UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

THE LONG-TERM EFFECTS OF A MULTI-INGREDIENT PRE-WORKOUT SUPPLEMENT ON EXERCISE PERFORMANCE IN ACTIVE FEMALES

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science

Kaela Hoecherl

College of Science and Health
Clinical Exercise Physiology

May, 2017

THE LONG-TERM EFFECTS OF A MULTI-INGREDIENT PRE-WORKOUT SUPPLEMENT ON EXERCISE PERFORMANCE IN ACTIVE FEMALES

By Kaela Hoecherl

We recommend acceptance of this thesis in partial fulfillment of the candidate's requirements for the degree of Master of Science in Clinical Exercise Physiology

The candidate has completed the oral defense of the thesis.

Andrew Jagim, Ph.D. — 4/21/17 Date
Thesis Committee Chairperson

Clayton Camic, Ph. D. — 4/21/17 Date
Thesis Committee Member

Carl Foster, Ph.D. — 4/21/17 Date
Thesis Committee Member

Thesis Accepted

Steven Simpson, Ph.D. — 5/19/17 Date
Graduate Studies Director

ABSTRACT

Hoecherl, K. H. The long-term effects of a multi-ingredient pre-workout supplement on exercise performance in active females. MS in Clinical Exercise Physiology, May 2017, 55pp. (A. Jagim)

Multi-ingredient pre-workout supplements (MIPS) are popularly used to enhance exercise performance, but little is known regarding the long-term effects. Further, limited data are available in female populations. Therefore, the purpose of this study was to examine the long-term effects of a MIPS on training adaptations in active females. Nineteen females participated in a randomized, double-blind, placebo controlled study. Participants completed a seven-week strength training program and followed dietary recommendations. Subjects reported to the laboratory for identical baseline and post-training testing sessions. Lower body power was assessed using a counter-movement vertical jump. Upper body and lower body strength were assessed by one-repetition maximum (1RM) on the bench press and leg press. Muscular endurance tests were assessed on the bench press and leg press by performing a set to failure at 75% of calculated 1RM. Both groups showed significant improvement in upper body strength (p=0.00) and lower body strength (p=0.00), but were not significantly different from each other for upper body (p=0.74) or lower body (p=0.53). There were no significant improvements for lower body power (p=0.86), upper body endurance (p=0.39), or lower body endurance (p=0.37). In conclusion, this study suggests that consumption of a MIPS does not significantly influence training adaptations.

ACKNOWLEDGEMENTS

I would first like to thank Dr. Andrew Jagim for letting me take part in this research study. Coming from no research experience, you helped me so much through the grueling process and I learned to appreciate the fine details I never would have known existed in the world of research.

I would also like to thank each of my committee members, Dr. Clayton Camic and Dr. Carl Foster. Your knowledge and insight has helped guide me through my research and helped me overcome the obstacles I came across throughout this study.

Finally, I would like to thank Chris Dodge for his endless help in the laboratory throughout the course of this study. You were always happy to help and never complained no matter how many times I bothered you with my silly questions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

INTRODUCTION

Dietary supplements are an increasingly popular way to enhance exercise performance for active individuals (Kedia et al., 2014). One type of supplement referred to as multi-ingredient pre-workout supplements (MIPS) are designed to be ingested prior to exercising and purported to improve work capacity and training intensity which may positively influence training adaptations over time (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011). A recent survey conducted by over 200 collegiate athletes found that 89% reported using some type of pre-workout supplement at the time of the survey (Eudy et al., 2013; Froiland et al., 2004).

Pre-workout supplements often contain a mixture of ingredients that may work synergistically to improve athletic performance after ingestion (Hoffman et al., 2016). Common ingredients of multi-ingredient pre-workout supplements typically include caffeine, branched chain amino acids (BCAAs), beta-alanine, creatine monohydrate, and L-carnitine. Each ingredient likely offers an individual physiological benefit through a specific mechanism of action. For example, caffeine has been shown to increase energy levels and improve performance during endurance exercises as well as short bouts of maximal exercises (Krelpke, 2016). It has also been shown to decrease subjective fatigue, lower perception of effort, and increase alertness during activity (Krelpke, 2016). While BCAAs may help to foster anabolic conditions by increasing protein synthesis, regulating protein metabolism, and suppressing the breakdown of protein (Krelpke, 2016). Additionally, beta-alanine has been shown to increase muscular endurance by buffering hydrogen ions (Krelpke, 2016), which may help an individual better maintain the intensity of their training or complete a higher training volume, presumably leading to improved results over time. Creatine monohydrate helps to saturate muscles with the substrate that is needed to sustain high intensity exercise (Krelpke, 2016). Increased creatine in the muscle will increase performance in short, high intensity exercise by increasing the capacity of the phosphagen system, which provides energy that is useful for explosive strength (Krelpke, 2016). L-carnitine assists with fat utilization by transferring long-chain fatty acids, such as triglycerides, into mitochondria where they can be oxidized to produce energy (Lockridge, 2017). L-carnitine has also been shown to reduce fatigue, which in turn will increase aerobic capacity and assist with burning calories (Lockridge, 2017).

By combining these ingredients there may be a synergistic benefit in performance. By taking a MIPS 10-30 minutes prior to exercising, subjects may perform a higher total number of repetitions during an exercise, average power output may increase, and improved perceived levels of energy and concentration may increase focus and reduce subjective fatigue compared to consuming a product containing caffeine alone (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011; Kedia et al., 2014; Spradley et al., 2012). For example, Jagim et al. (2016) reported an increase in upper body muscular endurance and power output, with concomitant decreases in subjective markers of fatigue, and increased alertness when exercising after consuming a pre-workout supplement. Gonzales, Walsh, Ratamess, Kang, and Hoffman (2011) found training volume and power performance increased after consuming a MIPS. Spradley et al. (2012) found that by consuming a MIPS, subjects showed significant improvement in agility, choice reaction performance and lower body muscular endurance, an increase in perceived energy, and decrease in subjective fatigue. Kedia et al. (2014) found that consuming a pre-workout supplement significantly improved subjective levels of concentration and energy and decreased subjective fatigue compared to the product containing caffeine alone. However, there are few studies that analyze how long-term supplementation may influence changes in training adaptations over time.

Since there are physiologic differences between males and females, it cannot be assumed that both sexes will have the same results to pre-workout supplements. In addition, they may require different dosages due to differences in body size. Further, the training goals of females may differ from males. Females tend to aim more towards weight loss and toning of their bodies, whereas men tend to aim towards increases in muscle mass (Obreshkov, 2013). A novel dietary supplement called FitMiss™ (MusclePharm Inc., Denver, CO) has introduced a line of products which claim to be created specifically for females. Several studies have investigated the effects of pre-workout supplements, however the majority of these studies were done with male populations in addition to only evaluating the acute effects of pre-workout supplements. Therefore, the purpose of this study was to determine the long-term effects of FitMiss™ Ignite™, a pre-workout supplement geared towards weight loss, on training adaptations in recreationally active females. The results of this study would help identify the long-term benefits of a commercially available multi-ingredient pre-workout supplement in females.

METHODS

Subjects

Nineteen recreationally active females were recruited to participate in the study. To eliminate those with any contraindications to exercise testing, the participants were required to complete a medical history questionnaire. Subjects that took part in the study were required to have been regularly physically active, defined as have completed one to two exercise sessions per week, for the previous six months. Subjects were also between the ages of 18-30, and could not be classified as obese based on body mass index (BMI: $< 30\ kg/m^2$). Subjects were not allowed to participate in this study if they had any of the following: any metabolic disorder including known electrolyte abnormalities, heart disease, arrhythmias, diabetes, thyroid disease, history of hypertension, hepatorenal syndrome, musculoskeletal disorders, autoimmune or neurologic disease, pregnant or breastfeeding. Subjects were also not allowed to participate if they were taking any thyroid, anti-hyperlipidemic, hypoglycemic, anti-hypertensive or anti-inflammatory medications, as well as not have taken any nutritional supplements and/or ergogenic aids in the previous 3 weeks before baseline testing, not including daily vitamin and/or protein supplementation. Participants using oral contraception were asked to continue using it. If they were not, participants were asked to refrain from using oral contraception until after the study was complete. If participants had lost or gained more than 4.5 kg over the previous 30 days, they were excluded from participation. In compliance with the Human Subjects Guidelines of the University of Wisconsin – La Crosse and the American

College of Sports Medicine, subjects meeting eligibility criteria were informed of their requirements during the study and provided written informed consent before participation.

Experimental Design

The study was a double-blind, placebo controlled, randomized design. A meeting was held for the participants during which time informed consent forms were signed, an explanation about the study was given, and subjects completed a familiarization session prior to participating in the study. Also at the meeting, participants completed health history, exercise history, and demographic forms as well as provided written consent. Prior to testing, participants were asked to fast for eight hours as well as abstain from any exercise for 24 hours with testing sessions being scheduled in the morning. For baseline testing, participants completed a lower body power test, followed by upper and lower body muscular strength tests, and finished with muscular endurance tests. Following baseline testing, the participants were matched based on their body mass index and muscular strength results and then assigned to either the supplement or placebo group. Participants were given specific dietary guidelines and were asked to follow these guidelines throughout the course of the study. All participants completed a seven-week strength training program. After commencement of the seven-week program, participants returned to the lab to complete the same testing protocols used at baseline.

Testing Procedures

Upon reporting to the lab for testing, participants first completed a ten-minute warm-up consisting of a two-minute, comfortable jog and several dynamic stretches that targeted major muscle groups of the upper and lower body. After warming up, participants completed a counter-movement vertical jump (CMVJ) test using the Just Jump System (Sports, Imports, Columbus, OH). The participants were allowed two attempts using less than maximal effort for practice. Three maximum effort CMVJ attempts were then recorded, each separated by two minutes of rest. Another attempt was allowed if the third attempt was greater than the first three. Attempts were continued until there was a decrease in jump height observed. No more than five CMVJ attempts were allowed. The best jump height was recorded and used for analysis.

All participants then completed maximal strength testing for the bench press and leg press exercises. A standard isotonic Olympic bench press and leg press (Hammer Strength, Life Fitness, USA) were used to test maximal strength for the subjects' one-repetition maximum (1 RM). Tests were performed according to standardized procedures (Kerksick et al., 2009). Prior to beginning 1 RM attempts, participants completed a standardized warm-up consisting of ten repetitions at 50% of their estimated 1 RM. For testing, weight was progressively added until a 1 RM was acquired, with two minutes of rest in between each maximal attempt. The participants first did maximal strength testing on the leg press, then followed by four minutes of rest, began warming up on the bench press for maximal strength testing. Bench press 1RM testing followed the same procedures as the leg press 1 RM test.

Four minutes after testing maximal strength, muscular endurance tests were completed based on the participants' 1 RM for both upper and lower body. The subjects were instructed to complete as many repetitions as possible at 75% of their established 1 RM until failure for the leg press and the bench press exercises, respectively. Only one attempt was given for each exercise. Participants rested for four minutes between the leg press and bench press exercises.

Supplementation Protocol

Subjects were randomly assigned to either a group that ingested a single serving of a MIPS (FitMiss™ Ignite™ created by MusclePharm, Denver, CO), or to a group that ingested a placebo of similar texture and taste prepared by the manufacturers. Participants were instructed to consume one serving of either the MIPS or placebo provided to them 30 minutes prior to each training session. On recovery days, the participants were asked to consume one serving following breakfast.

Dietary Intake

In order to facilitate moderate reductions in body weight, participants were asked to follow energy and macronutrient guidelines based on previously used methods (Helms, Aragon, & Fischen, 2014). The daily energy intake of the participants was based on the following equation:

<u>Daily Caloric Intake</u> = (1.3* [10 x weight (kg) + 6.25 x height (cm) – 5 x age (yrs.) – 161]) – 300 kcals

The 1.3 represents a "moderate" activity factor, and the 300-kcal reduction is the recommended daily energy deficit that is required to promote healthy weight loss (Helms, Aragon, & Fischen, 2014). In addition to these requirements, participants were instructed to consume 1.8 grams of protein per kilogram of bodyweight because higher protein intake has been found to be beneficial during weight loss practices (Layman et al., 2005). Subjects were asked to fill out four-day food logs at weeks zero, three, and seven to keep track of macronutrient and energy intake, as well as to assess adherence to their dietary recommendations. Food logs were assessed using the Food Processor dietary analysis

software (Version 10.9 ESHA Research Salem, OR, USA). Subjects were also instructed to record daily caloric intakes using a commercially available nutritional tracking software (MyFitnessPal) in order to help the participants meet their dietary recommendations.

Resistance Training Program

The subjects' training sessions were performed at a high-intensity with short rest intervals, similar to a previously used "boot camp" style training (Lopez et al., 2013). They consisted of full-body workouts focusing on multi-joint exercises. Subjects were required to complete three training sessions per week for a period of seven weeks. Similar to an athlete specific training program, exercises incorporated different modes of training and a variety of resistance training equipment such as kettlebells, Olympic bars and plates, dumbbells, medicine balls, and cable pulley machine.

Two days of the week incorporated exercise equipment that could be found in a gym. The weight was chosen by the participants. They were directed to choose a weight that makes the last 1-2 repetitions difficult but not impossible to complete, and increased their weights each week following the same guidelines. The third day of resistance training consisted of all bodyweight exercises to provide flexibility to participants who do not always have access to gym equipment. Participants completed three sets for every exercise each day of the week. For the weighted exercises, repetitions decreased as the weight increased each week. For the bodyweight exercises, repetitions increased each week. Rest periods were 30 seconds between sets and 60-90 seconds between exercises. Each training session took approximately 60-minutes to complete. Each training session was supervised by trained fitness professionals to ensure proper mechanics were performed and to provide participants with guidance, if needed. Volume of work was calculated by multiplying number of sets by number of repetitions by amount of weight used for each exercise. Subject compliance was set at 75%.

STATISTICAL ANALYSIS

All of the data was analyzed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL). An ANOVA was used to assess differences in baseline characteristics. A group (2) x time (2) mixed factorial ANOVA was used to assess changes in training adaptations. Data were considered statistically significant when the probability of type I error was $p < 0.05$. If a significant interaction was observed, a Tukey's honest significant differences (HSD) post-hoc analysis was performed in order to determine where significance was obtained.

RESULTS

Lower Body Power Performance

No significant improvements in CMVJ performance were observed following ingestion of the MIPS as seen in Table 1 ($p > .05$).

Table 1. Countermovement Vertical Jump Height (N=19)

	Pre (cm)	Post (cm)	*p* value
MIPS (n=9)	43.3 ± 7.47	44.5 ± 9.17	T: 0.25
Placebo (n=10)	43.4 ± 6.80	44.3 ± 6.98	GxT: 0.86

Values represent mean ± standard deviation.

Strength Performance

Although both groups showed improvements in upper body and lower body maximal strength ($p < .05$), there were no significant differences in bench press or leg press performance between groups as seen in Table 2 ($p > .05$).

Table 2. Upper and Lower Body Maximal Strength Performance (N=19)

	Pre	Post	Δ	*p* value
Bench Press (kg)				
MIPS	38.3 ± 8.52	41.1 ± 5.37	+2.8	T: 0.00*
Placebo	37.4 ± 9.52	39.7 ± 9.40	+2.3	GxT: 0.74
Leg Press (kg)				
MIPS	173.6 ± 36.53	196.8 ± 38.83	+23.2	T: 0.00*
Placebo	184.6 ± 31.22	200.9 ± 36.09	+16.3	GxT: 0.53

*Significant change from pre- to post-testing ($p<.05$)
#Change significantly different than the control group ($p<.05$)
Values represent mean ± standard deviation.

Muscular Endurance Performance

No significant improvements in upper or lower body muscular endurance performance were observed following ingestion of the MIPS as seen in Table 3 ($p > .05$).

Table 3. Upper and Lower Body Muscular Endurance Performance (N=19)

	Pre	Post	*p* value
Bench Press (# of reps)			
MIPS	10.8 ± 4.84	10.6 ± 2.51	T: 0.51
Placebo	11.3 ± 2.71	13.0 ± 4.22	GxT: 0.39
Leg Press (# of reps)			
MIPS	13.6 ± 4.69	16.1 ± 4.91	T: 0.16
Placebo	17.2 ± 6.14	17.8 ± 6.44	GxT: 0.37

Values represent mean ± standard deviation.

Food Logs

The compliance rate for subjects following their weekly nutritional recommendations was set at 75%. There were no significant group by time interactions (*p*

= 0.08) or main effects (p = 0.21) between the subjects' mean caloric and macronutrient intakes and the recommended daily intake that was provided throughout the course of the study as seen in Table 4 (p > .05).

Table 4. Seven-Week Mean Caloric Intake History (N=19)

	Recommended	Week 1	Week 3	Week 7
MIPS	1606.8 ± 119.56	1736.8 ± 276.32	1598.8 ± 252.34	1508.7 ± 257.34
Placebo	1637.4 ± 135.90	1465.1 ± 195.98	1547.3 ± 254.75	1489.6 ± 223.19

Values represent mean ± standard deviation.

Resistance Training Program

Volume of work was calculated by multiplying the number of sets by number of repetitions by amount of weight used for each exercise. Variances were equal between groups for the volume of work completed during the resistance training program (p > .05). There were no significant differences between groups for amount of work performed during week one (p=0.10), week three (p=0.85), and week seven (p=0.89).

Table 5. Average Volume of Work in kg During Seven-Week Resistance Training Program (N=19)

	Week 1	Week 3	Week 7
MIPS	7322.7 ± 1333.97	8050.7 ± 1795.69	7504.4 ± 1404.51
Placebo	9011.0 ± 2624.07	8231.5 ± 2209.00	7394.7 ± 1976.13

Values represent mean ± standard deviation.

DISCUSSION

Previous studies have found acute improvements in exercise performance following ingestion of a single serving of MIPS (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011; Jagim et al., 2016; Spradley et al., 2012). However, it is less known what kind of an impact these acute improvements may have on training adaptations over time. The purpose of the current study was to examine the long-term effects of ingesting a MIPS (FitMiss™ Ignite™) on lower body power, upper and lower body maximal strength, and upper and lower body muscular endurance in recreationally active females.

This study found that both the placebo and MIPS groups showed a significant improvement in upper and lower body maximal strength, but there was no significant group by time interaction, meaning the supplement failed to establish improvements compared to the placebo. In a similar study, Kedia et al. (2014) also found that consumption of a MIPS failed to significantly improve exercise performance after completion of a six-week training program. A possibility for having no significant improvements in maximal strength observed could be due to the product itself being formulated specifically for females. It is possible that dosages contained in this MIPS were too low to show any significant changes.

There were no significant differences observed between groups for lower body power. Ormsbee et al. (2012) found opposing results in a similar study. They found that ingestion of a MIPS coupled with resistance training increased anaerobic power in male participants. These opposing results could be due to low dosages in the product formulated specifically for females.

No significant differences were observed between groups for upper body muscular endurance. In a similar study, Schmitz, Hofheins and Lemieux (2010) found opposing results, showing an increase in upper body endurance after consumption of a MIPS. This may be due to the lack of upper body strength of participants. A few of the participants had a calculated 75% 1 RM lower than 45 pounds, which is the weight of the barbell. Due to the lack of a lighter barbell, these participants were forced to lift slightly more than 75% of their 1 RM until failure.

No significant differences were observed between groups for lower body muscular endurance. Willems, Sallis and Hasket (2012) found opposing results in a similar study. They found that ingestion of a MIPS increased the number of repetitions to failure for the leg press exercise. These findings may be due to the order of exercises completed at baseline and post-testing. Muscular endurance tests were performed after completion of maximal strength tests for the same muscle group. Although participants were given adequate rest prior to muscular endurance tests, it is possible that leg fatigue was a hindering factor in performance.

In conclusion, this study suggests that consumption of a MIPS does not significantly help to improve lower body power, upper and lower body maximal strength, or upper and lower body muscular endurance. Lack of differences may be due to lower dosages contained in the MIPS, which is specifically formulated for females. It is also important to note that participants were held accountable for meeting their own nutrition and exercise requirements. It is uncertain whether participants were adequately following these guidelines, as cheating was possible. Further research is needed and should incorporate greater supervision to assure subject compliance.

REFERENCES

Bhasin, S., Storer, T., Berman, N., Callegari, C., Clevenger, B., Phillips, J., Bunnell, T., Tricker, R., Shirazi, A, & Casaburi, R. (1996). The effects of supraphysiologic doses of testosterone on muscle size and strength in normal men. *New England Journal of Medicine, 335*(1), 1-7.

Eudy, A., Gordon, L., Hockaday, B., Lee, D., Lee, V., Luu, D., Martinez, C., & Ambrose, P. (2013). Efficacy and safety of ingredients found in preworkout supplements. *American Journal of Health-System Pharmacy, 70*, 577-588. DOI 10.2146/ajhp120118

Fernandez, R., Lundberg, T., Alvarez, L., Paz, J. (2014). Muscle damage responses and adaptations to eccentric-overload resistance exercise in men and women. *European Journal of Applied Physiology, 114*, 1075-1084. DOI 10.1007/s00421-014-2836-7

Froiland, K., Koszewski, W., Hingst, J., Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism, 14*(1), 104-20.

Gonzales, A., Walsh, A., Ratamess, N., Kang, J., & Hoffman, J. (2011). Effect of a pre-workout supplement on acute multi-joint resistance exercise. *Journal of Sports Science and Medicine, 10*, 261-266.

Helms, E., Aragon, A., & Fitschen, P. (2014). Evidence-based recommendations for natural bodybuilding contest preparation: nutrition and supplementation. *Journal of the International Society of Sports Nutrition, 11*(1), 20.

Hoffman, J., Kang, J., Ratamess, N., Hoffman, M., Tranchina, C., Faigenbaum, A. (2009). Examination of a pre-exercise, high energy supplement on exercise performance. *Journal of the International Society of Sports Nutrition, 6*(2).

Jagim, A., Jones, M., Wright, G., Antoine, C., Kovacs, A., & Oliver, J. (2016). The acute effects of multi-ingredient pre-workout ingestion on strength performance, lower body power, and anaerobic capacity. *Journal of the International Society of Sports Nutrition, 13*(1). DOI 10.11.86/s12970-016-01222-2

Kedia, A., Hofheins, J., Habowski, S., Ferrando, A., Gothard, M., Lopez, H. (2014). Effects of a pre-workout supplement on lean mass, muscular performance, subjective workout experience and biomarkers of safety. *International Journal of Medical Sciences, 11*(2), 116-126. DOI 10.7150/ijms.7073

Kerksick, C., Wilborn, C., Campbell, B., Roberts, M., Rasmussen, C., Greenwood, M., & Kreider, R. (2009). Early-phase adaptations to a split-body, linear periodization resistance training program in college-aged and middle-aged men. *The Journal of Strength & Conditioning Research, 23*(3), 962-971.

Krelpke, V. (2016). 4 key ingredients for your pre-workout. Retrieved August 3, 2016 from http://www.bodybuilding.com/content/4-key-ingredients-for-your-pre-workout.html

Layman, D., Evans, E., Baum, J., Seyler, J., Erickson, D., & Boileau, R. (2005). Dietary protein and exercise have additive effects on body composition during weight loss in adult women. *The Journal of nutrition, 135*(8), 1903-1910.

Lockridge, R. (2017). 11 super side effects from taking l-carnitine. Retrieved March 16, 2017 from https://www.bodybuilding.com/fun/11-super-side-effects-from-taking-l-carnitine.html

Lopez, H., Ziegenfuss, T., Hofheins, J., Habowski, S., Arent, S., Weir, J., & Ferrando, A. (2013). Eight weeks of supplementation with a multi-ingredient weight loss product enhances body composition, reduces hip and waist girth, and increases energy levels in overweight men and women. *Journal of the International Society of Sports Nutrition, 10*, 22.

Obreshkov, D. (2013). Fitness training for women, differences and similarities with men's. *Federation of the Sports Pedagogues of the Republic of Macedonia, 3*(1), 92-94.

Ormsbee, M., Mandler, K., Thomas, D., Ward, E., Kinsey, A., Simonavice, E., Panton, L., Kim, J. (2012). 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. *Journal of the International Society of Sports Nutrition, 9*(49), 1-12.

Schmitz. S., Hofheins, J., Lemieux, R. (2010). Nine weeks of supplementation with a multi-nutrient product augments gains in lean mass, strength, and muscular performance in resistance trained men. *Journal of the International Society of Sports Nutrition, 7*(40), 1-9.

Spradley, B., Crowley, K., Tai, C., Kendall, K., Fukuda, D., Esposito, E., Moon, S., Moon, J. (2012). Ingesting a pre-workout supplement containing caffeine, B-vitamins, amino acids, creatine, and beta-alanine before exercise delays fatigue while improving reaction time and muscular endurance. *BioMed Central*, 1-14. DOI 10.1186/1743-7075-9-28

Vanny, P., & Moon, J. (2015). Physiological and psychological effects of testosterone on sport performance: a critical review of literature. Retrieved August 1, 2016 from http://thesportjournal.org/article/physiological-and-psychological-effects-of-testosterone-on-sport-performance-a-critical-review-of-literature/

Willems, M., Sallis, C., Haskell, J. (2012). Effects of a multi-ingredient supplementation on resistance training in young males. *Journal of Human Kinetics*, *33*, 91-101. DOI: 10.2478/v10078-012-0048-y

APPENDIX A

INFORMED CONSENT

INFORMED CONSENT
University of Wisconsin- La Crosse

Protocol Title: Long-term effects of MusclePharm FitMiss Ignite supplementation on clinical health measurements, resting energy expenditure, body composition, and training adaptations in recreationally active females

I, ____ volunteer to participate in a research study being conducted by the University of Wisconsin – La Crosse.

1. Purpose and Procedures

- The purpose of this study is to determine the long-term effects of supplementation of MusclePharm FitMiss Ignite on clinical health measurements, resting energy expenditure, body composition, and training adaptations in recreationally active females.
- My participation will require me to:
  - Follow a high-intensity resistance training program for 8 weeks
  - Consume 1 serving of placebo or FitMiss Ignite 30 minutes prior to each training session and following breakfast on recovery dates
  - Complete two identical testing sessions (approximately 1 hour long), one pre and one post the training period of 8 weeks. Testing will be held in the Human Performance Lab in Mitchell Hall. Both testing sessions will be completed after fasting for 8 hours and refraining from exercise 24 hours prior to testing. The testing session will include:
    - Height and weight measurements
    - Resting Energy Expenditure and Respiratory Exchange Ratio: laying still for 20 minutes under a metabolic hood.
    - Body composition: sitting still for an air displacement test in the BodPod
    - Resting clinical health measurements including: blood pressure, heart rate, and a finger prick for a blood lipid panel
    - A dynamic warm-up followed by performance tests including: countermovement vertical jump, 1 RM bench press, 1 RM hip sled/leg press, 75% 1 RM bench press to failure, and 75% 1 RM hip sled/leg press to failure.
  - Reduce my caloric intake by 300 kcals to elicit moderate weight loss
  - Submit 4-day dietary logs at baseline, 4 weeks, and 8 weeks. Day-to-day nutritional logs will be performed using a free commercially available software (MyFitnessPal)
- Research will be conducted by Anna Nelson, Brooke Zajac, and Kaela Hoecherl, who are Clinical Exercise Physiology Graduate Students, under the direction of Dr. Andrew Jagim of the Department of Exercise and Sport Science.

2. Potential Risks

- I may experience muscle fatigue and soreness and possibly musculoskeletal injuries from participating in the high intensity resistance training program
- I may experience mild side-effects (dizziness, nausea, etc.) from supplementation but I will be given a weekly questionnaire on how well I tolerate supplementation and to report any side-effects.
- I understand that the risk of serious or life threatening complications is very low in apparently healthy adults.
- Testing will be stopped immediately if there are any complications or adverse side effects appear.

3. Benefits

- As a participant in this study, I will learn my own resting energy expenditure and body composition levels and how my body responds to exercise in terms of blood pressure, heart rate, and lipid levels.
- I have the potential of seeing healthy weight loss.
- I have the opportunity to participate in research to better the knowledge of exercise, sport science, and nutrition.

4. Rights & Confidentiality

- My participation is voluntary. I can choose to discontinue my involvement in the study for any reasons without penalty.
- The results of this study may be published in scientific literature or presented at professional meetings using grouped data only and my personal data will be kept confidential.

I have read the information provided on this consent form in its entirety. I have been informed of the purpose and procedures, potential risks and benefits, and my rights and confidentiality. I have asked any questions that concern me on this study and received clear answers.

If I have any future questions I will contact Anna Nelson, Brooke Zajac, or Kaela Hoecherl, Clinical Exercise Physiology Graduate Students at nelson.anna@uwlax.edu (651-402-3275), zajac.brooke@uwlax.edu (262-945-4304), hoecherl.kaela@uwlax.edu (262-945-1548) or I may also contact Dr. Andrew Jagim, study supervisor, at 608-785-6538 (office) or at ajagim@uwlax.edu. Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects at 608-785-8124 or irb@uwlax.edu.

Participant: ______________________________ Date: ______________

Researcher: ______________________________ Date: ______________

APPENDIX B

MEDICAL HISTORY QUESTIONNAIRE

MEDICAL HISTORY QUESTIONNAIRE

Medical History Inventory

Directions. The purpose of this questionnaire is to enable the staff of the Laboratory to evaluate your health and fitness status. Please answer the following questions to the best of your knowledge. All information given is **CONFIDENTIAL** as described in the **Informed Consent Statement.**

Name: ____________________________ Age _____ Date of Birth_______________

Name and Address of Your Physician:____

MEDICAL HISTORY

Do you have or have you ever had any of the following conditions? (Please write the date when you had the condition in the blank).

____Heart murmur, clicks, or other cardiac findings?
____ Frequent extra, skipped, or rapid heartbeats?
____Chest Pain of Angina (with or without exertion)?
____Cancer, Melanoma, or Suspected Skin Lesions?
____High cholesterol?
____Diagnosed high blood pressure? ____
____Heart attack or any cardiac surgery?
____Leg cramps (during exercise)?
____Chronic swollen ankles?
____Varicose veins? ____
____Frequent dizziness/fainting?
____Muscle or joint problems? ____
____High blood sugar/diabetes?
____Thyroid Disease?
____Low testosterone/hypogonadism?
____Psychological Disorders?

____Asthma/breathing difficulty?
____Bronchitis/Chest Cold?

____Stroke or Blood Clots?
____Emphysema/lung disease?
____Epilepsy/seizures?
____Rheumatic fever?
____Scarlet fever?
____Ulcers?
____Pneumonia?
____Anemias?
____Liver or kidney disease?
____Autoimmune disease?
____Nerve disease? Glaucoma?
____Bleeding Disorders

Do you have or have you been diagnosed with any other medical condition not listed?

____

____

Please provide any additional comments/explanations of your current or past medical history.

____

____

Please list any recent surgery (i.e., type, dates etc.).

____

____

List all prescribed/non-prescription medications and nutritional supplements you have taken in the last 3 weeks.

____

____

What was the date of your last complete medical exam?

____

____

Do you know of any medical problem that might make it dangerous or unwise for you to participate in this study? (including strength and maximal exercise tests) . If yes, please explain:

____

____

____

Recommendation for Participation (for Staff use only):

____ No exclusion criteria presented. Subject is ***cleared*** to participate in the study.
____ Exclusion criteria is/are present. Subject is ***not cleared*** to participate in the study.

Signed: ______________________________ Date: _____________

APPENDIX C

PERSONAL INFORMATION

PERSONAL INFORMATION WORKSHEET

Personal Information

Name:

____

Cell Phone: (   ) _______________ E-mail address: ______________________

Birth date: _____ / _____ / _____ Age: ______ Height: __________ Weight: __________

Exercise History/Activity Questionnaire

1. Describe your typical occupational activities.

2. Describe your typical recreational activities

3. Describe any exercise training that you routinely participate.

4. How many days per week do you exercise/participate in these activities?

5. How many hours per week do you train?

6. How long (years/months) have you been consistently training?

APPENDIX D

NUTRITIONAL RECOMMENDATIONS

Nutritional Recommendations

Hello!

Below are the nutritional recommendations we would like you to follow throughout the duration of the 7 week training program. The recommendations are tailored to you based on the results of your baseline testing session and are intended to favorably change your body composition (increase/maintain lean muscle mass and reduce body fat). The values are DAILY targets. You do not need to hit each value exactly on but try to be within 100-300 calories and 5-10 grams for proteins, carbohydrates & fat. The meals you consume are up to you as long as they fit the recommended amounts.

Calories:

Protein:

Carbs:

Fat:

We ask that you track your daily calorie intake over the next 7 weeks (at least 4-7 days per week) using the MyFitnessPal app. Make sure to add UWLHumanPerformanceLab as a friend so we are able to check in on how you are following your specific program. If you have any questions on how to use this app feel free to contact us and we can walk you through it.

Thank you for participating in the study and good luck!

APPENDIX E

RESISTANCE TRAINING PROGRAM

Name:______________________ Week #1

Exercise

Warm Up		**Day 1**					**Day 2**					**Day 3**		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Chest Press	Weight				Shoulder Press	Weight				Pushups	Weight			
(Machine)	Reps	10	10	10	(Dumbbell)	Reps	10	10	10	(Knees, if need be	Reps	10	10	10
Sumo Squat	Weight				Leg Press	Weight				Walking Lunges	Weight			
(Dumbbell)	Reps	12	12	12	(Machine)	Reps	10	10	10	(Bodyweight)	Reps	10	10	10
Lat Pulldown	Weight				Straight Leg	Weight				Calf Raises	Weight			
(Machine (Back)	Reps	10	10	10	Deadlift	Reps	10	10	10	(Bodyweight)	Reps	12	12	12
Alternate Lunges	Weight				Row (Machine)	Weight				Step Ups	Weight			
(Body weight)	Reps	12	12	12	Back	Reps	12	12	12	(Bodyweight)	Reps	10	10	10
Dumbell Row	Weight				Reverse Lunges	Weight				Supermans	Weight			
(Dumbbell)	Reps	12	12	12	Bodyweight	Reps	10/sid	10/sid	10/side	(Bodyweight)	Reps	12	12	12
Mountain Climber					Planks					High Plank				
(Dumbbell)	Reps	30 sec	30 sec	30 sec	Bodyweight	Reps	45 sec	45 sec	45 sec	(Bodyweight)	Reps	45 sec	45 sec	45 sec
Tricep Push Down	Weight				Thrusters	Weight				Tricep Dips	Weight			
(Rope/Pulley)	Reps	10	10	10	(Dumbbell)	Reps	10	10	10	(from chair)	Reps	10	10	10
Hamstrings	Weight				Upright Row	Weight				Squats	Weight			
(Machine)	Reps	10	10	10	(Dumbbell)	Reps	10	10	10	(Bodyweight)	Reps	12	12	12
Cool Down														

~For this first week do a warm up set of each exercise to test out the weight you should be using.

~Choose a weight that makes the last 1-2 reps difficult but not impossible to complete.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:______________________ Week #2

Exercise

Warm Up		**Day 1**					**Day 2**					**Day 3**		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Pullups	Weight				Walking Lunges	Weight				Mountain Climb	Weight			
(Bands if needed)	Reps	4	4	4	(Dumbell)	Reps	10	10	10	(bodyweight)	Reps	30 sec	30 sec	30 sec
Back Squat	Weight				Bear Crawl					V Pushups	Weight			
(Barbell)	Reps	10	10	10	Bodyweight	Distanc	50 ft	50 ft	50 ft	(bodyweight)	Reps	10	10	10
Bench Press	Weight				Pushups	Weight	10	10	10	Sumo Squat	Weight			
(Barbell)	Reps	10	10	10	(Bodyweight)	Reps				(bodyweight)	Reps	12	12	12
Deadlift	Weight				Burpess	Weight				Deadlift	Weight			
(Barbell)	Reps	12	12	12	(Bodyweight)	Reps	10	10	10	(hold light weight)	Reps	12	12	12
1-Arm Overhead P	Weight				Side Lunge	Weight				Wide Pushups	Weight			
(Dumbbell) Knees	Reps	10	10	10	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	10	10	10
Farmers Walk	Weight				Renegade Row	Weight				Glute Bridge	Weight			
(Dumbbell)	Reps	50 ft	50 ft	50 ft	(Dumbell)	Reps	6	6	6	(bodyweight)	Reps	12	12	12
Landmine	Weight				Thruster	Weight				Side Lunges	Weight			
(Barbell)	Reps	10	10	10	(Dumbell)	Reps	10	10	10	(bodyweight)	Reps	10	10	10
1-Arm DB Row	Weight				Plank					V Up Crunches	Weight			
(Machine)	Reps	10	10	10	(Bodyweight)	Reps	60 sec	60 sec	60 sec	(bodyweight)	Reps	10	10	10
Cool Down														

*The colored (paired) exercises are to be done in a superset fashion. Go from the first exercise immediately to the second.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:______________________ Week #3

Exercise

Warm Up		Day 1					Day 2					Day 3		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Chest Press	Weight				Shoulder Press	Weight				Decline Pushups	Weight			
(Machine)	Reps	8	8	8	(Dumbbell)	Reps	8	8	8	(Feet on Stair)	Reps	8	8	8
Sumo Squat	Weight				Leg Press	Weight				Curtsy Lunge	Weight			
(Dumbbell)	Reps	10	10	10	(Machine)	Reps	8	8	8	(bodyweight)	Reps	10	10	10
Lat Pulldown	Weight				Straight Leg	Weight				Tricep Dips	Weight			
(Machine (Back)	Reps	8	8	8	Deadlift	Reps	8	8	8	(from stair)	Reps	10	10	10
Alternate Lunges	Weight				Row (Machine)	Weight				Toe Touch Crunch	Weight			
(Body weight)	Reps	8	8	8	Back	Reps	10	10	10	(bodyweight)	Reps	12	12	12
Dumbell Row	Weight				Reverse Lunges	Weight				Single Leg Squats	Weight			
(Dumbbell)	Reps	10	10	10	Dumbells	Reps	10/sid	10/sid	10/side	(bodyweight)	Reps	10	10	10
Mountain Climber					Planks					High Planks				
Body Weight	Reps	30 sec	30 sec	30 sec	Bodyweight	Reps	45 sec	45 sec	45 sec	(bodyweight)	Reps	45 sec	45 sec	45 sec
Tricep Push Down	Weight				Thrusters	Weight				Calf Raises	Weight			
(Rope/Pulley)	Reps	10	10	10	(Dumbbell)	Reps	8	8	8	(Bodyweight)	Reps	12	12	12
Hamstrings	Weight				Upright Row	Weight				Bird Dogs	Weight			
(Machine)	Reps	10	10	10	(Dumbbell)	Reps	10	10	10	(bodyweight)	Reps	12	12	12

Cool Down

~For this first week do a warm up set of each exercise to test out the weight you should be using.
~Choose a weight that makes the last 1-2 reps difficult but not impossible to complete.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:______________________ Week #4

Exercise

Warm Up		Day 1					Day 2					Day 3		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Pullups	Weight				Walking Lunges	Weight				Clock Lunges	Weight			
(Bands if needed)	Reps	4	4	4	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	4	4	4
Back Squat	Weight				Bear Crawl	BW				V Pushups	Weight			
(Barbell)	Reps	10	10	10	Bodyweight	Distanc	50 ft	50 ft	50 ft	(bodyweight)	Reps	12	12	12
Bench Press	Weight				Pushups	Weight	12	12	12	Donkey Kicks	Weight			
(Barbell)	Reps	10	10	10	(Bodyweight)	Reps				(bodyweight)	Reps	12	12	12
Deadlift	Weight				Burpees	BW				Step Ups	Weight			
(Barbell)	Reps	12	12	12	(Bodyweight)	Reps	12	12	12	(bodyweight)	Reps	12	12	12
1-Arm Overhead P	Weight				Side Lunge	Weight				Side Plank	Weight			
(Dumbbell) Knees	Reps	10	10	10	(Dumbell)	Reps	6	6	6	(bodyweight)	Reps	30 sec	30 sec	30 sec
Farmers Walk	Weight				Renegade Row	Weight				Wall Sit	Weight			
(Dumbbell)	Reps	50 ft	50 ft	50 ft	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	30 sec	30 sec	30 sec
Landmine	Weight				Thruster	Weight				Narrow Pushups	Weight			
(Barbell)	Reps	10	10	10	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	10	10	10
1-Arm DB Row	Weight				Plank	Weight				SL Deadlift	Weight			
(Machine)	Reps	10	10	10	(Bodyweight)	Reps	60 sec	60 sec	60 sec	(bodyweight)	Reps	12	12	12

Cool Down

*The colored (paired) exercises are to be done in a superset fashion. Go from the first exercise immediately to the second.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:____________________ Week #5

Exercise

Warm Up		Day 1					Day 2					Day 3		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Chest Press	Weight				Shoulder Press	Weight				Pushups	Weight			
(Machine)	Reps	8	8	8	(Dumbbell)	Reps	8	8	8	(Knees, if need be	Reps	12	12	12
Sumo Squat	Weight				Leg Press	Weight				Walking Lunges	Weight			
(Dumbbell)	Reps	10	10	10	(Machine)	Reps	8	8	8	(Bodyweight)	Reps	12	12	12
Lat Pulldown	Weight				Straight Leg	Weight				Calf Raises	Weight			
(Machine (Back)	Reps	8	8	8	Deadlift	Reps	8	8	8	(Bodyweight)	Reps	14	14	14
Alternate Lunges	Weight				Row (Machine)	Weight				Step Ups	Weight			
(Body weight)	Reps	14	14	14	Back	Reps	10	10	10	(Bodyweight)	Reps	12	12	12
Dumbell Row	Weight				Reverse Lunges	Weight				Supermans	Weight			
(Dumbbell)	Reps	10	10	10	Bodyweight	Reps	12/sid	12/sid	12/side	(Bodyweight)	Reps	14	14	14
Mountain Climber					Planks					High Plank				
(Dumbbell)	Reps	20 sec	20 sec	20 sec	Bodyweight	Reps	60 sec	60 sec	60 sec	(Bodyweight)	Reps	60 sec	60 sec	60 sec
Tricep Push Down	Weight				Thrusters	Weight				Tricep Dips	Weight			
(Rope/Pulley)	Reps	8	8	8	(Dumbbell)	Reps	8	8	8	(from chair)	Reps	12	12	12
Hamstrings	Weight				Upright Row	Weight				Squats	Weight			
(Machine)	Reps	8	8	8	(Dumbbell)	Reps	8	8	8	(Bodyweight)	Reps	14	14	14
Cool Down														

~For this first week do a warm up set of each exercise to test out the weight you should be using.
~Choose a weight that makes the last 1-2 reps difficult but not impossible to complete.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:____________________ Week #6

Exercise

Warm Up		Day 1					Day 2					Day 3		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Pullups	Weight				Walking Lunges	Weight				Mountain Climb	Weight			
(Bands if needed)	Reps	6	6	6	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	45 sec	45 sec	45 sec
Back Squat	Weight				Bear Crawl					V Pushups	Weight			
(Barbell)	Reps	8	8	8	Bodyweight	Distanc	75 ft	75 ft	75 ft	(bodyweight)	Reps	12	12	12
Bench Press	Weight				Pushups	Weight	12	12	12	Sumo Squat	Weight			
(Barbell)	Reps	8	8	8	(Bodyweight)	Reps				(bodyweight)	Reps	14	14	14
Deadlift	Weight				Burpess	Weight				Deadlift	Weight			
(Barbell)	Reps	10	10	10	(Bodyweight)	Reps	12	12	12	(hold light weight)	Reps	14	14	14
1-Arm Overhead P	Weight				Side Lunge	Weight				Wide Pushups	Weight			
(Dumbbell) Knees	Reps	8	8	8	(Dumbell)	Reps	6	6	6	(bodyweight)	Reps	12	12	12
Farmers Walk	Weight				Renegade Row	Weight				Glute Bridge	Weight			
(Dumbbell)	Reps	50 ft	50 ft	50 ft	(Dumbell)	Reps	6	6	6	(bodyweight)	Reps	14	14	14
Landmine	Weight				Thruster	Weight				Side Lunges	Weight			
(Barbell)	Reps	8	8	8	(Dumbell)	Reps	8	8	8	(bodyweight)	Reps	12	12	12
1-Arm DB Row	Weight				Plank					V Up Crunches	Weight			
(Machine)	Reps	8	8	8	(Bodyweight)	Reps	75 sec	75 sec	75 sec	(bodyweight)	Reps	12	12	12
Cool Down														

*The colored (paired) exercises are to be done in a superset fashion. Go from the first exercise immediately to the second.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

Name:________________________ Week #7

Exercise

Warm Up		Day 1					Day 2					Day 3		
5-10 Minutes (Bike, etc)		Set	Set	Set			Set	Set	Set			Set	Set	Set
Chest Press	Weight				Shoulder Press	Weight				Decline Pushups	Weight			
(Machine)	Reps	6	6	6	(Dumbbell)	Reps	6	6	6	(Feet on Stair)	Reps	10	10	10
Sumo Squat	Weight				Leg Press	Weight				Curtsy Lunge	Weight			
(Dumbbell)	Reps	8	8	8	(Machine)	Reps	6	6	6	(bodyweight)	Reps	12	12	12
Lat Pulldown	Weight				Straight Leg	Weight				Tricep Dips	Weight			
(Machine (Back)	Reps	6	6	6	Deadlift	Reps	6	6	6	(from stair)	Reps	12	12	12
Alternate Lunges	Weight				Row (Machine)	Weight				Toe Touch Crunch	Weight			
(Body weight)	Reps	6	6	6	Back	Reps	8	8	8	(bodyweight)	Reps	14	14	14
Dumbell Row	Weight				Reverse Lunges	Weight				Single Leg Squats	Weight			
(Dumbbell)	Reps	8	8	8	Dumbells	Reps	10/sid	10/sid	10/side	(bodyweight)	Reps	12	12	12
Mountain Climber					Planks					High Planks				
Body Weight	Reps	45 sec	45 sec	45 sec	Bodyweight	Reps	75 sec	75 sec	75 sec	(bodyweight)	Reps	60 sec	60 sec	60 sec
Tricep Push Down	Weight				Thrusters	Weight				Calf Raises	Weight			
(Rope/Pulley)	Reps	8	8	8	(Dumbbell)	Reps	6	6	6	(Bodyweight)	Reps	14	14	14
Hamstrings	Weight				Upright Row	Weight				Bird Dogs	Weight			
(Machine)	Reps	8	8	8	(Dumbbell)	Reps	8	8	8	(bodyweight)	Reps	14	14	14

Cool Down

~For this first week do a warm up set of each exercise to test out the weight you should be using.

~Choose a weight that makes the last 1-2 reps difficult but not impossible to complete.

Notes: To document any changes or what you were feeling about the workout. Note if it was to easy or hard or if you had any pain.

APPENDIX F

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The purpose of this paper is to review the literature concerning the effects of a multi-ingredient pre-workout supplement (FitMiss™ Ignite™, MusclePharm Inc., Denver, CO) on training adaptations.

History of Dietary Supplements

The use of performance enhancing drugs as nutrients dates back to 776-393 BC, when the ancient Greeks used herbs, animal parts, medicines, hallucinogens, and even wine to give themselves an advantage when competing in the Olympic games (Kimpel, 2000; Jenkins, 2007). It was recommended that athletes and soldiers preparing for battle consume specific animal parts to obtain certain attributes such as agility, speed or strength associated with that animal (Jenkins, 2007). For example, the courage of a lion in its heart could be transferred to them if they ate that organ. Moving forward to 100 AD, Roman gladiators would consume hallucinogens and stimulants to prolong fatigue and help them feel less pain when injured in order to intensify their fights. Before a fight, they would feed their horses hydromel, an alcoholic beverage made from honey, to make them run faster (Aziz, 2006). Over the years, athletes continued to experiment with the amount, form and timing of administration in the search for optimal performance.

In 1928, the first rule against doping was made by the International Association of Athletics Federation (IAAF) which states:

> Doping is the use of any stimulant not normally employed to increase the poser of action in athletic competition above the average. Any person knowingly acting or assisting as explained above shall be excluded from any place where these rules are in force or, if he is a competitor, be suspended for a time or otherwise from

further participation in amateur athletics under the jurisdiction of this Federation. (IAAF, 2009)

Even after this rule was enforced, experimentation of performance enhancers continued. In the 1950's, athletes began taking amphetamines used by soldiers in WWII to minimize the uncomfortable sensations of fatigue while exercising (Noakes, 2004). It was not until February of 1968 that drug testing began at the Olympic Games (Mottram & Verroken, 2005). The death of cyclist Tommy Simpson, during the 13th stage of the Tour de France, from overdosing on amphetamines and brandy, created pressure on sporting agencies to take action against doping (Slater, 2008). The first mandatory drug testing in the Olympics in 1968 was only able to test for narcotic analgesics and stimulants. Due to insufficiently developed testing methods, anabolic steroids were not tested for, even though it was believed that they were being used by athletes at this time (Mottram & Verroken, 2005).

One type of supplement called "pre-workout" is ingested prior to exercising (10-30 minutes) and is designed to increase energy levels so that individuals can exercise at a greater intensity and for an extended period of time in hopes of achieving greater results from exercise (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011). In 1982, Ultimate Orange was invented and was the first product introduced to the market as a pre-workout supplement (MM Admin, 2016). It contained a high dose of caffeine mixed with ephedrine. Ephedrine is a stimulant that affects the involuntary nervous system, but has been banned from dietary supplements due to health concerns and negative side effects. It is also the major source for the production of the addictive compound methamphetamine (Lee, 2011).

Today, dietary supplements are defined and regulated by the Dietary Supplement Health and Education Act (DSHEA) of 1994. The Food and Drug Administration (FDA) regulates the supplements for good manufacturing practices, but they have little control over the dietary supplement marketplace (Kimpel, 2000). Under the DSHEA, a dietary supplement is defined as "a product intended to supplement the diet, and must contain one or more of the following ingredients: a vitamin, a mineral, an herb or other botanical, an amino acid, organ tissues, or a concentrate or extract of these ingredients" (Kimpel, 2000). Forms of dietary supplements include capsules, powders, tablets, soft gels, liquids, and teas. They are sold in health food stores, drug stores, grocery stores, national discount chains, through mail-order and the internet (Kimpel, 2000). Dietary supplements do have a few requirements that they must follow according to the DSHEA. They must be labeled as a dietary supplement. They must be intended for ingestion. They must not be represented as a sole item of a meal or of the diet. They must not be advertised as a cure or treatment for a disease. Dietary supplements are increasing in popularity for active individuals wanting to enhance their performance (Kedia et al., 2014). In 2004, a survey conducted by over 200 collegiate athletes showed that 89% were using some type of dietary supplement at the time of the survey (Eudy et al., 2013; Froiland et al., 2004).

Ingredients of Pre-workout Supplements

Pre-workout supplements have a mixture of ingredients that work together to improve athletic performance after ingestion (Hoffman et al., 2016). Common ingredients of multi-ingredient pre-workout supplements include caffeine, branched chain amino acids (BCAA's), beta-alanine, creatine monohydrate, and l-carnitine.

Caffeine is the most commonly consumed drug in the world (Antonio, 2004). The use of caffeine will most likely never decline because it is legal, inexpensive, medically safe, and socially acceptable (Sinclair & Geinger, 2000). It is a stimulant that is the most common in pre-workout supplements (Eudy et al., 2013). It has repeatedly been shown to increase energy levels and improve performance in endurance exercises as well as in short bouts of maximal exercises. It works to decrease subjective fatigue, lower perception of effort, and increase alertness (Kreipke, 2016). Coso et al. (2010) conducted a study that evaluated the benefits of caffeine ingestion on sprint performance during high-intensity exercise. They took eight trained cyclists and gave them either one, three, six, or nine milligrams of caffeine, or a placebo one hour before performing 65 minutes of high-intensity exercise. They found that caffeine improved sprint performance in a dose-response manner. Subjects who were given one milligram of caffeine had marginal effects, and subjects who were given nine milligrams of caffeine improved maximal power by 5% (Coso et al., 2010).

BCAA's help foster an anabolic environment by increasing protein synthesis, regulating protein metabolism, and suppressing the breakdown of protein. The three amino acids that make up BCAA's are leucine, isoleucine, and valine, and together they help decrease delayed onset muscle soreness, promote muscle growth, and increase energy (Kreipke, 2016; Stoppanni, 2016).

Beta-alanine is used to increase muscular endurance by buffering hydrogen ions. By consuming beta-alanine, the longer a person will be able to keep up the intensity of their exercise, therefore the more training volume they will achieve (Kreipke, 2016). A study done by Sale, Hill, Ponte, and Harris (2012) analyzed the effect of four weeks of beta-alanine supplementation in 13 males. The participants completed an isometric knee extension test until fatigue, at an intensity of 45% maximal voluntary isometric contraction, before and after supplementation. The researchers found that four weeks of beta-alanine supplementation improved endurance capacity of the knee extensors (Sale, Hill, Ponte, & Harris, 2012).

Creatine is the most popular supplement to increase strength performance (Lanhers et al., 2015). Creatine monohydrate helps to saturate muscles with the substrate that is needed for bigger lifts. It provides energy that is useful for explosive strength (Kreipke, 2016). It also pulls water into the muscles, creating muscle hypertrophy, which in turn promotes greater long-term muscle growth (Stoppanni, 2016). Lanhers et al. (2015) evaluated the effects of creatine supplementation on strength performance. They found that in exercises with a duration of less than three minutes, creatine supplementation is effective in lower limb strength performance, independent of training protocols, population characteristic, and supplementary doses and duration (Lanhers et al., 2015).

L-carnitine acts as a vasodilator to increase nitric oxide levels in the blood, which in turn increases blood flow. The increase in blood flow provides a "pump" feeling, which is when your muscles swell up while working out (Kreipke, 2016). L-carnitine has been shown to be a major factor in muscle fuel metabolism during exercise, resulting in increased fatty acid oxidation and energy expenditure (Kim, Pan, Lee, & Kim, 2015).

Effects of Pre-workout Supplements on Performance

Many studies have been conducted to test the effects of pre-workout supplements, but most of the studies were done on males and most only evaluated the acute effects of pre-workout supplements. Jagim et al. (2016) conducted a double-blind, randomized, placebo controlled study on the acute effects of taking a multi-ingredient pre-workout supplement in males. Twelve males were given either a multi-ingredient pre-workout supplement or a placebo prior to completing a counter-movement vertical jump test, five sets of repetitions at 85% of five repetition-maximum for back squat and bench press, followed by a single set of each to failure, and an anaerobic capacity sprint test. Subjects were also asked for their subjective markers of fatigue and energy levels. A week later, the subjects returned for testing and consumed the opposite of what was given to them the previous week. The results showed the participants had an increase in upper body muscular endurance and mean power output during an anaerobic capacity sprint test, decreased subjective markers of fatigue, and increased alertness when exercising at high-intensities after consuming the pre-workout supplement (Jagim et al., 2016).

Gonzales, Walsh, Ratamess, Kang, and Hoffman (2011) conducted a similar study. They asked eight resistance-trained college-aged men to consume either a multi-ingredient pre-workout supplement or placebo, assigned randomly to each participant. The subjects performed four sets of a maximum of ten repetitions of either barbell squat or bench press at 80% of their pre-determined one repetition-maximum (1 RM). They were given 90 seconds of rest between each set. The dietary intake 24 hours before testing was kept constant in both experimental and placebo groups. The results concluded that by consuming the multi-ingredient pre-workout supplement ten minutes prior to resistance training, there was a significant increase in performance. Subjects were able to produce a greater number of repetitions for both the barbell squat and bench press compared to the placebo group. In addition, subjects who ingested the supplement had a greater mean power performance for all four sets. These results show that by ingesting a high-energy supplement ten minutes prior to exercise, training volume and power performance will increase (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011).

Spradley et al. (2012) found similar results. Twelve recreationally active males were tested on three separate occasions, one week between each. The testing done each visit was identical. Testing included a maximal graded exercise test to determine aerobic capacity, 1 RM for bench press and leg press to determine 75% of 1 RM, intermittent critical velocity familiarization, and choice reaction tests (single-step audio and visual, one-tower stationary protocol, two-tower lateral protocol, three-tower multi-directional protocol, and three-tower multi-directional protocol with martial arts sticks). On the first visit for testing, all subjects were tested for their baseline measurements. On the second visit, subjects were randomly assigned to ingest either a pre-workout supplement or placebo 20 minutes prior to testing. On the last visit, subjects were provided with the cross-over treatment. The results were that by ingesting the pre-workout supplement prior to exercise, subjects showed significant improvement in agility, choice reaction performance and lower body muscular endurance. Subjects also had an increase in perceived energy and decrease in subjective fatigue after consuming the supplement (Spradley et al., 2012). Spradley and his colleagues concluded that the supplement may delay fatigue during strenuous exercise.

Kedia et al. (2014) evaluated the effects of a pre-workout supplement on males and females over a six week period. Forty-three young, healthy men and women were randomly assigned to ingest either a pre-workout supplement or a placebo every day while following a standardized resistance training program for six weeks. The placebo contained the same amount of caffeine as the supplement. Subjects were tested at baseline, week three, and week six. They found that consuming a pre-workout supplement significantly improved subjective levels of concentration and energy and decreased subjective fatigue compared to the product containing caffeine alone (Kedia et al., 2014).

Differences between Males and Females

Females, although similar to males, are physiologically different. Men are genetically more volumetric and stronger than women. Men have bigger sized hearts, higher levels of hemoglobin, and consume a greater amount of oxygen (Obreshkov, 2013). Fernandez, Lundberg, Alvarez, and Paz (2014) conducted a study that evaluated the adaptations to resistance exercise in men and women. Thirty-two recreationally active undergraduate students (16 males and 16 females) were tested for dynamic strength (1 RM), jump performance, maximal power at different percentages of 1 RM, and muscle mass in three different portions of the thigh before and after six weeks of resistance training. After six weeks of training, increases in 1 RM were greater in males (25%) than in females (20%). Males also showed a greater increase in power improvement at 80% of 1 RM than in females. The results suggest that improvements in maximal strength and power at high loads are slightly greater for men than for women (Fernandez, Lundberg, Alvarez, &. Paz, 2014).

Males have much higher levels of testosterone, which has been shown to have a positive effect on physical strength, stature, and performance (Vanny, & Moon, 2015). Bhasin et al. (1996) conducted a study to test the effects of testosterone supplementation in men. An experimental group, who were given testosterone injections, and a control group, who did not receive injections, both participated in a resistance training program for ten weeks. The group receiving testosterone injections showed increases in fat-free mass, muscle size and muscular strength compared to the control group.

Fernandez, Lundberg, Alvarez, and Paz (2014) conducted a study to compare adaptations to resistance training between males and females. Both sexes followed identical resistance training programs for a period of six weeks. They found that males showed more improvements in maximal strength and power compared to their female counterparts.

The goal of female training sessions are frequently different from males. Females tend to aim more towards weight loss and "toning" of their bodies, whereas males tend to aim towards increases in muscle mass. (Obreshkov, 2013). Since there are physiologic differences between males and females, it cannot be assumed that both sexes will have the same results to pre-workout supplements.

Summary

In conclusion, there is very little information on effects of pre-workout on females. Studies done on males cannot be generalized for both males and females due to the physiological differences between both sexes. There is also little research on the long-term effects of using a multi-ingredient pre-workout supplement. More research needs to be conducted on both the long-term effects of pre-workout supplements as well as the effects of pre-workout supplements on females.

REFERENCES

Antonio, J. (2004). Caffeine: the forgotten ergogenic aid. *National Strength and Conditioning Association, 26*(6), 50-51.

Aziz, R. (2006, August 29). History of Doping. *WADA Asia Education Symposium.*

Bhasin, S., Storer, T., Berman, N., Callegari, C., Clevenger, B., Phillips, J., Bunnell, T., Tricker, R., Shirazi, A, & Casaburi, R. (1996). The effects of supraphysiologic doses of testosterone on muscle size and strength in normal men. *New England Journal of Medicine, 335*(1), 1-7

Coso, J., Hamouti, N., Fernandez, V., Ortega, J., Muñoz, J., Mora, R. (2010). Dose-response benefits of caffeine ingestion on sprint performance during high-intensity exercise. *The American College of Sports* Medicine, 42(5), 106. DOI 10.1249/01.MSS.0000385974.33448.98

Eudy, A., Gordon, L., Hockaday, B., Lee, D., Lee, V., Luu, D., Martinez, C., & Ambrose, P. (2013). Efficacy and safety of ingredients found in preworkout supplements. *American Journal of Health-System Pharmacy, 70*, 577-588. DOI 10.2146/ajhp120118

Fernandez, R., Lundberg, T., Alvarez, L., Paz, J. (2014). Muscle damage responses and adaptations to eccentric-overload resistance exercise in men and women. *European Journal of Applied Physiology, 114*, 1075-1084. DOI 10.1007/s00421-014-2836-7

Froiland, K., Koszewski, W., Hingst, J., Kopecky, L. (2004). Nutritional supplement use among college athletes and their sources of information. *International Journal of Sport Nutrition and Exercise Metabolism, 14*(1), 104-20.

Gonzales, A., Walsh, A., Ratamess, N., Kang, J., & Hoffman, J. (2011). Effect of a pre-workout supplement on acute multi-joint resistance exercise. *Journal of Sports Science and Medicine, 10*, 261-266

Hoffman, J., Kang, J., Ratamess, N., Hoffman, M., Tranchina, C., Faigenbaum, A. (2009). Examination of a pre-exercise, high energy supplement on exercise performance. *Journal of the International Society of Sports Nutrition, 6*(2).