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The Effects of a Pre-Workout Energy Drink on Measures of Physical Performance

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ABSTRACT: The purpose of this study was to investigate the effects of a pre-workout commercial energy drink on parameters of exercise performance, including anaerobic power, muscular endurance, speed, and reaction time. This study used a randomized, double blind, placebo controlled, parallel design. Participants visited the laboratory on two different occasions. On the first visit, participants were assessed for anaerobic power (via a vertical jump test), muscular endurance, reaction time, reactive sprint test, and aerobic power (via a 1.5 mile run). On the second visit, participants were randomly assigned to ingest four ounces of the energy drink beverage or a similar-tasting placebo beverage 30-minutes prior to engaging in these same physical performance tests. The energy drink treatment had no effect on anaerobic power (vertical jump), reaction time, reactive sprint test, or aerobic power. For the push-up to fatigue test, a significant difference (p = 0.014) was observed with the energy drink treatment enhancing performance by 12% as compared to the placebo treatment (improvement of ~ 4%). For the sit-up to fatigue test, a non-significant difference (p = 0.075) was observed with the energy drink treatment resulting in an enhancement of performance by ~13% as compared to no improvement for the placebo treatment. In light of these findings, individuals whose upper-body muscular endurance performance is part of their physical fitness assessment program may benefit from pre-workout energy drink consumption. In contrast, individuals needing to demonstrate anaerobic/aerobic power, or reactive abilities should not expect an improvement in performance from pre-workout energy drink consumption.

Keywords: Type your keywords here, seprated by semicolons;

INTRODUCTION

Athletes and physically active individuals commonly use pre-workout beverages as a method of improving exercise performance. These beverages, commonly marketed as „energy drinks", are often ingested in hopes they will provide an ergogenic effect, thereby allowing the user to perform a greater volume of work, or perform a given workout at a greater intensity.

According to published research, energy drinks are the most popular dietary supplement besides multivitamins in the American adolescent and young adult population [1-3]. Petroczi and coworkers [4] reported that more than 40% of British athletes admit to using energy drinks for the purpose of enhancing their workouts and performance. Further, nearly 90% of athletes competing in the Ironman World Triathlon Championships admitted that they were planning on using caffeinated supplements prior to competition[5].

The basic, active ingredient in energy drinks is caffeine. The general recommendation for enhancing exercise performance is to ingest caffeine at a dosage of 3-6 mg/kg of body mass [6]. However, several studies have reported significant improvements in both aerobic [7, 8] and resistance exercise [9,10] after ingesting lower than the recommended dose of caffeine (approximately 2 mg/kg) contained in commercially available energy drinks. It is important to note that the observations of improved exercise performance have been reported when caffeine was ingested as part of an energy drink containing other ingredients, such as carbohydrate, vitamins, minerals, and "proprietary blends" of various nutrients purported to increase energy, alertness, metabolism, and performance (e.g., taurine, amino acids, glucoronolactone, Ginkgo biloba, green tea, etc.).

Improvements in exercise performance with lower than recommended amounts of caffeine (2 mg/kg rather than 3-6 mg/kg) may contribute to the hypothesis that the synergistic effects of the various ingredients (in addition to caffeine) contained in energy drinks are responsible for the reported improvements in exercise performance. While some studies have reported an improvement in exercise performance, other investigations have reported no improvements following the ingestion of a pre-workout energy drink. Specifically, no improvements in performance were reported for anaerobic [10,11] or high intensity aerobic [12] exercise following energy drink ingestion. Clearly, equivocal data exists in relation to the effects that pre-workout energy drink consumption has on exercise performance.

A majority of the scientific investigation on the effects of energy drinks has been conducted within the past ten years. This research has been broad to the extent that pre-workout energy drink ingestion has been investigated to determine its effects on variables including muscular strength, muscular endurance, aerobic capacity, speed/agility, and reaction time [7-13]. The purpose of the present study was to investigate the effects of a pre-workout commercial energy drink on several parameters of exercise performance, including anaerobic power, muscular endurance, speed, and reaction time. One novel aspect of the current investigation was the utilization of body weight for the assessment of muscular endurance. Previous studies have used submaximal (70% to 80% 1RM) external loads on the bench press and leg press to determine if prior energy drink ingestion improved local muscular endurance performance. Using body weight resistance as a measure of muscular endurance performance has become more common with the popularization of exercise programs such as CrossFit®, P90X®, and Insanity® workout programs. In addition, the Army Physical Fitness Test (APFT) also utilizes body weight resistance in several of their fitness assessments. Therefore, data related to improving certain fitness variables may be relevant in contexts that include military populations and tactical athletes.

METHODS

Participants

Forty-one healthy males (21.7 ± 1.7 yrs; 176.5 ± 7.5 cm; 81.2 ± 10.9 kg; 15.4 ± 5.0 % body fat) between the ages of 18-25 years volunteered to participate in the investigation. Subjects who reported smoking, any known injuries, metabolic disease, cardiovascular disease, or psychiatric disorders were excluded from participation. In addition, individuals allergic to any of the ingredients, or who reported taking medication that could interact with the following ingredients: sodium, calcium, magnesium, potassium, caffeine anhydrous, L-leucine, phenylethylamine, HCl, L-valine, L-isoleucine, N-acetyl-L-tyrosine, yohimbe, toothed clubmoss, yerba mate extract, green tea extract, 5-HTP or vinpocetine were excluded from participation in the study. The study was approved by the Institutional Review Board at Texas A&M University Corpus Christi prior to data collection, and all subjects were briefed regarding the risks of the study. In addition, each subject completed a health history questionnaire, a caffeine-usage questionnaire, and signed a written informed consent document before testing.

Experimental Overview

This study used a randomized, double blind, placebo controlled, parallel design. Participants visited the laboratory on two different occasions separated by no more than seven days. Prior to each visit, participants were asked to abstain from caffeine ingestion for 12 hours. Upon arrival to the laboratory, each participant was asked about his caffeine intake, thereby verifying caffeine abstinence for the previous 12-hours. On the first visit, participants underwent a battery of tests to determine anthropometrics (height, weight, body composition) and physical performance. Following the anthropometric measures, five measures of physical performance were conducted in the following order: anaerobic power (via a vertical jump test), muscular endurance, reaction time, reactive sprint test, and aerobic power (via a 1.5 mile run). On the second visit, participants were randomly assigned to ingest four ounces of the energy drink beverage (n = 22) or a similar-tasting placebo (n = 19) beverage 30-minutes prior to engaging in the physical performance tests. Rational for the 30-minute time period between ingestion of the energy drink and physical activity follows manufacturer recommendations. Table 1 contains the ingredients for the energy drink supplement. The placebo was designed by the manufacturer (Vital Pharmaceuticals, Inc. Weston, FL) to have the same volume, taste, and color as the energy drink beverage.

Procedures

Anthropometric information, including height (cm) and weight (kg) measurements were collected using standard procedures on a physician beam scale (Cardinal/Detecto Scale Co, Webb City, MO.). Body composition was assessed via bioelectrical impedance (BIA) using an OMRON HBF-306 Body Fat Analyzer (Vernon Hills, IL). A description of each of the performance tests follows.

Anaerobic Power. Anaerobic power was assessed with a maximal vertical jump using the Just Jump System (ProBotics Inc., Huntsville, AL.). This device includes a 68.6 x 68.6 cm mat that calculates vertical jump height by measuring vertical displacement time. Vertical jump height was calculated by measuring the amount of time the feet were not in contact with the mat. All participants were instructed to step on the mat and execute a maximal jump with a countermovement arm swing. The best of 3 attempts were recorded to the nearest 1.3 cm (0.5 inch).

Table 1. Energy Drink Ingredients

Ingredient	Amount
Calories	0
Electrolyte Matrix	
Sodium	10mg
Calcium	2mg
Magnesium	2.5mg
Potassium	26mg
Proprietary Blend	350mg
Caffeine Anhydrous	158mg
L-Leucine	*
B-Phenylethylamine HCL	*
L-Valine	*
L-Isoleucine	*
N-Acetyl-L-Tyrosine	*
Yohimbe	*
Toothed Clubmoss	*
Yerba Mate Extract	*
Green Tea Extract	*
5-HTP	*
Vinpocetine	*

* Amount not listed on dietary supplement label

Muscular Endurance. The upper-body muscular endurance push-up to fatigue test had been previously described by Hoffman and Collingwood [14]. Briefly, all participants were required to begin the test in the standard "up" position with the body rigid and straight and the hands positioned slightly wider than shoulder-width apart and the fingers pointed forward. A research assistant then placed their fist on the floor directly under the individual‟s chest. On the "go command" the participants lowered themselves until their chest contacted the research assistant‟s fist. Next, the participant extended their elbows until back in the "up" position. The participants performed as many push-ups as possible using this technique. Muscular endurance for the abdomen/trunk was collected via the sit-up to fatigue test. The technique used for this test was also adapted from the technique described by Hoffman and Collingwood [14]. Participants were instructed to lie on their back with their knees bent, heels flat on ground, hands across the chest, and a partner anchoring them to the ground by holding their feet. The participants performed as many correct sit-ups as possible.

Reaction Time. Reactive capabilities were assessed via a Dynavision D2TM light board trainer (Westchester OH, USA). Participants were placed about 38.1cm (15 inches) in front of the Dynavision D2TM trainer. To begin the test, participants placed their hand on a solid green light button, and then waited for a solid red light button to appear. Once the red stimulus light appeared, the participants used their same hand to press the red button as quickly as possible. The same scenario was repeated multiple times for both the right and left hands, and the data was collected by the system‟s computer.

Reactive Sprint Test. In addition to the reaction time test, a reactive sprint test was performed utilizing a SmartspeedTM (Coopers Plains, Australia) timing system. Participants were instructed to step up to the starting line and wait for a light stimulus to be activated from the timing system‟s remote units. When the light stimulus was activated, participants initiated their sprint for a distance 20 meters. Each participant made two attempts with the best time recorded for data analysis.

Aerobic Power. The 1.5-mile run was used to assess the participant‟s aerobic endurance. This test is adapted from the protocol outlined by Hoffman and Collingwood.[14] An indoor running track was used for this assessment in order to minimize any interference that may have been associated with outdoor weather conditions, such as wind and rain. Participants were instructed on the "go" command to begin running and cover the 1.5-mile distance around the indoor track as fast as possible. Upon completion, each participant‟s time was recorded to the nearest 0.10 second.

Statistical Analyses

The analyses in this study were evaluated using SPSS 20.0. Independent samples t-tests were used to compare the placebo and energy drink groups (energy drink x placebo) at both baseline and the treatment condition. Justification for not employing a repeated measures, factorial Multivariate Analysis of Variance (MANOVA) was due to the presence of multiple insignificant dependent variables (see Results section below) which may mask the effects of one significant dependent variable, resulting in a type II error [15]. An alpha of $p < 0.05$ was considered statistically significant for all comparisons. Normality of subject performance was determined for each subject on all the dependent variables. Data that changed by greater than 50% decline or improvement from the pretest to the posttest were eliminated because extraneous variables may have caused the physiological change rather than the experimental design.

RESULTS

The data were within normal distribution and equal variance limits and therefore parametric statistics were appropriate. All the data were used for these analyses with the exception of the sit-up test. Two participants‟ sit-up performance were considered outside the parameters of explained physiological change (performance change of 311% decline and 69% improvement); therefore these data were removed from the sit-up statistics results.

There were no differences observed between the energy drink group and the placebo group at baseline for any performance measure. Therefore, any differences found on posttest assessments were likely explained by treatment effect. When compared with the placebo, the energy drink treatment had no effect on anaerobic power (vertical jump), reaction time, reactive sprint test, or aerobic power (table 2). For the push-up to fatigue test, a significant difference was observed (p = .014) with the energy drink treatment enhancing performance by 12% (increasing from 52.9 ± 18.9 to 59.3 ± 19.6 repetitions) as compared to the placebo treatment, which demonstrated an improvement of approximately 4% (from 44.2 ± 10.3 to 46.0 ± 11.2 repetitions). For the sit-up to fatigue test, the energy drink treatment resulted in an enhancement of performance by approximately 13% (52.1 ± 18.9 to 59 ± 20.7 repetitions). In contrast, the placebo treatment had no effect on improving the sit-up to fatigue test (53.4 ± 17.7 to 53.1 ± 20.6 repetitions). While not significant, the changes in performance with energy drink ingestion approached statistical significance (p = 0.075). The muscular endurance data are presented in figure 1.

Table 2. Comparison of performance measures.

	Pretest	Posttest	p-value
Vertical jump (cm)			
Energy drink	61.0 ± 8.8	61.5 ± 7.7	
Placebo	63.3 ± 8.7	62.2 ± 8.4	.87
Reaction time (sec.)			
Energy drink	40.9 ± 5.9	44.3 ± 6.0	
Placebo	39.7 ± 4.4	42.7 ± 3.2	.32
Reactive sprint test (sec.)			
Energy drink	3.6 ± 0.18	3.6 ± 0.21	
Placebo	3.5 ± 0.13	3.4 ± 0.13	.88
1.5 mile run (secs)			
Energy drink	687.3 ± 100.8	678.3 ± 104.8	
Placebo	702.3 ± 55.3	681.7 ± 60.0	.85

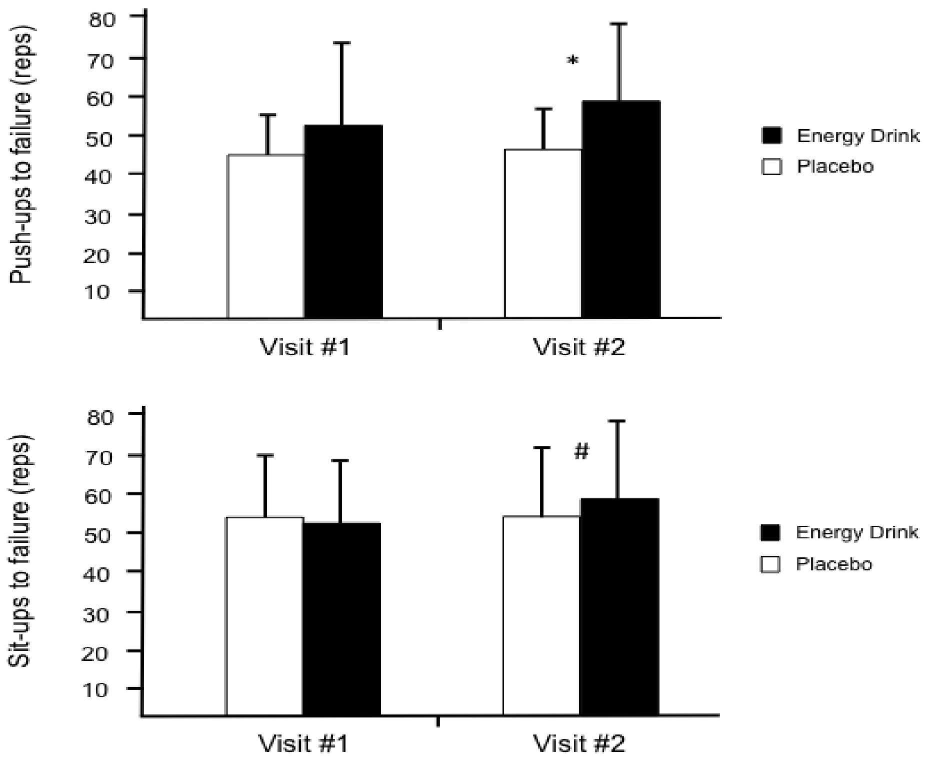

Figure 1 - Changes Muscular Endurance Following a Pre-Workout Energy Drink
*p < 0.05 vs. placebo; # p < 0.10 vs. placebo.

DISCUSSION

This is the first study to investigate the effects of a commercial energy drink on local muscular endurance (upper body and trunk) in which body weight served as the resistance. Results showed that the energy drink significantly improved push-ups to fatigue as compared with placebo, and the sit-up to fatigue test resulted in a trend for significance favoring the energy drink treatment. Given the trend for significance for the sit-up to fatigue test, it was prudent to calculate the effect size (Cohen‟s *d*) of the energy drink treatment [16]. The calculated effect size for the sit-up to fatigue test was 0.35. Given this small/moderate effect size, it is possible that the investigation was underpowered and that the sample size was not large enough to detect a difference between the two treatments.

Several other studies have also investigated the effects of a pre-workout caffeine-containing beverage on upper body muscular endurance [10,17]. Woolf and coworkers[17] reported that a caffeine containing beverage supplying 5mg caffeine/kg body mass resulted in more total weight lifted in the chest press (about 18% more weight lifted) as compared to a placebo in highly trained competitive male athletes. Forbes and colleagues [10] supplied physically active males and females with an energy drink (containing 2 mg caffeine/kg body mass) or placebo beverage sixty minutes prior to three sets of bench press exercise at 70% of 1-repetition maximum. The number of repetitions performed during the energy drink condition was significantly greater (about 6%) than the number of repetitions

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performed during the placebo condition. The amount of caffeine utilized in the present study was nearly 2mg/kg body mass. While body weight was used as the mode of resistance via the push-up exercise, the results are consistent with the other aforementioned investigations in which an improvement in upper body muscular endurance was reported.

To the best of our knowledge, the present study was the first to investigate the effects of pre-workout energy drink ingestion on trunk muscle endurance.

In contrast to the favorable findings in upper body muscular endurance, no other performance measure was improved as a result of pre-workout energy drink ingestion. In relation to endurance performance as measured by the 1.5-mile run, the energy drink imparted no improvement in performance. There have been a few other studies that have investigated energy drink ingestion prior to endurance exercise [7, 8, 12, 18, 19]. Nearly all of these investigations reported a significant improvement in endurance performance, with only one exception [12]. Reasons for the disagreement for the effects of pre-exercise energy drink ingestion in the present study as compared to the other reports are currently unknown. While each investigation used different amounts of caffeine and specific tests as a measure of endurance performance, the methods utilized in the current study were similar to other investigations that reported conflicting findings [7, 8, 18, 19]. Specifically, caffeine intake ranged from about 1.1 to 2.7 mg/kg body mass in the investigations reporting improvements following energy drink consumption, and 1.95 mg caffeine/kg body mass was used in the current study. Perhaps the duration of the endurance performance tests explains the equivocal findings. The length of the time to complete the endurance test (1.5 mile run) in the present study was approximately 11 minutes. This was shorter than the duration of time to complete the endurance tests in the other investigations, which ranged from 15 minutes to about one hour [7,8,18,19]. More research is needed to determine if a threshold exists for the length of an endurance performance test following energy drink ingestion.

We believe this was the first study to investigate the effects of a pre-workout energy drink on anaerobic power as measured via a vertical jump and a reactive sprint test. Other studies have measured peak power output, but used a Wingate test to assess this performance variable [10,11,13]. In each of these investigations, it was reported that pre-workout energy drink ingestion had no impact on peak power output. Based on these findings and the results of the current investigation, it does not appear that a pre-workout energy drink improves peak and/or anaerobic power output.

The results of this study indicate that the pre-workout energy drink had a significant effect on upper-body muscular endurance as measured by the push-up to fatigue test. It also had a non-significant effect on upper-body muscular endurance as measured by the sit-up to fatigue test when taken within 30 minutes before the exercise bout. Specifically, energy drink consumption 30-minutes prior exercise resulted in an improvement of push-up and sit-up to fatigue performance by 12% and 13%, respectively. The results of this particular study could be potentially applied to military personal due to the similarity of exercise mode. For example, the Army uses the "Army Physical Fitness Test" (APFT) to assess the conditioning levels of its soldiers. The APFT consists of a two-minute push-up test, a two-minute sit-up test, and a two-mile run. Therefore, ingestion of a caffeine-containing beverage 30 minutes prior to the APFT could potentially increase the soldiers‟ scores in some of these assessments. In spite of these improvements in upper body and trunk muscular endurance, there were no other performance benefits resulting from the pre-workout energy drinkingestion.

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It should be noted that caffeine will affect cardiovascular functions (i.e. mean arterial pressure, diastolic blood pressure, systolic blood pressure, and heart rate) in a dose-responsive relationship-meaning the more caffeine ingested, the greater increases in blood pressure and heart rate [20]. Therefore, individuals with a known heart disease and/or signs or symptoms of cardiovascular disease should use caution and consult a physician prior to caffeine use. In addition to this, some people experience gastrointestinal disturbances, increased anxiety, insomnia, and/or headaches when ingesting caffeine, especially in large doses. Therefore, the authors recommend athletes experiment with caffeine-containing energy drinks during practice and not prior to competition due to the possible negative reactions to caffeine.

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