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THE ACUTE EFFECTS OF A CAFFEINE CONTAINING SUPPLEMENT ON ANAEROBIC POWER AND SUBJECTIVE MEASUREMENTS OF FATIGUE IN RECREATIONALLY ACTIVE MALES

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Chelsea J. Hahn

College of Science and Health
Clinical Exercise Physiology

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By Chelsea J. Hahn

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2/19/16	
Andrew Jagim, Ph.D. Thesis Committee Chairperson	Date
	1-20-2016
Clayton Camic, Ph.D. Thesis Committee Member	Date
	1/20/2016
Matthew Andre, Ph.D. Thesis Committee Member	Date

Thesis accepted

	2/26/16
Steven Simpson, Ph.D. Graduate Studies Director	Date

ABSTRACT

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The consumption of caffeinated beverages to enhance performance is common in young adults. The purpose of this study was to examine the acute effects of a caffeine containing supplement on anaerobic power (AP) and subjective measurements (SM) of fatigue. Fourteen recreationally active college-aged males (mean value ± standard deviation, age 21 ± 0.7 yrs., height: 178.5 ± 5.1 cm, weight: 77.3 ± 9.6 kg, fat-free mass: 87.4 ± 4.8 kg) participated in a double-blind, placebo-controlled, crossover design study and ingested an energy drink or a non-caffeinated placebo prior to a bout of exercise. Participants reported to the lab for a total of four sessions consisting of two familiarization sessions and two experimental sessions separated by 48-72 hours. Anaerobic power was assessed using a counter-movement vertical jump (CMVJ) test and a non-motorized force treadmill sprint test during which the participants sprinted against 18% of their individual body mass for 25-seconds. Subjective measurements were obtained using a 5-point Likert scale. No statistically significant differences were observed between conditions for AP and CMVJ. The caffeine containing supplement significantly maintained SM of energy and fatigue compared to placebo. In conclusion, the current study suggests that consumption of a caffeine containing supplement did not affect AP but did help maintain feelings of energy and fatigue following high-intensity exercise.

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INTRODUCTION

Energy drinks have recently been increasing in popularity, touting benefits of increased mental and physical capabilities. Seventy percent of adolescents and young adults have reported using at least one nutritional supplement at some point in their life, with high-energy drinks being the most popular (Hoffman et al., 2008). Of the 70% that consume these supplements, 30% report consuming energy drinks on a regular or daily basis (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011). Caffeine is one of the most widely used drugs in the world, and is a common ingredient of energy drinks (Astorino & Roberson, 2010). In the United States, 90% of adults report consuming caffeine on a daily basis (Astorino & Roberson, 2010). Glucose, taurine, L-Theanine and ginseng, are examples of other commonly found ingredients in energy drinks (Childs, 2014). By combining ingredients there may be a synergistic benefit for the consumer. Energy drinks are largely unregulated by the United States Food and Drug Administration; however, it is recommend that no more than 6mg of caffeine per fluid ounce be consumed (Childs, 2014). With the number of energy drinks available to the public, research has not been able to address the efficacy of each product.

A majority of the research done on the effects of caffeine ingestion on exercise performance has used dosages ranging from 5-13mg/kg body mass (Spriet, 2014). These are considered to be moderate to high dosages of caffeine and have been reported to cause gastrointestinal discomfort, headaches, and dizziness. Lower dosages of caffeine (≤3mg/kg body mass) have not been researched as thoroughly; though the research that has been done suggests the undesirable side effects produced by moderate to high dosages of caffeine are not seen in participants consuming low dosages of caffeine (Spriet, 2014). The paucity of research on the potential ergogenic and cognitive effects of low dosages of caffeine ingestion in active individuals is an area that requires further research. High-intensity sprinting and AP activities, specifically, are an area of research where the effects of low dosages of caffeine ingestion are necessary.

Research has shown that caffeine ingestion can increase endurance performance, but the efficacy of caffeine ingestion on high-intensity short duration activities is ambiguous (Astorino & Roberson, 2010). Phosphocreatine (PCr) and adenosine triphosphate (ATP) production in the glycolytic pathway are the two main pathways for the production of anaerobic energy. While the PCr store can be consumed in a few seconds, these pathways are able to provide energy very quickly and in large quantities for short periods of time (Parolin et al., 1999). This allows for the completion of high-intensity short duration activities such as sprinting.

There have been several studies that have examined the acute effects of ingesting caffeine containing supplements on anaerobic power (AP). A study by Forbes, Darren, Little, Magnus, and Chilibeck (2007) examined the effects of Red Bull energy drink consumption on AP and muscle endurance in healthy young adults. Results showed that consumption of Red Bull versus a non-caffeinated placebo significantly increased muscular endurance as measured by an increase in total bench-press repetitions over the course of 3 sets (Red Bull = 34 ± 9 vs. placebo = 32 ± 8 repetitions $p<0.05$), but there was no effect on peak or mean power during the Wingate anaerobic test in male and female subjects. Further, a study by Fukuda, Smith, Kendall, and Stout (2010) examined the acute effects of consuming a caffeine, creatine, and amino acid supplement on anaerobic running performance and found that anaerobic running capacity increased by 10.8% following ingestion of the supplement. These results differed from the study by Forbes et al. (2007) where power was unaffected however the mode of exercise utilized a sprinting protocol instead of a biking protocol.

Aside from the performance-related effects of caffeine, there has also been research looking into the subjective measurements (SM) such as markers of energy, fatigue, alertness, and focus during exercise. For example, Childs (2014) conducted a meta-analysis on energy drink consumption and their subsequent influence on mood and cognitive performance. It was concluded that there is a lack of empirical evidence between the interactions of caffeine and other energy drink ingredients on mood and cognitive performance. However, there are several caffeine-based pre-workout supplementation studies that have shown positive improvements in alertness, energy, and focus, as well as a decrease in fatigue (Gonzalez, et al., 2011; Walsh, Gonzalez, Ratamess, Kang, & Hoffman, 2010; Hoffman et al., 2009; Alford, Cox, & Wescott, 2001) both during and following bouts of high-intensity exercise.

Hogervorst, Riedel, Kovacs, Brouns, and Jolles (1999) published two studies suggesting that low doses of caffeine improve cognitive performance during and after strenuous exercise. While both of the studies looked at aerobic exercise activities it cannot be ruled out that similar results could be found during high-intensity short duration exercise. One study had trained cyclists and triathletes complete cognitive tests—including memory, psychomotor, and attention tasks—before and immediately after 1 hour of exercise on a cycle ergometer (Hogervorst et al., 1999). Participants were given three different dosages of caffeine (150, 225, 320mg) prior to cycling. Results indicated that the two low doses of caffeine improved all cognitive functions following exercise and the higher dose provided no further improvement (Horgervorst et al., 1999). Researchers concluded that the ability to concentrate and make decisions was improved by caffeine ingestion immediately after strenuous exercise.

It is difficult to compare the benefits of various energy drinks due to differences in ingredients from one product to another and differences in exercise protocols used. One caffeine containing energy drink that has not been well-researched is a commercially available product called Spark®. Gwacham and Wagner (2012) examined the effects of Spark® ingestion prior to exercise on AP output of Division I American Football players (Gwacham & Wagner, 2012). Results indicated that there was no statistically significant increase in AP (p=0.066) or sprint time (p=0.097); however researchers did find a significant interaction between non-habitual caffeine users and Spark® for AP (p=0.045) and sprint time (p=0.032).

In April of 2015, the company that produces Spark® reformulated the product; at which time maltodextrin was removed. The removal of maltodextrin reduced the calories and carbohydrates in a serving of Spark®. To our knowledge, no published literature currently exists examining the benefits of the new formulation, particularly how it impacts high-intensity exercise performance and SM of fatigue. Therefore, the purpose of this study was to evaluate the acute effects of this caffeine containing supplement on AP and SM of fatigue in recreationally active males. We hypothesized that the caffeine-containing beverage would elicit a greater increase in AP and an improvement in SM of fatigue following consumption compared to a placebo in recreationally active males.

METHODS

Experimental Design

This study utilized a double-blind, placebo-controlled, crossover design. Following recruitment, participants visited the laboratory on four separate occasions. All participants completed a familiarization session consisting of practice trials on the non-motorized force treadmill and completion of paperwork. At this time, participants completed health and exercise history questionnaires and written consent was obtained. For the familiarization trials on the non-motorized force treadmill, participants completed three practice sprints using a load set at 18% of their body weight. Sprints were 10, 15, and 20-seconds in duration with 3-minutes of rest in between and participants were instructed to complete them with maximal effort. Participants then returned to the laboratory within 48-72 hours to complete a baseline testing session consisting of a body composition test and a second set of familiarization sprints on the non-motorized force treadmill. Participants were also asked to complete two maximal sprints lasting 20-seconds against a load set at 18% of their body weight.

Prior to coming in for the two experimental testing sessions, participants were instructed to avoid strenuous physical activity for at least 24 hours. Participants were also instructed to not eat at least 2-3 hours prior to testing. In addition, participants completed a 2-day food log prior to each testing session and were advised to consume a similar dietary intake for each session.

During the third and fourth visit (experimental testing sessions) participants first completed a 5-point Likert scale questionnaire (figure 1) to rate their baseline levels of energy, fatigue, alertness, and focus. The 5-point Likert scale has been used in previous research as a way to assess SM of fatigue (Hoffman et al., 2009). After completing the questionnaire, participants consumed either the caffeine-supplement or a placebo beverage and remained seated. Twenty-minutes after consuming the beverage, a resting blood lactate reading was taken and recorded. Participants then completed a 5-minute dynamic warmup consisting of body weight lunges, jumping jacks, body weight squats, broad jumps, and skips for height. Following the dynamic warmup, subjects completed a counter-movement vertical jump (CMVJ) test using a jump mat (Just Jump System). Participants were allowed three attempts with the highest attempt being recorded as their representative score. Jump height (cm) and body mass (kg) were later used to calculate lower body power as previously described (Johnson & Bahamonde, 1996). Next, participants walked on a motorized treadmill for 5-minutes at a comfortable walking pace (2.5-3.5mph). Participants then completed a 25-second maximal effort sprint test and verbal encouragement was given for the duration of the sprint.

Resistance was set at 18% of the participant's body weight. In a study by McLain et al. (2015) it was found that a resistance of 18% elicited the highest peak power values on the non-motorized treadmill. All participants started the test in a crouched, split-stance, standing position. This helped to ensure that the waist tether was in a taut position. The participants were then asked to sprint as fast as they could without pacing themselves for the duration of the test. Once the test was completed, participants immediately completed the questionnaire a third time and underwent an active recovery.

Active recovery lasted for 5-minutes at a comfortable walking pace (between 2.5-3.5 miles per hour) for each individual participant. Five minutes into the recovery a second blood lactate level reading was obtained. Anaerobic power values were determined from the anaerobic sprint test. During the fourth visit, participants received the opposite treatment (caffeine supplement or placebo) and completed the same protocol as the third visit.

Participants

Participants were recruited from a university in the Midwest region through verbal request. Each participant was provided with a cover letter and informed consent by the investigators. The protocol and requirements for participation were explained to them, and any participant meeting inclusion criteria signed the informed consent prior to beginning data collection. Participants then completed a PAR-Q (figure 2), health history questionnaire (figure 3), and caffeine questionnaire (figure 4) to further determine eligibility for the study. Approval for this study was given by the University Institutional Review Board for Human Subjects.

Inclusion criteria for this study entailed being a college-aged male who participated in at least 150-minutes of physical activity on a weekly basis, free from injury, and not a habitual caffeine user. Participant gender and age were self-reported prior to beginning the study.

Instrumentation and Testing

Body Composition

Air displacement plethysmography (*BODPOD, Cosmed USA*) was the digital instrument used to obtain participant body composition. A wall scale and Broca plane were used to measure height (cm) of each participant. A health-o-meter beam scale (*Health o meter® Professional Scales, McCook, IL*) was used to measure weight (lb.) of each participant. Weight measurement was then converted to kilograms. These measurements were necessary to identify the load (18% of individual body weight) in which participants would be sprinting against during the anaerobic sprint running test and to assess participant demographics.

Sprint Performance

A non-motorized Force 2.0 treadmill (*Woodway, Waukesha, WI*) was used to assess anaerobic sprint performance. Commonly used in previous research, the anaerobic sprint running test on a Woodway model has been shown to be a reliable method to assess AP characteristics (McLain et al., 2015). McLain et al. (2015) used intraclass correlation coefficients (ICC) and coefficient of variation (CV) levels to test the reliability of this testing modality (r = 0.96-0.97, CV = 6-7%). The treadmill in combination with the Pacer Performance Software (*Innervations, Perth, Western Australia*) was used to calculate the distance, velocity, power, work, and horizontal force generated by each of the participants. A speed sensor on the back of the treadmill was used to measure distance. The Pacer Performance Software was used to digitally filter the distance/time data and provide a velocity output as well as acceleration data, instantaneous velocity, horizontal force, and power. The waist tether worn by participants was connected to a load cell which measured horizontal force. (Andre et al., 2013).

Blood Analysis

Fingertip capillary blood samples were analyzed using the Lactate Plus Lactate Analyzer (*Lactate Plus, USA*). A resting blood lactate sample was taken prior to the warm-up and sprinting activities. A post-treadmill blood lactate sample was taken 5-minutes after sprinting on the treadmill.

Dietary Analysis

Food log data was entered into the ESHA database (*ESHA, Salem, Oregon*). The ESHA dietary analysis software categorized the food log information into calories, carbohydrates, fat, and protein. The analysis of the different categories was used to identify similarities and discrepancies in dietary intake prior to each testing condition. If a difference was observed, that subject was removed from analysis.

Supplement Preparation and Consumption

The beverages for the experimental testing sessions were prepared by a third party whose sole responsibility was to prepare and track the beverage conditions. The caffeine-containing supplement or placebo was placed in a blender bottle and 8 ounces of cold water was added to the bottle. The beverage was then shaken and chilled in a refrigerator prior to participant consumption. Participants consumed the beverage in the laboratory.

STATSITICAL ANALYSIS

Data were analyzed using SPSS version 23.0 software (*SPSS Inc., Chicago, IL*). Dependent variables included distance, average velocity, peak velocity, time of peak velocity, vertical jump height, time of peak power, average horizontal force, time of peak horizontal force, average work, average power, blood lactate levels, and subjective markers of fatigue. Independent variables included type of beverage consumed. Paired samples t-tests were used to analyze the differences between the caffeine containing supplement and the placebo data for all AP dependent variables. A series of two-way ANOVAs with repeated measures were used to analyze the pre- and post-treadmill Likert scale scores for energy, fatigue, alertness, and focus between conditions. A separate two-way ANOVA with repeated measures was run on the blood lactate levels. A one-way ANOVA with repeated measures was used to analyze the food log data. An alpha level of $p<0.05$ was considered to be statistically significant.

RESULTS

Initially, there were 18 participants in the study. One individual did not complete the study due to illness, one was removed due to inconsistencies in dietary intake, and two others were removed due to technical difficulties when equipment did not record data from the non-motorized treadmill. Descriptive characteristics of participants who completed the study are presented in Table 1.

Table 1. Descriptive characteristics of the participants (N=14).

Variable	Participants
Age (yrs.)	21 ± 0.7
Height (cm)	178.5 ± 5.1
Weight (kg)	77.3 ± 9.6
Fat mass (kg)	10.5 ± 5.0
Fat free mass (kg)	66.7 ± 6.2
Percent fat mass	12.6 ± 4.80
Percent fat free mass	87.4 ± 4.81

Data are reported as mean ± standard deviation.

A summary of AP variables measured by the treadmill in combination with the Pacer Performance Software for each condition are presented in Table 2. It was found that there was no significant difference (p <0.05) between the two conditions across all performance variables analyzed. A summary of AP variables measured by the CMVJ are presented in Table 3. It was found that there was no significant difference (p <0.05) between the two conditions across all performance variables analyzed. Differences in SM between the two conditions are presented in Table 4. A significant pre-post by group interaction was found between conditions for energy (p=0.040) and fatigue (p=0.035) scores. Tukey's post-hoc tests revealed that energy and fatigue levels were better maintained between pre- and post-treadmill scores following consumption of the caffeine containing supplement. There were no statistically significant differences between the two conditions for alertness or focus following consumption of the caffeine containing supplement.

Table 2. Anaerobic variables from treadmill and pacer performance software (N=14).

Variable	Spark®	Placebo	*p*-value
Distance (m)	114.12 ± 2.33	114.03 ± 2.45	0.88
Velocity			
Average (m/s)	4.55 ± 0.09	4.55 ± 0.09	0.90
Peak (m/s)	5.19 ± 0.14	5.16 ± 0.11	0.19
Time of Peak (s)	3.36 ± 1.52	3.46 ± 2.08	0.84
Power			
Average (W)	776.14 ± 67.45	767.46 ± 72.11	0.22
Peak (W)	2,689.92 ± 403.65	2,608.21 ± 318.23	0.43
Time of Peak (s)	5.22 ± 4.32	3.53 ± 4.38	0.30
Horizontal Force			
Average (N)	169.42 ± 13.07	167.37 ± 13.38	0.20
Peak (N)	595.10 ± 77.28	603.55 ± 121.74	0.81
Time of Peak (s)	0.99 ± 1.47	0.99 ± 2.01	0.97
Work			
Average (J)	555.31 ± 94.99	544.91 ± 83.50	0.67

Data are reported as mean ± standard deviation.

Table 3. Vertical jump measurements and lower body power calculations (N=14).

Variable	Spark®	Placebo	*p*-value
Vertical Jump			
Height (cm)	63.14 ± 5.18	63.80 ± 8.41	0.71
Average Power (W)	3,015.44 ± 348.80	3,044.35 ± 354.58	0.58
Peak Power (W)	5,647.94 ± 652.75	5,699.82 ± 657.77	0.58

Data are reported as mean ± standard deviation.

Table 4. Subjective Variables: energy, fatigue, alertness, and focus measured by the 5-point Likert scale (N=14).

Variable	Pre-treadmill	Post-treadmill	*p*-value
Energy			
Spark®	3.36 ± 0.63	3.00 ± 0.96	0.04*
Placebo	3.50 ± 0.52	2.57 ± 0.76	0.04*
Fatigue			
Spark®	2.64 ± 0.50	3.57 ± 1.02	0.03*
Placebo	2.43 ± 0.65	4.14 ± 0.54	0.03*
Alertness			
Spark®	3.57 ± 0.76	3.57 ± 0.76	0.46
Placebo	3.71 ± 0.61	3.50 ± 0.86	0.46
Focus			
Spark®	3.57 ± 0.76	3.50 ± 0.76	0.18
Placebo	3.71 ± 0.61	3.14 ± 0.86	0.18

*Significant pre-post by group interaction (p<0.05).
Data are reported as mean ± standard deviation.

Differences in blood lactate were measured pre- and post-treadmill. No statistically significant interaction (p=0.23) between conditions on blood lactate levels was observed. Pre-treadmill blood lactate levels were 1.6 ± 0.5 for the caffeine supplement and 1.4 ± 0.6 for the placebo condition. Post-treadmill blood lactate levels were 14.2 ± 1.0 for the caffeine supplement and 13.5 ± 1.3 for the placebo condition. Blood lactate values increased 89% during the caffeine supplement condition and increased 90% during the placebo condition.

DISCUSSION

The purpose of this study was to investigate the acute effects of a caffeine containing supplement on AP measurements and SM of fatigue in recreationally active males. Results of the current study suggest that the caffeine containing supplement had no impact on CMVJ or AP, but positively influenced SM of energy and fatigue compared to placebo following a bout of high-intensity exercise. To our knowledge, this is the first study to look at this recently reformulated commercially available beverage and one of a few to evaluate its ergogenic benefit on AP and SM.

It was hypothesized that the caffeine supplement would elicit a greater increase in AP and an improvement in SM of fatigue following consumption compared to a placebo in recreationally active males. Results indicated that there was not a statistically significant increase in CMVJ or AP; however, SM of energy and fatigue were better maintained after consuming the caffeine supplement. These results were consistent with previous findings which concluded there may be a significant impact on fatigue and energy during cognitive and AP tasks (Childs, 2014; Hoffman et al., 2009; Alford et al., 2001) following ingestion of a caffeinated supplement. For example, Alford et al. (2001) found significant improvements in mental performance—including reaction time, concentration, and memory—after consuming Red Bull and completing a 20-second anaerobic test on a cycle ergometer.

One study that looked at a multivitamin/mineral supplement suggested that a minor decrease in the rate of fatigue could occur after a 30-second Wingate anaerobic power test (Fry et al., 2006). The supplement that Fry et al. (2006) looked at did not contain caffeine. This is interesting to note because there could be a placebo-like effect, on SM, potentiated by seeing that caffeine is listed as an ingredient in a supplement. The researchers found this multivitamin/mineral supplement had no ergogenic effect on AP in resistance-trained men (Fry et al., 2006).

Previous studies have reported conflicting results on the influence of caffeine-containing supplements on AP. One review examined 17 studies and found that 11 of those studies revealed significant improvements in power-based activities, such as sprinting, following caffeine-containing supplement ingestion (Astorino & Roberson, 2010). Similarly, Beck et al. (2006) analyzed the potential ergogenic effects of a 201mg caffeine-containing supplement on muscular endurance and AP in resistance trained males. Results from the study indicated that upper-body muscular endurance measured by a 1-RM bench press increased, but there was no effect on AP measured by the Wingate anaerobic test (Beck et al., 2006). The lack of significance in AP could be due to 201mg being considered a low dosage compared to studies that have found increases in AP with moderate to high dosages of caffeine ingestion (Spriet, 2014).

While certain ingredient combinations may work synergistically to potentiate an ergogenic benefit, there is research to support ingestion of caffeine alone works to increase AP. Eighteen resistance trained males were found to have higher peak power values, measured by the Wingate anaerobic test, after ingesting 5mg/kg of caffeine versus a placebo (Woolf, Bidwell, & Carlson, 2008). The significant increase in power could be due to the fact that participants consumed a moderate amount (5mg/kg body mass) of caffeine. The increase in power could also be due to consuming a pure form of caffeine rather than ingesting a caffeine-containing supplement. The mixture of ingredients could have potentially negative effects on the caffeine.

The ergogenic effects of a low dosage caffeine-containing supplement have not been well studied using a lab based anaerobic sprint running test. To our knowledge, the caffeine supplement in this study has only been researched one other time. Gwacham and Wagner (2012) examined the acute effects of a caffeine containing supplement called Spark on AP output of Division I American Football players (Gwacham & Wagner, 2012). Subjects completed six 35 meter sprints with 10-seconds of recovery between sprints to assess AP. Results indicated that there was no statistically significant increase in AP or sprint time. The researchers did find a significant interaction between non-habitual caffeine users and Spark for AP (p=0.032) and sprint time (p=0.045).

There are a number of variables that could contribute to the lack of statistical significance. While caffeine habituation was a factor taken into consideration, the types of caffeine that participants may have consumed could vary in the levels of caffeine content. The typical type and amount of caffeine consumed by each participant was also self-reported. There has been research to show that dietary recall can have large amounts of variability (Jeacocke & Burke, 2010). Therefore, it needs to be taken into question how accurate the caffeine-habituation scores were. Most of the participants in this study reported feeling like they had consumed the caffeinated beverage, but that it did not make them feel as though they were more alert and focused. This could be due to the fact that participants received an absolute amount of caffeine rather than a relative amount based on body mass. In regards to energy-drink consumption it is more typical to receive an absolute volume than a relative volume (Gwacham & Wagner, 2012) as this is how most caffeinated dietary supplements are manufactured and consumed. However previous research has suggested caffeine dosages ranging from 2-9mg/kg of body mass may be needed for an ergogenic effect, but that a dosage of 5-6mg/kg of caffeine, appears to have the greatest ergogenic effect (Spriet, 2014; Astorino & Roberson, 2010; Beck, Housh, Malek, Mielke, & Hendrix, 2008; Beck et al., 2006), particularly for muscular endurance and AP-related activities. A relative amount of caffeine in a typically energy-drink generally ranges from 1-2mg/kg of bodyweight (Astorino & Roberson, 2010). The absolute amount of caffeine the participants received in the current study was 120mg, which translates to a relative dose of 1.5mg/kg and therefore was lower than dosages that have produced an ergogenic effect.

Dietary intake could have also been a confounding variable. Each participant was instructed to record their dietary intake on a food log sheet (figure 5) two days prior to their testing session. Participants were instructed to keep their diet similar between the two experimental testing sessions. Table 5 shows a comparison of dietary intakes for each day with data reported as mean ± standard deviation. One participant had to be removed due to having large discrepancies in dietary intake. There was a significant difference ($p<0.05$) found in caloric intake between the two conditions. Participants ate significantly more calories 2-days prior to receiving the caffeine supplement condition which could have potentially influenced performance; however, this is beyond the scope of the current study. Ideally, future studies should better control for dietary intake by providing the participants with standardized meals.

Table 5. Dietary intake of participant's 2-days prior to testing session (N=14).

Variable	Spark	Placebo	*p*-value
Kcals	2526.78 ± 612.99	2069.35 ± 470.08	0.03*
Carbs (g)	288.78 ± 82.56	261.14 ± 73.37	0.35
Fats (g)	83.14 ± 29.02	64.42 ± 23.10	0.07
Protein (g)	136.07 ± 45.50	115.35 ± 37.85	0.20

*Significant difference between conditions ($p<0.05$).

CONCLUSION

In conclusion, this study did not find any significant increases in CMVJ or AP, but did find that energy and fatigue levels were better maintained following ingestion of a caffeine containing supplement. Therefore, while it did not increase CMVJ or AP it may be appropriate to consume the current caffeine containing supplement for maintained feelings of energy and fatigue during anaerobic activities, particularly where repeat bouts may be required. As energy drink consumption continues to increase it is important to test their effects on various indicators of fitness and subjective markers.

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APPENDIX A

INFORMED CONSENT

Protocol Title: Effects of a Caffeine-Taurine Supplement on Anaerobic and Psychological Measurements in Males

Principal Investigator: **Chelsea Hahn**
901 State Street
Apt. 508
La Crosse, WI 54601
715-432-9445

Emergency Contact: **Dr. Andrew Jagim**
136 Mitchell Hall
University of Wisconsin-La Crosse
608-785-6538

Why have you been asked to take part in this research?

This study is evaluating how a caffeine-taurine containing supplement effects the anaerobic power measurements of recreationally active males. It is also looking at how this supplement effects psychological measurements. You have been invited to participate in this study because you are the right age that we are looking to study and you are recreationally active. Participating in this study is voluntary, and you may quit this study at any time. Please do not hesitate to ask questions about this consent form or the procedures if you do not understand something.

How many people will be in this study and how long will it last?

There will be 15 college age males participating in this study. The study will last for approximately four sessions. Each session will last 60 minutes.

What will happen if you agree to be part of this study?

If you agree to be part of this study, you will exercise on four different occasions. During the first meeting you will complete the necessary paper work, have height and body mass measured, and complete three practice runs on the treadmill that will be used for exercise testing. Each practice run will last between 10 to 20 seconds. At the second meeting you will complete two practice runs on the treadmill, lasting between 10 and 20 seconds. You will also complete two maximal runs lasting 20 seconds each. You will be hooked up to a set resistance of 18 percent of your body mass while on the treadmill.

Additionally, you will come in to the laboratory on two separate occasions for experimental testing and consume either a caffeine-taurine beverage or a placebo beverage. Prior to consumption of the beverage your blood lactate will be taken. The researcher will not know which beverage will be served to the participant during their first or second experimental testing session. After consuming the beverage you will complete a dynamic warm-up. Thirty minutes after consuming the beverage and warming up you will be hooked up to a set resistance on the treadmill and complete your first running anaerobic sprint test. We want you to give as much effort as you can during these tests. Blood lactate will again be taken following the maximal run on the treadmill.

What are the possible risks and discomforts from this study?

Similar to any form of exercise, you will get tired and your muscles may get sore. Following the sprint testing you may feel nauseous and/or experience vomiting. However, these effects will only be temporary. Blood lactate sampling may cause bruising around the testing site. There is a very low risk of serious injury or complication in healthy individuals.

How will you benefit from participating in this study?

There is a possibility that you will know more about your physical fitness level. Additionally, you will help other researchers understand the possible effects of a caffeine-taurine supplement on anaerobic power and psychological measurements.

Do you have to participate?

Participation in this study is voluntary. You may stop participating at any point without penalty.

What are the costs of participating?

There are no costs for you to participate in this study.

What are your rights and confidentiality during this study?

All of the data will be kept confidential through the use of number codes. If this study is published or presented for scientists and teachers, your data will not be personally identifiable.

Questions regarding the requirements of this study will be answered by Chelsea Hahn, (715-432-9445), or her advisor (Dr. Andrew Jagim, 608- 785-6538). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects (608-785-8124).

Participant's Understanding:

Have all your questions regarding how the research study might affect you been answered?
Yes / No (Circle one)

If you are interested in participating in this study, please sign your name. **You will not be penalized or treated differently for not participating in this study.**

Participant's name: ______________________________
Print

Participant's signature: ______________________________ Date: ____________

Researcher's signature: ______________________________ Date: ____________

Narrative Statement

1. Consumption of energy drinks is popular amongst college students. There are many options available for college students to choose from when it comes to caffeinated beverages. What effect would AdvoCare SPARK®, a caffeinated beverage from an increasingly popular company have on anaerobic power and psychological measures? The purpose of this study is to find whether there is a statistically significant effect on anaerobic power performance as well as psychological measurements in recreationally active college aged males. The participants will consume either SPARK® or a placebo beverage 30 minutes prior to completing a 25 second anaerobic sprint running test on a non-motorized treadmill. Participants will also complete a five point Likert scale asking about their level of alertness, focus, energy, and fatigue.

   The expected start date for this study is September 2015. The planned date of completion is May 2016.

2. The participant population will consist of 15 recreationally active males. Participants will be of college age (age 18-26). This population was chosen because there is not much information on the effects of AdvoCare SPARK® on recreationally active college age males.

3. All participants will be provided with information regarding the study as well as an informed consent for the participant to complete. The primary researcher will be available to answer questions from the participants before signing the informed consent.

4. All of the participant's data and results will remain confidential, and there will be numbers assigned to each participant's name during the recording of data. The primary researcher and advising professor will be the only people to have access to the individual participant information. Only aggregate data will be presented during publication or presentation.

5. There is a very low risk other than the normal fatigue that is associated with running. The amount of time required from the subjects will be approximately 60 minutes per week for a period of three weeks.

6. There will be individuals trained in CPR, Advanced Cardiac Life Support, and First Aid available during the testing as well as emergency protocol in place.

7. Benefits for the individual include knowledge of his fitness level as well as a possible increase in physical fitness. This will be beneficial to future researchers interested in looking at the effects of AdvoCare SPARK® in a recreationally active college-age population.

APPENDIX B

DATA COLLECTION SHEETS

Figure 1.) 5-point Likert Scale

<u>Focus and Alertness 5-point Likert Scale</u>

*Please rate on a scale of 1-5 (1 = very low; 2 = low; 3 = average; 4 = high; 5 = very high) by circling the corresponding number.

Please rate your ***energy level:***

1	2	3	4	5
Very Low	Low	Average	High	Very High

Please rate your ***fatigue level:***

1	2	3	4	5
Very Low	Low	Average	High	Very High

Please rate your ***feelings of alertness:***

1	2	3	4	5
Very Low	Low	Average	High	Very High

Please rate your ***feelings of focus for task:***

1	2	3	4	5
Very Low	Low	Average	High	Very High

Figure 2.) PAR-Q

PAR-Q & YOU

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

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

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

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

If you answered

YES to one or more questions

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

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

NO to all questions

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

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.

DELAY BECOMING MUCH MORE ACTIVE:

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

PLEASE NOTE: If your health changes so that you answer yes to any of the questions, you must let the trainer know.

Informed Use of the PAR-Q: The trainers assume no liability for persons who undertake physical activity with a pre-existing injury or illness. If in doubt after completing this questionnaire consult your doctor prior to physical activity.

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

NAME.. DATE..

SIGNATURE...TRAINER..

Note: This physical activity clearance becomes invalid if your condition changes so that you would answer YES to any of the seven questions. If this occurs please seek GP advice prior to exercising.

Figure 3.) Health History Questionnaire

FIGURE 2-1. AHA/ACSM Health/Fitness Facility Preparticipation Screening Questionnaire*

Assess your health status by marking all *true* statements

History

You have had:

____ a heart attack
____ heart surgery
____ cardiac catheterization
____ coronary angioplasty (PTCA)
____ pacemaker/implantable cardiac
defibrillator/rhythm disturbance
____ heart valve disease
____ heart failure
____ heart transplantation
____ congenital heart disease

Symptoms

____ You experience chest discomfort with exertion
____ You experience unreasonable breathlessness
____ You experience dizziness, fainting, or blackouts
____ You take heart medications

Other health issues

____ You have diabetes
____ You have asthma or other lung disease
____ You have burning or cramping sensation in your lower legs when walking short distances
____ You have musculoskeletal problems that limit your physical activity
____ You have concerns about the safety of exercise
____ You take prescription medication(s)
____ You are pregnant

If you marked any of these statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with a ***medically qualified staff.***

Cardiovascular risk factors

____ You are a man older than 45 years
____ You are a woman older than 55 years, have had a hysterectomy, or are postmenopausal
____ You smoke, or quit smoking within the previous 6 months
____ Your blood pressure is >140/90 mm Hg
____ You do not know your blood pressure
____ You take blood pressure medication
____ Your blood cholesterol level is >200 mg/dL
____ You do not know your cholesterol level
____ You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister)
____ You are physically inactive (i.e., you get <30 minutes of physical activity on at least 3 days per week)
____ You are >20 pounds overweight

If you marked two or more of the statements in this section you should consult your physician or other appropriate health care provider before engaging in exercise. You might benefit from using a facility with a ***professionally qualified exercise staff†*** *to guide your exercise program.*

____ None of the above

You should be able to exercise safely without consulting your physician or other appropriate health care provider in a self-guided program or almost any facility that meets your exercise program needs.

*Modified from American College of Sports Medicine and American Heart Association. ACSM/AHA Joint Position Statement: Recommendations for cardiovascular screening, staffing, and emergency policies at health/fitness facilities. Med Sci Sports Exerc. 1998;1018.

†Professionally qualified exercise staff refers to appropriately trained individuals who possess academic training, practical and clinical knowledge, skills, and abilities commensurate with the credentials defined in Appendix D.

Figure 4.) Front of Caffeine Questionnaire—participants

Caffeine Questionnaire

Please circle your response to each question.

1. Do you consume caffeine?
   a. Yes
   b. No
2. In what form do you consume caffeine? Circle all that apply.
   a. Coffee
   b. Energy drink
   c. Soda
   d. Other: ____________________
3. How many days per week do you consume caffeine?
   a. Daily
   b. Most days (4-6 times per week)
   c. Occasionally (1-3 times per week)
   d. Rarely
4. What time(s) of day do you consume caffeine? Circle all that apply.
   a. Morning
   b. Noon
   c. Afternoon
   d. Evening
5. How much caffeine do you have at a time?
   a. Small serving 8oz
   b. Medium serving 16oz
   c. Large serving 20+oz
6. Why do you consume caffeine? ____

   ____

   ____

   ____

   ____
7. How long have you been consuming caffeinated beverages?
   a. <6 months
   b. 1-3 years
   c. 3+ years

Figure 4.) Back of Caffeine Questionnaire—researchers

Researcher Key:

Question 1. A=1, B=0

Question 2. Each one circled = 1

Question 3. A=2, B=2, C=1, D=0

Question 4. Each one circled =1

Question 5. A=1, B=1, C=0

Question 7. A=1, B=1, C=0

Question	Score
Question 1	
Question 2	
Question 3	
Question 4	
Question 5	
Question 7	
TOTAL:	

Low: score of **0-3** – they are eligible to participate.

Moderate: score of **4-7** – if they are consuming caffeine daily they are not eligible to participate.

High: score of **8-13** – this score indicates that they are not eligible to participate in the study.

Figure 5. Food Log

University of Wisconsin La Crosse
Human Performance Lab -Food Log

Name: ______________________________

Instructions:
1) Record everything that you eat througout the day
2) Precisely record the food item (brand if applicable), preparation method, and TOTAL quantity consumed
3) Break down mixed dishes or recipes by listing their component parts
4) For dairy and meat products, indicate fat level (i.e. low fat, extra lean, 2%, etc.)

FOOD ITEM	PREPARATION METHOD (i.e. fried, grilled, etc.)	QUANTITY							
		gm	mL	cups	T or tsp.	oz.	Pieces	Sm, Med, Lg	Other
MEAL 1:									
MEAL 2:									
MEAL 3:									
MEAL 4:									
MEAL 5:									

APPENDIX C

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The purpose of this paper is to review the literature related to consumption of caffeine containing supplements and their effects on anaerobic power (AP) and on subjective markers (SM) of fatigue. Evaluation of literature on the anaerobic sprint running test (ASRT) will also be reviewed.

Caffeine Background

Caffeine is one of the most widely used drugs in the world, and is a common ingredient of energy drinks (Astorino & Roberson, 2010). In the United States, 90% of adults report consuming caffeine on a daily basis (Astorino & Roberson, 2010). Glucose, taurine, L-Theanine and ginseng, are other commonly found ingredients in energy drinks (Childs, 2014). Energy drinks are largely unregulated by the United States Food and Drug Administration; however, it is recommend that no more than 6mg of caffeine per fluid ounce (Childs, 2014). With the number of energy drinks available to the public, research has not been able to address the efficacy and safety of each product.

One energy drink that has not been well-researched is a commercially available product called Spark. Gwacham and Wagner (2012) examined the effects of Spark on anaerobic power output of Division I American Football players (Gwacham & Wagner, 2012). Subjects completed six 35 meter sprints with 10-seconds of recovery between sprints to assess AP. Results indicated that there was no statistically significant increase in AP or sprint time, however, researchers found a significant interaction between non-habitual caffeine users and Spark for AP and sprint time. With caffeine being commonly found in energy drinks and supplements it is important to understand how much caffeine is necessary to result in an ergogenic effect.

When it comes to energy-drink consumption it is more typical to receive an absolute volume than a relative volume (Gwacham & Wagner, 2012). Previous research has cited that dosages ranging from 2-9mg/kg of caffeine have had an ergogenic effect, but that a dosage of 6mg/kg of caffeine, or more, has a greater ergogenic effect (Astorino & Roberson, 2010; Beck, Housh, Malek, Mielke, & Hendrix, 2008, Beck et al., 2006). An absolute volume of caffeine in an energy-drink generally ranges from 1-2mg/kg of bodyweight (Astorino & Roberson, 2010).

Caffeine Usage and its Effects on Anaerobic Power

Caffeine is the most widely used drug in the world, and is commonly ingested in energy drinks (Astorino & Roberson, 2010). In 2001, Graham published a paper on caffeine and exercise and found that caffeine was completely absorbed within the stomach and small intestine 45 minutes after ingestion, and that its half-life in the body was approximately 3-4 hours (Graham, 2001). Several studies have started exercise testing prior to 45 minutes after caffeine ingestion. The time frame that these studies used was beginning exercise 10-30 minutes following caffeine ingestion (Outlaw et al., 2014; Fukuda, Smith, Kendall, & Stout, 2010; Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011). Results of these studies have varied on their findings relative to AP. One study looking at the effects of a pre-workout supplement containing caffeine and taurine on AP found that there were statistically significant increases in upper body AP but not in the lower body (Outlaw et al., 2014). Another study looking at the acute effects of consuming a caffeine and an amino acid supplement on anaerobic running performance found that running performance increased by 10.8% following ingestion (Fukuda, Smith, Kendall, & Stout, 2010). In a study looking at pre-workout supplement that contained caffeine and amino acids it was found that there were improvements in overall AP just 10 minutes after consumption (Gonzalez, Walsh, Ratamess, Kang, & Hoffman, 2011).

One of the most popular energy drinks is Red Bull (Forbes, Candow, Little, Magnu, & Chilibeck, 2007). One study examined the effects of Red Bull energy drink consumption on anaerobic and muscle endurance in healthy young adults (Forbes et al., 2007). Subjects participated in a crossover design study and were then randomized to either the Red Bull group or the non-caffeinated placebo group. Muscular endurance was assessed using bench press and AP was assessed using the Wingate Anaerobic Test (WAnT). Results showed that consumption of Red Bull versus the non-caffeinated placebo did significantly increase muscular endurance. There was no statistically significant effect on peak power or average power as measured by the WAnT.

Caffeine is typically combined with other ingredients in energy drinks (Childs, 2014). Childs did a review of the ingredients typically found in energy drinks and several of the ingredients that she lists are in the caffeine containing supplement Spark®. Since caffeine is combined with other ingredients the independent contribution of caffeine and other ingredients to the overall effect of an energy product is largely unknown.

Taurine is an ingredient found in Spark®. It is a nonessential sulfur-containing amino acid thought to play a role in metabolic processes (Childs, 2014). According to Childs, the reason this ingredient is typically found in energy drinks is because it falls into the amino acid category. When there is an increased availability of amino acids, there will be enhanced protein synthesis and neurotransmitter reserve which influences mood and performance.

Aside from energy drinks that combine caffeine with taurine there are only a limited number of studies looking at caffeine mixed with other ingredients (Childs, 2014). These other ingredients include: glucose, L-theanine, and ginseng. This is interesting because energy drinks are largely unregulated by the US-FDA. The US-FDA recommends approximately 6mg of caffeine per fluid ounce as a serving size. This varies between energy drinks. Spark contains 120mg of caffeine per 8 fluid ounce serving. Taking 120 divided by 8 fluid ounces the total comes to 15mg of caffeine per fluid ounce which is 2.5 times the amount recommended by the US-FDA.

Effects of Caffeine on Subjective Measurements

A study by Gonzalez et al. (2011) examined the effects of a pre-workout supplement on resistance training exercises and subjective measurements (SM). Researchers used a visual analog scale (VAS) to have subjects assess feelings of focus, energy, and fatigue. The VAS for each subject was assessed immediately before exercise and after exercise. Results showed that there were no statistically significant improvements for feelings of focus and energy. Results also indicated that there was not a decrease in feelings of fatigue (Gonzalez et al., 2011).

In contrast to the findings above, Hoffman et al. (2009) found that a pre-workout supplement used on male strength and power athletes improved SM. Twelve male strength and power athletes used a five point rating scale right before exercise and were asked to rate their energy level, fatigue level, feelings of alertness, and feelings of focus.

Results showed a statistically significant increase in all four categories of SM (Hoffman et al., 2009).

Emma Childs (2014) compiled a review of literature on energy drinks and their influence on mood and cognitive performance. Results indicated that there is a lack of empirical evidence between the interactions of caffeine and other energy drink ingredients. There were some similarities on certain ingredient combinations on mood. For increases in explicit memory a combination of glucose and caffeine was found to be the best combination. Caffeine mixed with L-theanine produced increases in mental alertness, attention, and memory. Caffeine mixed with taurine appeared to counteract the stimulating effects of caffeine on mood and attention.

Spark is a caffeine-taurine containing supplement. Knowing this, it will be important to test SM. Childs did not look into any research that used Spark. This is not to say that decreases in mood and attention will not happen with ingesting Spark, but it could be due to a variety of combinations of caffeine with ingredients other than taurine.

Anaerobic Sprint Running Test – Validity, Reliability, and Load

The gold standard for testing AP has been the Wingate Anaerobic Test (WAnT) which is a valid and reliable way to assess AP characteristics and is frequently used by researchers (Hachana et al., 2012). The Wingate test evaluates relative peak power output (PP), mean power output (MP), and rate of fatigue (FI). Peak power output has been found to be closely related to 40 meter sprint performance, and MP output has been closely related to 300 meter running performance (Jacobs, Mahoney, & Johnson, 2003). While this test has been found to be closely related to bipedal movements it is more closely related to pedaling activities such as cycling.

An anaerobic sprint running test (ASRT) is another way of testing AP. A study by McLain et al. (2015) looked to determine the test-retest reliability of the ASRT on a nonmotorized treadmill. Twenty-six collegiate male athletes completed three 25-second maximum effort sprints against 18% of their individual body mass on a nonmotorized treadmill (McLain et al., 2015). Researchers found that the test-retest reliability between the three trails during the ASRT were high. Researchers concluded that the ASRT on a nonmotorized treadmill may be a more sport-specific test to assess AP for coaches and athletes.

In another study examining the validity of the ASRT, 40 members of the armed forces completed a WAnT and an ASRT. The ASRT in this study was applied to six 35-meter maximal running performances with a 10-second recovery between each run (Zagatto, Beck, & Gobatto, 2009). Researchers found that the ASRT had significant correlations with the WAnT. Similar to the study by McLain et al. (2015) it was thought that an advantage of the ASRT compared to the WAnT was that the ASRT was more specific to running and other bipedal activities. The researchers concluded that this procedure was reliable and valid and can be used to measure running AP and predict short-distance performances.

Research on the appropriate resistance load for the nonmotorized treadmill varies. A study examined loads appropriate for finding PP during an ASRT (Andre, Fry, & Lane, 2013). Researchers found that at a resistance load of 35% of an individual's body weight the greatest PP was achieved. What the researchers also discovered was that individuals who were larger, strong, and more powerful produced PP at a higher relative load than smaller, weaker, and less powerful individuals during the ASRT on the nonmotorized treadmill (Andre et al., 2013). In the study by McLain et al. (2015) the researchers used loads ranging from 12 to 20% of the individuals body mass. Determining the optimal load for the ASRT appears to be an area where more research is necessary.

Summary

There has been a lot of research done on energy drinks containing caffeine and the effects that these types of beverages can have on AP and SM of fatigue. Each energy drink is not created equal and differences in ingredient combinations and amounts makes determining the exact effects difficult. Only one study has been published on the caffeine containing supplement Spark®. Subjective measurements have never been looked at in regards to this product and testing has not been done on recreationally active male individuals. This study will address the acute effects of this caffeine containing supplement on AP measurements and SM of fatigue in recreationally active males.

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