amount in the respective supplement for

Assault Black) with sucralose and appropriate coloring and the final was with the Assault Black pre-workout supplement. Each supplement condition was mixed in 500ml of water

Warm up – Subjects rode for five minutes at a self-selected resistance on a cycle ergometer. After this they performed stretching as needed before starting the testing portion of the session.

Vertical jumps – Directly after the warm up the subject performed 5 maximal counter movement jumps, using their dominant hand, utilizing the Vertec. Subjects were given a one-minute rest period between each jump trial.

The second test to be performed was the multiple Wingates. For the Wingate portion of the testing, the subjects were properly fitted to the Monark 894E ergometer cycle. The load for each subject was 7.5% of the subject's weight in kilograms, which is the same percentage of weight used during the standard thirty-second Wingate test. Subjects then performed the follow testing protocol during each of the three experimental testing sessions:

i. 2 minute – warm-up at normal pace
ii. 5 second – maximal effort under load
iii. 55 second – normal pace
iv. 5 second – maximal effort under load
v. 55 second – normal pace
vi. 5 second – maximal effort under load
vii. 55 second – normal pace
viii. 5 second - maximal effort under load
ix. 55 second – normal pace
x. 5 second – maximal effort under load
xi. 55 second – normal pace
xii. 5 second – maximal effort under load
xiii. 55 second – normal pace
xiv. 5 second – maximal effort under load
xv. 55 second – normal pace
xvi. 5 second – maximal effort under load
xvii. 55 second – normal pace
xviii. 5 second – maximal effort under load
xix. 55 second – normal pace
xx. 5 second – maximal effort under load
xxi. 1 minute –cool down

Upon completion of the Wingate test protocol, the subject's lactate level was tested for the second time.

The third test was another round of vertical jumps. Directly after the Wingate test, the subjects performed 5 maximal counter movement jumps, using their dominant hand, utilizing the Vertec. Subjects were given a one-minute rest period between each jump trial.

Subjects then scheduled their third meeting, which was controlled for the same time of day and day of the week and were told to abstain from physical exertion 24 hours before the testing. The subjects went through the same testing protocols as the first experimental session; the difference being the subject received a different conditioned beverage from that of the first experimental session.

Subjects then scheduled their final meeting, which was controlled for the same time of day and day of the week and were told to abstain from physical exertion 24 hours before the testing. The subjects then went through the same testing protocols as the first experimental session; the difference being the subject will receive the last conditioned beverage option.

After completion of the final experimental session, each subject was debriefed on their performance, with the researcher answering any questions the subjects may have.

Data Analysis

The data analysis was done using a repeated measure analysis of variance (ANOVA) with LSD (least squares difference) post hoc analysis. Dependent t-tests were also utilized to analysis the difference between the supplement and placebo use, to determine cause and effect for both the cycle test and the vertical jump performance exercise.

Chapter 4 – Results

This thesis analyzed power output performance and its relationship to the treatment condition (Supplement, Placebo + Caffeine, and Placebo) consumed by the subjects. For the purpose of this study, significance was set at $p < 0.05$. Each of the hypotheses proposed were answered utilizing the methodology outlined in chapter 3 and the results of each portion are reviewed below.

Subject Attrition

Of the 13 male subjects who volunteered for the study, all 13 completed the study.

Demographics

The average demographics of the subjects was as followed, Age: 23.3±4.2 (years), Height, 69±2.9 (inches); Weight, 199.6±33.9 (pounds); Body Fat, 21.6±8.9 (%); Fat Free Mass, 155.2±23.5 (pounds); and Reach, 87.2±4.5 (inches). The subjects self reported participating, on average, in 4.5 hours of aerobic activity (jogging, cycling, walking, etc.) and 6.3 hours of resistance training per week.

Wingate

Subjects performed the Multiple 5 second Wingate bike protocol during each of their 3 experimental visits, with the only difference being the treatment ingested at the start of each test. Maximum power output was $F(9, 324) = 37.126$ $p<0.0001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.825$). Mean power output was $F(9,325) = 52.245$ $p<0.0001$, post hoc utilizing LSD resulted in

no significance difference between the treatments (p=0.852). Minimum power output was F (9, 325) = 52.417 p<0.0001, post hoc utilizing LSD resulted in no significance difference between the treatments (p=0.88). Maximum-Minimum power output change was F (9, 324) = 7.081 p<0.0001, post hoc utilizing LSD resulted in no significance difference between the treatments (p=0.565). The Wingate performance data for each treatment is shown in Table 1, Figure 1, Figure 2, Figure 3 and Figure 4.

Table 1 – Wingate Power Output (watts)

Group	Average Max	Average Mean	Average Minimum	Average Max-Min(change)
Supplement	783.1±155.7	705±143.7	604.9±143.3	178.1±72.4
Placebo+Caffeine	769.8±166.5	694.6±157.2	602.6±152.4	167.1±65.8
Placebo	778.2±165	702.1±153.6	610.5±145.8	167.7±70.11

Notes: All units are mean ± standard deviation

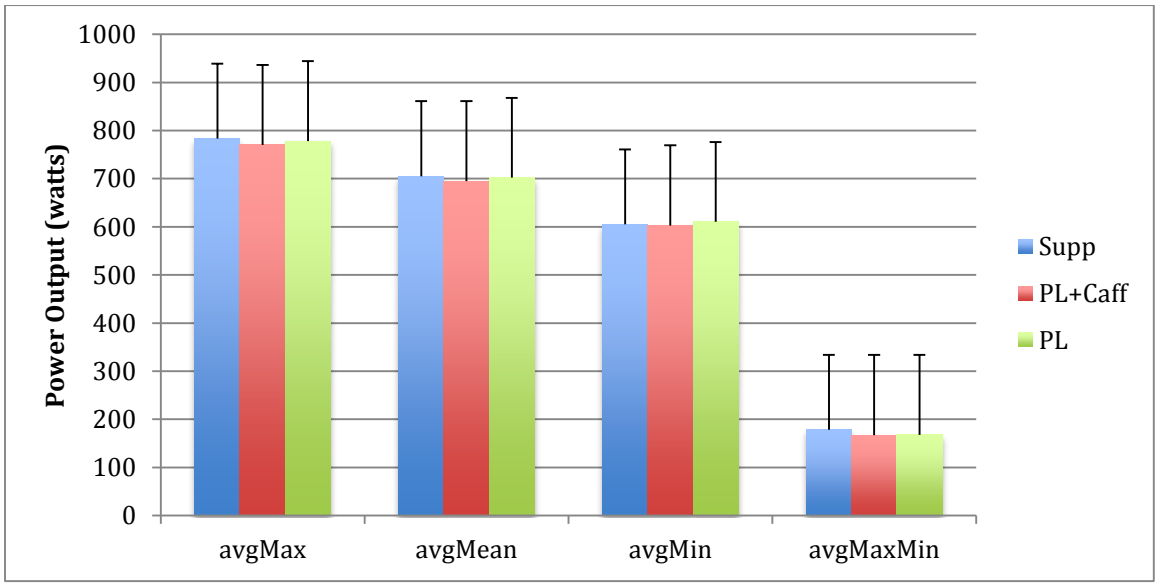

Figure 1 – Wingate Power Output

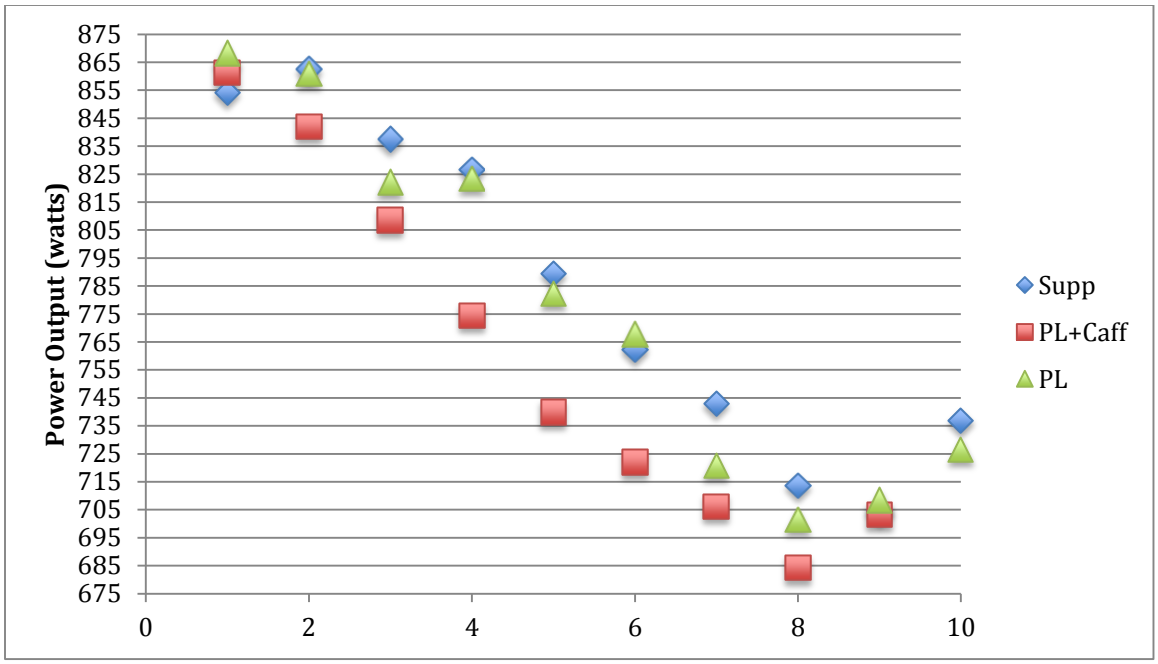

Figure 2 – Average Maximum Wingate Power Output

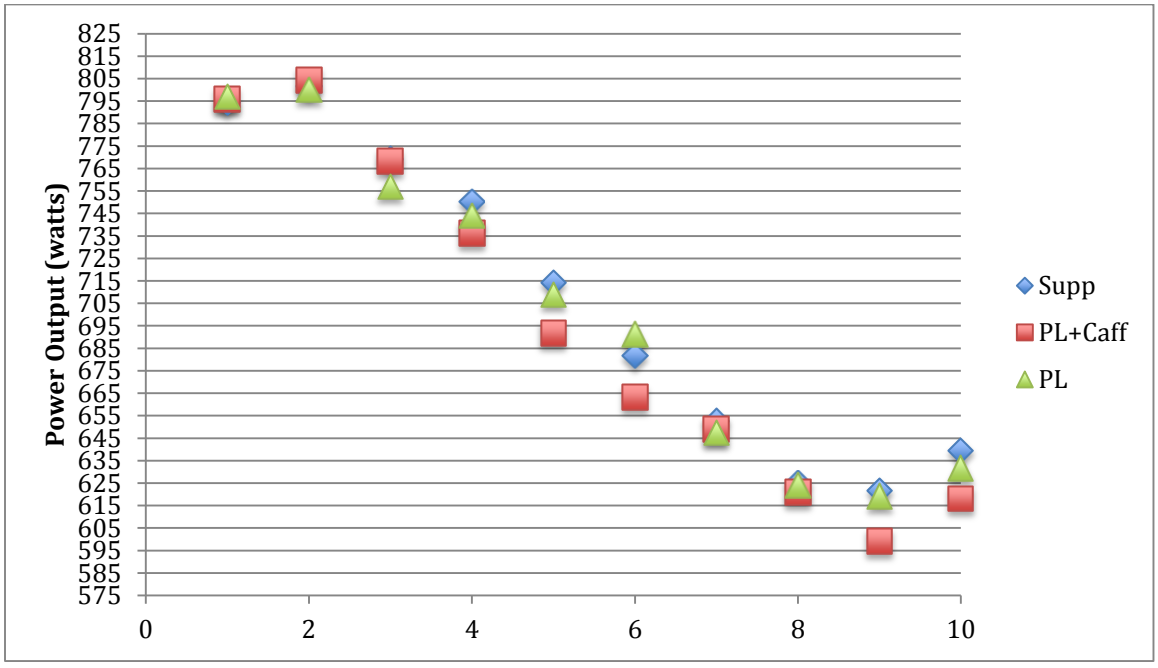

Figure 3 – Average Mean Wingate Power Output

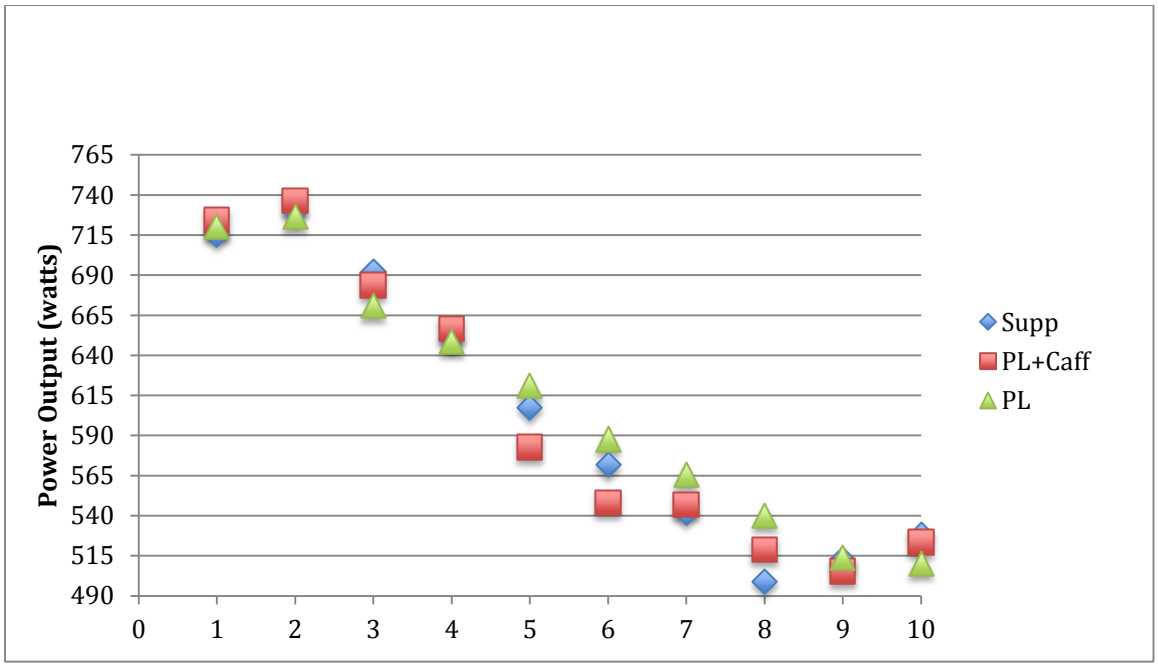

Figure 4 – Average Minimum Wingate Power Output

Vertical Jump

Subjects performed the vertical jump protocol outlined in chapter 3 during each of their 3 experimental visits, with the only difference being the treatment ingested at the start of each test. The best performance from the Pre-Wingate and Post-Wingate vertical jumps was used for each subject. Results from the vertical jump were $F(1, 36) = 12.016$ $p<0.001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.889$). The vertical jump performance data for each treatment is shown in Table 2, Figure 5, and Figure 6.

Table 2 – Vertical Jump Height (inches)

Group	Pre-Wingate Jump	Post-Wingate Jump	Pre-Post (change)
Supplement	26.5±4	25.9±3.7	0.57±1.2
Placebo+Caffeine	26.7±3.9	26.1±3.7	0.53±1
Placebo	26.6±3.8	25.9±3.7	0.69±1

Notes: All units are mean ± standard deviation

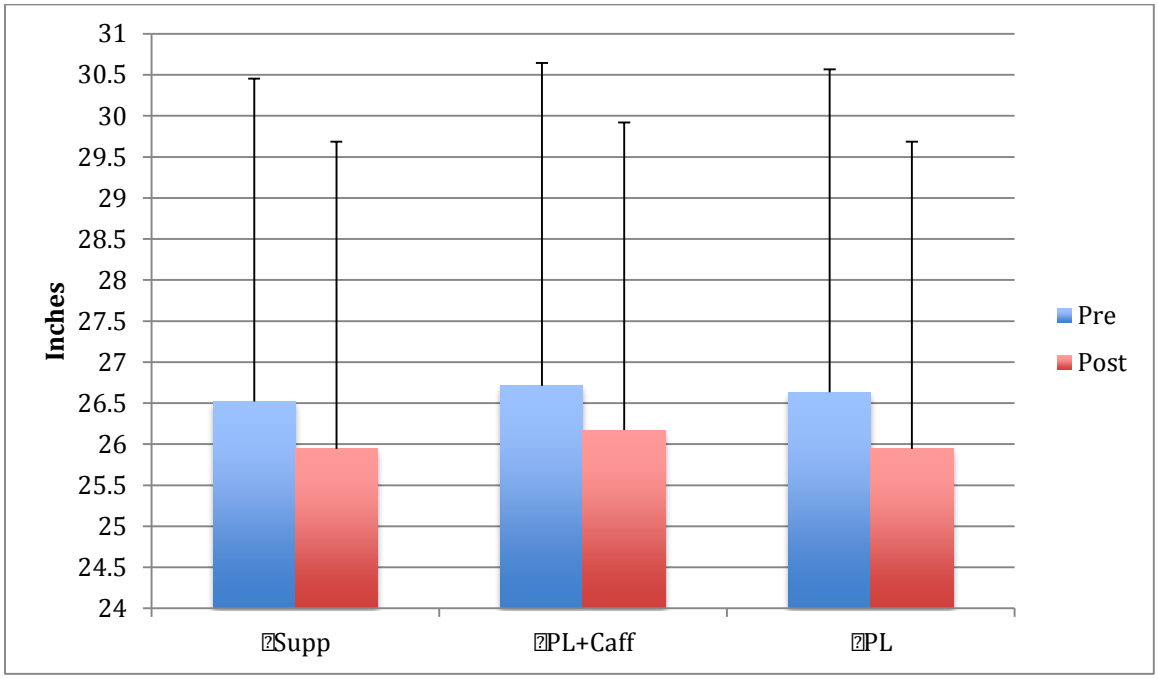

Figure 5 – Average Vertical Jump Height (inches)

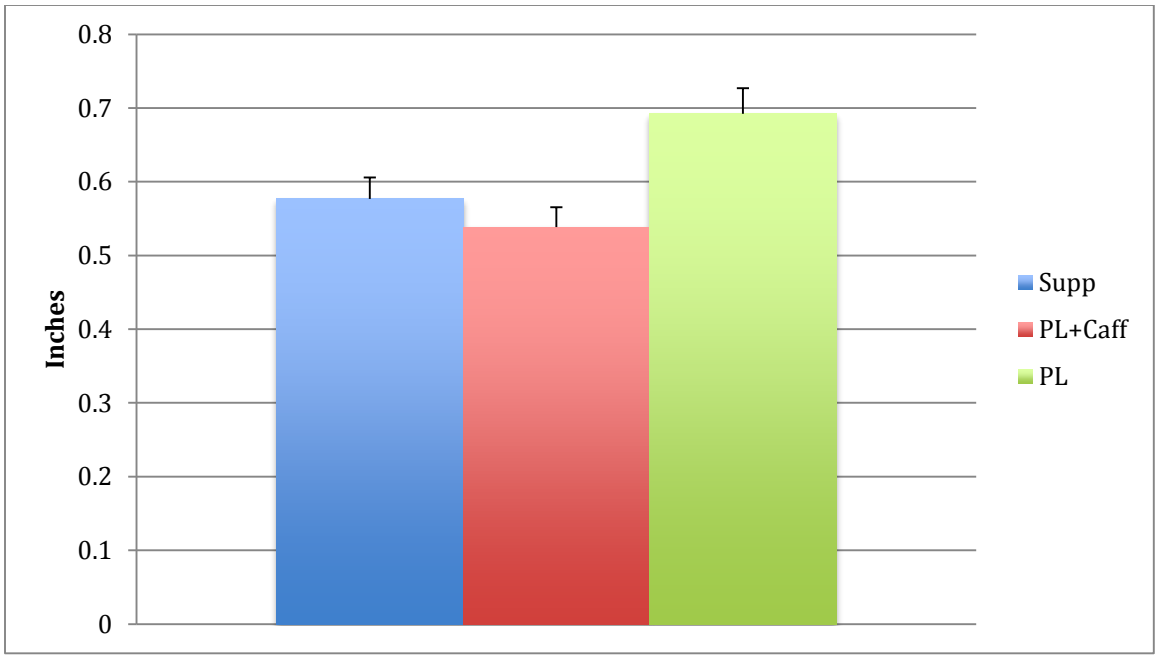

Figure 6– Average Vertical Jump Pre-Post Height Change

Lactate

Subjects had their lactate tested at the beginning of the session to get a baseline measurement, followed by a second lactate test immediately after the completion of the Wingate bike test. The only difference being the treatment ingested at the start of each testing session. The results from the lactate test were $F(1, 36) = 121.942$ $p<0.0001$, post hoc utilizing LSD resulted in a significance difference ($p=0.029$), in that the placebo + caffeine treatment showed an higher increase in pre to post Wingate lactate compared to the other two treatments. The lactate test data for each treatment is shown in Table 3 and Figure 7.

Table 3 – Lactate Test

Group	Pre-Wingate	Post-Wingate	Pre-Post (change)
Supplement	2.2±1.2	11.3±2.4	-9.1±2.6
Placebo+Caffeine	4.1±4.6	13.4±4.2	-9.3±6.9
Placebo	2.8±3.1	10.7±2.8	-7.8±4.3

Notes: All units are mean ± standard deviation

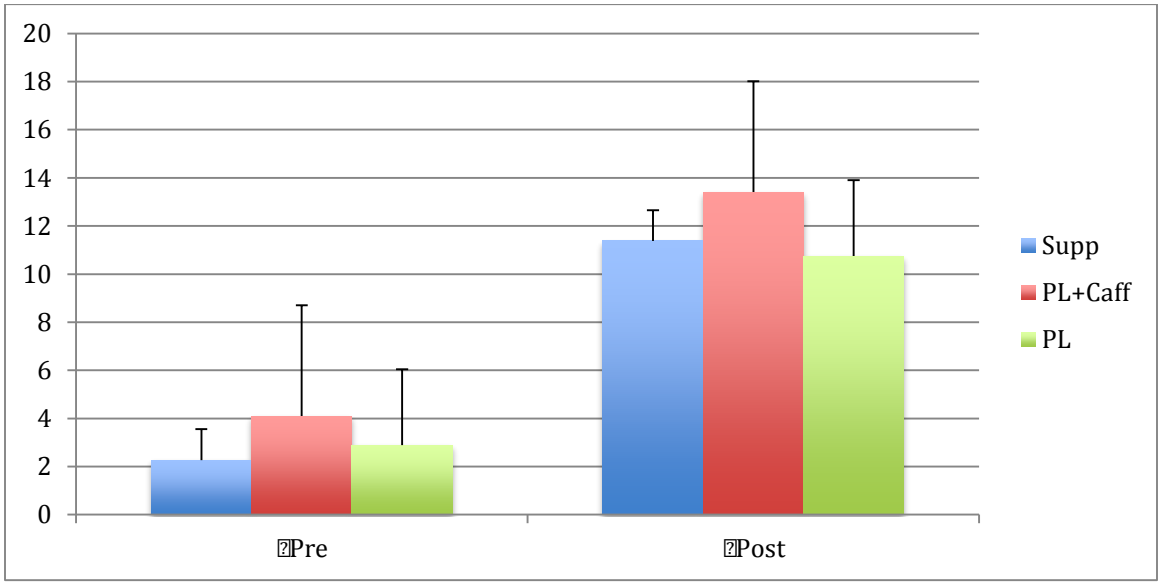

Figure 7 – Average Lactate Pre-Post Test

Visual Analog Scale

The visual analog scale (VAS), described in chapter 3 was filled out by each subject upon arrival for testing, again 20 minutes after ingesting the treatment, and again immediately following the completion of the Wingate bike test. VAS allowed the

subjects to rate their level of energy, focus, fatigue and anxiety/restlessness on a scale from 0 to 10. Results for the energy portion of the VAS were $F(2, 72) = 36.736$ $p<0.0001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.712$). Results for the focus portion of the VAS were $F(2, 72) = 13.95$ $p<0.001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.5$). Results for the fatigue portion of the VAS were $F(2, 72) = 18.066$ $p<0.001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.207$). Results for the anxiety/restlessness portion of the VAS were $F(2, 72) = 73.351$ $p<0.0001$, post hoc utilizing LSD resulted in no significance difference between the treatments ($p=0.471$). The VAS results for each treatment is shown in Table 4, Table 5, Table 6 and Table 7.

Table 4 – Energy - Visual Analog Scale Change Score

Group	Energy Post Treatment-Pre Treatment	Energy Post Wingate-Post Treatment	Energy Post Wingate-Pre Treatment
Supplement	1.2	-1.8	-0.6
Placebo+Caffeine	0.5	-1.5	-1
Placebo	0.4	-1.3	-0.8

Table 5 – Focus - Visual Analog Scale Change Score

Group	Focus Post Treatment-Pre Treatment	Focus Post Wingate-Post Treatment	Focus Post Wingate-Pre Treatment
Supplement	1.1	-1.5	-0.3
Placebo+Caffeine	0.1	-0.6	-0.5
Placebo	0.2	-1	-0.7

Table 6 – Fatigue – Visual Analog Scale Change Score

Group	Fatigue Post Treatment-Pre Treatment	Fatigue Post Wingate-Post Treatment	Fatigue Post Wingate-Pre Treatment
Supplement	-1.2	2.5	1.2
Placebo+Caffeine	-0.9	2.4	1.5
Placebo	-0.03	2.3	2.3

Table 7 – Anxiety/Restlessness – Visual Analog Scale Change Score

Group	A/R Post Treatment-Pre Treatment	A/R Post Wingate-Post Treatment	A/R Post Wingate-Pre Treatment
Supplement	-0.3	0.7	0.3
Placebo+Caffeine	0	0.9	0.9
Placebo	-0.2	0.5	0.3

Chapter 5 – Discussion

This research investigation was the first known investigation to examine the effect of the pre-workout supplement Assault Black on the maintenance of acute power production and maintenance. The results suggest the pre-workout supplement increased maximum and mean power production, while also improving the subject's perceived level of energy, focus and decreasing the subject's perceived level of fatigue.

Subject Sample

When performing a treatment research study such as this one, it is ideal to have a large number of subjects to better show a relationship between the different treatments. The original goal was to have 20 subjects participate in the research, but due to limited number of students on campus during summer semester the study consisted of only 13 subjects. This is still a larger number of subjects than the Spradley et al, 2012 and Hoffman et al, 2009 study, which some of this study was based off of. Future research could benefit from a larger sample participating in the study.

Wingate

Power output results for the Wingate bike test showed the differences between the groups to not be statically significant between treatments. However the Supplement treatment had the highest average maximum power output (Supp: 783.1$\pm$155.7, PL+Caff: 769.8$\pm$166.5, PL: 778.2$\pm$165.8), and average mean power outputs (Supp: 705$\pm$143.7, PL+Caff: 694.6$\pm$157.2, PL: 702.1$\pm$153.6). The highest average minimum power output was produced by the placebo treatment (PL: 610.5$\pm$145.8, Supp: 604.9$\pm$143.3, PL+Caff:

602.6±152.4). The placebo plus caffeine treatment produced the lowest average maximum-minimum change (PL+Caff: 167.1±65.8, Supp: 178.1±72.5, PL: 167.7±70.1). When examining the average maximum power output produced at the first work series of the Wingate bike protocol (Wingate 1) and the last work series (Wingate 10), the supplement treatment had the lowest average maximum power output decrease (Supp: 117.3, PL+Caff: 153.7, PL: 141.8).

Previous research has suggested a pre-workout supplement with similar ingredients improved lower body muscular endurance (Spradley et al, 2012). Other past studies have shown no power increases during a 20 second Wingate anaerobic power test with the use of a pre-workout type supplement (Hoffman et al, 2009). These results would suggest the use of a pre-workout supplement with similar ingredients (Assault Black) improved subject's ability to produce higher max power outputs (peak power). Also from the results of the higher average mean power output suggest the subjects would maintain this increase in power longer than with the use of the other two treatments (Placebo + Caffeine and Placebo) during a modified Wingate bike test.

Vertical Jump

Past research in examining the use of beta-alanine supplementation on improving jump performance resulted in an improvement in maximal and mean power during countermovement jumps (Gross et al, 2014). The results from the vertical jump test from this study showed no statistical significances between the treatments. The difference between the highest vertical jump performance before the Wingate bike test and the highest vertical jump performance after the Wingate bike test (Supp: 0.57, PL+Caff: 0.53,

PL: 0.69) could be do to the elevated levels of fatigue created by Wingate bike test. For future research it could be beneficial to preform a larger series of vertical jumps, both Pre and Post Wingate, to examine the ability to maintain peak vertical jump height throughout both series of jumps or possibly the number of jumps needed to achieve maximal height once the Wingate bike test was performed.

Lactate

The results from the lactate test were $F(1, 36) = 121.942$ $p<0.0001$, post hoc utilizing LSD resulted in significance ($P=0.029$), in that the placebo + caffeine treatment showed an higher increase in pre to post Wingate lactate compared to the other two treatments.

A point of interest that arises from the results of this portion of the experiment is how the supplement treatment was able to produce the highest average maximum and mean power outputs while not producing the largest average lactate results after the completion of the Wingate bike test. This could possibly be attributed to the increase production of carnosine from the beta-alanine within the supplement, which pass research has shown to help buffer out the hydrogen ions from the lactate acid (Baguet et al., 2009).

Visual Analog Scale

The results from the visual analog scale (VAS) test showed no statistical significances between the treatments. There was however differences in the overall averages based on the treatments.

Energy

The subjects had a greater increase in the average level of perceived energy 20 minutes after the ingestion of the treatment during the supplement treatment (Supp: 1.2, PL+Caff: 0.5, PL: 0.4). The subjects had the lowest decrease in the average level of perceived energy after the Wingate bike test during the placebo treatment (Supp: -1.8, PL+Caff: -1.5, PL: -1.3). The subjects had the lowest decrease in the average level of perceived energy after the Wingate bike test compared to the subject's arrival for testing during the supplement treatment (Supp; -0.6, PL+Caff: -1, PL: -0.8).

Focus

The subjects had a greater increase in the average level of perceived focus 20 minutes after the ingestion of the treatment during the supplement treatment (Supp: 1.1, PL+Caff: 0.1, PL: 0.2). The subjects had the lowest decrease in the average level of perceived focus after the Wingate bike test during the placebo plus caffeine treatment (Supp: -1.5, PL+Caff: -0.6, PL: -1). The subjects had the lowest decrease in the average level of perceived focus after the Wingate bike test compared to the subject's arrival for testing during the supplement treatment (Supp: -0.3, PL+Caff: -0.5, PL: -0.7).

Fatigue

The subjects had the greatest decrease in the average level of perceived fatigue 20 minutes after the ingestion of the treatment during the supplement treatment (Supp: -1.2, PL+Caff: -0.9, PL: -0.03). The subjects had the lowest increase in the average level of perceived fatigue after the Wingate bike test during the placebo treatment (Supp: 2.5, PL+Caff: 2.4, PL: 2.3). The subjects had the lowest increase in the average level of

perceived fatigue after the Wingate bike test compared to the subject's arrival for testing during the supplement treatment (Supp: 1.2, PL+Caff: 1.5, PL: 2.3).

Anxiety/Restlessness

The subjects had the greatest decrease in the average level of perceived fatigue 20 minutes after the ingestion of the treatment during the supplement treatment (Supp: -0.3, PL+Caff: 0, PL: -0.2). The subjects had the lowest increase in the average level of perceived fatigue after the Wingate bike test during the placebo treatment (Supp: 0.7, PL+Caff: 0.9, PL: 0.5). The subjects had the lowest increase in the average level of perceived fatigue after the Wingate bike test compared to the subject's arrival for testing during the placebo treatment (Supp: 0.37, PL+Caff: 0.9. PL: 0.3).

Previous research in examining the effects of perceived energy, focus and fatigue in combination with the use of a pre-workout type supplement was shown to by significantly higher with the use of the supplement compared to the placebo (Hoffman et al, 2009). Other past research has attributed this increase in perceived energy, focus and decrease perceived fatigue to be possibly be caused by the caffeine within the pre-workout (Spradley et al, 2012), but the results here point to another possible ingredient or combination of ingredients.

Conclusion

Based on the findings of this research study, the results suggest the pre-workout supplement, Assault Black, may increase an individual's average maximum and average mean power production during acute, high intensity physical activity. Even though the increases are not statistical significant during this acute study, these increases in

performance, even though small, can possibly accumulate over time, adding up to larger performance increases with time. This is where a longitudinal study with the use of supplementation while examining power production and maintenance would be beneficial. The results also suggest the supplement provides an increase in an individual's average feeling of energy and focus as well as lowers the individual's average level of fatigue.

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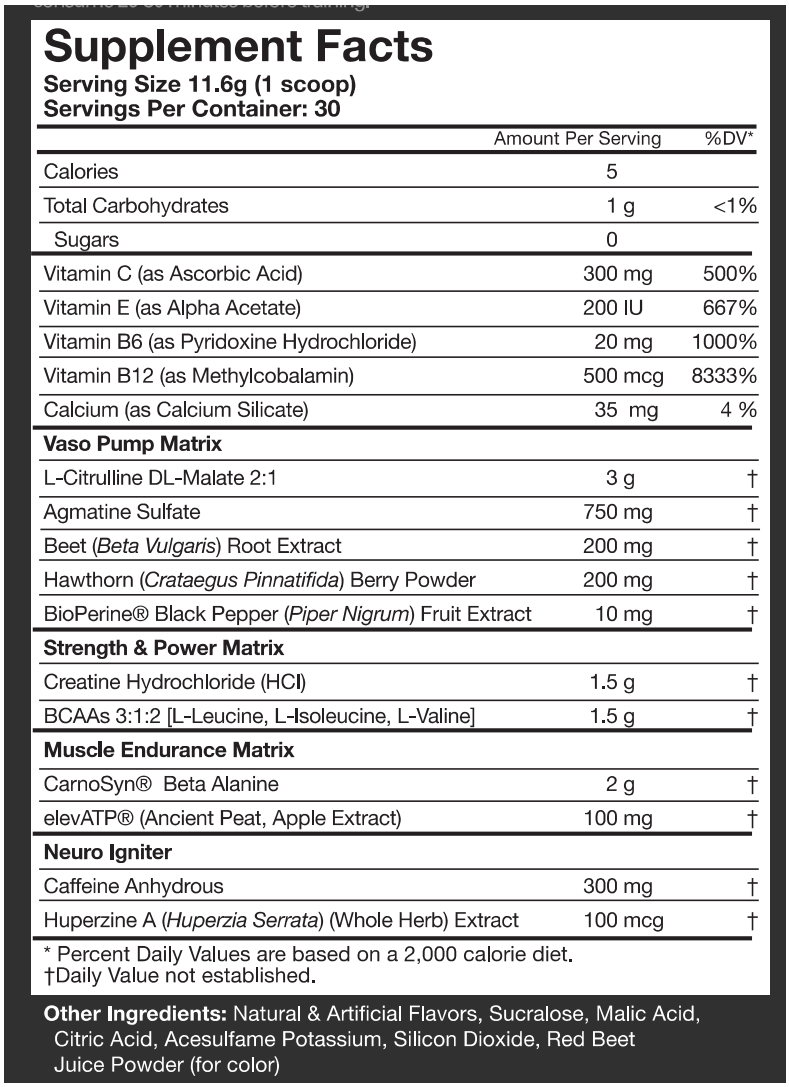
APPENDIX A:

Assault Black Supplement Label



Supplement Facts

Serving Size 11.6g (1 scoop)
Servings Per Container: 30

	Amount Per Serving	%DV*
Calories	5	
Total Carbohydrates	1 g	<1%
Sugars	0	
Vitamin C (as Ascorbic Acid)	300 mg	500%
Vitamin E (as Alpha Acetate)	200 IU	667%
Vitamin B6 (as Pyridoxine Hydrochloride)	20 mg	1000%
Vitamin B12 (as Methylcobalamin)	500 mcg	8333%
Calcium (as Calcium Silicate)	35 mg	4 %
Vaso Pump Matrix		
L-Citrulline DL-Malate 2:1	3 g	†
Agmatine Sulfate	750 mg	†
Beet (*Beta Vulgaris*) Root Extract	200 mg	†
Hawthorn (*Crataegus Pinnatifida*) Berry Powder	200 mg	†
BioPerine® Black Pepper (*Piper Nigrum*) Fruit Extract	10 mg	†
Strength & Power Matrix		
Creatine Hydrochloride (HCl)	1.5 g	†
BCAAs 3:1:2 [L-Leucine, L-Isoleucine, L-Valine]	1.5 g	†
Muscle Endurance Matrix		
CarnoSyn® Beta Alanine	2 g	†
elevATP® (Ancient Peat, Apple Extract)	100 mg	†
Neuro Igniter		
Caffeine Anhydrous	300 mg	†
Huperzine A (*Huperzia Serrata*) (Whole Herb) Extract	100 mcg	†

* Percent Daily Values are based on a 2,000 calorie diet.
†Daily Value not established.

Other Ingredients: Natural & Artificial Flavors, Sucralose, Malic Acid, Citric Acid, Acesulfame Potassium, Silicon Dioxide, Red Beet Juice Powder (for color)

Figure 8 - Assault Black Supplement Label