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The Impacts of a Caffeinated Energy Drink on Rating of Perceived Exertion, Completion Time, Heart Rate, Volume of Oxygen Consumption, and Respiratory Exchange Ratio on a 10-Mile Cycle Ergometer Trial

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The Impacts of a Caffeinated Energy Drink on Rating of Perceived Exertion, Completion Time, Heart Rate, Volume of Oxygen Consumption, and Respiratory Exchange Ratio on a 10-Mile Cycle Ergometer Trial

A THESIS

APPROVED FOR THE DEPARTMENT OF KINESIOLOGY AND HEALTH STUDIES

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Abstract

Research involving caffeinated energy drinks and endurance cycling protocols is limited. Many studies have been conducted consisting of sprint trials and shorter duration protocols. Understanding the interaction the human body has with energy drinks is important to contribute to the existing body of literature and discover benefits from these supplements. The purpose of this study was to determine the effect two doses of a caffeinated energy drink (70 mg or 140 mg), or placebo have on performance time, rating of perceived exertion (RPE), heart rate (HR), respiratory exchange ratio (RER) and volume of oxygen consumption (VO_2) for a cycling bout of 10 miles. The researcher utilized 16 recreationally experienced male cyclists that were caffeine naïve, and aged 18-60, for this study. Following pre-screening, subjects met for 3 separate 10-mile cycling trials, each time ingesting a different dose/type of drink as randomized by the researcher. Sample sizes ranged from 13-16 due to missing observations in data and 1 subject not completing the trials. Subjects ingested the randomized drink upon arrival and waited for 20 minutes before starting their 5 minute warm-up on the stationary ergometer. Rating of perceived exertion, RER, HR, and VO_2, were reported in 2 mile increments, with performance time being reported once. For the variables RPE, VO_2, and HR the means between distances (2, 4, 6, 8, & 10 miles) were significantly different ($p < .001$) within each dose. For RER, only the control group means were significantly different ($p = .009$) from 2-4-6-8-10 miles. For the variables RPE, RER, and HR the means between doses were not significantly different. For VO_2, only at 2 miles were the Control means between doses significantly different ($p = .033$). Effect size was highly correlated with the p-values ($r = -0.789$, $p < .001$) for all variables. The researcher concluded that no confident explanation of unanticipated significant findings could be declared, and the null hypothesis was accepted. Future research should include a higher dose of caffeine, and also utilize a homogenous, competitive group of cyclists as determined by fitness level, BMI, experience, and type of cycling. Familiarization trials should be utilized as well to limit the occurrence of a learning curve among subsequent trials.

CHAPTER ONE: INTRODUCTION

Significance

Caffeine has been widely studied for years in many different contexts. Unlike previous research, the current study utilized a longer distance in the cycling protocol. This study employed recreational cyclists and a popular energy drink to explore the potential performance enhancing effects of the substance. Energy drinks are not regulated by the Food and Drug Administration (FDA), therefore there is a need to further study their potential effects. Most researchers only look at the effect of caffeine covering a short distance or a specific period of time (Wiles, Coleman, Tegerdine, & Swaine, 2006), or in doses based on body weight, such as 5 mg/kg body weight (Astorino, Cottrell, Lozano, Aburto-Pratt, & Duhon, 2012). The key to making this study unique is the distance the cyclists traveled after consuming an energy drink in typical quantities. Sprint tests and 1 km laboratory tests are frequently conducted (Wiles et al., 2006); however, there have not been many studies covering longer distances.

The importance of the current study was to determine if caffeine ingested as a popular energy drink impacted cycling performance while cycling 10 miles on an indoor cycle ergometer. The caffeine load, 70 mg or 140 mg, was chosen to represent a medium and high dose. The full can of the energy drink contains 140 mg of caffeine; therefore, half a can equals 70 mg of caffeine. Also, utilizing a popular energy drink was important to determine its effectiveness on performance. The researcher was interested in seeing if typical consumption (½ to 1 can) impacted actual performance in caffeine naïve subjects. Doses were administered to subjects 20 minutes before the trial began, since caffeine has been shown to peak within the bloodstream 35-45 minutes after ingestion (Liguori, Hughes, &

Grass, 1997). Oxygen uptake (VO_2) and respiratory exchange ratio (RER) were measured utilizing the OxyCon portable VO_2 analyzer, manufactured by Care Fusion™; and the values were recorded every 2 miles during the 10 mile cycling distance. Rating of perceived exertion (RPE) and heart rate (HR) were also recorded every 2 miles, and completion time of the 10 mile distance was recorded at the end of each trial.

Background

Caffeine is consumed by over 85% of Americans on a daily basis (Liguori et al., 1997). Caffeine can be found in many forms including: coffee, tea, sports drinks, pills, pre-workout powders, and energy drinks. Caffeine is an ergogenic aid that can potentially enhance performance with cycling (Astorino et al., 2012). This drug affects users in different ways. People who are sensitive to caffeine may experience anxiety, jittery behavior, restlessness, or even gastrointestinal issues. The Food and Drug Administration (FDA), as discussed by the Mayo Clinic, states that a heavy dose of caffeine is 500-600 mg per day (Spriet & Graham, 2013). The average cup of coffee contains 100-120 mg of caffeine; therefore reaching the heavy dose would only take about 4 cups of coffee (Spriet & Graham, 2013). The National Collegiate Athletic Association (NCAA) and the International Olympic Committee (IOC) have certain limits on caffeine for athletes in sport and anything above this limit will result in the athlete being banned from competition. For the IOC, the upper limit for caffeine consumption is 12 micrograms (µg)/ml and for the NCAA the upper limit is 15µg/ml (Spriet & Graham, 2013). One microgram equates to 0.001 milligrams. These limits are in existence because caffeine could potentially give athletes an unfair advantage on the playing field (Del Coso, Salinero, Gonzalez-Millan, Abian-Vicen, and Perez-Gonzalez, 2012).

Dosages of caffeine studied have varied from 1 mg/kg to upwards of 10 mg/kg (Astorino et al., 2012 ; Ivy et al., 2009). It was important to conduct the current study to see how two typical doses of caffeine in the form of an energy drink affected cycling 10 miles using an indoor cycling ergometer. Del Coso et al. (2012) stated that caffeine is the most often ingested type of legal drug in the world and is widely available in many forms, including food. "In the sports setting, caffeine is consumed prior to competing by 74% of elite national and international athletes, based on the caffeine concentration found in the urine samples obtained for doping analysis" (Del Coso et al., p.1, 2012).

The doses utilized in the present study, 70 mg or 140 mg caffeine, would amount to .09 – 1.86 mg/kg body weight in an average weight rider of 75 kg. This is not a very large dose compared to the use of caffeine at 6 mg/kg utilized by Irwin et al. (2011); however, the significance of the current study was to review how consumption of energy drinks in typical doses (1/2 to 1 can; 70 mg or 140 mg) might potentially affect cycling performance. Since many of the world's athletes and the general population utilize caffeine, it was important to see how this substance affected cycling performance beyond short distances, as typically examined.

Caffeine and cycling have been studied at length, looking at numerous variables mainly in laboratory settings, with a few studies utilizing outdoor settings. One study that employed laboratory protocol and outdoor road cycling looked at the differences in pedaling biomechanics (Bertucci, Grappe, & Groslambert, 2007). The researchers determined that the mechanics of the indoor ergometer were vastly different that the typical race bike due to the inertia of the flywheel and outdoor factors. The true environment of cycling occurs outdoors; however, conducting a study outdoors introduces many factors that the researcher cannot

control. Bertucci, Grappe, & Groslambert's study (2007) compared the use of an indoor cycle ergometer and two outdoor conditions: uphill cycling and level ground cycling. The information presented gave the researcher insight into how the mechanics and dynamics of the flywheel on the indoor ergometer compared and contrasted to an outdoor race bike. For example, a stationary cycle ergometer creates differences that an outdoor bicycle may limit or have additional effects on. Specifically, when cycling outdoors, one can utilize standing and full body weight in order to achieve maximal performance. Riding indoors on a stationary cycle, the flywheel of the cycle keeps turning; therefore, the cyclist cannot gain any advantage from a potential elevation change (i.e. the downhill slope outdoors).

Statement of Purpose

The purpose of this study was to determine the effect that two doses of a caffeinated energy drink (70 mg or 140 mg), or placebo have on performance time, RPE, HR, RER and VO_2 for a cycling bout of 10 miles. The researcher utilized experienced, recreational, caffeine naïve, male cyclists, aged 18-60, for this study in order to potentially generalize the effects energy drinks have on similar populations of cyclists. The independent variable in this study is caffeine, with the dependent variables being performance time, RER, RPE, VO_2, and HR. The literature consists of many studies that mainly review sprint testing, or shorter distance laboratory protocols; therefore, this study was unique because it examined the impact of a caffeinated energy drink (70 mg, 140 mg, and placebo) on time, RPE, RER, HR, and VO_2 over a non-typical distance of 10 miles.

Hypothesis

The researcher hypothesized that the higher dose of the caffeinated energy drink (140 mg) would elicit a significant difference in performance time, RPE, VO_2, RER, and HR at a

given intensity when compared to the moderate dose (70 mg), and placebo. A second hypothesis stated that the moderate caffeine dose (70 mg) would elicit a significant difference in performance time, RPE, RER, VO_2, and HR at a given intensity over the placebo; (while the consumption of placebo will not produce the afore mentioned results). Conversely, the null hypothesis stated that there would be no significant difference in performance time, RER, RPE, VO_2, and HR for the high dose, moderate dose, or placebo trials.

Operational Definitions

- Caffeine can be defined as a central nervous system stimulant (Spriet & Graham, 2013). Caffeine can be found in many forms such as food and medicine. The main function of caffeine is to produce alertness and may also aid in performance.
- RPE is a 15-point single-item scale ranging from 6 to 20 that assesses levels of perceived exertion. The scale ranges from no exertion at all (6) to maximal exertion (20), (Borg, 1998; See Appendix J).
- VO_2 is physiologically defined as volume of oxygen consumed, and the average, peak, or max can be recorded.
- RER is defined as the respiratory exchange ratio, and represents the amount of carbon dioxide produced and oxygen consumed via the gases (VCO_2/VO_2) collected during exercise (See Appendix I).
- Caffeine naïve will be defined as consumption of no more than 1-2, 5 oz. cups of coffee (75 mg average of caffeine per cup) per day, or 2-4, 16 oz. caffeine containing carbonated beverages (40 mg average per beverage) per day.
- Abstinence from caffeine is defined as participants who do not ingest caffeinated substances.

- Experienced cyclists will be defined as having cycled (indoor and/or outdoor) consistently for at least one year prior to the testing.
- Performance time is defined as time to completion of the 10 mile distance.
- Ergogenic aid is defined often as a supplement used "to increase potential for work output" (Williams, 2002). Ergogenic aids are often utilized in athletics and competitions to enhance aspects of performance.
- Placebo is a product that is used to improve performance through the power of suggestion (McArdle, Katch, & Katch, 2000).

Assumptions

An assumption made about this study was that the participants were honest in reporting caffeine intake and cycling experience. Several other assumptions were made concerning subjects. Specifically, subjects were: well-rested; properly hydrated; performed the test to the best of their ability; abstained from caffeine for 48 hours prior to the test; and abstained from vigorous activity for 48 hours prior to the test.

Limitations

- The use of an indoor Monark cycle ergometer does not mimic typical indoor stationary bicycles or outdoor bicycles. Cyclists who typically perform outdoors had to adjust to the indoor environment. Due to the testing being conducted during the winter season, the researcher understood these limitations.
- Collecting RPE at 2 mile increments proved to be a limitation with the study, due to the researcher having to ask this while the rider was cycling to their full potential (i.e. rider confusion/exhaustion).
- The OxyCon portable VO_2 analyzer potentially inhibited the subjects' comfort levels,

breathing, and general mobility.

- The inability to control the subjects' caffeine intake, physical activity outside of testing sessions, and if the participants rode to their best ability limited generalizability.
- The dropout rate from the study could not be controlled by the researcher.
- Individual reactions to the energy drink substance could vary widely.
- Fitness level of participants was not used in participant screening.

Delimitations

- All individuals were male.
- All individuals were in the age range of 18-60.
- The cycling distance chosen for the study (10 miles) was selected based on lack of existing research at that distance.
- Type (energy drink) and dosage (70 mg, 140 mg, & placebo) of caffeine ingested was selected based on typical consumption patterns.

Summary

The purpose of the study was to examine the effects of three ingested levels of caffeine (placebo, 70 mg caffeine, & 140 mg caffeine) via a popular energy drink on the time required to cycle 10 miles, RPE, RER, VO_2, and HR of experienced, caffeine naïve, recreational, male cyclists, aged 18-60. The benefits of this study translate to the cycling community by determining if these popular energy drinks had any impact on the aforementioned performance variables. Since energy drinks are widely utilized by recreational cyclists, uncovering information with regard to cycling performance clarifies the usefulness of these potential ergogenic aids.

CHAPTER 2: REVIEW OF LITERATURE

The effects of caffeine have been widely studied in the cycling community, varying from sprint tests to minimal endurance tests. The purpose of this literature review is to evaluate the effects a popular energy drink has on cycling performance. A variety of topics will be discussed such as: cycling outdoors and indoors, physiological effects of caffeine, caffeine use in sports and society, and ingested forms of caffeine and variations in doses. Cycling and caffeine has been mainly studied with shorter distances, different doses/forms of caffeine administered, and the environment has been primarily indoors in a laboratory setting. Examining these studies and understanding what has been accomplished in the field will provide the gateway to further research and questions. This literature review will examine numerous areas that relate to the main topic of caffeine and cycling. As the review comes to a conclusion, the purpose of the researcher's own study will fill the gaps in the current research and highlight the need for the current study. The purpose of the researcher's study was to determine how caffeine ingested in the form of an energy drink affected cycling performance during a 10 mile trial as measured by the variables of time, RPE, RER, HR, and VO_2.

Caffeine

Caffeine has been widely studied in a variety of ways for numerous years. There are indications that it does improve athletic performance; yet, specifics as to why it may improve performance have not been determined. Caffeine increases alertness, increases focus, may produce an increase in heart rate, and spark central nervous system activity (Spriet & Graham, 2013). The physiological effect of caffeine is explained in the following quote from an American College of Sports Medicine (ACSM) position stance:

> "The American Alliance for Health states that there are three possible ways that caffeine may provide ergogenic effects. 'First, the metabolic theory suggests that caffeine provides improved endurance due to an increased utilization of fat as fuel and a sparing effect on carbohydrate utilization. Secondly, caffeine may increase the calcium content of the skeletal muscle and enhance the strength of muscle contraction. Lastly, caffeine has a direct effect on the central nervous system as a stimulant, which can help with fatigue, increased alertness, and increased muscle recruitment" (Spriet & Graham, 2013).

Caffeine can be administered in many different ways. The most common way it can be ingested is orally in one's diet, via liquid or food. There are also uncommon methods of administration; such as, injected or in suppository form (McDaniel, McIntire, Streitz, Jackson, & Gaudet, 2010). Power output, strength, long distance, sprint trials, and varying intensity exercises have all employed the use of caffeine to determine the ergogenic properties of the drug. Caffeine effects people differently due to the varying numbers of and types of adenosine receptors in the body, and there is little evidence supporting any negative effects with regards to performance (McDaniel, et al., 2010).

Energy Drinks and Pre-Workout Supplements

Red Bull™ was introduced in Austria in 1987 exactly ten years before it arrived in the United States (Reissig, Strain, & Griffiths, 2009). Energy drinks are a large part of the supplement industry and has grown many times over since the market first got its start around the time Red Bull appeared. Some consider the use of energy drinks to be detrimental to one's health (Reissig et al., 2009). Prevalent in todays' society, it is not hard to observe someone with an energy drink, or to see an ad for this type of supplement. Reissig et al.,

(2009) compiled a review that detailed the use, sale, types, and settings in which energy drinks are prevalent. Energy drink sales increased from about 100 million dollars in 2002, to 650 million dollars in 2006, and 12.5 billion dollars in 2013 (Reissig, et al., 2009). The FDA has attempted to regulate caffeine containing beverages, by limiting caffeine to .02%, or 71 mg per 12 fluid ounces (oz.). Reissig and colleagues (2009) noted that drink producers initially agreed and complied with this ruling, but steered clear of the unenforced limitations soon after. Since energy drinks do not only contain caffeine, some of their ingredients can be listed as herbs or natural sources that are not monitored or regulated by the FDA. The FDA does not enforce the regulation of ingredients contained in energy drinks; therefore, many do not list the caffeine content on the can. It is of importance to mention that over the counter caffeine products (100 mg of caffeine per serving), such as energy drinks, caffeine pills, and energy shots, have to contain a warning label that mentions the effects of caffeine, but a "500 mg energy drink can be marketed with no such warnings and information on caffeine dose amount in the product" (Reissig et al., p. 7, 2009). These findings are alarming since the popularity of energy drinks continues to rise. The energy drink used in the present study was a MONSTER™ Energy Zero Ultra. MONSTER™ is the second most popular energy drink sold in the Unites States, averaging 16 ounces per can, with a mean caffeine concentration of 10 mg/oz. of fluid (MONSTER™, 2013).

Ivy et al., (2009) looked at the effects of a caffeinated energy drink on cycling performance time. The subjects consisted of 6 male and 6 female elite competitive cyclists that had previous experience with time trials, between the ages of 25 and 30 years of age. They completed two trials in random order, and were given either Red Bull™ or placebo approximately 40 minutes prior to the cycling event. The researchers noted that caffeine

peaks in the blood within 30-60 minutes after ingestion. The participants were provided 300 ml (milliliters) of water every 20 minutes while cycling in the indoor laboratory. The amount of energy drink given to the subjects was the equivalent of two cans of Red Bull™, which also contained other substances other than caffeine such as: taurine, pantothenic acid, vitamin B6, glucoronolactone, carbohydrates, niacin, and 10 micrograms of vitamin B12. The present study's energy drink (MONSTER™) contained all of the above listed ingredients as well, but in different amounts. Energy drinks almost always contain other substances including the caffeine dose that may have an effect on someone's performance. Subjects performed a practice trial before the experimental trials began; also their VO_2 max and maximal workload (W_{max}) was determined. Subjects VO_2 max was established when VO_2 plateaued while exercise intensity increased and RER was greater than 1.10. It is of interest to note that the participants did not know how long that they had been cycling; all time recording devices were out of sight. Subjects were instructed to pedal at or above 90 revolutions per minute (rpm). The time-trial was conducted to replicate cycling for one hour at a workload of 70% of the subject's specific W_{max}. The participants were instructed to keep a training log for 48 hours prior to the time trials and were told to keep the same dietary intake before their second trial. Caffeine ingestion was instructed to be kept stable. The subjects fasted for a 12 hour period prior to meeting at the laboratory for the treatment trials. Rate of perceived exertion was analyzed using a nonparametric Kruskal-Wallis test, and time was analyzed using a paired *t* test. The researchers found that performance improved with energy drink when compared with placebo (3,690 ± 64 seconds (s) vs. 3,874 ± 93 s; $p < .01$). There was no difference found in RPE. The authors concluded that consuming a readily available energy drink before an event does help with performance time without altering RPE

in cyclists.

Energy drinks contain many ingredients, although caffeine is usually the most common. In the world of athletics and sports, energy drinks have become prevalent in recent years as a performance enhancing supplement. Del Coso et al. (2012) studied the effects of two different doses of energy drink on muscle performance. The researchers' purpose was to evaluate the effects of a 1 mg or 3 mg dose of caffeine per kilogram of body weight on performance in upper body and lower body power-load testing. The order was randomized and the participants included nine men and three women. Participants had not been involved in resistance training for the prior three months and had no injuries or smoking history. They were also light caffeine users, approximately 60 mg per day, or one cup of coffee. The subjects' 1 repetition maximum (1RM) was taken for the half-squat and bench-press exercises. Each participant was involved in three separate test sessions consuming 1 mg/kg body weight, 3 mg/kg, or placebo, 60 minutes prior to testing. The focus of the study was unique; researching muscle strength and power in relation to consumption of energy drinks. Resting metabolic rate (RMR), HR, and blood pressure were measured 60 minutes after the caffeine substances were ingested, along with execution of the half-squat and bench press exercises. Loads from 10% to 100% of their 1RM were performed using a rotator encoder. It is important to note that a phone survey was conducted the morning after the trials asking questions regarding sleep quality, nervousness, gastrointestinal problems and other discomforts that could occur with an energy drink supplement. A one-way repeated measures ANOVA was used for the variables of HR, RMR, and blood pressure. A two-way repeated measures ANOVA was used with the variables of power-load and force-velocity to study the differences in the caffeine doses. The researchers found that both doses of caffeine increased

blood pressure and HR in the subjects ($p < .05$). The 3 mg/kg dose of caffeine in the energy drink substance showed an increase in the amount of power produced in both the half squat and bench press exercises ($p < .05$). Del Coso et al. (2012) noted that the 1 mg/kg did not produce significant difference in the power load of the subjects, but that the greater dose did in fact produce greater power with the loads from 30% to 100% of their 1RM. The authors discussed that the greater dose is needed to improve upper body and lower body power and strength.

Energy drinks are one of the supplements used in sports that may contain high amounts of caffeine; however, there are other supplements and substances that athletes use to aid in performance. One of these is commonly known as a 'pre-workout' supplement. ‘Pre-workout’ is usually a type of powder substance that can be mixed with water or most types of sports drinks. This substance is usually distributed by the scoop and there are warning labels not to exceed one to two scoops of the product. Most pre-workout powders contain high amounts of caffeine and also many other ingredients as well. Smith, Fukuda, Kendall, and Stout (2010) researched a pre-workout substance that also contained creatine, and amino acids. The purpose of the study was to determine the effects this supplement had on aerobic and anaerobic running performance over a three week training program. The type of training conducted was high-intensity interval training (HIIT). The study utilized a random design, with a placebo control. The subjects consisted of 24 moderately trained athletes that either were given the treatment ($n = 13$) or placebo ($n = 11$). The pre-workout supplement utilized was Game Time™ (Corr-Jensen Laboratories Inc.) that consisted of 18 g of powder, 40 kcals, whey protein, cordyceps, creatine, ginseng, citrulline, and caffeine. The placebo only contained the powder and maltodextrin. The supplements were ingested roughly 30 minutes

prior to the testing sessions. The HIIT program consisted of three days per week, for three weeks, with testing before and after the training sessions. Maximum VO_2 tests were conducted during the familiarization week of testing, along with timed runs to exhaustion. The HIIT training sessions consisted of sprints on a treadmill following intervals of rest, three times per week. The authors did find overall significance ($p < .05$) in the treatment group. There were some individual responses that showed an increase in VO_2 max in the placebo group. The other ingredients in the pre-workout may have led to the increases in VO_2 max, but the authors could not pinpoint these factors (Smith, et al., 2010).

Physiological Effects of Caffeine

Caffeine elicits different responses in each individual, and this is due to many factors. Body mass, history of usage, type and dose ingested, and timing all impact the response caffeine produces. Astorino, et al. (2012) researched the repeatability of caffeine's ergogenic effects on cycling performance. A test-retest design was employed, with nine endurance-trained male cyclists, participating in five separate laboratory sessions. Practice tests were taken on days one and two, with actual trials on days three through five. One hour before testing, each subject ingested 5 mg/kg caffeine or placebo substance. The time trials consisted of 10 km after a 10 minute warm-up period. The subjects were informed of RPE and how the scale is utilized, and were instructed to ride to the best of their abilities to perform the trials. The participants also completed 24 hour nutrient logs pre exercise, and were instructed to abstain from caffeine for 48 hours prior to each session. Caffeine was shown to significantly increase performance time ($p = .02$), when compared to placebo. The repeatability across the three performance sessions showed improvements of 1.6% an 1.9% in time, respectively. These results indicated that there was not much improvement reported

in performance with caffeine usage, hinting of a repeatability issue with the results. The authors concluded that individualizing the tests by keeping the finalized data separate, would help control for differences in physiological responses to caffeine (by kg of body weight), and report the individual data points in the future instead of grouping all subjects together in aggregate. Post-hoc tests can allow for determining which subject could have shown significance between trials and doses.

Jackman, Wendling, Friars, and Graham (1996) examined the metabolic, catecholamine, and endurance responses to caffeine during brief intense exercise. Researching the possible effects caffeine has on muscle metabolism was the primary focus of this study. Fourteen subjects ingested either placebo or caffeine (6 mg/kg) and cycled for two minutes, rested for six, cycled for two, rested for six, and then cycled to exhaustion. Eight of the participants had muscle and venous blood samples taken pre and post exercise session. The caffeine substance showed an increase in endurance (4.12 ± .36 for placebo and 4.93 ± 0.6 min for caffeine). Muscle lactate was significantly increased in conjunction with caffeine in the last bout to exhaustion, resulting in the conclusion that caffeine consumption was effective in bouts of activity lasting less than six minutes.

Caffeine was believed to dehydrate individuals due its' diuretic effects on the body. Only extreme levels of caffeine intake, upwards of 600 mg, were associated with dehydration. However, even with the minimal diuretic effects, this only increases an individual's fluid intake over time, lessening the occurrence of dehydration to occur. Low to moderate doses of 38 to 400 mg per day were found to improve mood, sleep, hydration levels, and brain function, with a reduced occurrence for negative effects (Ruxton, 2008).

Caffeine affects humans in a variety of ways. It can produce alertness, wakefulness, a

sense of energy, and focus. It may also produce anxiety, jitters, restlessness, raised heart rate and blood pressure, and a sense of paranoia in some. Assessing one's own tolerance is advised before ingesting a large dose of caffeine (Seifert, et al., 2011). Healthy people can tolerate caffeine in moderate amounts, but the heavy doses have been shown to cause health problems. These problems can range from seizures, paranoia and panic attacks, to strokes and even sudden death. Other adverse reactions could include: irritability, anxiety, insomnia, upset stomach, tachycardia, vomiting, abdominal pain, cerebral edema, and paralysis. Those that take medications, or are already diagnosed with heart disease or thyroid disease, are at a higher risk for these events. It is important to note that manufacturers are not required to list the amount of caffeine on a beverage, such as an energy drink. Therefore, whatever amount may be listed could potentially vary. The United States poison control centers do not specifically record the number of overdoses on energy drinks because these are usually reported as caffeine or other substance exposure (Seifert, et al., 2011). "In healthy adults, a caffeine intake of </= 400 mg/day is considered safe; acute clinical toxicity begins at 1 gram (g), and 5 to 10 g can be lethal" (Seifert, et al., 2011).

Dosage and Dosage Timing

The British Nutrition Foundation compiled a review of studies examining caffeine and how it impacts mood, cognitive function, performance, and hydration (Ruxton, 2008). Fifteen years of studies consisting of varying caffeine dosages were reviewed in order to determine if a higher or lower dose would provide the greatest impact. A high caffeine intake can lead to sleep problems, anxiety, digestive problems, and irritability. Ruxton (2008) noted that most caffeine ingested in the United Kingdom, 45 mg per person per day on average, is from tea. Most studies reviewed included doses of caffeine ranging from 37.5 mg to 450 mg.

"Caffeine is believed to impact mood and performance by inhibiting the binding of both adenosine and benzodiazepine receptor ligands to brain membranes" (Ruxton, 2008). Caffeine alters brain chemistry, and may manifest in the physicality of a person. Tolerance to caffeine is different in each person, and should be respected. Caffeine was noted to improve and restore cognitive function in sleep deprived subjects with a dose of 84 to 600 mg taken as a single bolus (dose) (Ruxton, 2008).

Liguori et al., (1997) studied the differences in the caffeine effects of coffee, cola, and capsules, when absorbed by the human body. Caffeine is readily available in many sources, and it is important to understand the doses and potential effects it can have on performance. It is a common belief that caffeine levels in coffee have a greater effect than those of colas, while both substances contain caffeine, the dose is very different. Coffee (brewed, black) contains a caffeine dose of 102 mg/6 oz., whereas cola has 36 mg/12 oz. These researchers studied the salivary concentrations of individuals post caffeine consumption, using the vehicles of cola, coffee, and capsule (placebo). The capsule was utilized to serve as the control method. The subjects consisted of 13 volunteers, 8 men and 5 women. They were asked a series of questions pertaining to caffeine history, average dosage per day and types of caffeine ingested, and smoking and alcohol history. Exclusion criteria included anyone who had more than one alcoholic beverage per day, or someone with a chemical or drug dependency problem. Subjects were also excluded if trying to alter their caffeine intake, such as, adjusting their daily totals, or on a restricted calorie diet. The researchers added 200 mg caffeine to either the coffee or cola, which increased the dosage totals to 400 mg. Coffee, cola, or capsule was distributed at random to the participants on a Monday, Wednesday, and Friday, over a two week period. Each session lasted approximately four hours and subjects

were allowed to read, write, listen to music, or converse; however, they were not allowed to talk about the substances and how they were feeling. The researchers stayed in the room to make sure the protocol was followed. Each subject provided a saliva sample, and completed a mood questionnaire and a behavior checklist. There were no significant differences ($p >$ .05) found between coffee and cola as a caffeine absorption vehicle, in time to peak, or post consumption. The saliva samples showed that 400 mg caffeine of either coffee or cola peaked within 35-45 minutes after ingestion. The differences in caffeine sources and the vehicles in which they were disbursed were shown to not impact the final outcomes of the trial.

Doses of caffeine can range from the extremely high (10 mg/kg) to relatively low (1-3 mg/kg) in research studies. Jenkins, Trilk, Singhal, O'Connor, and Cureton (2008) examined the effects of low doses of caffeine on cycling performance. The doses utilized were 1, 2, and 3 mg/kg of caffeine per kilogram of body weight. Performance was measured by RPE on 13 subjects with experience in cycling. A stationary ergometer was used in a laboratory setting. Subjects performed 15 minutes of cycling at their respective 80% VO_2 peak, recovered actively for four minutes, then cycled a 15 minute performance piece (all-out for the duration of the test). Rating of perceived exertion was obtained every three minutes, and blood lactate was assessed during the 15^{th} and 30^{th} minute. When compared with the placebo group, caffeine doses of 2 and 3 mg/kg raised performance by 4% ($p = .02$) and 3% ($p =$ .077) respectively. No effects were shown on RPE during the event. The authors concluded that individual responses need to be studied to determine the individuality of the drug interactions and ergogenic properties.

Many studies deliver an acute dose of caffeine before an activity to determine

caffeine's effects on performance. It is ideal to recruit participants who are low habitual caffeine users in order to avoid having tolerance to or history of caffeine ingestion becoming a negative factor (Del Coso et al., 2012). Irwin et al. (2011) conducted a study to determine if a withdrawal period of caffeine before the acute dose would elicit a greater response in performance. Forty-eight hours is the typical withdrawal period from caffeine and the authors of this study decided to utilize a four day period to determine the impact of a controlled withdrawal. Twelve male cyclists and triathletes were recruited for the study that reported a caffeine use of 240 ± 162 mg/day. Peak VO_2 and peak power output were tested before the actual testing procedures. Subjects reported to the laboratory a total of seven times for pre-testing, two experimental trials, and four testing sessions. There was several treatment conditions paired at random to produce responses such as: placebo vs. placebo, placebo vs. caffeine, caffeine vs. placebo, and caffeine vs. caffeine. For 4 days prior to the testing period, subjects were given treatment depending on which category the researchers placed them in. These randomized groups were designed in order to elicit uncontrolled responses from the cyclists. The pre-test caffeine was a 3 mg/kg of caffeine, whereas the day of test caffeine dose was 6 mg/kg (given 90 minutes before testing). Results showed that acute effects of caffeine occurred regardless of the pre-test treatment; the caffeine vs. placebo group had a 3.6% difference when compared to the caffeine vs. caffeine group (p = .002, Effect Size (ES) = 0.46). There was a 3.0% difference in the placebo vs. placebo and placebo vs. caffeine groups (p = .021, ES= 0.40). Twenty-one of the twenty-four trials were faster with the acute dose of caffeine; independent of the pre-trial treatment. The researchers concluded that a controlled withdrawal period from caffeine did not elicit greater responses in the cyclists, but that the acute dose did improve the work completed (1040.85 ± 74 kJ

average). The habitual use of caffeine by the subjects is speculated to have had an effect on the responses collected.

When designing a study that involves a substance/treatment, it is important to examine all of the aspects of that variable. Caffeine is widely consumed by athletes and non-athletes alike. Determining when to distribute the substance is critical to elicit certain types of responses. Bell and McLellan (2002) noted that caffeine has a half-life of 4-6 hours, which means that a higher dose of caffeine would potentially stay in the body for longer periods of time. Most research studies conducted give the dose about one hour prior to the testing session to elicit the greatest response from caffeine. The purpose of the study (Bell & McLellan, 2002) was to see if the duration of caffeine's ergogenic effect would elicit a response in users vs. nonusers. Twenty-one subjects were recruited (13 caffeine users and 8 nonusers), consisting of 15 male and 6 female. Prior to testing, their VO_2 max was measured via a stationary cycle ergometer in a laboratory setting. They reported to the laboratory on six separate occasions and completed a ride at 80% of their maximal oxygen consumption after consuming either placebo or a caffeinated dose of 5 mg/kg body weight. The subjects completed these tests one time per week after the placebo or caffeine dose, at 1, 3, or 6 hours post consumption. For the subjects that abstained from caffeine, exercise times were (for the 1, 3, & 6 hours post consumption) 32.7 ± 8.4, 32.1 ± 8.6, & 31.7 ± 12.0 min in order of treatment distribution. The placebo values consisted of 24.2 ±6.4, 25.8 ± 9.0, and 23.2 ± 7.1 min. For the subjects that habitually ingested caffeine, the values were (at 1, 3, and 6 hours post ingestion): 27.4 ± 7.2, 28.1 ± 7.8, and 24.5 ±7.6 min. Only the exercise times at 1 and 3 hours post consumption were significantly greater than the similar placebo trials of 23.3 ± 6.5, 23.2 ± 7.1, and 23.5 ±5.7 minutes. The authors concluded that the ergogenic effects of

caffeine were more prevalent in the nonusers due to the absence of a tolerance or build-up in their systems.

Placebo Effect, Heart Rate, & Respiratory Exchange Ratio

The placebo effect can occur through the power of suggestion via the mind. The authors Beedie, Stuart, Coleman and Foad (2006) studied the effects that placebo, when believed to be caffeine, had on cycling performance. Six male cyclists participated in two 10 km time trials to gather a baseline, and three actual time trials. The subjects were told they would be given a placebo, 4.5 mg/kg or 9.0 mg/kg dose before their cycling trial. They were all given only placebo to determine how this affected their performance. All subjects were interviewed and said they had experienced caffeine related symptoms. The group that believed they had taken the 9.0 mg/kg dose increased their performance by 3.1% more power than baseline. The group that was told they were taking a 4.5 mg/kg dose also improved their performance by 1.3% more power. The placebo group even had a 1.4% decrease in performance because they were told they would be ingesting only placebo. All results reported used a significance level of $p < .05$. Few studies have been conducted merely on the placebo effect, and future studies to further quantify this effect are needed. The researchers saw a placebo effect, both positive and negative, in the well-trained group of cyclists.

Madsen, Klavs, MacLean, Kiens and Christensen (1996), examined the effects of glucose supplementation, glucose with branched chain amino acids (BCAAs) supplementation, and placebo on 9, male, trained cyclists performing a 100 km endurance bout. These sessions were separated by 7 days; after 3-5 familiarization trials. The subjects were instructed to perform the bouts to the best of their ability, much like the present researcher's guidelines. The subjects performed the trials on their own bicycles in a lab, and

the bicycles were placed on a trainer that securely held the back frame of the bike. Heart rate, expired gas samples, and blood samples were taken at the 10, 30, 60, 90, 120, and 150 minute marks, as well as at the end of the 100 km distance. The data was analyzed by a two-way analysis of variance for repeated measures. Significance ($p < .05$) and all data were described via the means. Significant differences were not observed for the performance time variable; however, it is vital to state that the three times were: Glucose (Trial G) only (160.1 +/- 4.1 min), BCAA + Glucose (Trial B) (159.8 +/- 3.7 min), and in Placebo (Trial P) only (159.8 +/- 3.7 min). The subjects were randomly assigned a dose, and the researchers did not know what their subjects were ingesting either (double-blind, random assignment). The researchers also found in Trial G, a mean VO_2 in l/min of 3.31 +/- 0.06; Trial B, 3.50 +/- 0.06 l/min; and Trial P, 3.39+/- 0.04 l/min. Heart rate means were reported as: Trial G, 154 +/- 3; Trial B, 154 +/- 3; and Trial P, 151 +/- 2 beats per minute. Respiratory exchange ratio values were reported at minute 120 of the trials as: Trial G, 0.862 +/-0.012; Trial B, 0.867 +/- 0.008; and Trial P, 0.846 +/- 0.013. The researchers reported that while RER did not show a significant difference ($p = .08$), that the RER did drop more dramatically in the placebo group.

Caffeine in Sports

Caffeine is widely used by the public, and it is frequently used in sports. Athletes take a risk when utilizing substances that have a questionable effect on performance. Sokmen et al., (2008) compiled a review of considerations that athletes need to take into account when consuming caffeinated substances. Caffeine is found naturally in coffee beans, tea, and cocoa beans, and is the world's most consumed pharmacologic and psychoactive product (Sokmen et al., 2008). The central nervous system is greatly affected by caffeine.

The hormones, metabolism, muscular function, cardiovascular function, lung functions, and renal function during activity and homeostasis are affected. There are many positive and negative reports relating to caffeine usage, the athletes and coaches must do their research and be smart in regards to consumption and dosage. An athlete's size, gender, prior history of caffeine usage, and age all must be taken into consideration. "The stimulation of the sympathetic nervous system by caffeine acts on multiple metabolic pathways to improve endurance performance" (Sokmen et al., p. 983, 2008). Studies of the past hinted that carbohydrate stores were saved and fat was utilized for energy and this was how performance increased. However, recently it has surfaced that caffeine may delay central nervous system fatigue, and have a hypo-analgesic effect on the musculature of the body, therefore also decreasing RPE. The researchers also noted that normal doses of caffeine do not actually dehydrate someone, or cause poor athletic performance (due to hydrating with fluids and the maintenance of stable electrolyte balance). This is a common misconception among competitive athletics and athletes (Sokmen et al., 2008). "The half-life of caffeine is approximately 4 to 6 hours, and plasma concentration has been shown to peak in 30-60 minutes" (Sokmen et al., p. 983, 2008). This suggests that caffeine should be ingested roughly 60 minutes prior to an endurance event. This ties into the methods design of the present study since the participants consumed the caffeine substance 30 minutes prior to the timed trial; having the substance peak at 60 minutes, ensured that the subjects experienced a peak roughly midway (5 miles) through their ride.

Caffeinated substances and their effects on humans, specifically during performance, justify the inclusion of caffeine in the category of performance enhancing substances. Many of these substances are not regulated by any governing body, so athletes have full access to

taking and using these products. Supplementation can only aid the athlete so much; this is when actual nutrition makes the greatest difference in performance. Fueling the body with the appropriate nutritional intake is vital in performing to one's best ability.

Nutritional Intake and Cycling Environment

Saris, van Erp-Baart, Brouns, Westerterp, and ten Hoor, (1989) studied the nutritional intake of cyclists during the Tour de France. The purpose of the study was to determine if the cyclists were gaining adequate nutrition for the amount of energy that was being expended. Five male cyclists were studied over the 22 day period of the Tour de France, which consists of 4000 km with up to 2700 m in altitude changes. This race only allows for one day of rest during the three week period of distance cycling. This endurance race is one of the most grueling courses known to man. Comparable contests include century runs (100 miles distance), and swimming the English Channel. Data collection included daily food logs, and their energy expenditure (EE) was estimated during this time by their sleeping and resting durations, and their cycling bouts each day. These cyclists had participated in the Tour at least three times prior to this race. A nutritionist noted that energy drinks made up a substantial part of the cyclists' daily calorie logs. The average EE from carbohydrate intake consisted of 62% and fat was 23%. The cyclists took concentrated vitamin/mineral supplements to aid in their lack of nutrients from food sources. The average intake was surprisingly balanced, researchers noted. The average EE of the cyclists was 6100 kilocalories. The authors noted that the major source of fat intake, 27.3%, came from sweet cakes, and that given a better food source the cyclists may have performed better. Liquid carbohydrate sources seemed to aid in their performance as well. Nutritional intake is just as important as energy drinks and supplements that an athlete may ingest. The top athletes in

their arena of sport often follow their nutrition to extreme levels in order to gain the most benefit from their bodies for performance.

Cycling, whether indoors, outdoors, laboratory setting, or even off-road, are all different types of environments. Bertucci, Grappe, and Groslambert (2007) conducted a study that reviewed these. They wanted to determine if cycling in a laboratory or outdoors required different biomechanics. The variables also studied were crank torque profile and perceived exertion in either setting. The true environment of cycling is outdoors with a variety of terrain and weather issues. The authors utilized seven male cyclists that participated in seven different tests to determine these differences. The cadences of the cyclists were one factor, ranging from 60 rpm, to 100 rpm. The researchers noted that at the same cadences, cycling indoors elicits a greater perceived exertion due to stiffness and dampening of the flywheel, as opposed to an outdoor race bicycle (Bertucci et al., 2007). It is important to note that the wind velocity was ranging from 0-1.4 meters per second across trials, as measured by an anemometer. Taking weather into account is important because the researchers noted this still did not affect the perceived exertion as much as the indoor setting. A Wilcoxon test was used to determine the statistical significance in the RPE variables between conditions. The RPE in the laboratory environment was significantly higher ($p < .05$) when compared with the outdoor environments. There have not been many studies conducted in off-road cycling performance and how the differences relate to the cyclists effort. This study was reviewed due to the outdoor, off-road nature of the study. Reviewing indoor and outdoor cycling protocols is necessary to understand the research and how it translates to actual cycling.

Impellizeri, Rampinini, Sassi, Mognoni, and Marcora (2005) conducted a study with

13 competitive off-road male cyclists to determine the outdoor effect on performance. Peak VO_2, peak power output, lactate threshold, and onset of blood lactate accumulation were all calculated one week prior to the race day. Time to completion of course and ranking within the group determined correlation between the physiological variables to body mass. The race consisted of 31 km with 1260 m in altitude climb, and the temperature was 25° Celsius. The course was competition level, and was closely monitored. The researchers found that the measured variables, when held standard and normalized to body mass, did correlate significantly to competition time. The best 6 riders and the worst 6 riders had average times from 5453 s ± 312 to 6139 s ± 267, respectively, with an effect size of 1.52. The authors concluded that maximal and submaximal aerobic fitness testing is an accurate way to measure off-road cyclists, but that the norms should be standardized to body mass of an athlete. Off-road performance and power output greatly relate to one another, and these variables should be further studied to determine if aerobic testing for these athletes can be done in a more accurate way.

The environment in which one performs a cycling experiment greatly influences the outcome and the results of the test. Ganio et al. (2011) studied the effects caffeine produces on leg muscle pain during exercise in hot and cool environments. Exercising in the heat can require more energy; independent of the intensity level at which the activity is performed. The heat causes different physiological responses than the cold, and these need to be accounted for when performing and designing research studies. Ganio et al. (2011) recruited 11 male cyclists that participated in four different sessions to determine the effects caffeine may produce in different environments. The study was randomized and employed a double-blind strategy. The subjects cycled for 90 minutes at 65 ± 7% of their VO_2 max, immediately

followed by a 15 minute performance ride. The participants ingested 3 mg/kg of caffeine or placebo one hour prior to exercise, and 45 minutes after beginning the session. The researchers measured central, local, and overall perceived exertion. Throughout the warmer (33° C) performance period, all levels of RPE were significantly greater ($p < .05$), independent of the caffeine substance. Caffeine did not reduce pain in the 12° C group ($p = .542$), but in the 33° C groups' caffeine dose did reduce pain by 27% ($p = .032$). Although there are apparent differences identified, caffeine improved performance regardless of the temperature in which the study was conducted. The authors concluded that caffeine did reduce leg pain overall in warmer and cooler environments, but that in warmer environments it aided in producing the same hypo analgesic effect that other researchers had found.

Intake Regulations/Restrictions

Spriet and Graham (2012) wrote an article on the current use and status of caffeine for the ACSM. The ACSM is a governing body that promotes fitness and health, and is a network for professionals and students. The article discusses a previously stated topic, referring to caffeine being the most widely used substance in the world, and its use continuing to grow in the population. Athletes must be consciously aware of caffeine's effects when ingesting this substance, and ethical and moral questions often arise when they do so. The FDA has attempted to regulate caffeine containing beverages, by limiting caffeine to .02%, or 71 mg (milligrams) per 12 fluid oz. Certain levels of caffeine in the urine are a marker for doping, or misuse of the product. The International Olympic Committee (IOC) states that a level of 12 micrograms or more in the urine meets the doping status criteria, whereas the National Collegiate Athletic Association (NCAA) has a level of 15 micrograms. Caffeine has been on and off the banned list of substances for many years. Chronic users

who train with caffeine can simply abstain before their race/event and the testing will not show that they are over the limit, even if they use the substance prior to the race. It is projected that abstaining from caffeine before taking a dose will elicit greater benefits than chronic use. (Spriet & Graham, 2012).

Oxygen Consumption (VO_2) & Performance Time

Oxygen consumption (VO_2) can be measured for many different purposes and can be beneficial in determining the physiological component that make a study unique. Peak, maximal, and average oxygen consumption can all be utilized to serve a specific purpose. Hogervorst, et al., (2008) utilized caffeine to determine if physical performance was improved for an exhaustive exercise bout. Their caffeine substance was delivered by way of a carbohydrate containing energy bar, to 24 male participants. The well-trained cyclists ingested the bar, containing 45 g of carbohydrate and 100 mg of caffeine, or 300 milliliters (mL) of placebo beverage, or a carbohydrate bar with equivalent calories that did not contain caffeine. The groups were randomly selected, and participated in three separate trials. The duration of exercise completed was 2.5 hours at 60% of the cyclists' respective VO_2 max. Further supplementation (whichever group they were in) was given at the 55 and 115 minute mark, and 200 mL of water was administered at the beginning and every 20 minutes of exercise. The researchers analyzed the data via repeated-measures ANOVA. The participants self-reported an average daily caffeine dose of 170 mg/day (this is important to note for future studies utilizing caffeine). There were no significant differences in mean heart rate reported between trials (p = .14). However, there was a significant difference found with maximum heart rate between the caffeine dosed bar and the placebo beverage (p = .001). The authors did not find significance in the RPE of subjects between treatments.

Caffeine did show the most significance in the time to exhaustion variable ($p < .001$). The time to exhaustion in the caffeine and carbohydrate bar groups were significantly longer than the placebo beverage only group ($p = .031$). Caffeine improved the time to exhaustion by 354 seconds, a 27% improvement. The researchers did not find differences in the relative intensity (% VO_2 max) between trials ($p = .15$). The authors concluded that there was a definite increase in concentration, faster response speed, and caffeine did produce significant effects on the variables of time to exhaustion, and maximal heart rates between trials.

Wiles, Coleman, Tegerdine, and Swaine (2006) conducted a study examining the effects of caffeine on performance time, speed and power. Their study was conducted in a laboratory setting consisting of a one kilometer (0.65 mi) time-trial. Wiles et al. (2006) utilized 8 male subjects that were placed in three groups: placebo, control, or 5 mg/kg body weight dosage of caffeine. There were three separate testing events determining peak power, performance time, and speed. The authors found that caffeine did in fact improve performance time; caffeine vs. placebo, vs. control (71.1 s ± 2.0 s vs. 73.4 s ± 2.3 s vs. 73.3 s ± 2.7 s) p =0.02. This change represented 3.1% improvement in time versus the placebo group ($p = .0005$). Peak power was shown to increase from 864 ±107 watts in the placebo group, and 830 ± 87 watts in the control group, to the final 940 ± 83 watts in the caffeine dose group ($p = .027$). The researchers found that these results were consistent with the literature, with the shorter duration time-trial cycling tests.

Rating of Perceived Exertion

Doherty and Smith (2005) compiled a meta-analysis over caffeine ingestion and RPE during and after exercise. Twenty-one studies were reviewed with 109 effect sizes that met the inclusion criteria. The researchers found 44 studies that measured the effects of caffeine

on RPE. Subjects abstained from caffeine between 12 and 168 hours, with a median time of 24 hours, and the time between dosage and activity ranged from 30 to 360 min (median of 60 min). The caffeine doses ranged from 4-10 mg/kg with a median of 6.0 mg/kg. The authors found a 6% reduction in RPE when caffeine usage was employed. It was concluded that caffeine does in fact alter RPE levels, but the specifics as to why have not yet been determined.

Doherty, Smith, Hughes, and Davison (2004) utilized 11 male cyclists and employed the pre-loaded cycle protocol to determine the effects of caffeine. The subjects cycled for two minutes at 100% of their maximal power (determined pre-trials), followed by one minute of all-out effort. The cyclists participated in a ramp-test to determine their max power output, and then completed two other cycling trials. The caffeine load prescribed was 5 mg/kg or placebo in a randomized, double-blind procedure. It is important to note that the cyclists used their own bikes for these procedures. The 6-20 Borg scale for RPE measurements was employed for this study. The RPE was lower in the caffeine group by 1 RPE point at 30, 60, and 120 s during the pre-load test ($p < .05$). The average power-output during the all-out effort section of the test was also higher following the caffeine usage when compared with placebo [794 ± 164 vs. 750 ± 163 W; ($p = .05$)]. The authors concluded that cycling performance at higher intensities can be improved following a moderate caffeine ingestion which may be related to a lowering of RPE. "On the other hand, the performance element of a test in which athletes set their own pace closely mimics the physiological and perceptual responses the athletes experience in competition and thus confers a large measure of ecological validity" (Doherty et al., 2004). Real world experiences that can be closely mimicked in laboratory setting often translate to having a high external validity. RPE is

subjective and can be difficult to use in a research study due to the variety of reasons. The best way to control for this is to thoroughly explain Borg's RPE scale in order to enhance the subjects' understanding of the variable and methods of measurement.

The International Association for the Study of Pain (1979) defined pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Gliottoni, Meyers, Arngrimsson, Broglio, & Motl, p. 150, 2009). Twenty-four college aged males were recruited for this study to determine the effects of caffeine on quadriceps muscle pain during acute cycling events in low vs. high caffeine users. The subjects' caffeine use was self-reported and they were placed in two groups. Low caffeine use consisted of </= to 100 mg/day; n = 12, and high caffeine users >/= to 400 mg/day; n = 12. The muscle-pain in the quadriceps was measured using a scale from 0-10 that contains 12 categories. An incremental exercise test using a laboratory cycle ergometer was performed to determine VO_2 peak. There was one day of pre-experimental testing and two days of experimental testing. The subjects were required to record nutritional intake for seven days prior to the testing sessions. On testing days, subjects ingested placebo or 5 mg/kg caffeine, 60 min. prior to performing 30 min of cycling at 80% of their VO_2 peak. Every 5 minutes the subjects recorded their muscle pain rating during both sessions of work. The average pain ratings in the caffeine and the placebo group were 3.00 ± 1.6 and 3.8 ± 1.7 respectively. The authors found that the caffeine contributed to a lower perception in leg muscle pain, in both the low and high users of caffeine. They also noted that this was not what they expected to find. Their research hypothesis stated that an acute dose of caffeine in habitual users would not decrease leg pain as much as in low users of caffeine. They found that an acute dose did in fact lower leg pain in both groups. Caffeine

has been shown to have a hypo analgesic effect on the musculature of the legs, therefore limiting the perceived pain felt after ingestion during exercise.

Another study that highlights the perception of leg muscle pain during cycling exercise after caffeine ingestion was conducted by Motl, O'Connor, and Dishman (2003). Sixteen, low-caffeine consuming, college-aged males participated in the study which involved a high dose of caffeine (10 mg/kg) or placebo being distributed 60 minutes prior to testing. The subjects were non-smokers and of average body weight. Thirty minutes of moderate cycling (60% of VO_2 peak), was performed after the caffeine or placebo was consumed. The groups were randomly assigned the treatment, and the perceptions of leg muscle pain were significantly reduced after the high dose of caffeine was consumed (p = .01; $p < .05$). This study also employed the category scale from 0-10 that had verbal cues with each level. "Pain ratings assessed by the category scale were significantly correlated (r = .79-.94) with concurrent pain intensity assessed by a standard 10 cm visual analogue scale with verbal anchors of 'no pain' and 'worst possible pain'" (Motl et al., p. 317, 2003). This study also discussed the hypo analgesic effects of caffeine on the body. This could be due to the effect on the central nervous system. Authors noted that future studies may examine the hypo-analgesic effect of caffeine at greater exercise intensities that provide for higher leg muscle pain. Caffeine history of the subjects can greatly alter the expected elicited response; therefore future studies need to accommodate this problem and explore greater intensities with caffeine being the main variable.

The last study to be examined was conducted by Yeomans, Ripley, Davies, Rusted, and Rogers (2002). The researchers examined the effects of caffeine on performance and mood, and these variables were plotted against the level of caffeine abstinence. Designing a

study requires giving the treatment at precisely the right time to subjects, in this case the caffeine dose, while also noting the participants' caffeine history and usage. Using habitual caffeine consumers that may or may not experience a withdrawal period prior to testing is a good idea to control for accurate elicited responses, but recruiting caffeine abstainers would be ideal for a research study. Thirty moderate (self-reported) caffeine consumers (19 women and 11 men) were employed for this study; they were given a drink with 0, 1, or 2 mg/kg caffeine at their breakfast followed one hour later by another drink with either 0 or 1 mg/kg caffeine. Mood and performance measures were taken 45 minutes post ingestion of each substance, using the Bond-Lader mood scales, and the rapid visual information processing (RVIP) task. The Bond-Lader mood scales produce three mood levels: mental alertness, calmness, and contentedness. Reaction time from the RVIP task was significantly affected by the breakfast load of caffeine; $F(2,23) = 4.49$, $p < .05$). The reaction time of the participants given placebo at breakfast had an average of 521.9 ± 15.1 ms, 45 minutes after the dose given, which was significantly different ($p < .05$) than those given the 1 mg/kg (475.6 ± 15.0 ms) or 2 mg/kg (460.1 ± 15.2 ms). "In line with many previous studies, caffeine decreases reaction time and increased response accuracy on the performance task as well as increasing rated mental alertness" (Yeomans et al., p. 247, 2002). The authors concluded that caffeine did increase response acuity and decrease reaction time, which could prove to be beneficial in athletes in their competitive season.

Summary

To reiterate the importance of this review, many variables were examined to further justify the need for new research. Delving into the current research and justifying aspects of the present study provide for validation of the topic. Reissig et al. (2009) studied the

prevalence of energy drinks and the usage of them in sports performance. Ivy et al. (2009) looked at the effects of a caffeinated energy drink on cycling performance time. Wiles et al. (2006) conducted a study examining the effects of caffeine on performance time, speed and power. Hogervorst et al., (2008), produced a study that examined caffeine in the form of an energy bar, being ingested before a 2.5 hour exhaustive cycling bout. They found that there were significance differences between maximal heart rates, and time to exhaustion between groups. Further research needs to be conducted as to why this physiologically occurs. Maximal heart rates and improved time to exhaustion may not necessarily mean that the cardiovascular system is working at a greater efficiency. These studies further indicate that a study on the effects a popular energy drink may have on cycling performance time, VO_2, RER, HR, and RPE, over a distance of 10 miles, is much needed in the research community. These results can be utilized by the recreational cycling population, with a potential for experimentation in the competitive circuit as well.

CHAPTER THREE: METHODOLOGY

Participants

Institutional Review Board (IRB) approval was obtained before any recruitment began (Appendix A). Participants were recruited from the University of Central Oklahoma (UCO) via flyers (Appendix G), and a UCO email blast sent to male students, faculty, and staff. Flyers were posted in the Kinesiology and Health Studies Department, and placed at the front desk of the Wellness Center. The participants were well informed prior to any testing and assured that their participation was voluntary for the duration of the study. The inclusion criterion included: subject's age, sex, cycling history, caffeine usage, and health status. Caffeine naïve (1-2 5 oz. cups of coffee, or 2-4 12 oz. sodas per day) (Spriet & Graham, 2013) or abstainers of caffeine were required for this study. Subjects were males between 18 and 60 years of age, with experience in cycling, and currently participating recreationally. Experience was justified as having cycled (indoors or outdoors) for at least one year. Subjects were classified as "apparently healthy". Participants were required to fill out a Physical Activity Readiness Questionnaire (PAR-Q) asking qualification questions to determine their risk-classification (Appendix C). An informed consent was also explained to and signed by the subject (Appendix E). There was a pre-testing meeting to cover all of the details of the study to inform the subjects of the step-by-step process of the study, and to secure their informed consent. Subjects unable to attend the pre-test meeting scheduled meetings individually to secure pre-screening materials. A Questionnaire for Proposed Subjects and Participation Information Sheet (Appendix B) was also filled out by the subjects. Subjects were given a comprehensive list containing common caffeinated foods and beverages at the pre-test meeting (Appendix H) since they were required to abstain from

caffeine for 48 hours prior to each trial. The exclusion criteria involved injury, disease, females, under the age of 18, over the age of 60, and insufficient experience with indoor or outdoor cycling for at least one year.

The sample size was estimated from research by Wiles, Coleman, Tegerdine and Swaine (2006) that examined the effects of caffeine ingestion on performance time. Descriptive statistics were run reporting mean, standard deviation, range, and sample size per variable. A 1-factor repeated measures analysis of variance was utilized to statistically analyze the data once it was collected. To estimate sample size, Mean 1 – Mean 2 divided by the Standard Deviation of control led to a .81 Cohen's D, effect size (r = .81). By using the statistical power of the t-test for one sample or two related samples, a desired power of .80 estimated the sample size of 14 in order to produce statistical significance.

The researcher recruited 16 subjects to participate in the cycling trials. This was a manageable sample size and the researcher did not report any difficulties in recruitment, scheduling, or communication. Attrition rates were not a problem due to the three separate trials being conducted on the UCO campus in the Kinesiology Lab in the Wellness Center. Subjects were then randomly assigned in order of testing; the moderate dosage (8oz. MONSTER™ Zero Ultra Energy Drink- 70 mg of caffeine, AND 8 oz. of placebo beverage), the high dosage (16 oz. of MONSTER™ Zero Ultra Energy Drink- 140 mg caffeine) and the control (placebo trial). The control trials' placebo consisted of 16oz. of carbonated flavored water. The volume of liquid was kept the same for each trial, independent of contents. The doses were randomly switched for the second and third cycling bout.

Instrumentation

The participants were instructed to abstain from caffeine for 48 hours prior to the proposed testing time at the UCO Wellness Center Lab. Each subject was included in three separate trials. The participants wore comfortable clothing of their choice, and were provided with one bottle of water after each cycling bout for hydration purposes. The caffeine substance, provided by the researcher, was administered using MONSTER™ Energy Zero Ultra Drink. This drink contains 140 mg of caffeine per 16 oz. can, and 70 mg per 8 oz. A stop watch was used by the researcher to collect completion time and the cycle ergometer contained a digital face plate that recorded distance. The subjects were instructed to cycle the 10 mile distance as efficiently as possible; they were given minimal coaching cues from the researcher. The pace and resistance was self-selected to mimic the subject's typical exercise bout. However, the resistance setting the subject chose during the first trial was duplicated for the remaining second and third trial. Rating of Perceived Exertion was obtained at 2 mile checkpoints by the researcher via verbal feedback from the subject. The 6-20 Borg scale was utilized (Appendix J). Volume of oxygen consumption and RER were analyzed using the OxyCon Mobile portable gas analyzer system. Volume of oxygen consumption, HR, and RER were recorded at 2 mile check points throughout the trial. Resting heart rate was recorded at pre- and post-trial. The temperature and humidity of the room were recorded from a monitor on the wall. The subjects completed a 5 minute warm-up, then the 10 mile bout, and then performed an active cool-down of 5 minutes on the cycle ergometers. The subjects then sat in a chair for 2-3 minutes, and then their recovery heart rate was obtained. This was repeated 3 separate times per subject, with one week between trials, as supported by Wiles et al., 2006.

Procedures

The tests were conducted at the UCO Wellness Center, in the Kinesiology Lab. The subjects were recruited via flyers at UCO, and UCO email blasts. All of these methods were approved beforehand by the Internal Review Board (IRB) at UCO (Appendix A). Subjects were male, recreational cyclists between the ages of 18 and 60, with experience in cycling having cycled (indoor/outdoor) for at least one year prior to the testing. Experience was determined by a questionnaire with a series of questions relating to fitness level and type/duration of exercises completed during a 7 day period (Appendix B). The questionnaire contained questions regarding the participants' current caffeine consumption on a typical day/week, and the types/doses of caffeine ingested. Caffeine naïve was defined as 1-2, 5 oz. cups of coffee, or 2-4, 12 oz. carbon containing caffeinated beverages per day (200 mg or less) (Spriet & Graham, 2013). Each dose was randomly distributed per subjects' trial, and the protocol was repeated for three separate trials, 7 days apart, with different doses measuring the same variables. The sample size consisted of 16 participants. The tests were conducted with one participant at a time in the laboratory, and the subject self-selecting their own music (if chosen), pace, and resistance.

The rules, design, risks, dangers, protocol and purpose of the study was explained thoroughly. The participants were informed before the testing trials began (Appendix E), and they were instructed to ask questions to ensure compliance and full understanding. They arrived at the testing location having abstained from caffeine, and vigorous exercise for at least 48 hours prior to the testing. Each dose (140 mg, placebo, & 70 mg) was given to the subject 20 minutes prior to the start of the trials. Participants did not know before-hand which dose was to be administered. The researcher kept dosage volume consistent among

trials.

Participants wore the OxyCon Mobile analyzer harnessed to their back, and the face mask was placed securely upon their face. This recorded their VO_2, HR (via a POLAR heart rate strap) and RER throughout the entire trial in 2 mile increments. The subjects were instructed to cover the distance at a self-selected pace and resistance, and to cycle to the best of their ability. The participant RPE was measured every 2 miles throughout the 10 mile trial. Subjects were allowed to self-select resistance, pace, and music (if they desired). These procedures were repeated for each test session (3 sessions). It was explained to the subjects that as they were approaching each 2 mile increment, they would be asked their RPE level, and this would be recorded. RPE was explained to the participants before the trials began, and was collected via verbal feedback. The Borg scale of perceived exertion (RPE) was utilized (Borg, 1998): The RPE scale is a 15-point single-item scale ranging from 6 to 20 that assesses levels of perceived exertion (Appendix J). The scale ranges from no exertion at all (at 6) to maximal exertion (at 20). The levels of 6-20 often correlate with the person's heart rate; for example, an RPE of 14 might equate to a heart rate of 140 bpm. Subjects were instructed to abstain from caffeine in all forms for 48 hours prior to the cycling trial.

Design and Analysis

The data were summarized by variable, dose, and distance using summary statistics (sample size, mean, standard deviation, and range) and line graphs (mean and standard deviation). There were 16 participants in the study but the analysis for each variable included only those participants who had complete data (sample size range 13-16). A one-factor analysis of variance, repeated measure design, was used to determine significant differences between the means at distances within each dose and between the means of doses

within each distance. For a significant difference, the multiple comparison test, Least Squared Difference, was used to determine which means were significantly different. The format for reporting significant differences uses "-"; for example, 2-4,6 indicates that the mean at 2 miles is significantly different than the means at 4 and 6 miles. In addition to *p*-values, the effect size, partial eta-squared, was reported as a measure of the proportion of variability within a given variable that is explained by either dose or distance.

CHAPTER FOUR: RESULTS

The purpose of this study was to determine the effect that two doses of the caffeinated energy drink (70 mg or 140 mg), or placebo (control) have on time to completion, RPE, HR, RER and VO_2 for a cycling bout of 10 miles. Resting Heart Rate (RHR) was also analyzed at pre- and post-trial for subjects. There were no outliers reported in the current data set, however, there were missing data observations which resulted in varied sample sizes.

Data Analysis

The data were summarized by variable, dose, and distance using summary statistics (sample size, mean, standard deviation, and range) and line graphs (mean and standard deviation). There were 16 participants in the study but the analysis for each variable included only those participants who had complete data (sample size range 13-16). A one-factor analysis of variance, repeated measure design, was used to determine significant differences between the means at distances within each dose and between the means of doses within each distance. For a significant difference, the multiple comparison test, Least Squared Difference, was used to determine which means were significantly different. The format for reporting significant differences uses "-"; for example, 2-4,6 indicates that the mean at 2 miles is significantly different than the means at 4 and 6 miles. In addition to *p*-values, the effect size, partial eta-squared, is reported as a measure of the proportion of variability within a given variable that is explained by either dose or distance.

Data in this study included RPE, VO_2, RER, HR, and Time to completion. These variables were measured at three doses (control, 70 mg, and 140 mg). Rating of perceived exertion, VO_2, RER, and HR were measured at five distances (2, 4, 6, 8, and 10 miles). Resting HR was measured pre- and post-trial and time to completion was measured once.

Data was analyzed using SPSS 21.0 (SPSS Inc., Chicago, IL) and Excel. P-values less than .05 were considered significant. Traditional cut points for effect size are: small, 0 – 0.3; medium, 0.3 – 0.5; and large, greater than 0.5.

Results

Summary statistics for demographics are shown in Table 1. The average age was 30.0 and ranged from 23 to 51 years. Biking experience ranged from1 to 20 years (average 4.97 years) and was inversely correlated with body mass index (BMI) (r=-0.690, p = .003). The largest variability between subjects was caffeine consumption which ranged from 0 (2 subjects) to 800 mg. None of the demographic variables were significantly correlated with completion times of the three doses. The average height was 71.3 inches with a range of 66.5 to 76.0 inches. Subjects had an average weight of 85.7 kg, with a range of 75.0 kg to 97.7 kg. The mean daily consumption of caffeine per subject was 168.6 mg.

Results of the statistical analyses of the differences between means for the doses at each distance and the distances within each dose are shown in Tables 2-7. For the variables RPE, VO_2, and HR the means between distances (2, 4, 6, 8, & 10 miles) were significantly different ($p < .001$) within each dose. For RER, only for the control group were the means significantly different (p = .009) between 2-4-6-8-10 miles. For the variables RPE, RER, and HR the means between doses were not significantly different. For VO_2, only at 2 miles were the Control means between doses significantly different (p = .033). Effect size was highly correlated with the p-values (r=-0.789, $p < .001$) for all variables.

RPE

Sample size consisted of all 16 subjects. The means at each distance within each of the doses increased linearly (Table 2; Figure 1). With the exception of 2 miles, means for the

control trial were slightly higher than for 70 mg dose and 140 mg dose. For the control trial the means increased from 10.4 at 2 miles to 14.4 at 10 miles. The 70 mg dose means increased from 10.3 at 2 miles to 14.1 at 10 miles. Similarly, the 140 mg dose means increased from 10.6 at 2 miles to 14.1 at 10 miles

VO_2

For VO_2 (n = 14), the means at each distance for 70 mg were lower than those for the control and 140 mg. At 2 miles, the mean for 70 mg was significantly lower (p = .033) and at 6 miles, it was approaching significance (p = .065). The means for 70 mg increased linearly from 2 to 10 miles whereas the means for the control and 140 mg peaked slightly at 6 miles and again at 10 miles (Figure 2). Similar patterns for significant differences between means occurred within the control and 140 mg doses; means for 2 and 4 miles were significantly different than means for 6, 8, and 10 miles (Table 3; Figure 2).

RER

Sample size consisted of 14 subjects. The means increased linearly only for the control trial for the 2-6 mile checkpoints, but a decrease in means was seen from the 6 mile point to the 8 and then to the 10 mile mark (Table 4; Figure 3). The 140 mg and 70 mg trials both saw a series of increases and decreases in means throughout the trial. RER for the control group peaked at 6 miles and was significant (p = .009) between miles 2-6, 4-6, 6-8, and 6-10.

HR

Sample size consisted of 15 participants. The means also increased linearly across distance for each dose. Significance was found (p < .001) for all means within doses except

the mile 6-8 means in the control group (Table 5; Figure 4). Although not significant, mean for 140 mg group were slightly higher than 70 mg and control groups.

TIME

Sample size consisted of 16 subjects. There was no statistical significance reported (p = .237) between doses (Table 6; Figure 5). However, the fastest mean time occurred in the control trial and the slowest mean times were observed with the 140 mg dose group.

Resting Heart Rate

Sample size consisted of 13 subjects. RHR was analyzed to determine changes pre- and post-trial and between groups. The range was greatest at pre-trial with the control group (54-90 bpm), and at post-trial with the 140 mg group (60-120 bpm). Significance between doses was not found (p = .547); however, within doses significance was found (p = .001 for control; p < .001 for the 70 mg dose; and p = .004 for the 140 mg dose) (Table 7; Figure 6).

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CHAPTER FIVE: DISCUSSION

The purpose of this study was to determine the effect of two doses of a caffeinated energy drink (70 mg or 140 mg), or placebo had on performance time, RPE, HR, RER and VO_2 for a cycling bout of 10 miles. The researcher hypothesized that the higher dose of the caffeinated energy drink (140 mg) would elicit a significant difference in performance time, RPE, VO_2, RER, and HR at a given intensity; when compared to the moderate dose (70 mg), and placebo. A second hypothesis stated that the moderate caffeine dose (70 mg) would elicit a significant difference in performance time, RPE, RER, VO_2, and HR at a given intensity; while the consumption of placebo will not produce the afore mentioned results. Conversely, the null hypothesis stated that there would be no significant difference in performance time, RER, RPE, VO_2, and HR for the high, moderate, or placebo group.

Results from this study showed that an energy drink delivered in three different doses did not produce any performance enhancing benefits, and the null hypothesis was accepted. However, there were some noticeable trends in the data and significance was found for certain variables and distance markers in the trials. Although there were not any significant results found related to the research question, there was still meaningful data revealed in the results of this study.

Recreational cyclists and a popular energy drink were used to explore the potential performance enhancing effects of the caffeinated energy substance. The average cup of coffee contains 100-120 mg of caffeine; therefore reaching the heavy dose would only take about 4 cups of coffee (Spriet & Graham, 2013). The present study utilized three doses: 140 mg, 70 mg, and a placebo (control) substance. Due to unrefined study protocol in the beginning of data collection, the researcher cannot say that the doses were truly randomized.

Madsen et al., 1996, conducted a study with similar characteristics used in the current study: similar variables, trials, endurance protocol, and variable interaction with placebo. Significant differences were not observed for the performance time variable; however, it is vital to state that the placebo response is reflected via the variable Trial times: Glucose (Trial G) only (160.1 +/- 4.1 min), BCAA + Glucose (Trial B) (159.8 +/- 3.7 min), and in Placebo (Trial P) only (159.8 +/- 3.7 min). The placebo group, while not significant, yielded the fastest mean times. The present study found the fastest 10 mile performance to completion times in the placebo trial (26.32 minutes). The 140 mg dose elicited a mean time of 27.17 minutes and the 70 mg dose elicited a mean time of 26.91 minutes. The researcher believes this primarily happened due to subject familiarization of the study protocol. By the third trial the subjects saw a decrease in performance time regardless of dosage ingested.

Ivy et al., (2009), utilized 6 female and 6 male elite, competitive cyclists and examined the variables of RPE and performance time. Rate of perceived exertion was analyzed using a nonparametric Kruskal-Wallis test, and time was analyzed using a paired *t* test. The researchers found that performance improved with energy drink when compared with placebo (3,690 ± 64 seconds (s) vs. 3,874 ± 93 s ($p < .01$). There was no difference found in RPE between trials. The current study found significance within each dose, but not between the dose groups. This refers to the means being significantly different from different points in the trial (for each dose), for example, from mile 2 to mile 8 in the placebo group, the RPE went from 10.4 to 13.8. This is to be expected with physical activity though; as time progresses and expenditure and exertion increase, RPE typically increases.

The present study found at 2 miles, the mean VO_2 for 70 mg was significantly lower ($p = .033$) than 140 mg and placebo, and at 6 miles, it was approaching significance

(p = .065). Volume of oxygen consumption also reported a large effect size of 0.517 for the 70 mg dose which shows a high trend. The researcher noted that perhaps a slight dose of caffeine (70 mg) as opposed to a larger dose (140 mg) may elicit an improved VO_2 at earlier distances at lower intensities. Similar patterns for significant differences between means (increasing linearly with distance) occurred within the control and 140 mg doses ($p < .001$); means for 2 and 4 miles were significantly different than means for 6, 8, and 10 miles (Table 3). Hogervorst, et al., (2008) utilized caffeine to determine if physical performance (HR and VO_2) was improved for an exhaustive exercise bout. The duration of exercise completed was 2.5 hours at 60% of the cyclists' respective VO_2 max. The researchers did not find differences in the relative intensity (% VO_2 max) between trials (p = .15); similar to the VO_2 results of the current study (Table 3).

The present study did not achieve statistical significance between doses for the HR variable either, but within trials significance was found ($p < .001$), except the placebo doses between miles 6 and 8. The effect size per dose (placebo: r= 0.662, 70 mg: r= 0.713, and 140 mg: r= 0.759) show an increasing HR trend independent of the dose. Hogervorst, et al., (2008) utilized twenty-four subjects, compared to the present study's sample size of 16. Average daily caffeine consumption of Hogervorst, et al., (2008) subjects consisted of 170 mg; whereas, the present study's participants reported an average daily consumption of 168.62 mg. There were no significant differences in mean HR reported between trials (p = .14). In the present study HR was expected to increase as distance increased as the trend indicated (Figure 4).

Respiratory exchange ratio was reported by Ivy et al., 2009, from minutes 5-10, 30-35, and 40-45, but was only utilized to establish VO_2 max only during the last three minutes

of the cycling bout. Respiratory exchange ratio was used to establish a VO_2 max when it reached a value greater than 1.10 (Appendix I). In the present study RER was measured throughout the 10 mile cycling trials, but was recorded only at the 2, 4, 6, 8, and 10 mile points. Respiratory exchange ratio was found significantly different (p = .009) for the control group trial (placebo), but not for the 140 mg and 70 mg doses. During the control trials RER was shown to increase up until mile 6 then decrease to mile 10 (Figure 3). This could be due to the riders expelling their greatest effort during the beginning of the trial, in the absence of caffeine, and then having to taper off in order to finish the 10 miles efficiently (see Table 4). The 140 mg and 70 mg dosed trials both saw an increase and decrease in the means across the 10 mile distance (Figure 3), which also shows an increase in effort and a decrease in effort (i.e. potential pacing). Respiratory exchange ratio will physiologically increase and decrease as effort and energy levels fluctuate.

Strengths

One of the main strength of this study is the lab equipment the researcher had access to. The OxyCon Mobile unit, manufactured by Care Fusion™, which UCO possesses, is not a common piece of equipment. It is a portable, highly expensive, gas analyzer, and can be worn by the subject with ease. The researcher was trained on the equipment, and felt comfortable with her knowledge base in moving forward with the study.

The researcher also experienced minor scheduling difficulties and only had one participant who was unable to complete all three trials. There were no unexpected issues with subjects, and all subjects were on time for their data collection appointments. The researcher only had 3 potential subjects report to the initial informational meeting, but received an overwhelming email response from the mass email that was distributed to male

students, faculty, and staff at UCO.

Another observed strength of the study was the willingness of the participants to push themselves to expel their best effort each time they performed a 10 mile cycling trial. They also seemed quite competitive with themselves and made many comments about their performance on previous trials compared to the current trial they were completing. The subjects all possessed an interest in the study and also how their performance for each trial varied. Questions were asked of the researcher reflecting critical thinking regarding the study protocol and components that the general population one would assume not ask.

Limitations

Multiple limitations exist in this study. A small sample size (n = 16) could be viewed as a limitation for this study, since the researcher was examining and analyzing many variables. However, Doherty, Smith, Hughes, and Davison (2004) only utilized 11 male cyclists and Wiles et al. (2006) utilized 8 male subjects. Many cycling studies do not incorporate large sample sizes. This could be due to many factors such as: exertion required of the protocol, time commitments, having to abstain from caffeine in certain instances, abstaining from vigorous activity before a trial, and few subjects meeting the inclusion criteria for studies.

Missing data for certain variables led to different sample sizes. Rating of perceived exertion (n = 16), VO_2 (n = 14), RER (n = 14), HR (n = 15), Time (n = 16), and RHR (n = 13) for a range of 13-16 participants. For VO_2, RER, and HR, there was missing data collected due to the mobile gas analyzer malfunctioning in some way. In these few instances, the researcher simply moved on with data collection and recorded what available data she could. Resting heart rate had a sample size of 13 due to the researcher not allowing for time

to collect this variable at the beginning and/or end of 3 out of the 47 trials.

One subject expressed increasing his carbohydrates the night before one of the trials, which the researcher could speculate on a performance enhancement due to that. Also, the overall nutrition, hydration, and rest levels of the subjects the researcher did not control. The varying fitness levels of the participants could have also led to the present results, and honesty about abstaining from caffeine could have also been an issue. The stationary bicycle does not mimic a rode type or mountain style bicycle, and it was expressed by the subjects the discomfort they were feeling due to the seat design.

Another limitation observed could be the length of the protocol. The researcher initially asked subjects to allow for 60-90 minutes for each trial, but the process was found to only take between 50-65 minutes from start to finish. This is still quite a time commitment to ask of subjects, keeping in mind it was repeated for three separate trials. The researcher experienced overall pleasant attitudes from subjects, and no complaints were made of the time commitment.

The researcher had two participants that had a unilateral tibial amputation. These gentlemen were avid athletes and this physical disability was not perceived by the researcher to negatively impact the study. They were able to strap both of their feet to the pedals on the stationary ergometer just like the other participants.

Future Directions

The researcher notes that utilizing a larger dose of caffeine would be a new direction to take this study that may elicit significance results between dosage groups. The doses utilized in the present study, placebo, 70 mg or 140 mg caffeine, would amount to .09 – 1.86 mg/kg body weight in an average weight rider of 75 kg. This is not a very large dose

compared to the use of caffeine at 6 mg/kg utilized by Irwin et al., (2011), but was selected to represent typical doses.

Utilizing competitive cyclists such as Ivy et al., (2009), could potentially produce more consistent results in future trials. The present study emphasized recreational riders and the typical dose consumed before a recreational cycling bout. However, the subjects ranged from triathletes and mountain bikers, to road racers and the occasional rider. The current study utilized cyclists with a range of experience consisting of one to twenty years. Upon completion of this study, the researcher noted that utilizing subjects with similar backgrounds and experience in cycling might prove to be beneficial in the future. Homogenous fitness levels (as defined by a certain VO_2max), similar body composition, and the use of cycling shoes that clip into the bike's pedals could enhance and provide for more accurate results.

Familiarization trials would be an effective tool to utilize in the future. The present study consisted of three separate trials, and the researcher documented that by the third trial (regardless of dosage) that the subjects had faster times. This could be due to becoming familiar with the study protocol and knowing how the subjects could pace themselves more efficiently. Astorino, Cottrell, Lozano, Aburto-Pratt, and Duhon (2012) researched the repeatability of caffeine's ergogenic effects on cycling performance. A test-retest design was employed, with nine endurance-trained male cyclists, participating in five separate laboratory sessions. Practice tests were taken on days one and two, with actual trials on days three through five. Caffeine was shown to significantly increase performance time (p = .02), when compared to placebo. The repeatability across the three performance sessions showed increases of 1.6% and 1.9% in time improvement, respectively. The practice sessions, or familiarization trials, showed repeatable, accurate results.

Another recommendation for future research is to have the participants keep a nutritional dietary log for 48 hours prior to each testing session, and to have the subjects keep this pattern of intake consistent for each subsequent trial.

Practical Applications

Recreational cyclists that consume energy drinks in typical quantities may not be receiving the actual benefits they perceive to attain from the proposed ergogenic energy substance. The present study did not find statistical significance which translates to performance enhancing benefits, with a 10 mile cycling bout. These drinks are costly and if they are perceived to provide performance enhancing benefits then the population will continue to purchase and ingest them. The researcher did find significance among certain variables at different points throughout the 10 mile cycling trials, for the variables RPE, VO_2, and HR the means between distances (2, 4, 6, 8, & 10 miles) were significantly different ($p <$ .001) within each group. For RER, only for the control group were the means significantly different ($p = .009$). For the variables RPE, RER, and HR the means between groups were not significantly different. For VO_2, only at 2 miles were the means between groups significantly different ($p = .033$). Effect size was highly correlated with the p-values ($r = -0.789$, $p < .001$). The researcher cannot say that this type of energy substance elicits performance enhancing benefits for the recreational cycling population.

Other energy substances are readily available such as: coffee, different types of tea, caffeinated powders and drinks. For recreational cyclists, there is no regulated limit on intake, such as the limits set by the IOC (12 micrograms (µg)/ml) and for the NCAA (15µg/ml) (Spriet & Graham, 2013). One microgram equates to 0.001 milligrams. Cyclists may have their own personal methods and supplements that they perceive to provide

performance enhancing benefits, and the researcher recommends that research be examined to check these protocols for safety and safe levels of supplementation.

Conclusions

It can be concluded that the energy drink utilized by the researcher, delivered in 2 different typical doses, and placebo substance, does not elicit performance enhancing benefits in a sample size of 16 male participants cycling 10 miles on an indoor stationary ergometer. The performance enhancing variables measured were: VO_2, RER, RPE, Time, and HR. It is important for recreational cyclists to listen to his or her body and fuel adequately depending on his or her goals and consciously choose to ingest typical amounts of energy drinks for reasons other than performance enhancement.

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Tables

Table 1

Summary Statistics for Subject Demographics

		Age	Height	Weight	Caffeine	Experience	BMI
	Mean	30.0	71.30	85.706	168.625	4.97	26.172
n=16	SD	8.1	2.73	6.945	192.054	5.11	1.992
	Range	23-51	66.5-76	75.0-97.72	0-800	1-20	23.15-29.22

Note. Age reported in years; height in inches; weight in kilograms; caffeine in milligrams, experience reported in years, body mass index (BMI) reported as weight in kilograms divided by height in meters squared. SD = standard deviation.

Table 2

Summary Statistics for RPE

DOSE (n=16)		Distance (miles) 2	4	6	8	10	p-value Sig Diff	ES
CONTROL	Mean	10.4	11.7	12.9	13.8	14.4	*<0.001	0.717
	SD	2.2	1.6	1.2	1.4	1.8	ALL	
	Range	6-14	9-15	11-15	12-16	12-18		
70 mg	Mean	10.3	11.4	12.6	13.6	14.1	*<0.001	0.683
	SD	2.0	1.5	1.1	1.4	1.6	ALL	
	Range	6-13	8-14	11-15	12-16	12-17		
140 mg	Mean	10.6	11.5	12.5	13.4	14.1	*<0.001	0.681
	SD	1.7	1.4	1.5	1.5	2.1	ALL	
	Range	7-12	8-13	9-15	11-17	12-19		
	p-value	0.751	0.703	0.293	0.335	0.448		
	ES	0.019	0.023	0.079	0.070	0.052		

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Table 3

Summary Statistics for VO_2

DOSE (n=14)		Distance (miles) 2	4	6	8	10	p-value Sig Diff	ES
CONTROL	Mean	21.65	22.10	24.81	23.88	25.05	*<0.001	0.335
	SD	4.87	5.73	5.78	5.96	5.93	2-6,8,10;	
	Range	12.9-29.1	9.6-29.3	12.4-33	13.5-35	14.6-37.4	4-6,8,10	
70 mg	Mean	19.29	21.36	21.89	23.56	23.64	*<0.001	0.517
	SD	4.71	5.17	5.06	5.64	6.28	2-4,6,8,10;	
	Range	10.5-28.2	10.1-28.5	12.3-30.8	13.5-33	10.3-31	4-8,10; 6-8,10	
140 mg	Mean	21.71	22.20	24.50	24.19	25.57	*<0.001	0.355
	SD	5.78	5.71	6.51	6.98	8.00	2-6,8,10;	
	Range	11-30.3	8.4-30.3	10.9-34.6	7.7-35	5.9-36.2	4-6,8,10	
	p-value	*0.033 140-Cont,70	0.708	0.065	0.907	0.351		
	ES	0.231	0.026	0.189	0.007	0.073		

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Table 4

Summary Statistics for RER

DOSE (n=14)		Distance (miles) 2	4	6	8	10	p-value Sig Diff	ES
CONTROL	Mean	1.060	1.076	1.106	1.081	1.069	*0.009 2-6; 4-6; 6-8,10	0.226
	SD	0.067	0.058	0.068	0.075	0.079		
	Range	0.93-1.15	1-1.18	1-1.23	0.97-1.26	0.96-1.26		
70 mg	Mean	1.064	1.057	1.073	1.078	1.074	0.532	0.050
	SD	0.084	0.061	0.060	0.075	0.087		
	Range	0.94-1.25	0.96-1.16	0.99-1.17	0.93-1.22	0.92-1.21		
140 mg	Mean	1.061	1.076	1.089	1.074	1.084	0.466	0.065
	SD	0.063	0.049	0.058	0.064	0.081		
	Range	0.97-1.19	0.98-1.14	0.97-1.18	0.95-1.16	0.95-1.24		
	p-value	0.969	0.425	0.152	0.941	0.812		
	ES	0.002	0.064	0.135	0.005	0.016		

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Table 5

Summary Statistics for HR

DOSE (n=15)		Distance (miles) 2	4	6	8	10	p-value Sig Diff	ES
CONTROL	Mean	124.5	132.6	139.9	142.9	147.3	*<0.001 ALL except 6-8	0.662
	SD	16.9	19.5	22.2	24.1	23.6		
	Range	90-152	96-156	99-174	99-180	107-186		
70 mg	Mean	122.5	130.9	136.3	141.7	146.1	*<0.001 ALL	0.713
	SD	18.7	21.8	25.4	26.8	29.7		
	Range	93-147	97-158	101-169	99-173	104-180		
140 mg	Mean	124.9	133.6	139.9	145.7	153.0	*<0.001 ALL	0.759
	SD	22.0	22.1	24.9	23.5	23.0		
	Range	86-152	93-160	87-168	103-176	105-188		
	p-value	0.676	0.670	0.635	0.507	0.120		
	ES	0.028	0.028	0.032	0.047	0.141		

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Table 6

Summary Statistics for TIME

DOSE (n=15)		Distance (miles) 2	4	6	8	10
CONTROL	Mean					26.321
	SD					2.781
	Range					21.01-30.33
70 mg	Mean					26.910
	SD					3.678
	Range					19.48-32.54
140 mg	Mean					27.173
	SD					2.480
	Range					22.51-31.39
	p-value					0.273
	ES					0.089

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Table 7

Summary Statistics for Resting HR

DOSE (n=13)		Pre	Post	p-value Sig Diff	ES
CONTROL	Mean	72.9	86.6	*0.001	0.641
	SD	10.9	11.0		
	Range	54-90	72-108		
70 mg	Mean	69.8	87.5	*<0.001	0.682
	SD	11.4	12.3		
	Range	54-85	66-108		
140 mg	Mean	72.5	87.2	*0.004	0.511
	SD	9.4	15.3		
	Range	58-88	60-120		
	p-value	0.547	0.963		
	ES	0.049	0.003		

Note. Significant p-values are indicated with an asterisk (*). SD = standard deviation, ES = effect size.

Figures

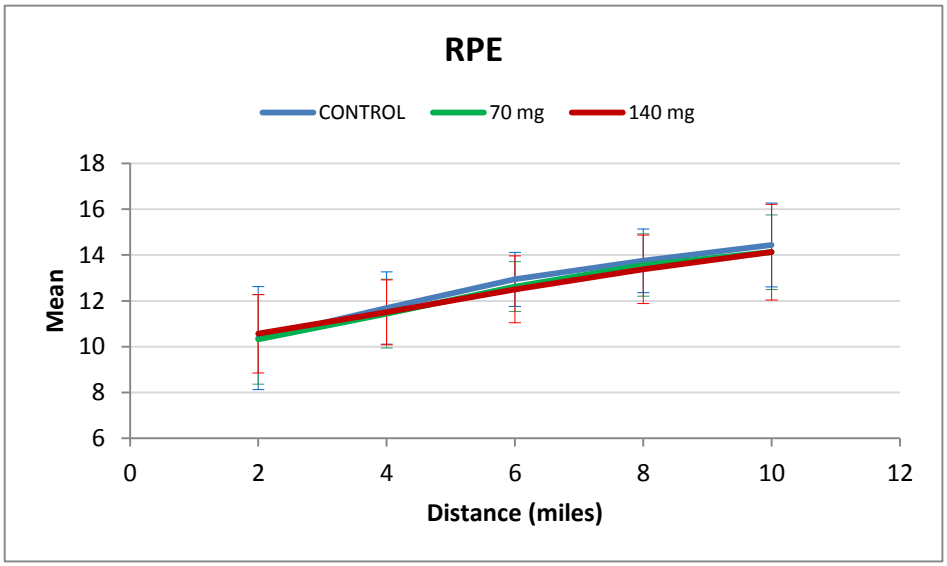

Figure 1. Summary Statistics for RPE shown at 2 mile increments across the 10 mile cycling trials color-coded by dose.

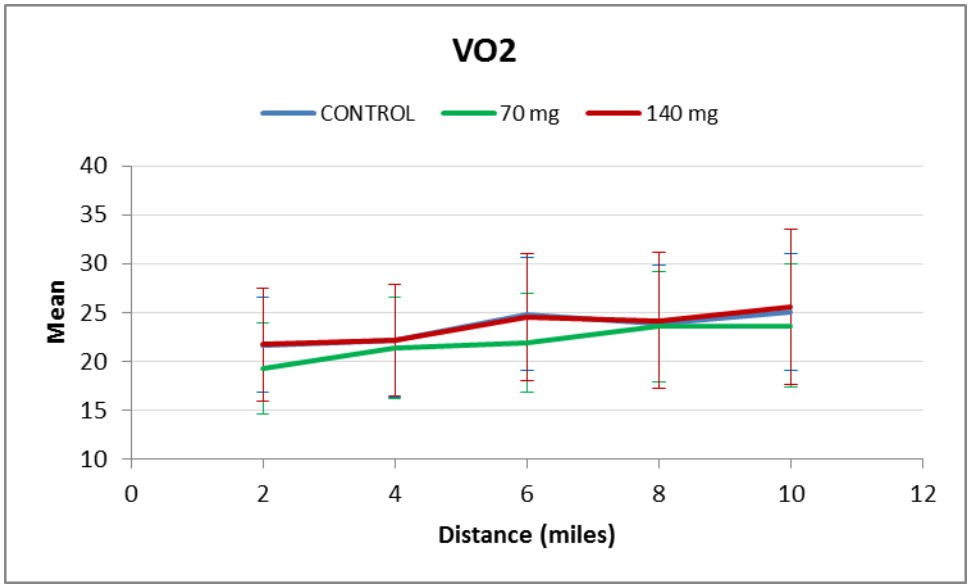

Figure 2. Summary Statistics for VO_2 shown at 2 mile increments across the 10 mile cycling trials color-coded by dose.

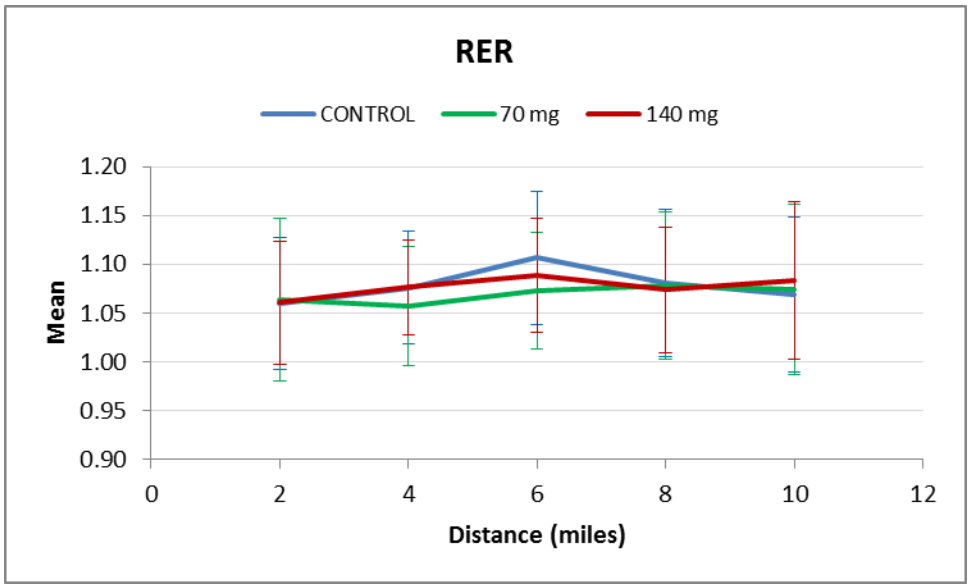

Figure 3. Summary Statistics for RER shown at 2 mile increments across the 10 mile cycling trials color-coded by dose.

Figure 4. Summary Statistics for HR shown at 2 mile increments across the 10 mile cycling trials as color-coded by dose.

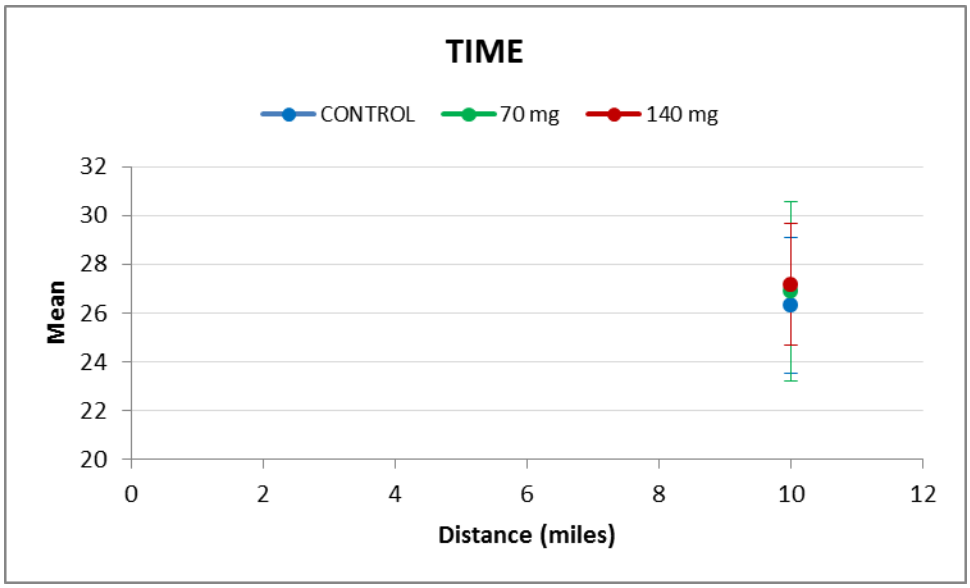

Figure 5. Summary Statistics for Completion Time of the 10 mile cycling trials, shown color coded by dose. Control = 26.321 minutes; 70 mg = 26.910 minutes; 140 mg = 27.173 minutes.

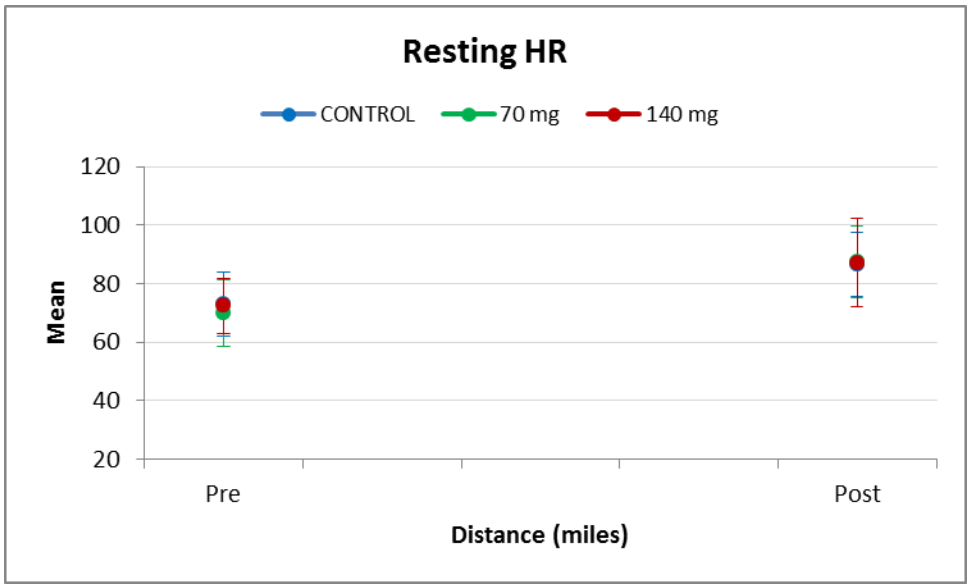

Figure 6. Summary Statistics for Resting HR at pre- and post-trial color-coded by dose.

Resting heart rate pre: Control = 72.9; 70 mg = 69.8; 140 mg = 72.5

Resting heart rate post: Control = 86.6; 70 mg = 87.5; 140 mg = 87.2

APPENDIX A:

Institutional Review Board Approval Letter

December 18, 2013 IRB Application #: 13196

Proposal Title: The Impacts of a Caffeinated Energy Drink on Rating of Perceived Exertion, Completion Time, Heart Rate, Volume of Oxygen Consumption, and Respiratory Exchange Ratio During a 10-Mile Cycle Ergometer Trial.

Type of Review: Initial-Expedited

Investigators:

Ms. Nicole Doyle

Dr. Darla Fent
Department of Kinesiology and Health Studies
College of Education and Professional Studies
Campus Box 189
University of Central Oklahoma
Edmond, OK 73034

Dear Ms. Doyle and Dr. Fent:

Re: Application for IRB Review of Research Involving Human Subjects

We have received your materials for your application. The UCO IRB has determined that the above named application is APPROVED BY EXPEDITED REVIEW. The Board has provided expedited review under 45 CFR 46.110, for research involving no more that minimal risk and research category 7.

Date of Approval: 12/18/2013

Date of Approval Expiration: 12/17/2014

If applicable, informed consent (and HIPAA authorization) must be obtained from subjects or their legally authorized representatives and documented prior to research involvement. A stamped, approved copy of the informed consent form will be sent to you via campus mail. The IRB-approved consent form and process must be used. While this project is approved for the period noted above, any modification to the procedures and/or consent form must be approved prior to incorporation into the study. A written request is needed to initiate the amendment process. You will be contacted in writing prior to the approval expiration to determine if a continuing review is needed, which must be obtained before the anniversary date. Notification of the completion of the project must be sent to the IRB office in writing and all records must be retained and available for audit for at least 3 years after the research has ended.

It is the responsibility of the investigators to promptly report to the IRB any serious or unexpected adverse events or unanticipated problems that may be a risk to the subjects.

On behalf of the UCO IRB, I wish you the best of luck with your research project. If our office can be of any further assistance, please do not hesitate to contact us.

Sincerely,

Melissa Powers, Ph.D.
Assistant to the Chair, Institutional Review Board
Campus Box 159
University of Central Oklahoma
Edmond, OK 73034
405-974-5497
irb@uco.edu

APPENDIX B:

QUESTIONNAIRE FOR PROPOSED SUBJECTS AND PARTICIPANT INFORMATION FORM

Questionnaire for Proposed Subjects

1. What is your age, height, and weight?
2. What is your experience with indoor/outdoor cycling (how long have you participated)?
3. What is your current weekly physical activity consisting of?
4. What is your daily caffeine intake consisting of? (type and dosage; Average cup of coffee = 120 mg)
5. Do using typical doses of caffeine produce any feelings of anxiety following intake?
6. Is there any reason you could not participate in this study (perform a 10 mile cycling bout on an indoor stationary cycle ergometer)?

Participant Information Form

Please fill out the following contact information.

Name: _____ Age: _____

Home Phone: _____ Cell Phone: _____

Email: _____

APPENDIX C:

PHYSICAL ACTIVY READINESS QUESTIONNAIRE (PAR-Q)

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

→ **DELAY BECOMING MUCH MORE ACTIVE:**

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME _____

SIGNATURE _____ DATE _____

SIGNATURE OF PARENT or GUARDIAN (for participants under the age of majority) _____ WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

CSEP | SCPE

APPENDIX D:

TIMELINE OF THESIS

Timeline of Thesis

Tasks	Sept '13	Oct '13	Nov '13	Dec '13	Jan '14	Feb '14	Mar '14	Apr '14	May '14	June '14
Proposal to Comm. Members			X							
IRB Approval			X	X						
Recruit participants				X	X					
Administer tests					X	X				
Data Analysis						X	X	X		
Defense								X		
Graduation									X	

APPENDIX E:

INFORMED CONSENT FORM

UNIVERSITY OF CENTRAL OKLAHOMA

INFORMED CONSENT FORM

Research Project Title: The Impacts of a Caffeinated Energy Drink on Rating of Perceived Exertion, Completion Time, Heart Rate, Volume of Oxygen Consumption, and Respiratory Exchange Ratio on a 10-Mile Cycle Ergometer Trial

Researcher (s): Nicole Doyle

A. Purpose of this research: The purpose of this research is to determine the potential effects a popular energy drink (administered in 2 doses, 70 mg and 140 mg), or placebo, may have on RPE, completion time, heart rate, RER and VO_2; for a stationary, indoor cycle ergometer session of 10 miles.

B. Procedures/treatments involved: Subjects will be instructed to abstain from caffeine containing substances at least 48 hours prior the trial start. Upon arrival subjects will ingest their specific dose of MONSTER Ultra Zero Energy Drink of 70 mg, 140 mg, or placebo substance. They will wait approximately 30 minutes, perform a 5 minute warm-up of self-selected pace and resistance, then begin the 10 mile cycling trial. The subject will be wearing the OxyCon Mobile portable VO2 gas collection analyzer, which consists of a breathing mask and harness type backpack system. Their VO2, RER, RPE, heart rate, and completion time will be recorded. The variables of heart rate, RER, VO2, and RPE will be recorded at 2 mile increments. The subjects will be instructed to perform the 10 mile test to the best of their ability, with the option of listening to music. Subjects will be provided with one, 16.9 ounce (oz) bottle of water. Subjects will perform a 5 minute active cool-down on the cycle ergometer, and then will be allowed to leave the facility after sitting for

approximately 10 minutes. After signing this form you will be asked to fill out the Physical Activity Readiness Questionnaire (PAR-Q) that asks questions regarding your ability to participate in physical activity, the questionnaire for proposed subjects, and the participant information form required for the study.

C. Expected length of participation: Three testing sessions that last approximately 60-90 minutes per session. The trials should be completed over a 3-week time frame.

D. Potential benefits: Knowledge of average VO_2 for the 10 mile duration, and how caffeine in the form of a popular energy drink may affect your cycling performance time, VO_2, RER, RPE, and heart rate.

E. Potential risks or discomforts: Potential discomforts associated with participation in this study may include muscle soreness and muscle fatigue. In addition, caffeine related symptoms may arise, such as: jitters, anxiety, and/or a light to moderate headache. By signing this form, you indicate that you understand the UCO is not liable for any injuries that may occur during your participation in this study.

F. Medical/mental health contact information (if required): Medical assistance is located at The Mercy Health Clinic. The Clinic is located on the first floor of the University Wellness Center and is open from 8:00-5:00, Monday through Friday; the telephone number is (405) 974-2317. The University Counseling Center is located in the Nigh University Center, Suite 402, and is open 8:00-5:00, Monday through Friday. They can be reached at (405) 974-2215.

G. Contact information for researchers: For questions about the study or an injury related to the study, please contact the principal investigator.

Nicole Doyle
(918) 698-7564
ndoyle@uco.edu

Dr. Darla Fent
(405) 974-3599
dfent@uco.edu

H. Contact information for UCO IRB: For questions about your rights as a research participant, please contact:

Dr. Richard Sneed
(405) 974-5479
irb@uco.edu

I. Explanation of confidentiality and privacy: All data collected will be labeled with a code number that will not be identifiable to you. Information regarding your participation will be kept completely confidential and stored in a locked file cabinet in Wantland Hall room 102. The electronic information will be kept on a flash drive and kept by the primary investigator (Nicole Doyle). Both types of data will be kept secure for three years then destroyed. In no way will the subject's data be tied to their name. This study may result in scientific presentations and publications; however, your identity will be kept confidential.

J. Assurance of voluntary participation: Your participation is entirely voluntary for this study and you are free to withdraw from the study at any time without penalty.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am at least 18 years old. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Research Subject's Name: _____

Signature: _____ Date _____

APPENDIX F:

DATA COLLECTION SHEET

Code: _____

Data Collection Sheet

Cycling Performance- Distance 10 miles

	Date:_____ *70 mg DOSE*	*Date:_____* *140 mg DOSE*	*Date:_____* *PLACEBO*
Time			
RPE 2mi markers	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:___ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:_____ 16.09km:_____
VO_2 (OxyCon) 2mi markers	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:_____ 16.09km:_____
RER (OxyCon) 2mi markers	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____
Heart Rate (OxyCon) 2mi markers	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:____ 16.09km:_____	3.21km:_____ 6.43km:_____ 9.65km:_____12.87km:_____ 16.09km:_____
RHR			

Dosage:	**Dosage:**	**Dosage:**
Height:	**Height:**	**Height:**
Weight:	**Weight:**	**Weight:**
Age:	**Age:**	**Age:**

APPENDIX G:

EMAIL/FLYER EXAMPLE

A Research Study for Men ages 18-60

We need YOU for an exciting research study!

UCO Master's student Nicole Doyle is looking for people interested in joining this interactive research study! This study has been designed as part of the requirements for a Master's Thesis and has been IRB approved. It is a safe, supervised study led by Nicole Doyle from the University of Central Oklahoma's Department of Kinesiology and Health Studies. This study will utilize a popular energy drink and explore the possible cycling performance enhancing benefits.

- Recreational cycling experience (indoor/outdoor) >/= 1 year!
- Energy Drink provided!
- 3 separate cycling bouts, testing performance time, heart rate, respiratory exchange ratio, volume of oxygen consumption, & rating of perceived exertion!
- The testing is conducted at the UCO Wellness Center.

Location: UCO Wellness Center, Room 125

Days: To Be Determined

Time: 60-90 minutes of your day, 3 separate trials!

To learn more, come to an Informational Meeting on

Date: **_January 22nd, 2014_**
Time: **_5:30pm_____**
Location: **UCO Wellness Center, Room 127**

For more information, please plan to attend our information meeting or contact:
Nicole Doyle, (918)698-7564, ndoyle@uco.edu

NOTE: The cycling study is a research study being conducted by Nicole Doyle from the University of Central Oklahoma to determine if a popular energy drink has an effect on performance time & RPE for an extended indoor cycle ride. Your participation in the study may involve minimal risk. In addition, all participants must meet qualifications for the study in order to participate. Potential risks and qualifications for the study will be discussed at the informational meeting.

APPENDIX H:

LIST OF COMMON CAFFEINE CONTAINING FOODS/DRINKS/MEDICATIONS

Taken from the Center for Science in the Public Interest

Coffees	Serving Size	Caffeine (mg)
Dunkin' Donuts Coffee with Turbo Shot	large, 20 fl. oz.	436
Starbucks Coffee	venti, 20 fl. oz.	415
Starbucks Coffee	grande, 16 fl. oz.	330
Panera Frozen Mocha	16.5 fl. oz.	267
Starbucks Coffee	tall, 12 fl. oz.	260
Starbucks Caffè Americano	grande, 16 fl. oz.	225
Panera Coffee	regular, 16.8 fl. oz.	189
Starbucks Espresso Frappuccino	venti, 24 fl. oz.	185
Dunkin' Donuts Coffee	medium, 14 fl. oz.	178
Starbucks Caffè Mocha	grande, 16 fl. oz.	175
Starbucks Iced Coffee	grande, 16 fl. oz.	165
Maxwell House Ground Coffee—100% Colombian, Dark Roast, Master Blend, or Original Roast	2 Tbs., makes 12 fl. oz.	100-160
Dunkin' Donuts Cappuccino	large, 20 fl. oz.	151
Starbucks—Caffè Latte, Cappuccino, or Caramel Macchiato	grande, 16 fl. oz.	150
Starbucks Espresso	doppio, 2 fl. oz.	150
Keurig Coffee K-Cup, all varieties	1 cup, makes 8 fl. oz.	75-150
Folgers Classic Roast Instant Coffee	2 tsp., makes 12 fl. oz.	148
Starbucks Doubleshot Energy Coffee, can	15 fl. oz.	146
Starbucks Mocha Frappuccino	venti, 24 fl. oz.	140
Starbucks VIA House Blend Instant Coffee	1 packet, makes 8 fl. oz.	135
McDonald's Coffee	large, 16 fl. oz.	133
Maxwell House International Café, all flavors	2⅔ Tbs., makes 12-16 fl. oz.	40-130
Seattle's Best Coffee—Iced Latte or Iced Mocha, can	9.5 fl. oz.	90
Starbucks Frappuccino Coffee, bottle	9.5 fl. oz.	90
International Delight Iced Coffee	8 fl. oz.	76
Maxwell House Lite Ground	2 Tbs., makes 12 fl. oz.	50-70

Coffee		
Dunkin' Donuts, Panera, or Starbucks Decaf Coffee	16 fl. oz.	15-25
Maxwell House Decaf Ground Coffee	2 Tbs., makes 12 fl. oz.	2-10
Teas	**Serving Size**	**Caffeine (mg)**
Starbucks Tazo Awake—Brewed Tea or Tea Latte	grande, 16 fl. oz.	135
Starbucks Tazo Earl Grey—Brewed Tea or Tea Latte	grande, 16 fl. oz.	115
Starbucks Tazo Chai Tea Latte	grande, 16 fl. oz.	95
Starbucks Tazo Green Tea Latte—Iced or regular	grande, 16 fl. oz.	80
Black tea, brewed for 3 minutes	8 fl. oz.	30-80
Snapple Lemon Tea	16 fl. oz.	62
Lipton Pure Leaf Iced Tea	18.5 fl. oz.	60
Green tea, brewed for 3 minutes	8 fl. oz.	35-60
Lipton 100% Natural Lemon Iced Tea, bottle	20 fl. oz.	35
Arizona Iced Tea, black, all varieties	16 fl. oz.	30
Nestea Unsweetened Iced Tea Mix	2 tsp., makes 8 fl. oz.	20-30
Arizona Iced Tea, green, all varieties	16 fl. oz.	15
Lipton Decaffeinated Tea—black or green, brewed	8 fl. oz.	5
Herbal Tea, brewed	8 fl. oz.	0
Soft Drinks	**Serving Size**	**Caffeine (mg)**
FDA official limit for cola and pepper soft drinks	12 oz.	71 (200 parts per million)
Pepsi MAX	12 oz.	69
Mountain Zevia (Zevia)	12 oz.	55
Mountain Dew, regular or diet	12 oz.	54 (20 oz. = 90)
Diet Coke	12 oz.	47 (20 oz. = 78)
Dr Pepper or Sunkist, regular or diet	12 oz.	41 (20 oz. = 68)
Pepsi	12 oz.	38 (20 oz. = 63)
Coca-Cola, Coke Zero, or	12 oz.	35 (20 oz. = 58)

Diet Pepsi		
Barq's Root Beer, regular	**12 oz.**	**23 (20 oz. = 38)**
7-Up, Fanta, Fresca, ginger ale, or Sprite	**12 oz.**	**0**
Root beer, most brands, or Barq's Diet Root Beer	**12 oz.**	**0**
Energy Drinks	Serving Size	Caffeine (mg)
Jolt Energy Drink	**23.5 fl. oz.**	**280**
Rockstar Citrus Punched	**16 fl. oz.**	**240**
NOS Active Sports Drink (Coca-Cola)	**22 fl. oz.**	**221**
5-hour Energy	**1.9 fl. oz.**	**208**
Full Throttle	**16 fl. oz.**	**200**
Monster Energy	**16 fl. oz.**	**160**
Rockstar	**16 fl. oz.**	**160**
Venom Energy Drink (Dr Pepper/Seven Up Inc.)	**16 fl. oz.**	**160**
NOS Energy Drink (Coca-Cola)	**16 fl. oz.**	**160**
AMP Energy Boost Original (PepsiCo)	**16 fl. oz.**	**142**
Mountain Dew Kick Start	**16 fl. oz.**	**92**
Red Bull	**8.4 fl. oz.**	**80**
V8 V-Fusion+Energy	**8 fl. oz.**	**80**
Ocean Spray Cran-Energy	**20 fl. oz.**	**55**
Glacéau Vitaminwater Energy	**20 fl. oz.**	**50**
Starbucks Refreshers	**12 fl. oz.**	**50**
Caffeinated Snack Foods	Serving Size	Caffeine (mg)
Crackheads[2]	**1 box, 40g**	**600**
Crackheads Espresso Bean Candies, regular	**1 package, 28 pieces**	**200**
Wired Waffles	**1 waffle**	**200**
Perky Jerky	**1 package, 1 oz.**	**150**
Arma Potato Chips	**1 package, 2 oz.**	**70**
Cracker Jack'D	**1 package, 2 oz.**	**70**
MiO Energy, all flavors	**1 squirt, ½ tsp.**	**60**
Crystal Light Energy	**½ packet**	**60**
Jelly Belly Extreme Sport Beans	**1 package, 1 oz.**	**50**
Jolt Gum	**1 piece**	**45**
Alert Gum	**1 piece**	**40**

Blue Diamond Almonds, Roasted Coffee Flavored	**1 oz.**	**25**
Ice Cream & Yogurt	Serving Size	Caffeine (mg)
Bang!! Caffeinated Ice Cream	**4 fl. oz.**	**125**
Cold Stone Creamery Mocha Ice Cream	**Gotta Have It, 12 fl. oz.**	**52**
Starbucks Coffee Ice Cream	**4 fl. oz.**	**45**
TCBY Coffee Frozen Yogurt	**large, 13.4 fl. oz.**	**42**
Dannon All Natural Coffee Lowfat Yogurt	**6 oz.**	**30**
Häagen-Dazs Coffee Ice Cream	**4 fl. oz.**	**29**
Stonyfield Gotta Have Java Nonfat Frozen Yogurt	**4 fl. oz.**	**28**
Starbucks Mocha Frappuccino Ice Cream	**4 fl. oz.**	**25**
Baskin Robbins Jamoca Ice Cream	**4 fl. oz.**	**20**
Dreyer's or Edy's Grand Ice Cream—Coffee or Espresso Chip	**4 fl. oz.**	**17**
Breyers Coffee Ice Cream	**4 fl. oz.**	**1**
Häagen-Dazs Coffee Almond Crunch Snack Size Bar	**1.8 oz.**	**10**
Dreyer's, Edy's, or Häagen-Dazs Chocolate Ice Cream	**4 fl. oz.**	**less than 1**
Chocolate Candy & Chocolate Drinks	Serving Size	Caffeine (mg)
Starbucks Hot Chocolate	**grande, 16 fl. oz.**	**25**
Hershey's Special Dark Chocolate Bar	**1.5 oz.**	**20**
Hershey's—Milk Chocolate Bar	**1.6 oz.**	**9**
Hershey's Kisses	**9 pieces, 1.4 oz.**	**9**
Hershey's Cocoa	**1 Tbs.**	**8**
Dove Dark Chocolate Silky Smooth Promises	**5 pieces, 1.4 oz.**	**4**
Silk Chocolate Soymilk	**8 fl. oz.**	**4**
Hershey's Chocolate Lowfat Milk, bottle	**12 fl. oz.**	**2**
Over-The-Counter Pills	Serving Size	Caffeine (mg)
Zantrex-3 weight-loss	**2 capsules**	**300**

supplement		
NoDoz or Vivarin	**1 caplet**	**200**
Excedrin Migraine	**2 tablets**	**130**
Midol Complete	**2 caplets**	**120**
Bayer Back & Body	**2 caplets**	**65**
Anacin	**2 tablets**	**64**

APPENDIX I:

Respiratory Exchange Ratio Chart

Respiratory Exchange Ratio (RER)

RER	FAT%	CARB%
1.00	0	100
.98	6	94
.96	12	88
.94	19	81
.92	26	74
.90	32	68
.88	38	62
.86	47	53
.84	53	47
.82	62	38
.80	68	32
.78	74	26
.76	81	19
.74	88	12
.72	94	6
.70	100	0

Taken from: http://www.unm.edu/~lkravitz/Media/RER.jpg

APPENDIX J:

Rating of Perceived Exertion Chart

The Borg Scale

6	No exertion at all
7	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

(Borg, 1998)