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The Effects of Caffeine on Ratings of Perceived Exertion and Completion Times in a 1.5-Mile Run Test in College-Aged Males

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The Effects of Caffeine on Ratings of Perceived Exertion and Completion Times in a 1.5-Mile Run Test in College-Aged Males

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ABSTRACT

Significance: This study has the potential to provide evidence of the ergogenic effects of caffeine from Red Bull by investigating two parameters of athletic performance, including ratings of perceived exertion and overall completion times. A lower perception of exertion may assist athletes and other individuals to work longer and harder. While other ergogenic aids are available, caffeine in the form of energy drinks are easily accessible and inexpensive. Some ergogenic aids, such as anabolic steroids, have known potential dangers. A better understanding of caffeine's benefits and ergogenic effects could serve as a potential substitute for the dangerous use of other ergogenic aids. Furthermore, addressing energy drinks, specifically Red Bull, can further increase understanding of caffeine's ergogenic effect. **Purpose:** The purpose of this study was to examine the effects of caffeine from Red Bull on selected aspects of running performance during a 1.5 mile run test in college-aged males. The study compared the following measures: 1) ratings of perceived exertion collected during and at the completion of the exercise following ingestion of one of two levels of caffeine or a placebo and 2) completion times following ingestion of one of two levels of caffeine or a placebo prior to performance. **Methodology:** A total of 13 male subjects volunteered for the study (age range of 18-24 years, 22.15 ± 1.52 years) that were apparently healthy with no known physical, metabolic, or physiological limitations to participate. Subjects were in the pre-determined weight range of 63 kg to 86 kg as well. Over the span of three weeks and three testing periods, the subjects ingested either a placebo, a moderate-dosage of caffeine from Red Bull (40 mg) or a high-dosage of caffeine from Red Bull (80 mg).

Ratings of perceived exertion (RPE) were measured using the 1-10 Borg scale and recorded every 3 laps during the 1.5 mile run. Completion times were recorded at the end of the 1.5 mile run. Subjects' height and weight measurements were recorded during preliminary procedures which were used to figure body mass index (BMI). BMI was compared to completion times to examine a possible correlation. **Results:** In regards to completion times, a trend (9 out of 13; 69%) is apparent in a reduction in completion times among the moderate and high dosages. However, there was no significance (p = 0.30; Effect size = 0.096) between dosage groups with regard to mean completion times. In regards to a possible correlation between BMI and completion times, there was no linear correlation. RPE was recorded every 3 laps and upon completion of the test. Results indicate no significant difference at completion (p = 0.074, Effect size = 0.196). However, there were significant difference between dosage groups at laps 9 (p = 0.008) and 12 (p = 0.019). **Conclusions:** This study indicates that caffeine from Red bull did not have significant differences in completion times between dosage groups. However, differences were indicated during mid-test for RPE levels. Energy drinks and caffeine can have a significant effect on some aspects of athletic performance. Higher caffeine dosages and variations in testing procedure could positively alter results in future research and investigations.

CHAPTER I

Introduction

Caffeine is a widely available stimulant and a socially acceptable drug found in numerous products ranging from food to soft drinks. The FDA's National Center for Drugs and Biologics has indicated that there are more than 1,000 proprietary drugs that list caffeine as an ingredient (www.fda.gov). A recent survey found that coffee was responsible for 90% of all caffeine consumed in the United States (Graham, 2001). Although caffeine is often marketed as a weight loss aid, it can also be beneficial in increasing alertness and productivity (Jacobson & Edgley, 1987).

There is a long history of caffeine consumption and has since become the most commonly consumed drug in the world (Lundsberg, 1998). Energy drinks have become the latest trend as a popular caffeine source. Perkins and Williams (1975) found that there were formal, scientific reports concerning the ergogenic effects of caffeine over a century ago. The debate over which caffeine should be allowed in competitive sports also has a long history. In 1939, Boje, an early researcher in the field of ergogenic aids, recommended that caffeine be banned from athletic competitions (Perkins & Williams, 1975). Since there have been numerous studies that have examined the ergogenic effects of caffeine, including increased time to exhaustion (Cole et al, 1996). During high intensity exercise, ingestion of caffeine has been shown to have an association with decreased rate of perceived exertion (RPE) (Bell & McLellan, 2002). These results may indicate the potential for caffeine consumption to enable performance of longer bouts of exercise.

The ergogenic effects of caffeine are unclear and poorly understood. Some studies suggest that caffeine intake leads to an increase in fatty acid metabolism, which in turn, leads to glycogen sparing during exercise (Bellet, Kershbaum, & Finck, 1968). However, other studies have shown no effect of fat metabolism (Bell & McLellan, 2002). Because caffeine is such a poorly understood substance, it is important to continue research and investigation on its metabolic and ergogenic effects. A possible ergogenic effect is a decrease in RPE levels.

Although there are many sources of caffeine, one that is becoming popular is in the form of energy drinks. Energy drinks are marketed as having the ability to enhance energy levels during exercise or physical activity. Many of the energy drinks do not contain energy in the form of kilocalories, leading to an apparent "lack of energy." This presents the question of which ingredients are responsible for a perceived increase in energy. While caffeine is often included as an ingredient, two other common ingredients are guarana (*paullinia cupana*) and ginseng (*panax ginseng*). These two additional ingredients have been marketed along with caffeine as weight loss aids (Magkos and Kavouras, 2004). Energy drinks are usually marketed primarily to those between ages 18 and 30 as a stimulant (Graham, 2001).

In 2002, there were approximately 27 energy drinks on the market for public consumption (Bonci, 2002). Many energy drinks are marketed as having the ability to increase time to completion and improve athletic performance (Graham, 2001). However, limited research has addressed these claims. This research and associated study will investigate the ergogenic effects of energy drinks, specifically Red Bull.

Purpose of the Study

This study examines the effects of caffeine from energy drinks on RPE and completion time in college-aged males. Red Bull, a popular and readily available energy drink, will be the sole source of caffeine in the study. Red Bull is a common form of caffeine ingested by the general population, as well as by the physically active. A standard form of Red Bull available to the consumer is a 8.3 oz can which contains 80 mg of caffeine. Caffeine levels in this study are to be administered in low (40 mg / 4.15 oz of Red Bull or half a can) and high (80 mg / 8.3 oz of Red Bull or a full can) dosages, as well as the administration of a placebo. The purposes of this study are to compare the following measures among college-aged males age 18 – 24 years: 1) rating of perceived exertion collected during (laps 3, 6, 9, and 12) and at the completion (lap 18) of the exercise bout following ingestion of one of two dosages of caffeine or a placebo and 2) completion times in the 1.5 mile run test following ingestion of one of two caffeine dosages or a placebo prior to performance.

Since the ergogenic effects of caffeine are not clearly understood, there is the question of whether or not caffeine ingestion really can improve athletic performance and positively effect RPE. There is some evidence that caffeine acts directly on the central nervous system in various ways, including the release of the hormone beta-endorphins which could potentially change the individual's perception of pain and level of exertion (Rodrigues et al., 1990). Certain levels of caffeine have been banned in some competitive sports, most commonly in the Olympics, but to what extent would caffeine improve completion times and perception of exertion? This study is being undertaken to

investigate how various levels of caffeine ingested in the form of a popular energy drink affect these two aspects of performance.

Significance of the Study

This study has the potential to provide evidence of the ergogenic effects of caffeine from Red Bull by investigating two parameters of athletic performance. A lower perception of exertion indicated by a lower reported RPE may assist athletes and other active individuals to work longer and harder. And, as a stimulant, caffeine intake may decrease performance time in certain cardiovascular fitness tests. While other ergogenic aids are available, caffeine is easily accessible and inexpensive. In addition, some ergogenic aids, such as anabolic steroids, have known potential dangers associated with their usage. A better understanding of caffeine's benefits and ergogenic affects could serve as a potential substitute for the dangerous use of other ergogenic aids.

A common ergogenic aid available to the general population is energy drinks. Energy drinks, such as Red Bull, are easily accessible to the public because they are inexpensive and available in several different brands.

Hypotheses

HO1: There will be no significant difference between means for treatment groups and RPE reported during a 1.5 mile run test.

HO2: There will be no significant difference between means for treatment groups and completion times for a 1.5 mile run test.

Limitations of the Study

1. The participants are asked to fast six hours prior to testing to optimize caffeine absorption. The researcher however is unable to fully monitor if this request is being followed by the subjects.
2. The researcher is not able to assess individual sensitivity to caffeine and apply it towards administration.
3. The participants' previous exposure to caffeine is only under advisement two days prior to testing. Subjects are asked to refrain from any caffeine use two days prior to their testing time. Although it takes four days for caffeine to be expelled from the body by 99.9% (Jacobsen & Edgley, 1987), the subjects were instructed to refrain for two days in order to get the subjects in for testing at their convenience.
4. The researcher is not measuring lactate levels or other factors to determine further associated affects of caffeine.
5. The subjects were requested to abstain from vigorous exercise for 24 hours prior to all three testing sessions.
6. Inter-tester reliability may be a factor as RPE is a self-perceived scale and equipment, such as the stopwatch, is primarily used by the researcher.

Delimitations of the Study

1. The study will include 13 college-age males ranging from 18 to 24 years of age.
2. Subjects were recruited form the Department of Kinesiology and Health Studies at the University of Central Oklahoma.

3. All participants are within a weight class ranging from 63 kg to 86 kg. Through keeping the subjects in a specified weight range, it is possible to administer the same placebo (0 mg), low (40 mg), and high (80 mg) dosage of caffeine.

4. The participants regularly consumed no more than one cup of coffee per day, or 80 mg of caffeine, except for the two days prior to testing in which they ingested no caffeine.

5. The participants maintained their regular workout schedules, which include cardiovascular and resistance training. All subjects participated in some type of physical activity prior to recruitment. These workout schedules were refrained from 2 days prior to testing.

6. The participants have no known medical or health issues.

Assumptions

1. Regular physical activity is maintained prior to test preparation, as well as diet and limited caffeine intake.
2. Participants react or respond to caffeine in a similar way.
3. Participants will perform at their optimal level at each trial and that their motivation level is constant and consistent.
4. Subjects are homogeneous in their activity levels indicated by Godin Leisure Time Activity Level Questionnaire.
5. Since caffeine intake is only monitored two days prior to testing, it is assumed that there will be no residual caffeine from previous ingestions during testing.
6. All equipment utilized was properly calibrated prior to testing and used correctly by standards set by field protocols.

7. Subjects will follow all instructions provided by the researcher and ask questions if they are unsure of any instructions.

Definitions

One and a half mile run test. A commonly used field test which has an associated predictability of VO_2 max in healthy college-age subjects. This test may not be as accurate in other populations, perhaps because of lack of motivation and lack of familiarity with exercise training (Brooks, Fahey, & Baldwin; 2005).

Body Mass Index. A ratio of body weight to height that is useful for classifying the health risks of body weight. It is based on the concept that a person's weight should be proportional to their height (Fahey, Insel, & Roth, 2007).

Central nervous system. Represents the largest part of the nervous system, including the brain and spinal cord. It is conceived as a system devoted to information processing, where an appropriate motor output is computed as a response to a sensory input (McArdle, Katch, & Katch, 2000).

Ergogenic. The word ergogenic is derived from the Greek words *ergo* (work) and *gen* (production of). It is commonly defined as "to increase potential for work output." Ergogenic aids are commonly used in competition and sports to improve performance by enhancing mental strength, physical power or mechanical edge (Williams, 2002).

Placebo. A substance intended to improve performance through the power of suggestion (McArdle, Katch, & Katch, 2000).

Rating of perceived exertion (RPE). A validated numerical scale (Borg 6 – 20 or 1 – 10 category-ratio scale of perceived exertion) designed to allow individuals to rate how she or he perceives their exertion level to be during physical activity (McArdle,

Katch, & Katch, 1996). RPE can be utilized as a reliable indicator in monitoring a participant's exercise tolerance, as well as provide individuals of all fitness levels with easily understood guidelines in regards to their exercise intensity. Since RPE can also be an indicator of impeding fatigue levels, it can be used to monitor progress toward maximal exertion (ACSM, 2000).

CHAPTER II

Literature Review

Introduction

Caffeine (1,3,7-trimethylxanthine) is a naturally occurring plant alkaloid that is found in over sixty different plant species, including *Caffea Arabica* (coffee) and *Cola acuminate* (Cola). Because caffeine has no nutritional value, it is classified as a stimulant (Keisler & Armsey, 2006). Caffeine is the most commonly used drug in the world with its highest usage being in the United Kingdom and Scandinavia (400 mg/person/day) (Cauli & Morelli, 2005). At least 80% of Americans daily consume caffeine in some form, whether it is through over the counter stimulants, food, or beverages. The average American consumes about 200 mg per day, which is the equivalent to two cups of coffee (Paluska, 2003). While there are natural and artificial forms of caffeine, the most prevalent form is coffee. Coffee accounts for 75% of overall caffeine consumption and ranks second to oil in terms of international trade commerce (Keisler & Armsey, 2006). Caffeine is a well-known ingredient of energy drinks, such as Red Bull. Red Bull is marketed to improve performance and often consumed by active individuals such as athletes looking for a competitive edge.

Physiology of Caffeine

Caffeine is both water-soluble and fat-soluble and it is unlikely that body fat should become a factor in caffeine distribution (Graham, 2001). Caffeine is metabolized in the liver through the cytochrome P450 system (Keisler & Armsey, 2006). Once caffeine is ingested into the body, it is quickly absorbed through the gastrointestinal tract and distributed throughout the entire body entering all tissues. Approximately 90% is

cleared from the stomach within 20 minutes (Keisler & Armsey, 2006). Caffeine crosses the biological membranes of the blood-brain barrier and the placenta barrier (James, 1991). Peak levels of the caffeine absorption rate are reached between 30 and 120 minutes, with the average time being 60 minutes (Jacobsen & Edgley, 1987). Caffeine has a half-life between three and five hours (Keisler & Armsey, 2006). There are many factors that can alter caffeine's half-life, which include age, gender, smoking, diet, and medication. Clearance is nonlinear and significantly slower for higher dosages (Paluska, 2003).

There are various factors that influence the peak levels and absorption in the body, some of which include the quantity of caffeine ingested (Passmore, Kondowe, and Johnston, 1987), the presence of food in the GI tract (Graham, 2001), and the form in which the caffeine is ingested (Liguori, Hughes, & Grass, 1997). To control for some of these factors, Jacobsen and Edgley (1987) required that their subjects fast for six to eight hours prior to testing which is also being required for the present investigation.

In related studies performed (Trice & Haymes, 1995; Stebbins, Daniels, & Lewis, 2001), subjects were required to abstain from caffeine for a minimum of 24 hours before the experiment. However, 99% of caffeine in the body is cleared within four days and it is recommended that a wash out period of four days be administered to allow for maximal caffeine effects (Jacobsen & Edgley, 1987). In the current study, subjects were instructed to abstain from caffeine for two days prior to each testing in order to conveniently schedule the subjects each week. Also, other studies have used less than four days and have found significant results.

Caffeine Dosage

An important variable to consider is the dose of caffeine administered to subjects. Not taking into account body size can cause variations in absorption, which can then create distortions in results by masking effects that do exist or showing effects that do not exist (Jacobsen & Edgley, 1987). Jacobsen (1998) presented the idea that there is a dose-dependent curve in which moderate doses (less than 300 mg) tend to improve performance while higher doses (more than 700 mg) diminish further improvements in performance. Caffeine dosage has been difficult to track and make recommendations since the various studies investigating dosage have used various protocols and were exploring different reactions and results. In addition, many studies administer dosages equally among the genders and do not consider gender differences. The smaller body weight of women generally results in the caffeine dosage being about 20% higher than their male counterparts (Graham, 2001). The current study is also taking into account body mass index to test any correlation between BMI and completion times. Although the subjects fall within a predetermined weight range, there could be some variation in how quickly they are able to complete the test. There is limited research addressing a possible correlation between caffeine and BMI.

Jacobsen and Edgley (1987) investigated the effects of caffeine on simple reaction time. With a total of 30 subjects, which consisted of 19 males and 11 females with a mean age of 21 years, the researchers conducted a double-blind study that involved the subjects responding to a light stimulus followed by their prescribed movement. The subjects consumed caffeine, ranging from 40 – 120 mg, in the form of soft drinks, tea, and coffee. The researchers found that moderate amounts of caffeine

(300 mg) were directly related to changes in reaction time, while larger doses (600 mg) decreased reaction times.

Bruce et al (2000) found that doses of 6 and 9 mg/kg were effective in increasing both performance and power during a simulation of 2000-meter rowing. Along the same lines, Kovacs et al (1998) researched the effect of caffeine with a sport drink and found that even the lowest dosage (2.1 mg/kg) showed ergogenic effects, while the larger dosages (3.2 and 4.5 mg/kg) had an even greater effect.

In regards to running, Pfitzinger (2004) suggests that a 1 to 6 mg/kg dose of caffeine ingested one hour prior to exercise can improve long-distance running performance, including completing the test at a quicker pace. In addition, it is suggested that doses larger than this recommended amount does not improve performance due to the possibility of negative side effects (Pfitzinger, 2004

Effect on Central Nervous System

The most commonly associated effects of caffeine are those upon the central nervous system. The central nervous system (CNS) is comprised of the brain and the spinal cord and directs the functions of all tissues of the body (McArdle, Katch, and Katch, 2000). The peripheral nervous system receives numerous sensory inputs and transmits them to the brain via the spinal cord. The brain then processes this incoming information and discards 99% as unimportant. After sensory information has been evaluated, specific areas of the CNS initiate nerve impulses to organs or tissue to make an appropriate response (Davis et al., 2002).

These responses can be affected by stimulants which excite the CNS. A stimulant such as caffeine is intended to increase mental alertness and reduce fatigue. Ingestion of

caffeine has been shown to reduce or delay fatigue during exercise (Davis et al., 2002) and has been shown to decrease perceived effort during exercise (Crowe, Leicht, & Spinks, 2006).

Effect on Cardiovascular System

In addition to its prominent effects on the central nervous system, it also acts as an important modulator of the cardiovascular system. Caffeine's most prominent effect is elevating blood pressure for up to several hours following ingestion. This effect can occur both at rest and during exercise or during mental exertion (Stebbins, Daniels, & Lewis, 2001; Lovallo et al, 2006). Caffeine can also enhance mean arterial blood pressure during exercise (Stebbins, Daniels, & Lewis, 2001). It also increases cortisol and epinephrine levels at both rest and prolonged periods of stress.

Caffeine and Aerobic Performance

Graham and Spriet (1991) and Costill et al (1978) have all reported caffeine-induced improvements during aerobic exercise and correlating performance. To further support their research and findings, Ivy et al (1979) conducted studies that demonstrated prolonged time to exhaustion and increased oxidative rates, while concurrently showing a decrease in glycogen consumption. The study used caffeine doses ranging from 300 – 800 mg and had subjects exercise at intensities ranging from 60 – 80% VO_2max. Subjects ingesting the caffeine dosages, compared to the placebo, were able to exercise harder and longer (Ivy et al, 1979).

An additional theory to consider involves the subject's perceived exertion, commonly addressed at their rating of perceived exertion (RPE). Bell et al (1998) conducted a study and found that caffeine reduced the sensation of fatigue, which in turn

allowed the subjects to work longer and harder. The researchers attributed the results to increased central nervous system stimulation, contractile muscle response, or both (Bell et al, 1998).

While most research investigating caffeine's influence on aerobic performance is done through cycling protocols, few have focus on its effect on running. Graham and Spriet (1995) examined caffeine's effects on running performance and various caffeine dosages. The subjects were asked to run at an exercise intensity of 85% of their VO_2max until they reached exhaustion. One hour prior to exercise, the subjects were administered a placebo, 3 mg · kg caffeine, 6 mg · kg caffeine, or 9 mg · kg caffeine. The 3 mg and 6 mg treatments showed average time improvements of 22 ± 9% and 22 ± 7%, respectively. There was no significant difference between times in the placebo trial time and the 9 mg trial time. Furthermore, the subjects reported mental confusion during the 9 mg trial and lactate production was significantly higher during the trial. The authors concluded that is practical that individuals do not need to ingest more than 6 mg · kg caffeine prior to exercise (Graham & Spriet, 1995).

As the previous study does not fully represent real-life situations, a study conducted by Bell, McLellan, and Sabiston (2002), chose a protocol that would have more real-life application. Twelve subjects ingested either a placebo, 4 mg · kg caffeine, 0.8 mg · kg epinephrine, or a combination of both. One and half hours following treatment administration, the subjects warmed up for two minutes and then proceeded to start a 10-km treadmill run. The subjects controlled the pace at which they ran and were told to finish the run as quickly as possible. The results indicated that the subjects ran significantly faster in both the epinephrine and combination treatments compared to the

placebo and caffeine alone. The authors concluded that the caffeine was not beneficial due to the relatively high intensity of test (Bell, McLellan, & Sabiston, 2002).

Norager and colleagues (2005) studies the effects of caffeine on endurance among those aged ≥ 70 years old. The authors chose this age group because of the growing number of older adults pursuing an active lifestyle, as well as the increased number of older adults involved in rehabilitation programs. The purpose of the study was to investigate whether 6 mg · kg caffeine could improve physical performance and reduce RPE during exercise among the subjects aged ≥ 70 years. The authors hypothesized that caffeine would improve cycling endurance by 65%, as well as create a significant improvement in stability, reaction, and movement times among the thirty subjects included in the study.

One hour prior to exercise, the subjects randomly received either a capsule of caffeine (6 mg · kg) or of a placebo. The second test trial the subjects received the treatment they were not administered the first trial. Endurance was measured on a cycle ergometer with an increasing workload of 25 watts every second minute until 65% of their expected minimal heart rate was achieved. RPE was measured after five minutes and at exhaustion using Borg's 20-point scale.

Results showed that caffeine increased cycling endurance by 25%, which was statistically significant ($p = 0.0001$). The treatment also reduced RPE after five minutes of cycling by 11% ($p = 0.002$) and postural stability by 25% ($p = 0.03$). There was no significant effect on reaction ($p = 0.42$) and movement time ($p = 0.83$) (Norager et al., 2005).

Effect on Skeletal and Smooth Muscle

Besides the stimulation of the central nervous system, caffeine also enhances neuromuscular transmission and improves skeletal muscle contractility (Spiller, 1984). Caffeine has also been believed to reduce mental and physical fatigue by stimulating the cerebral cortex, which in turn affects mental alertness, mood, and behavior (McArdle, Katch, & Katch, 2000). It has also been shown to increase muscle contractility in skeletal muscle through increased calcium availability, which is the result of its effect of relaxing smooth muscle (James, 1991).

Although not a significant effect, caffeine also acts to relax arterial, alveolar, and bronchial smooth muscle in the lungs. This results in increased rate and depth of breathing (Jacobsen & Kulling, 1989).

Caffeine and Anaerobic Performance

Caffeine's effect on anaerobic performance is a relatively new issue under investigation. Caffeine is thought to have an influence because of its ability to stimulate calcium release and its effect on neuronal excitability and neuromuscular transmission (Paluska, 2003).

Studies that involve testing for such effects use protocols which are very high intensity, short duration exercises that typically last from a few seconds to two minutes (Graham et al, 1998). In a double-blind study conducted by Trice and Haymes (1995), the researchers investigated the effects of caffeine during high-intensity, intermittent exercise. Eight males subjects ingested either caffeine (5 mg · kg) or a placebo one hour prior to exercise at 85 – 90% of their maximum workload. The subjects were asked to complete three 30-minute cycling periods at a pace of 70 rpm with five minutes rest

between each bout. Time to exhaustion significantly increased by 16.25 minutes following caffeine ingestion (77.5 ± 5.26 minutes for the caffeine and 61.25 ± 2.20 for the placebo). However, there was no significant effect of RPE between the two treatments.

Caffeine and Performance

Most researchers define time to exhaustion as the ability to maintain a workload calculated to elicit 80 – 85% of VO_2max (Denadai & Denadai, 1998). Several studies have shown that caffeine increases time to exhaustion (Graham & Spriet, 1991; Denadai & Denadai, 1998; Jacobsen & Kulling, 1989), and only a few studies dispute this proposed ergogenic effect (Bell et al, 2002). Jackman et al (1996) is an exception. The participants were asked to perform short-term bouts at VO_2 max and then cycle to exhaustion.

In a study conducted by Bell and McLellan (2002), the researchers investigated the effects of caffeine on both habitual and non-habitual caffeine users. The study included 21 subjects, which broke down into 13 caffeine users and 8 non-users. The habitual users were those who reported a usual ingestion of 300 or more mg per day. The non-habitual users reported ingesting less than 50 mg per day. The study's protocol was cycling at 80% VO_2 max until exhaustion. All subjects performed one ride per week for six weeks and were either given a placebo or 5 mg/kg caffeine. Regardless of ingestion time, the caffeine significantly improves the non-habitual users' performance compared to the placebo. The non-habitual users' average cycling times with caffeine taken 1, 3, or 6 hours prior to activity were 32.7 ± 8.4 min, 32.1 ± 8.6 min, and 31.7 ± 12 min, respectively. The corresponding times for placebo ingestion trials were 24.2 ± 6.4 min,

25.8 ± 9.0 min, and 23.2 ± 7.1 min. These results show that the non-habitual users received greater and longer-lasting performance benefits from caffeine ingestion compared to the placebo. The non-habitual users also performed better than the habitual-users. The habitual-users' times were 27.4 ± 7.2 min, 28.1 ± 7.8 min, and 24.5 ± 7.6 min, respective to the 1, 3, and 6 hour post-ingestion times. The results also showed that the habitual-users' performance began to decrease six hours following ingestion, while the non-habitual users' performance remained enhanced at a level similar to right after initial ingestion. A possible explanation for this effect, proposed by the researchers, is that caffeine threshold levels between the two groups contributed to the effects of caffeine on performance. Compared to the placebo, caffeine increased achieved VO_2 after fifteen minutes of cycling for both groups, as well as increased glucose levels in both groups during exercise.

Jacobsen and Kulling (1989) have suggested that caffeine may be capable of increasing time to exhaustion on occasions only when effort is performed at intensities that allow subjects to exercise for more than one hour. Exercises that can be performed beyond this time show intensities below the anaerobic threshold, which suggests that caffeine may alter performance only in exercises below this intensity.

Denadai and Denadai (1998) presented the objective to determine the effects of caffeine (5 mg/kg) on the time to exhaustion and RPE during exercise performed below and above the anaerobic threshold. The subjects consisted of eight untrained males with a mean age of 20 years, all of whom were non-habitual caffeine consumers. With anaerobic threshold being defined as the intensity (watts) corresponding to a lactate concentration of 4 mM, the subjects performed a progressive test on a cycle ergometer.

The initial workload was 25 watts (W), which increased by 25 W every five minutes until exhaustion. On three different measurement trials, the subjects were asked to cycle until exhaustion at two different intensities: approximately 10% below and 10% above anaerobic threshold. RPE was measured using the Borg scale.

The results indicated that the subjects' RPE was always higher in the placebo trials than in caffeine trials, but only in exercise below anaerobic threshold. The results also showed that caffeine can improve performance only in exercise below anaerobic threshold due to the subjects' longer time to exhaustion. The researchers speculate that the increased time to exhaustion is in correlation to the lower RPE reported.

Bridge and Jones (2006) examined the effects of caffeine ingestion on an 8 km run performance. The randomized, double-blind study was conducted using eight male distance runners. The subjects ran the 8 km race an hour after ingesting either a placebo, caffeine capsule (3 mg/kg), or no supplement (control). They chose their low dosage based on other studies which indicated improvements using the amount chosen (Graham & Spriet, 1995). Nutritional status was controlled for 24 hours prior to each of the three trials and the subjects were instructed to arrive at each race fully hydrated. Each of the three trials was separated by one week. In addition to measuring heart rate (HR), the researchers also measured for RPE using the Borg scale.

The results indicated that caffeine ingestion one hour prior to testing led to a significant improvement in 8 km performance time ($p = 0.002$). Caffeine ingestion resulted in an average time improvement of 23.8 seconds relative to the control group. Pair-wise comparison also showed significant difference between caffeine and control trials ($p = 0.012$).

Caffeine led to higher mean heart rate during the trials compared to the control and placebo trials (1.9 beats ± 0.9). In regards to RPE, values during the caffeine trial were lower (6.6 ± 0.9) than during the control (7.0 ± 0.5) and placebo (7.0 ± 0.8) trials. However, these values were not statistically significant ($p = 0.346$). The researchers speculated a lower RPE in their study, especially in relation to the higher rate and increased performance time, suggests that caffeine may provoke a central nervous system effect by reducing fatigue and the perception of effort.

In an interesting study conducted by Kendrick et al (1994), the researchers investigated the effects of caffeine and ethanol on treadmill performance. The four subjects included in the study ran on a treadmill for sixty minutes at a predetermined intensity to elicit an average intensity of 80 – 85% the runner's VO_2 max. Prior to exercise, the subjects were administered caffeine (2.5 mg · kg · body weight) in 150 ml of grapefruit juice, 25 ml of ethanol in 150 ml of grapefruit juice, or 150 ml of grapefruit juice (placebo).

Results showed that the administration of caffeine had no effect on submaximal performance. However, the ethanol was found to adversely influence treadmill performance in three of the four subjects, increase the heart rate response to exercise, and depress blood glucose (Kendrick et al, 1994).

Adverse Effects

The physiologic effects are widespread and include central nervous system stimulation, increase in urine production, activation of cardiac muscle, and relaxation of smooth muscle (Paluska, 2003). In addition, routine use can cause tolerance and dependence. Lower doses of caffeine (< 300 mg, also referred to as a caffeine-naïve

level) can increase peacefulness, elation, arousal, concentration, mental acuity, and performance. Higher doses can increase the likelihood for adverse effects, especially for nonhabitual users. Paluska (2003) has identified numerous adverse affects, which include heart palpitations, restlessness, dizziness, faintness, hunger, and increased calcium loss, loss of concentration, mild hallucinations, anxiety, influenza-like symptoms, GI disturbance, and agitation.

Another adverse effect caused by caffeine which is of particular concern to athletes and coaches is that of diuresis. The concern that caffeine causes dehydration during physical activity has caused many athletes to avoid its consumption. This concern arises from the idea that unmatched fluid losses can affect plasma volume, total body water, temperature regulation, and stroke volume (Paluska, 2003). However, data does not support that caffeine negatively affects an individual's hydration status at rest. Even during exercise, caffeine does not promote significant diuresis or dehydration (Graham, Hibbert, & Sathasivam, 1998). Graham (2001) also found that there is no significant perspiration or temperature regulation disturbances associated with caffeine consumption during submaximal exercise.

Ergogenic Aids

It is human nature for individuals to shape their physical world to aid them in their endeavors, including the optimization of human performance. Although the most effective way to improve performance is systematic training over prolonged periods of time, athletes and non-athletes will turn to ergogenic aids to surpass traditional training effects. Ergogenic aids provide a way to produce more work (from the Greek word "ergon") than would normally be possible or achieved (Coyle, 1984). There are many

substances that theoretically have ergogenic properties and their range of acceptability varies from a cold glass of water to dangerous drugs. For a substance to be considered an ergogenic aid and enhance physical work output it must act upon one of the basic pathways by which work is generated. Food is stored within the body and provides the fuel that is catabolized, which in turn, releases energy usually in the form of adenosine triphosphate. This energy is then used for muscle contraction (McArdle, Katch, & Katch, 2000).

An ergogenic aid can act in four different places in the process of energy production and transformation. One, it can act as a supplementary source of fuel. Two, an increase is catabolism of fuel could increase the rate of energy flux, which could then increase work output. Caffeine, therefore, has the potential to affect fuel metabolism. Three, substances that minimize the accumulation of by-products of fuel catabolism could help minimize fatigue. Four, since the nervous system exerts an influence on work output by coordinating the recruitment of muscle fibers, numerous treatments, including placebos, affect neurological function (Coyle, 1984).

Proposed Mechanisms for Ergogenic Action

It is widely known that caffeine can improve concentration, reduce fatigue, and increase alertness because of its effect on the central nervous system. Many authors have speculated that caffeine's ergogenic effects arise from its psychological effects. Costill and colleagues (1978) recognized that caffeine reduced perceived effort during intense activities. Caffeine has also been observed to lower rating of perceived exertion (RPE) by increasing nerve impulse transmission and delaying muscle fatigue (Anderson et al,

2000). Caffeine also enhances motoneuronal excitability, which leads to the facilitation of motor unit recruitment (McArdle, Katch, & Katch, 2000).

While several mechanisms of ergogenic effects have been proposed, there are three hypotheses that have generated the most discussion and research. The first hypothesis involves the mobilization of intracellular calcium. Caffeine enhances muscle function by increasing calcium release from the sarcoplasmic reticulum (Paluska, 2003). This has caused many authors to propose that the greater calcium concentrations produce an ergogenic effect by increasing and enhancing muscle contraction and muscular endurance, improving neuromuscular transmission, and increasing peak force generation (Kalmar & Cafarelli, 1999). Powers and Dodd (1985) have also recognized caffeine's effects on intracellular calcium (Ca^{++}) and suggest that an alternation of Ca^{++} permeability occurs in the sarcoplasmic reticulum of the muscle, which results in an increase in Ca^{++}. The increase in Ca^{++} can positively affect the force of skeletal muscle contractions (McArdle, Katch, & Katch, 2000). An increase in muscle contraction force results in an increase in efficiency of movements (Bell, Jacobs, & Ellerington, 2001). Kalmar and Cafarelli (1999) found that the amount of caffeine required to produce measurable calcium shifts is low. However, the amount required to produce meaningful calcium release is high enough to compromise performance due to possible adverse effects.

The second hypothesis is that of catecholamine augmentation and glycogen sparing. Caffeine inhibits phosphodiesterease, the enzyme responsible for the degradation of 3', 5'-cyclic monophospate (cAMP). Caffeine significantly increases muscle cAMP after the initiation of exercise. This has led researchers to propose that

cAMP stimulates catecholamine release, which includes epinephrine and norepinephrine (Greer, Friars, & Graham, 2000). Catecholamines alter muscle contractility, cardiovascular response, glucose uptake, fatty acid mobilization, glucose production, and glycogen preservation (Graham, 2001).

There is much debate about the glycogen-sparing hypothesis, which suggests that augmented catecholamines stimulate lipolysis and promote free fatty acid release (Paluska, 2003). Muscle glycogen stores are preserved and can be utilized later during prolonged exercise, which leads to the delayed onset of fatigue and exhaustion (McArdle, Katch, & Katch, 2000).

The glycogen-sparing hypothesis also suggests that following caffeine ingestion, an increase in lipolysis follows. Anderson et al (2000) found that caffeine increases plasma free fatty acid concentrations and slows down the rate of muscle glycogen depletion, which delays fatigue during endurance exercise. Costill and colleagues have published a series of studies that have provided evidence that caffeine ingestion had led to an increased time to exhaustion during exercise, especially cycling (Costill et al, 1977; Costill et al, 1978). Results of these studies showed support that caffeine has an ergogenic effect of glycogen sparing. Costill and colleagues (1978) found that caffeine increased fat metabolism during exercise. The researchers noticed the increase in lipolysis correlated with a decrease in glycolysis. However, research challenging this proposed ergogenic effect has only presented inconclusive evidence.

The third proposed hypothesis is that of adenosine receptor antagonism. Adenosine receptors are found throughout the body, including the brain, smooth and cardiac muscle, and adrenal medullae (Paluska, 2003). Caffeine delays fatigue by

blocking adenosine receptors; adenosine is released during exercise and limits the release of dopamine, which assists in limiting central nervous system fatigue during exercise (Bell, Jacobs, & Ellerington, 2001). Even low doses of caffeine antagonize adenosine, which diminishes renin activity, stimulates lipolysis, and alters catecholamine release. Renin is an enzyme produced in the kidneys to help balance sodium and potassium levels in the blood, which affect blood pressure (McArdle, Katch, & Katch, 2000). However, chronic caffeine use increases the number of adenosine receptors which could explain the potential tolerance to caffeine's effects (Harland, 2000). The majority of research supports adenosine receptor antagonism as the primary mechanism for caffeine's ergogenic effects.

There are other ergogenic effects of caffeine that have been identified as well, but do not necessarily fall under the three major proposed hypotheses. Anderson et al (2000) discussed that caffeine is a vaso-dilative agent that improves oxygen flow, which in turn delays the creation and accumulation of lactic acid from pyruvate. Similarly, caffeine ingestion (7 mg · kg) results in greater expired minute ventilation during submaximal steady-state exercise (Powers & Dodd, 1985).

Ethical Considerations

Caffeine has been consumed since around 850 AD in the form of coffee when it was made popular in Egypt (Chou, 1992). The potential for caffeine to have ergogenic effects also holds a long history. Since the early 1900's, the fatigue-masking effects of caffeine have been researched. Asmussen and Boje (1948) suggested that caffeine had the potential to mask fatigue, which enabled subjects to obtain a higher power output

compared to exercise without caffeine ingestion. Research focused on its potential to improve exercise performance in the late 1970's (Keisler & Armsey, 2006).

In relation to sport, the ancient Greek belief that athletes should succeed on their endeavors without the use of aids to support their effort is embraced by the International Olympic Committee (IOC) as their ideal. In 1972, the IOC removed caffeine from its list of banned doping agents. The reasoning behind the removal was that caffeine is a common part of any athlete's diet and there was not much literature supporting its possible ergogenic effects. However, with increased research on caffeine as an ergogenic aid, the IOC once again banned certain levels of caffeine in the blood (Powers & Dodd, 1985). The IOC doping rule reads that "doping is the administration of or the use by a competing athlete of any physiological substance taken in abnormal quantity with the intention of increasing in an artificial and unfair manner his performance in competition" (Williams, 1994). The level of plasma caffeine that is considered illegal by the IOC is very high (12 μg/ml) and would probably be reached by injections or suppositories (Powers & Dodd, 1985). The National Collegiate Athletic Association has also recognized caffeine as an ergogenic aid and set their urine levels at 15μg/ml, which is equivalent to approximately eight cups of coffee (Keisler & Armsey, 2006).

Although urine specimens are frequently monitored to control for performance enhancing substances, urinary caffeine concentrations poorly reflect plasma levels due to variability (Graham, 2001). Less than two thirds of athletes who consume caffeine up to 13 mg/kg will have urinary concentrations above the legal limit (Paluska, 2003).

Caffeine and Energy Drinks

Among the several ingredients of energy drinks, such as Red Bull, caffeine and sugar (glucose) are most likely to improve exercise performance. In addition to low glucose levels being linked to fatigue during exercise, glucose is the primary fuel source of the central nervous system. The human body stores sugar in two ways: as glucose in the blood stream or in the liver and muscle as glycogen (McArdle, Katch, & Katch, 2000). Stored glycogen is used when required to form adenosine triphosphate, a high-energy compound (Wilmore & Costill, 2004). Muscle fatigue has often been linked to the depletion of glycogen in the body. A common way to prevent or delay muscle fatigue is to ingest sugar prior to exercise or physical activity. A quick and simple way to ingest sugar and caffeine before exercise is through the ingestion of energy drinks, such as Red Bull. Red Bull (8.3 fl oz) itself contains 80 mg of caffeine and 21 grams of sucrose. Use of energy drinks, especially for its caffeine content, is driven by its perceived ergogenic effects (Magkos and Kavouras, 2004).

While sugar and caffeine are among the ingredients of energy drinks, there are also sugar-free versions available. Since sugar provides an immediate fuel source (glucose), this leads to the speculation that it can spare glycogen during exercise (McArdle, Katch, & Katch, 1996). While glycogen-sparing is a known effect of caffeine, there are other ways in which caffeine can improve performance. Caffeine acts on the central nervous system, increasing mental alertness and concentration. It also elevates mood, delays fatigue, lowers RPE, and quickens response time (Wilmore & Costill, 2004).

Caffeine and Rating of Perceived Exertion

There is evidence that caffeine acts directly on the central nervous system in different ways, including stimulating the release of beta-endorphins. Beta-endorphins are hormones which may change the perception of pain and distress caused by physical exertion (Rodrigues et al., 1990). Physical exertion can be self-reported and measured using a rating of perceived exertion (RPE) scale. RPE is a subjective tool that can be used to measure how intense the subject believes they are working during exercise.

In a study conducted by Wiles et al (1992), the researchers investigated the effects of caffeinated coffee on perceived exertion along with other independent variables including running speed, blood lactate, and respiratory factors. They studied low doses of caffeine, equivalent to the amount found in two strong cups of coffee. The researchers chose a lower dosage because they wanted to mimic an athlete's "normal" dietary habits before performance. Using a motorized treadmill, the researchers examined the effects of caffeine on the time taken to run 1500 meters, the selected speed with which the subjects completed a one-minute "finishing burst" at the end of the high intensity run, and RPE.

The researchers found the ingestion of caffeine decreased the time taken to run the 1500 meter protocol, as well as increases in speed during the "finishing burst." Overall, the average mean time to complete the run was 4.2 seconds faster following caffeine ingestion. However, the researchers found no statistical significance in RPE. The researchers expected this because all subjects were attempting to run at their maximal perceived exertion during the testing protocol.

Hadjicharalambous and colleagues (2006) also investigated the effects of caffeine on RPE using a bicycle ergometer. Eight, well-trained male athletes participated in this

double-blind study. The study not only examined RPE, but also metabolism and performance following the consumption of a high-fat diet. Four hours before test one; the subjects consumed a standardized high-carbohydrate meal (90% of energy intake in the form of carbohydrates). This served as the control test. Four hours before test two and test three, the subjects consumed a high-fat meal (1 g · kg; 90% of energy intake in the form of fat). One hour before exercise following the high-fat meals, the subjects ingested capsules containing caffeine (7 mg · kg in test two; 7.5 mg · kg in test three). In tests two and three, rating of perceived exertion were significantly lower.

In a study conducted by Rodrigues and colleagues (1990), a bicycle test protocol was also used to measure the effect of caffeine on RPE. The study, which included six male athletes, took the subjects through two identical submaximal exercise bouts following the ingestion of decaffeinated coffee with or without caffeine. The subjects exercised for three minutes at 300 and 600 kg · m · min, after which the workload increased to 1200 kg · m · min. The subjects were asked to maintain this workload until exhaustion. Results indicated that RPE was significantly lower at the workload of 1200 kg · m · min, when the subjects had ingested caffeine.

Summary

A review of literature examining the impact of caffeine on athletic performance has produced a wide range of findings.

Bruce et al (2000) investigated the effects of caffeine in dosages of 6 and 9 mg/kg during a 2000-meter rowing exercise. Results indicated an increase in both performance and power among participating subjects.

Graham and Spriet (1995) and Costill et al (1978) have reported improvements in performance times during aerobic performance.

Ivy et al (1979) administered dosages ranging from 300 – 800 mg for subjects running at various exercise intensities. Results indicated prolonged time to exhaustion and increased oxidative rates among subjects.

Denadai and Denadai (1998) measured the effects of caffeine on the time to exhaustion and RPE in a progressive cycling test. The researchers found that caffeine led to a lower RPE when ingested prior to exercise.

Similar to the current study, Graham and Spriet (1995) examined the effects of caffeine on running performance after their subjects ingested various dosages (3, 6, and 9 mg/kg). The researchers measured completion time and found that the 3 mg and 6 mg treatments significantly improved average completion time.

While research has been conducted investigating effects of caffeine, as well as different dosages and protocols, there is still limited understanding concerning how caffeine can significantly improve performance. Furthermore, the majority of previous research has administered caffeine in the form of capsules, coffee, or soda. Very few have used energy drinks as the source of caffeine. This study is being conducted to examine lower dosages of caffeine from energy drinks and their effect on RPE and completion time in a 1.5 mile run test.

The research in the current study addresses the question of how caffeine from energy drinks could potentially aid in athletic performance. While aspects of performance could include a multitude of measurements, this study will focus on rating of perceived exertion and completion time.

CHAPTER III

Methodology

Subjects

Thirteen college-aged males between the required ages of 18 and 24 were recruited from the University of Central Oklahoma to participate in the study. Subjects included were considered healthy and had no apparent or known physical reason not to participate.

Preliminary Procedures

To screen activity levels among the subjects, the Godin Leisure-Time Exercise Questionnaire (Appendix A) was administered. This simple questionnaire is used to measure a person's leisure time exercise. It was designed to be easy to complete quickly without a need for extensive review. It can further be used to monitor the impact of health program promotions in the community. A higher score indicates regular participation in an exercise program (Godin & Shephard, 1985). Subjects who had either a low (5 or less) or an extremely high (20 or more) composite score were excluded from the study.

In addition to the Godin Leisure-Time Exercise Questionnaire, the subjects also qualified for the study after completing a Physical Activity Readiness (PAR-Q) (Appendix B) and a caffeine-screening questionnaire (Appendix C). The PAR-Q is designed to identify immediate contraindications to exercise, such as hypertension, heart disease, and other physical and physiological limitations. Subjects were also required to meet the following inclusion criteria: a) have no presence of cardiac, pulmonary, or metabolic disease; b) physically active (participating in at least 30-minutes of physical

activity per day as recommended by ACSM); c) not taking any medications contraindicated to exercise or caffeine ingestion; d) non-habitual caffeine consumers of less than 300 mg per day; and e) male. The caffeine-screening questionnaire's intended purpose was to examine each subject's history of caffeine consumption and their possible sensitivity towards its ingestion.

Prior to any testing, all subjects agreed to the following conditions: a) abstinence from all caffeinated products two days (48 hours) before each of the three randomized testing bouts over the span of three weeks, b) keep themselves hydrated, but especially two days (48 hours) before testing bouts, and c) limit aerobic and anaerobic exercise two days (48 hours) before testing. The purposes of these conditions were to maximize caffeine absorption and minimize athletic impairment. A list of caffeine-containing substances that were to be avoided was given to each subject (Appendix D).

All subjects were briefed on the procedures of the investigation, as well as given written instructions to follow (Appendix E). In addition, they were encouraged to voice any concerns or questions they may have had regarding their participation in the study.

Prior to interaction with participating subjects, approval was granted from the University of Central Oklahoma Institutional Review Board.

Equipment and Testing Procedure

The following equipment and materials were used to successfully conduct testing procedures: Sportline stopwatch (model 220), data sheets (Appendix F) to record RPE and completion times, non-transparent paper cups, tonic water to serve as part of the component of the placebo, grape Kool-Aid to serve as part of the component of the placebo, Red Bull energy drink (non-sugar free), University of Central Oklahoma indoor

track (1.5 miles equivalent to 18 laps), Borg's RPE scale (1- 10), and Wellness Center student self-serve height and weight machine (SECA 220 model).

A randomized, double-blind design was used in which each subject ingested three different treatments, which included a high-caffeine dosage, moderate-caffeine dosage, or a placebo. The placebo included a mixture of tonic water and grape Kool-Aid (4.15 oz. of tonic water and 4.15 oz. of Kool-Aid). The moderate-caffeine dosage (40 mg of caffeine) included a mixture of tonic water and Red Bull (4.15 oz. of tonic water and 4.15 oz. of Red Bull). The high-caffeine dosage (80 mg of caffeine) included 8.3 oz of Red Bull with no additional components.

All subjects reported to the human performance laboratory at the Wellness Center on the University of Central Oklahoma campus.

All subjects completed the informed consent form, approved by the University of Central Oklahoma's Institutional Review Board (IRB), before any testing began. All subjects completed the Physical Activity Readiness Questionnaire (Appendix B), Godin Leisure-Time Questionnaire (Appendix A), and a caffeine-screening questionnaire. Height and weight were measured using the Wellness Center self-serve height and weight machine (SECA 200 model).

In addition to using this time for data collection, each subject was briefed on testing protocols and procedures. This included: a) explaining the 1.5 mile run test; b) how they should run the distance, which included the attempt to complete as quickly as possible; c) allowing for question and answer time; d) explaining the Borg RPE scale (including at what times they were to report their RPE levels); and e) what is expected of them in the two days (48 hours) prior to testing.

Subjects reported to the Wellness Center on the University of Central Oklahoma campus on their assigned time and day. The thirteen subjects reported one at a time throughout each testing day and in 30-minute intervals. They reported to the testing facility both hydrated and having consumed a pre-exercise meal no earlier than six hours earlier to ensure better absorption of the caffeine. No pre-set guidelines were required concerning their pre-testing meal. All subjects tested individually to avoid the threat of competitiveness, which could potentially affect their overall completion time.

Since all the subjects fell within the pre-determined weight class, no changes were required in caffeine dosages according to weight per kilogram. Therefore, moderate and high dosages were the same for all participants.

The investigation's protocol called for a double-blind study. In accordance, neither the subjects nor the primary researcher knew what dosage (placebo, moderate dosage, or high dosage) was being administered and to whom for each of the three testing days. The researcher's assistant was solely responsible for tracking, preparing, and administering dosages. The subjects were given identification numbers which matched up with their dosage for that particular testing day. No names were used on testing days to prevent violation of double-blind design standards.

Testing was completed over a span of three weeks at the UCO Wellness Center.

Testing

Prior to subject arrival, all equipment used was calibrated to make certain accurate measurements were obtained. The researcher's assistant also prepared in isolation the dosages to be administered prior to the subjects' arrival. The researcher did not enter this area while this procedure was being completed. The on duty-manager of

the Wellness Center was reminded and informed of the day's proceedings. The first subject reported to the Wellness Center and greeted by the assistant. Each of the thirteen subjects were scheduled to arrive thirty minutes apart thereafter. Upon arrival, the subjects remained downstairs in the designated area where the researcher's assistant greeted them and provided further instructions. The researcher remained upstairs at the indoor track awaiting subjects following their ingestion and absorption time.

Immediately following their check-in, subjects ingested one of the three dosages that were assigned by the assistant. Dosages were randomly assigned so each subject ingested one of the three dosages (placebo, moderate, or high) on each separate testing day. Materials used in this step included non-transparent paper cups with their identification numbers written on them using a black Sharpie marker every time by the assistant. Ingestion was followed with a 15-minute absorption period in which the subject was required to sit comfortably while still remaining in the check-in area. This time was found to be significant by Jacobsen and Edgley (1987) to ensure optimal absorption of caffeine within the body. During the absorption period, the assistant again, in detail, provided instructions for the 1.5 mile run. They were also visually introduced to the RPE scale for the first time and given instructions on how to accurately report their rating of perceived exertion at the appropriate times.

The subjects were instructed to complete the 1.5-mile run quickly as possible. However, if the need to slow down due to pain or fatigue arose, they were advised to do so but begin the test again, if possible, as soon as they could. Subjects were instructed to report their RPE every three laps (laps 3, 6, 9, 12, 15, and 18). The researcher displayed

a poster of the RPE scale being utilized every three laps so subjects could easier report their level.

Following the check-in, ingestion, and absorption time, the subjects met the researcher at the indoor track upstairs in the UCO Wellness Center. They were instructed to then perform a five-minute warm up by walking on the indoor track. The subjects reconvened with the researcher and were provided an additional visual reference of the RPE scale. A starting / finishing line was placed on the track using white athletic tape and the subjects were instructed to begin and end at this point. After they were provided another opportunity for questions and clarification, they were instructed to begin on the command of "go."

Subjects were in control of what speed they ran on the indoor track since they were instructed to complete the 1.5-mile run test as quickly as possible. Subjects were asked to report their RPE every three laps until completion of the test. Completion times were recorded when the subject completed eighteen (18) laps. Subjects ended the test with a 5-minute cool-down, which consisted of subjects walking at a slower pace on the indoor track. Subjects were also encouraged to ingest water and saltine crackers if they felt the caffeine had upset their stomach in any way.

In accordance to standards of performing a double-blind study, the assistant set up the dosage rotation schedule for each of the three days. The researcher remained unaware of who was receiving which dosage. Dosage rotation is represented in Appendix G.

Statistical Treatment

A repeated measure ANOVA was used to analyze RPE scores and completion times. SAS® version 9 for Windows™ and SPSS® version 12 were used to analyze all data among the subjects. Statistical significance was set at $p < 0.05$.

CHAPTER IV

Results

This investigation examined the effects of three treatment levels of caffeine on the 1.5-mile run completion time and RPE. The participant characteristics include: age, height, weight, Godin total and average daily caffeine consumed.

Demographic data for the subjects is shown in Table 1:

Table 1

Group Demographic Statistics

Demographics	N	Minimum	Maximum	Mean	Std. Deviation
Age	13	20	24	22.15	1.52
Weight (kg)	13	63	86	76.46	7.31
Height (in)	13	65	76	70.54	3.45
Godin Total	13	6	17	10.77	3.42
Average Caffeinated Product Consumption per day (oz) -	13	7	21	10.77	5.43

A total of 13 male subjects volunteered for this study (age range of 18 – 24 years, mean of 22.15 ± 1.52 years) that were apparently healthy with no known physical, metabolic, or physiological limitations to participate. A subject population which was moderately physically active according to the Godin Leisure Time Questionnaire (10.77 ± 3.42) (Appendix H) was included for this study.

As can be seen in Table 1, all subjects were in the pre-determined age range of 20 – 24 years old, as well as inclusion on the weight range of 63 to 86 kg. Subjects were also included based on their Godin Leisure-Time Questionnaire totals, which was in the

approved range of 5 – 20. This range is associated with the assumption that these subjects represent the general population and can successfully complete the exercise all three testing times. Subjects' average caffeine consumption ranged from 7 ounces (of caffeinated product, primarily soda) per day to 21 ounces (of caffeinated product, primarily soda) per day with a mean of 10.77 ounces per day. Caffeine-naïve subjects, those who consume less than 300-mg of caffeine per day were used for this particular study. Twelve ounces of Mountain Dew is the equivalent of 55-mg of caffeine. Therefore, even those subjects consuming 21 ounces of caffeinated product per day were not exceeding the consumption limit.

Hypotheses

HO1: There will be no significant difference between means for treatment groups and RPE reported during a 1.5 mile run test.

There was no significant difference in RPE at the final lap ($p = 0.074$) of the 1.5-mile run test. However, significant differences were identified between means of treatment groups at lap 9 ($p = 0.008$) and lap 12 ($p = 0.019$).

HO2: There will be no significant difference between means for treatment groups and completion times for a 1.5 mile run test.

There was no significant difference ($p = 0.300$) between dosage groups for completion times in the 1.5-mile run test.

Results

Completion Times

Subjects completed three separate trials with a randomized treatment administered prior to each test. Individual completion times for the three administered dosages are shown in Table 2.

Table 2

Individual Completion Times (minutes / seconds)

Identification Number	Placebo	Moderate	High
P121	10.01	9.41	9.4
P141	12.18	12.16	11.42
P161	9.52	9.44	9.31
P181	12.12	12.15	12.07
P211	11.33	11.29	10.54
P271	8.17	8.15	8.13
P261	12.4	12.34	11.58
P241	12.44	11.56	12.12
P221	9.56	9.2	10.01
P191	9.58	10.23	10.1
P171	10.59	12	11.01
P111	11.5	13.36	12.49
P131	12.11	12.08	11.52

There was no significant difference ($p = 0.30$, Effect size = 0.096) between dosage groups with regard to mean completion times. Mean completion times and their standard deviations are shown in Table 3.

Table 3

Summary Statistics for Completion Times

Mean and Std. Deviation	Placebo	Moderate	High
	10.89 ± 1.40	11.03 ± 1.57	10.75 ± 1.30

During preliminary procedures, subjects' height and weight measurements were recorded on the SECA 220. This data was used to figure the subjects' body mass index (BMI), which was compared to completion times to examine a possible correlation. BMI

and associated completion times can be seen in Table 4. The result of this analysis is seen in Figure 1.

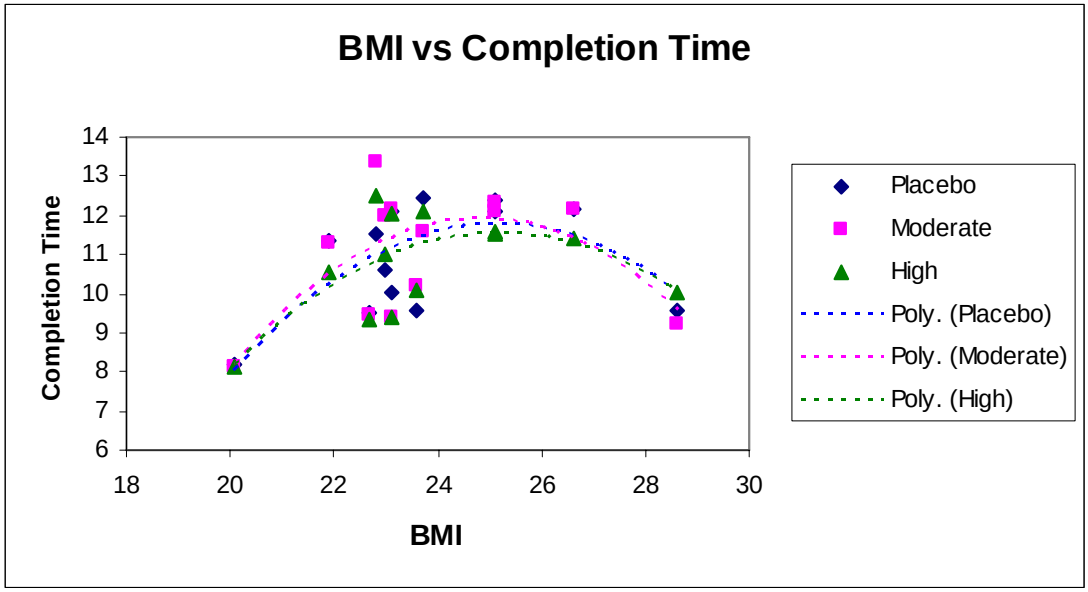

Figure 1

Correlation between BMI and Completion Times

As can be seen in Figure 1, there is no linear correlation between BMI and completion times among these subjects.

Table 4

BMI vs. Completion Times

BMI vs. Completion Times			
Placebo CT	*Moderate CT*	*High CT*	*BMI*
10.01	9.41	9.40	23.1
12.18	12.16	11.42	26.6
9.52	9.44	9.31	22.7
12.12	12.15	12.07	23.1
11.33	11.29	10.54	21.9
8.17	8.15	8.13	20.1
12.4	12.34	11.58	25.1
12.44	11.56	12.12	23.7
9.56	9.2	10.01	28.6
9.58	10.23	10.1	23.6

10.59	12.0	11.01	23.0
11.5	13.36	12.49	22.8
12.11	12.08	11.52	25.1

Rating of Perceived Exertion (RPE)

Statistical significance ($p < 0.05$) existed among various times during the 18 laps run by the subjects. Mean RPE by lap completion is shown in Figure 2.

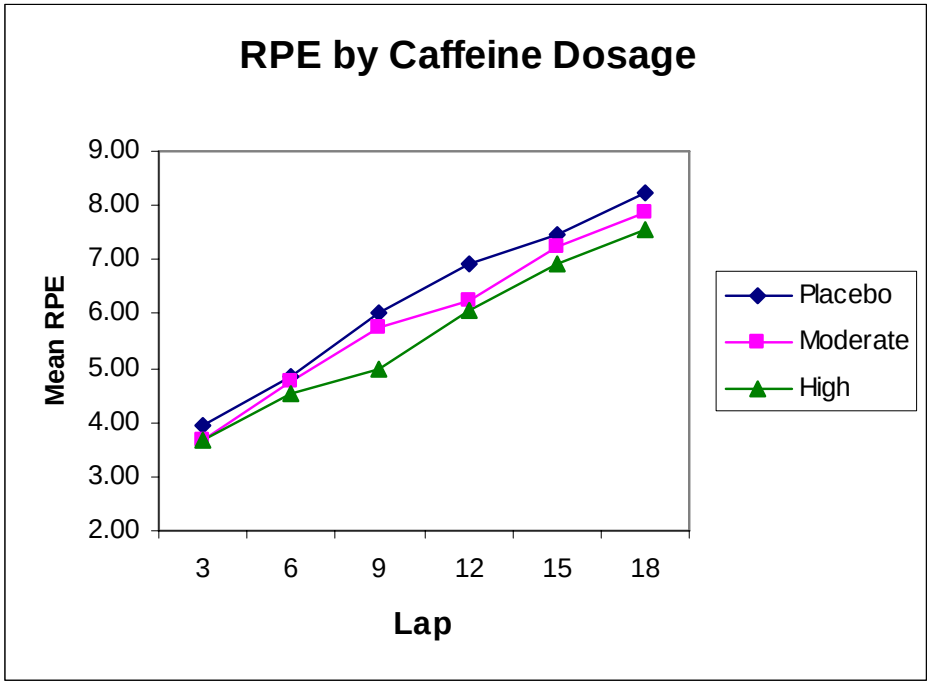

Figure 2

RPE vs. Lap Completion

As indicated by Figure 2, there is a trend among all dosage groups for RPE to rise with increasing lap completion. Means for each lap during administered placebo dosages at no time fell below RPE means for moderate and high dosages. At the first report for RPE (lap 3), the means for each dosage are very similar (placebo = 3.9, moderate = 3.6, high = 3.6). At the final lap, there was no significant difference ($p = 0.074$, Effect size = 0.196) between groups with regard to mean RPE. However, the greatest significant

difference ($p = 0.008$) occurred at lap 9, with additional significance ($p = 0.019$) shown at lap 12. Values and outcomes in significant difference for every 3 laps are shown in Table 5.

Table 5

Significant Values for RPE at Recorded Laps

Lap Number	*p*-value	Significant Differences
3	0.607	No significant difference between dosage groups.
6	0.461	No significant difference between dosage groups.
9	0.008	Significant difference between dosage groups; High is significantly lower than Placebo and Moderate.
12	0.019	Significant difference between dosage groups; High is significantly lower than Placebo.
15	0.220	No significant difference between dosage groups.
18	0.074	No significant difference between dosage groups.

Table 6

RPE Data

Placebo

Variable	*N*	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
Lap 3	13	3.92	1.25	3.00	7.00
Lap 6	13	4.84	1.14	4.00	7.00
Lap 9	13	6.00	0.91	4.00	8.00
Lap 12	13	6.92	0.75	6.00	8.00
Lap 15	13	7.46	0.77	6.00	9.00
Lap 18	13	8.23	0.72	7.00	9.00

Moderate

Variable	*N*	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
Lap 3	13	3.92	1.25	3.00	7.00
Lap 6	13	4.84	1.14	4.00	7.00
Lap 9	13	6.00	0.91	4.00	8.00
Lap 12	13	6.92	0.75	6.00	8.00
Lap 15	13	7.46	0.77	6.00	9.00
Lap 18	13	8.23	0.72	7.00	9.00

High

Variable	*N*	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
Lap 3	13	3.69	1.54	2.00	6.00
Lap 6	13	4.53	1.19	2.00	7.00
Lap 9	13	5.00	1.08	3.00	7.00
Lap 12	13	6.07	1.03	5.00	8.00
Lap 15	13	6.92	0.75	6.00	8.00
Lap 18	13	7.53	0.87	6.00	9.00

CHAPTER V

Discussion, Conclusions, and Recommendations for Future Studies

Discussion and Conclusion

The purpose of this study was to investigate the effects of various levels of caffeine administered via the energy drink Red Bull on 1.5-mile run completion time and rating of perceived exertion for college-aged males. Red Bull is a common ergogenic aid among athletes and the general population. Energy drinks, including Red Bull, is primarily marketed to those between the ages of 18 and 30 as a stimulant (Graham, 2001). This study chose to investigate specific effects of Red Bull on an active population in this age range in quantities commonly marketed for consumption by the public.

The first hypothesis stated that there would be no significant difference between treatments based on the amounts of caffeine from Red Bull on completion time. The results of the present investigation demonstrated that there were no significant differences between treatments for completion time regardless of which treatment was administered.

Although the current study demonstrated no significant differences between treatment groups, previous research has found significance when investigating the effects of caffeine when using significantly higher intake levels. Ivy et al (1979) conducted studies that resulted in prolonged time to exhaustion and increased oxidative rates. The researchers found that the subjects who ingested the caffeine dosage (300 – 800 mg), compared to the placebo, had the ability to exercise longer and harder.

In a study conducted by Bell and McLellan (2002), the researchers investigated the effects of caffeine on habitual and non-habitual users. The subjects were instructed to

cycle once a week for six weeks after consuming either a placebo or 5 mg/kg caffeine. This dosage administered to subjects in the current study would equal 315 – 415 mg of caffeine. Results showed that regardless of ingestion time, caffeine significantly improved non-habitual users' cycling times compared to the placebo.

Graham and Spriet (1995) conducted an investigation similar to the current study. The researchers examined the effects of various dosages of caffeine on running performance. Prior to exercise, the subjects ingested a placebo, 3 mg/kg, 6 mg/kg, or 9 mg/kg of caffeine. The 3 mg and 6 mg treatments showed average time improvements of 22 ± 9% and 22 ± 7%, respectively. The 9 mg trial produced negative results of mental confusion and undesirable completion times. The authors concluded that it is practical that individuals do not need to ingest more than 6 mg/kg of caffeine prior to exercise. This range of 3 – 9 mg/kg applied to the current study would equal 189 – 774 mg of caffeine.

Although the current study had a non-significant trend for lower completion times in relation to higher caffeine dosages, future studies are recommended to administer higher dosages as previous research has done. Research has indicated that appropriate levels range from 3 mg/kg to 6 mg/kg (Graham & Spriet, 1995).

The second hypothesis stated that there would be no significant differences between groups based on the amount of caffeine from Red Bull on rating of perceived exertion. Results indicated significance between treatment groups at laps 9 and 12.

Previous studies have indicated significance between treatment groups when addressing RPE as well, but with a lower requirement for caffeine levels. Bell et al

(1998) conducted a study involving running and found that caffeine reduced the subjects' sensation of fatigue, which allowed the subjects to work longer and harder.

In a study conducted by Norager et al (2005), the researchers investigated the effects of caffeine on an older population. While this study included college-aged males, it is also important to concentrate on older adults since this age group is increasingly pursuing an active lifestyle. Norager and colleagues administered a caffeine dosage of 6 mg/kg or a placebo and instructed their subjects to cycle with an increasingly workload of 25 watts every two minutes. RPE was measured at five minutes and upon completion of the test. Results not only showed an increase in cycling endurance by 25%, but also a reduction in RPE after 5 minutes of cycling by 11%.

Previous research and the current study provide evidence that a variety of age groups can benefit from the consumption of caffeine with lower perceived exertion levels. And, RPE has shown to be an unproblematic measurement of exertion among the different age groups.

Denadai and Denadai (1998) investigated the effects of caffeine on RPE. In their study, eight males with a mean age of 20 were included. The subjects performed a progressive test on a cycle ergometer and reported RPE every five minutes. The results indicated that the subjects' RPE was higher in trials in which no caffeine was ingested.

Bridge and Jones (2006) investigated the effects of caffeine on running performance. The researchers included eight male distance runners who would ingest either a placebo, a caffeine capsule (3mg/kg), or serve as the control. RPE was measured using the 1 – 10 Borg scale. Results indicated a significant improvement in performance times with an average improvement time of 23.8 seconds relative to the control group.

This study also indicated lower RPE levels during caffeine trials. The researchers speculated that the lower RPE was due to the stimulation of the central nervous system.

In the current study, there are several factors that could have contributed to its nonsignificant findings in regards to RPE and completion time. These items include subjects' physical and mental distress about the not knowing what they were ingesting and lack of control over factors such as pre-race nutrition and practices. One subject reported feeling nauseous after consuming the high-dosage, although he did not know the particular makeup of the treatment. Bonci (2004) explains that energy drinks can cause digestive difficulties in some individuals.

Another factor that could have contributed to performance results is the lack of control by the researcher over pre-race nutrition. The subjects were instructed to eliminate their caffeine intake the 48 hours before testing, as well as fasting six hours prior. While these factors are identified under the assumptions of the study, it would have been beneficial to have more control over the subjects' diet and caffeine intake.

An additional non-controlled variable that could have affected results was the intensity at which the subjects performed the 1.5-miles. Although the race allowed for optimal real-life applicability of results, it also allowed for wide variability of exercise intensity.

This study found that caffeine from Red Bull did not significantly improve completion time, but did improve RPE levels at approximately mid-test (.75 miles and 1.25 miles). However, there was a trend (9 out of 13 subjects) in lower completion time relative to a higher dose of caffeine. Results from previous research and this study support potential ergogenic effects of caffeine and energy drinks on aerobic performance.

This study has shown that the common energy drink, Red Bull, may assist in optimizing performance even in lower dosages.

Since there is limited research examining the effects of energy drinks as performance parameters, further investigations are warranted.

Recommendations for Future Studies

There are several recommendations for future studies after completing this process. First, it would have been beneficial to have a sample size larger than the one used in this study. Second, it was interesting to discover that the most efficient way to communicate with subjects was through cell phone text messaging. This was evident after there were limited responses following e-mails and phone calls. However, if a text message was sent to a subject, there was in most instances an immediate response.

Although running on an indoor track provided real-life applicability, it also provided physical and mental limitations to the subjects. The sharp turns on their designated running lane proved to be problematic even in the third testing period. It is recommended that an outer lane be used with adjustment to lap numbers to equal the same designated distance. Furthermore, almost every subject complained of how mundane the test became since it involved completing 18 laps indoors. It may have been more beneficial to move the same test to an outdoor track where the subjects would not feel confined or bored. One subject provided his preference of using the treadmill versus the track so he could monitor his speed and progression.

It would be interesting to see how females respond to caffeine in a similar testing protocol. Although menstrual cycles could potentially affect results, especially that of RPE, a shorter study could be administered to eliminate that variable. An important

consideration to apply to future studies with females is to consider gender differences in weight and adjust dosages to their smaller body weights. The smaller body weight of women usually results in the caffeine dosage being about 20% higher than their male counterparts (Graham, 2001).

This study used non-sugar free Red Bull as its source of caffeine and did not consider and make assumptions of the possibility of provided sugar effecting performance. However, there is 21.5 grams of sucrose in an 8.3 oz. can of Red Bull. In addition, the Kool-Aid contains 16 grams of sugar per serving (8 fl oz) which was used in the placebo treatment. To eliminate this additional energy source, future studies should utilize the sugar-free version of Red Bull and placebo.

Completion time was the only time recorded in this study. In future studies, more lap times could be recorded to examine the incremental effect of caffeine on performance. By recording solely the completion time and not times throughout the exercise, it limited data collection and potential results.

In the future, studies need to be designed to investigate the effects of higher dosages of caffeine on similar testing protocols. Significant differences in RPE were seen mid-test in laps 9 and 12 at the 80 mg caffeine level. Since RPE peaked early at these caffeine levels, the RPE for higher intakes could theoretically occur later in the run. Further studies could examine this possibility. Furthermore, higher dosages than used in this study would be used to assess the effects of caffeine. As indicated by previous research, an acceptable and noteworthy range to administer is 3 mg/kg to 6 mg/kg (Bridge & Jones, 2006; Bell & McLellan, 2002; Graham & Spriet, 1995).

Since running is an attainable form of physical activity to most anyone who is able-bodies, further investigations need to utilize this mode of exercise.

Future studies are needed which further investigate the potential ergogenic effects of energy drinks. There has been limited previous research and the current study shows significant effects on some aspects of performance, specifically perceived exertion. Studies which investigate energy drinks should administer the dosages in the range of 3 – 6 mg/kg. Previous research (Graham & Spriet, 1995; Bridge & Jones, 2006) has indicated significant results when administering these dosages.

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APPENDIX A

Godin Leisure-Time Questionnaire

GODIN LEISURE TIME EXERCISE QUESTIONNAIRE

1. Considering a 7-day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number)?

Times Per Week

a) STRENUOUS EXERCISE
(HEART BEATS RAPIDLY) _____

(e.g., running, jogging, hockey, football, soccer, roller skating, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling

b) MODERATE EXERCISE
(NOT EXHAUSTING) _____

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing)

c) MILD EXERCISE
(MINIMAL EFFORT) _____

(e.g., yoga, archery, fishing from river bank, bowling, golf, easy walking, horseshoes)

2. During a typical 7-day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

□ Often _____
□ Sometimes _____
□ Never / rarely _____

By signing below, I promise that my answers to the questions associated with this questionnaire are true and not misleading in any way. I understand what the questions were asking and have answered honestly.

Printed Name _____ **Signature** _____
Date _____ **Witness** _____

APPENDIX B

Par-Q

Physical Activity Readiness Questionnaire PAR-Q

For most people physical activity should not pose any problem or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read them carefully and check the yes or no opposite the question if it applies to you.

YES NO

1. ☐ ☐ Has your doctor ever said you have heart trouble?
2. ☐ ☐ Do you frequently have pains in your heart and chest?
3. ☐ ☐ Do you often feel faint or have spells of severe dizziness?
4. ☐ ☐ Has a doctor ever said your blood pressure was too high?
5. ☐ ☐ Has your doctor ever told you that you have a bone or joint problem such as arthritis that has been aggravated by exercise, or might be made worse with exercise?
6. ☐ ☐ Is there a good physical reason not mentioned here why you should not follow an activity program even if you wanted to?
7. ☐ ☐ Are you over age 65 and not accustomed to vigorous exercise?

If you answered YES to one or more questions...

If you have not recently done so, consult with your personal physician by telephone or in person before increasing your physical activity and/or taking a fitness test.

If you answered NO to all questions...

If you answered PAR-Q accurately, you have reasonable assurance of your present suitability for an exercise test.

APPENDIX C

Caffeine Screening Questionnaire

Thesis Study – Subject Recruitment and Screening

Name: _____ Age: _____
Weight: _____ Height: _____

Contact Information

Phone: _____
E-mail(s): _____

Times Available for Participation

** Please "X" the days during the week you would be available to participate in testing (testing will take place for 3 weeks, once per week).

Sunday	Monday	Thursday	Friday	Saturday

Caffeine Usage

PLEASE ANSWER THE FOLLOWING QUESTIONS HONESTLY AND TO THE BEST OF YOUR KNOWLEDGE.

1. On average, how many times per day do you can consume caffeinated products? (tea, coffee, energy drinks, etc). _____
2. How often do you consume energy drinks during a one-month period? (Throttle, Red Bull, Monster Energy, etc). _____
3. On the attached sheet, please circle the following caffeinated products you consume most frequently. Next to the item, please write the number of days per week you consume this product.

Initial Health Screening

PLEASE ANSWER THE FOLLOWING QUESTIONS HONESTLY AND TO THE BEST OF YOUR KNOWLEDGE. WRITE "YES", "NO", OR "I DON'T KNOW" NEXT TO THE QUESTION.

1. Do you have any known injuries (back, knee, etc.) that would prevent you from performing to your optimal ability?
2. Are you currently taking any medications that you have been told you should not take concurrently with energy drinks or highly-caffeinated products?
3. Have you ever had a bad reaction or experience following the use of energy drinks or highly-caffeinated products?

APPENDIX D

Caffeine-Containing Foods, Beverages, and Drugs

CAFFEINE-CONTAINING FOODS, BEVERAGES, AND DRUGS

Product	Serving Size	Caffeine (mg)
OTC Drugs		
NoDoz, maximum strength; Vivarin	1 tablet	200
Excedrin	2 tablets	130
NoDoz, regular strength	1 tablet	100
Anacin	2 tablets	64
Midol	1 tablet	64
Coffees		
Coffee, brewed	8 oz.	135
Coffee, instant	8 oz.	95
General Foods Int. Coffee, Café Vienna	8 oz.	90
Maxwell House Cappuccino, Mocha	8 oz.	60 – 65
General Foods Int. Coffee, Swiss Mocha	8 oz.	55
Maxwell House Cappuccino, Amaretto	8 oz.	25 – 30
Maxwell House Cappuccino, decaffeinated	8 oz.	3 – 6
Coffee, decaffeinated	8 oz.	5
Teas		
Tea, leaf or bag	8 oz.	50
Snapple Iced Tea, all varieties	16 oz. bottle	42
Lipton Natural Brew Iced Tea Mix	8 oz.	25 – 45
Lipton Tea	8 oz.	35 – 40
Tea, green	8 oz.	30
Arizona Iced Tea, all varieties	16 oz. bottle	15 – 30
Tea, instant	8 oz.	15
Soft Drinks		
Mountain Dew	12 oz.	55.5
Diet Coke	12 oz.	46.5
Coca-cola classic	12 oz.	34.5
Dr. Pepper	12 oz.	42
Pepsi-cola	12 oz.	37.5
Barqs Root Beer	12 oz.	22.5
Chocolate or Candies		
Hershey's Special Dark Chocolate Bar	1 bar (1.5 ounces)	31
Hershey bar (milk chocolate)	2 pieces	10
Cocoa or hot chocolate	8 oz.	5
Baking chocolate	1 oz.	35
Sweet chocolate	1 oz.	20
Frozen Desserts		
Ben & Jerry's No Fat Coffee Yogurt	1 cup	85
Starbucks Coffee Ice Cream	1 cup	40 – 60
Haagen-Dazs Coffee Ice Cream and Yogurt	1 cup	30 – 58
Starbucks Frappuccino Bar	1 bar (2.5 oz.)	15

APPENDIX E

Informed Consent / Subject Instructions

UNIVERSITY OF CENTRAL OKLAHOMA
INDIVIDUAL'S CONSENT TO VOLUNTARY PARTICIPATION IN A RESEARCH PROJECT

TITLE OF PROJECT:	The Effects of Caffeine on Rate of Perceived Exertion and Completion Times in a 1.5-mile Run Test in College-Aged Males
PRINCIPLE INVESTIGATOR:	Melissa Wood, Graduate Student, Kinesiology and Health Studies Department, University of Central Oklahoma
FACULTY ADVISOR:	Darla Fent, Ph.D. Kinesiology and Health Studies Department, University of Central Oklahoma

Introduction:
This is to certify that I, _____ agree to participate as a volunteer in a study concerning the potential ergogenic effects of caffeine administered via energy drinks. Such effects that will be examined are the rate of perceived exertion and completion times for a 1.5-mile run test. Supervision of testing will be under the direction of Dr. Darla Fent and Melissa Wood.

The testing protocol requires that each subject independently run on an indoor track for a total of 1.5 miles, which is the equivalent to eighteen (18) laps.

I understand that if anytime during the test I feel uncomfortable or feel like I need to stop, I am encouraged to do so. I am not required to run the entire test if it puts me in physical or mental discomfort. I will not be penalized or excluded from the study if I do not run the entire 1.5 miles of the test.

Purpose:
The main purpose of this study is to investigate what potential effects caffeine may have on various aspects of running performance, including rate of perceived exertion and completion times. Caffeine dosages will be administered in 40-mg and 80-mg dosages. A 40-mg dosage is the equivalent to a half cup of caffeinated coffee. An 80-mg dosage is the equivalent to one full cup of caffeinated coffee.

Description of the Study:
The subject will complete a standard Par-Q (Physical Activity Readiness Questionnaire) and Godin Leisure Time Activity Questionnaire to ensure they have no disabilities or conditions that may prohibit participation in this study.

1. Prior to subject arrival, all equipment used was calibrated to make certain accurate measurements were recorded.

2. The appropriate staff of the Wellness Center was reminded of the day's proceedings to ensure no interference or conflicting participation on required equipment utilized for the 1.5 mile run test.
3. The researcher's assistant isolated themselves away to prepare dosages and organize its administration. The researcher did not enter the laboratory while this procedure was being completed.
4. The first subject reported to the human performance laboratory in the UCO Wellness Center. Each of the twelve subjects was scheduled to arrive thirty minutes apart thereafter. Upon arrival, the subjects entered the laboratory where only the researcher's assistant greeted them and provided further instructions. Questions were always encouraged to ensure optimal understanding of both the 1.5 mile run test and of the RPE scale.
5. Immediately following their check-in, subjects ingested one of the three dosages which were assigned by the assistant. Dosages were rotated all three testing days so that each subject ingested each of the three dosages (placebo, moderate, or high). Materials used in this step included non-transparent paper cups with their identification numbers written on them.
6. Ingestion was followed with a 20-minute absorption period in which the subject was required to sit comfortably while still remaining in the human performance laboratory. This time was significant to ensure optimal absorption of caffeine within the body.
7. During the absorption period, the assistant again, in detail, provided instructions for the 1.5 mile run. They were also visually introduced to the RPE scale and

given instructions on how to accurately report their rate or perceived exertion at the appropriate times.

8. After this 20-minute time period was completed, the subjects performed a 5-minute warm-up on the treadmill located upstairs in the University of Central Oklahoma Wellness Center. ACSM recommends that cardiorespiratory fitness be preceded with a 5-minute warm-up period. The incline was kept at 0% grade and speed remained constant at 3.5% during the five-minute warm-up.
9. Following the check-in, ingestion, and absorption time, the subjects met the researcher at the upstairs track they were to be tested on. The subjects were again asked if they had any questions and if they fully understood the procedure.
10. Subjects were strongly encouraged to complete the test in the quickest time possible to the best of their ability.
11. Subjects were asked to report their RPE at the completion of 1.5 miles. The researcher recorded their RPE levels according to identification numbers. Completion times were recorded at the completion of 1.5 miles / 18 laps.
12. Subjects ended the test with a 5-minute cool-down, which consisted of them walking at a slower pace. Before leaving, next scheduled test times were confirmed.

Risks:

Subjects will not be asked to do any physical activity that they do not feel comfortable performing, nor will they be asked to respond physically in a manner that results in any known risk to the subjects.

i. There is a possibility that subjects may experience temporary muscle soreness from 1.5-run test.
ii. Injury may occur if warm-up, cool-down, and safety procedures are not followed. Every effort is made to minimize these occurrences.

Benefits:
Information regarding my own personal responses to the exercise and treatment will be available to me as the conclusion of testing upon my request.

Alternative to Participation:
The alternative to participation is not to participate in this research study or in any part of this program. Subjects can choose to drop out of the study at any time they begin to feel uncomfortable with the study.

Compensation for Injury:
Subjects understand that no compensation will be available to me from the University of Central Oklahoma. No other financial aid will be provided for any long-term injury that may occur from participation in this study.

Course Credit / Compensation for Participation:
Subjects involved in this research project shall not receive course credit of compensation for participation.

Contacts for Questions about Research Subject's Rights:
Any questions concerning this research project can contact Dr. Darla Fent or Melissa Wood at (405) 974-3599 or (405) 820-6262, respectively. Any questions concerning subject's rights, as a research participant, can be directed to the Jackson College of Graduate Studies and Research at (405) 974 – 3341.

Contacts for Questions of Concerns about Student Health:
Any questions concerning health or injury during this research project can contact the UCO Student Health Center at (405) 974-2317. I also understand and acknowledge that the principle investigator of this study personally took me to the facilities of the Student Health Center to ensure that I knew the location, hours, and services of the Center. I am encouraged to visit the Student Health Center at any time during this study if I feel physical discomfort from participation.

Subject Assurance:
All information obtained about me will be kept confidential and will not be released in a format that will allow my indemnification without my written consent. Data obtained about me can be released in a statistical manner as long as my confidentiality is assured. Subjects are to understand that information matching names and ID numbers of subjects will be destroyed following the statistical analysis phase of the study.

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 have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that copy of this Informed Consent Form has been given to me to keep.

Research Subject:

Printed Name: _____ Date: _____

Signature: _____ Date: _____

Witness: _____ Date: _____

APPENDIX F

Data Sheets

THE EFFECTS OF CAFFEINE RESEARCH STUDY
SUBJECT DATA COLLECTION

SUBJECT IDENTIFICATION NUMBER: _____

Time of caffeine ingestion: _____ Testing Day: _____

REPORTED RPE LEVELS (0 – 10)

Lap 3: _____
Lap 6: _____
Lap 9: _____
Lap 12: _____
Lap 15: _____
Lap 18: _____

RUNNING / COMPLETION TIMES

.75 miles / 9 laps: _____
1.5 miles / 18 laps: _____

APPENDIX G

Dosage Rotation

Dosage Rotation for Day One

Subject Identification Number	*Dosage Assignment*
P121	Moderate
P141	Moderate
P161	Placebo
P181	Placebo
P211	Placebo
P271	Moderate
P261	Moderate
P241	Placebo
P221	Placebo
P191	Moderate
P171	Moderate
P111	Moderate
P131	High

Dosage Rotation for Day Two

Subject Identification Number	*Dosage Assignment*
P121	Placebo
P141	High
P161	High
P181	High
P211	Placebo
P271	High
P261	High
P241	High
P221	High
P191	High
P171	Moderate
P111	High
P131	Moderate

Dosage Rotation for Day Three

Subject Identification Number	*Dosage Assignment*
P121	High
P141	Placebo
P161	Moderate
P181	Moderate
P211	High
P271	Placebo
P261	Placebo
P241	Moderate
P221	Moderate
P191	Placebo
P171	Placebo
P111	Placebo
P131	Placebo

APPENDIX H

Godin Leisure-Time Questionnaire Results

Godin Results	
Subject	*Total*
P121	11
P141	13
P161	13
P181	8
P211	15
P271	17
P261	9
P241	13
P221	12
P191	6
P171	9
P111	8
P131	6