Advances in Physical Education
2011. Vol.1, No.1, 1-5

Scientific Research
DOI:10.4236/ape.2011.11001

The Effects of Pre-exercise High Energy Drink on Exercise Performance in Physically Active Men and Women

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Received August 1st, 2011; revised August 14th, 2011; accepted August 17th, 2011.

The effect of a pre-exercise energy sport drink on the exercise performance was examined in twenty recreationally active subjects. A randomized, double-blind, placebo-controlled research study design was conducted. Subjects underwent two testing session separated by 7 days, consisted of handgrip strength test, counrmovement (CMJ) and vertical jump (VJ) as well as incremental test to exhaustion on motorized treadmill. Before the second trial, they were randomly provided either a placebo (PLA;maltodextrin) or the supplement (NP; commercially marketed as Ultimate Nox Pump^{TM,}). Analysis of variance revealed no differences between supplement and placebo group in strength, CMJ, VJ and maximal oxygen uptake (VO_{2max}) ($p > 0.05$). Significant difference between groups over time was observed in maximal heart rate, heart rate recovery and time to exhaustion ($p < 0.05$). The present study indicate that a high energy drink consumed 40 minutes before exercise can enhance exercise performance by increasing the total time to fatigue during incremental testing.

Keywords: Caffeine, Endurance, Heart Rate, Ergogenic Aid

Introduction

Several physiological and pharmacological agents have been used by both athletes and recreationally active population to enhance exercise performance. In addition, there is a growing number of sports supplements commercially promoted as effective nutritional ergogenic aids nowadays, with annual sale expected to surpass 9 bilion dollars by the year 2011 in US alone (Report Buyer, 2007). However, there is often a lack of objective evidence to support those claims (Juhn, 2003). During the past decade, the high-energy drinks have been introduced by sport supplement industry. The main ingredients of such beverages are caffeine, creatine, carbohydrates, B vitamins and amino acids, with most of them proved to have ergogenic effect (Graham, 2001; Bemben & Lamonte, 2005; Jeukendrup *et al*., 1999). High-energy drinks also contain taurin and glucuronolactone, ingredients that have been found to elevate mood, alertness, and concentration (Mandel *et al*., 1985; Alford, 2001) and therefore might also contribute to enhanced performance. Although the ergogenic potential of these ingredients has been established, effects of their combination on exercise performance have not been extensively examined. A recent study has suggested that when stimulants or energy compounds are provided in more complex combination (e.g. high energy drinks), the ergogenic effect may be enhanced (Hoffman, 2007). Anecdotally, it appears that recreational population uses high energy drinks for both endurance and power/strength performance enhancement. They believe that using high energy supplements will result in increased overall performance. Unfortunately, most information available is based upon empirical evidence. There has been little research to examine the ergogenic effects of such drinks, particularly when administered pre-exercise. While it has been presented that upper body strength training volume significantly increased in 15 healthy young adults (Forbes *et al*., 2007), no differences in bench press and leg press 1-repetition maximum, total weight lifted and anaerobic power were also reported (Astorino *et al*., 2007; Hoffman *et al*., 2009). Furthermore, though high energy drink have been found to augment endurance performance and aerobic power in recreationally active subjects (Walsh *et al*., 2010; Byars *et al*., 2010), no differences in run time-to-exhaustion, perceived exertion or maximal blood lactate concentration were observed in 17 physically active university students (Candow *et al*., 2009). As previous studies are equivocal, additional research appears warranted. Moreover, none of the above mentioned studies controlled the subject's nutrition during the study and especially 48 h preceding testing, which could bias the obtained results. Therefore, the purpose of the present study is to examine the effects of pre-exercise high energy drink on wide range of exercise performance indices in recreational athletes conducting study with controlled pre-exercise diet regimens. We hypothesized that single dose of pre-exercise high energy drink will increase handgrip strength, anaerobic power, aerobic power and time to exhaustion in physically active young men and women.

Methods

Subjects

Twenty healthy, recreationally active subjects (M=10; F=10) were recruited to participate in this study. The physical characteristics of the subjects are presented in Table 1. Following an explanation of all procedures, risks, and benefits, each subject gave his informed consent before participation in this study. Subjects were advised to refrain from physical

Table 1.
Selected physical characteristics of the subjects.

Variables	*Nox-pump* (n = 10)	*Placebo* (n = 10)
Age	20.40 ± 4.56	22.60 ± 4.55
Height (cm)	172.71 ± 9.75	174.51 ± 7.65
Weight (kg)	67.47 ± 14.23	70.03 ± 3.87

Note: *Values* are mean ± SD. No significant differences were found between groups at $p < 0.05$

activity for 24 hours, food and drink for 2 hours before exercise testing, and instructed not to engage in additional physical activity during the study. All research procedures were approved by the institutional review board.

Experimental Procedures

The study was conducted using a randomized, double-blind, placebo-controlled research design. Three days prior to the baseline testing subjects met a nutritionist who instructed them how to maintain normal dietary pattern during the study. Each participant was given a balanced general isoenergetic dietary plan (roughly based on estimated basal metabolic rate and physical activity) for the 48h period before each testing. Compliance was monitored by analysing 3-d food records with average daily energy intake, macronutrient content, and B complex vitamins intake calculated (Nutribaze, Phoenix, AR, USA). Subjects were strongly instructed not to use any performance-enhancing nutritional supplementation between trials. Each subject reported to the laboratory for 2 identical experimental testing sessions at the same time of day (Winget *et al*.,1985) and the same day of the week, one week apart. Total participation time for each testing session was approximately 1 hour. During the first visit to laboratory, weight and height were measured for each subject. Body mass was measured using BC-554 body composition monitor (Tanita Corp., Tokyo, Japan) to the nearest 100 g, and height was determined with portable stadiometer (SECA, Hamburg, Germany) to the nearest millimeter, with barefoot subjects wearing underwear only. All anthropometric measures were carried out by the same investigator. Subjects underwent a battery of tests consisted of hand grip test, countermovement (CMJ) and vertical jump (VJ) test as well as an incremental test to exhaustion on a motorized treadmill. Handgrip strength (kg) was measured with a Jamar hydraulic hand dynamometer (J. A. Preston Corporation, Clifton, NJ, USA). After the individual size adjustment, the subject maximally squeezed the grip twice with every hand, while being in the upright stance and dynamometer holding close to body (arms fully extended). The higher value was included in further analysis.CMJ and VJ were estimated using a contact mat (Jump Mat, Axon, USA). Before testing, the subjects were allowed to warm up on their own (e.g., jogging, calisthenics) but were requested not to engage in static stretching. During a warm-up period, several familiarization jumps were conducted. CMJ requires the individual to begin in an upright posture with their feet shoulder width apart and with hands on the hips. After a brief downward phase (semi squat position) subjects jump straight up in the air with an all-out effort, maintaining hands on the hips to prevent arms from contributing to the jump and landing with extended legs on both feet at the same time. VJ has basically the same kinematical pattern, with arms allowed to swing thus contributing to jump height as only difference. Three attempts for each jump type were allowed with the highest value included in further analysis. Jump height was calculated from the time the subject was off the mat by the computer which was connected to the platform. Incremental pseudo-ramp test protocol was conducted on a computer-driven motorized treadmill (13620 treadmill, Vacumed, California, USA) with heart rate monitored continuously throughout the test session with a Polar S-810 (Polar ElectroOY, Finland). Expired air was collected and analyzed through a 2-way valve using VistaVo2Lab automated gas analysis system (VacuMed, California, USA). The gas analyzer and volume transducer were calibrated according to manufacturer's specification. Following warm-up (3 min of running at 3.8 mph), incremental protocol was applied until volitional fatigue. The highest heart rate (HR) at the end of the test was recorded as HR_{max}, while decrease of HR in the first minute after the test was recorded as heart rate recovery (HR_R) index (Shetler *et al*. 2001). In addition, time to exhaustion (END) and maximal oxygen uptake (VO_{2max}) were obtained. VO_{2max} was defined as the average of the two highest single consecutive 20-s VO2 mean values attained toward the end of the test.

Intervention

Before the second trial, subjects were randomly assigned to high energy drink (NP) or placebo (PLA). Either drink was administered 40 minutes before the testing session. Men and woman were equally represented in both groups. NP is commercially marketed as pre-workout energy drink (Ultimate Nox-pump^{TM}, Dorian Yates Ultimate Formulas Ltd, Los Angeles, USA) consisted 15 g of a powder containing 6000 mg of carbohydrates (fructose, ribose, sucralose), 1500 mg of L-carnitine, 2000 mg of amino acids (trimetylglicine, choline, N-acetyl-L-tyrosine, L-phenylalanin), 3800 mg of creatine, 500 mg of taurine, 350 mg of glucuronolactone, 150 mg of caffeine, 200 mg of B vitamins , and mixed with 250ml of water. The nutritional composition per serving of the supplement was 49 calories. Placebo consisted of an equivalent amount of cellulose mixed with water. Beverages were administered in uniform containers and identifiable only by numeric code to both the investigators and the subjects.

Statistical Analysis

The data are expressed as means (SD). Statistical significance was assessed using Student's t test for correlated samples. Two-ways analysis of variance with repeated measures was used to assess changes in exercise performance indices between groups over time. Statistical significance was set at $p < 0.05$. Data were analyzed using SPSS software (version 13.0; SPSS, Inc., Chicago, IL).

Results

All results are shown in Table 2. There were no significant differences in strength, CMJ, VJ and VO_{2max} within or between trials ($p > 0.05$). Significant difference in HR_{max} and HR_R were observed in experimental group between trials ($p < 0.05$; Table 2), with mean change of 3,1 and 8,3 beats/min, respectively. No significant difference in HR_{max}, HR_R were seen in placebo group between trials. Endurance (END) significantly increased in experimental group ($p < 0.05$) after supple-

Table 2.
Results of physiological tests during the study.

Variables	*Nox-pump* (n = 10)		*Placebo* (n = 10)	
	Trial 1	*Trial* 2	*Trial* 1	*Trial* 2
Hand grip strength (kg)	83.80 ± 27. 32	83.80 ± 26. 03	82.00 ± 28. 39	81.60 ± 28.50
CMJ (cm)	30.67 ± 5.47	32.01 ± 5.02	31.11 ± 7.94	31.71 ± 7.96
VJ (cm)	36.73 ± 6.44	38.36 ± 6.67	37.67 ± 9.18	38.00 ± 9.39
VO_{2max} (ml/kg/min)	44.74 ± 4.91	46.14 ± 4.01	43.18 ± 7.18	43.41 ± 8.15
HR_{max} (beats/min)	190.5 ± 9.61	193.6 ± 9.93*†	194.5 ± 9.55	193.1 ± 8.87
HR_R (beats/min)	151.8 ± 9.36	160.2 ± 11.01*†	161 ± 9.97	158.6 ± 15.94
END (sec)	546 ± 90.54	594.00 ± 76.48*†	501 ± 91.83	505.5 ± 83.15

Note. Values are means ± SD. CMJ - Countermovement jump; VJ - Vertical jump; VO_{2max} - maximal oxygen consumption; HR_{max} - maximal heart rate; HR_R - recovery heart rate. * Indicates significant difference trial 1- versus trial 2 at $p < 0.05$; † significant difference nox-pump vs. placebo at $p < 0.05$.

mentation as compared with initial results ($p < 0.05$), with mean change of 48s. END was similar within the Placebo group at pre- and post-supplementation trials ($p > 0.05$). Finally, significant difference between groups over time was observed in HR_{max}, HR_R and END. There were no side effects reported from the exercise testing or high energy drink ingestion.

Discussion

The results of the study indicate that the pre-exercise high energy drink does enhance exercise performance by improvement in endurance performance represented by the time to exhaustion (END). In addition, higher maximal heart rate (HR_{max}) and slower heart rate recovery (HR_R) after endurance test, evidenced by higher values of recovery heart rate one minute after exercise, were obtained. Results showed no significant improvement in anaerobic performance indices.

Carbohydrate ingestion within 60 minutes prior to exercise has been reported to have a negative or positive effect on endurance exercise performance, depending on carbohydrate content of the supplement. Furthermore, if carbohydrate-rich supplement is consumed, as was the case in our study, decline in endurance performance should be expected, (Coombes & Hamilton, 2000). The rise in blood glucose concentration causes a peak in insulin-blood concentration at the beginning of exercise, with consequent extraordinary high muscle glucose uptake-rate during the performance. However, this mechanism have been proved detrimental for long term endurance performance (≥ 1 hour), with substrate availability unlikely to play a significant role in exercise performance lasting ≥30 minutes (Kuipers *et al*., 1999). Amino-acids are usual high energy drink ingredient, proposed to enhance post exercise recovery. This is linked with enhanced magnitude of protein synthesis after the session, with additionally improved effect if combined with carbohydrate (Wolfe, 2006). However, acutely ingested amino acids are not known to have any effect on acute exercise performance (Hoffman *et al*., 2008). Majority of studies suggested that creatine supplementation is effective for improving performance in high-intensity exercise tasks, with no evidence of any affect on endurance running performance (Tarnopolsky *et al*., 2005). The performance-enhancing effects of Cr have been attributed to several factors, including improved Cr phosphate (CrP) resynthesis, increased buffering capacity, and greater shuttling of mitochondrial ATP into the cytoplasm (Bemben & Lamont, 2005). However, creatine loading scheme,with 20 to 30g/day for 3 days all longer, must be conducted in order to obtain ergogenic effects (Demant, & Rhodes, 1999). Considering that acutely ingested amino acids and creatine are not known to have an effect on acute exercise performance, improved exercise performance in our study is likely the result of the high energy compounds (e.g. caffeine, taurine and glucuronolactone) found in the high energy drink. Although the design of this study does not permit isolation of the cause of the ergogenic effect, it seems that mechanism underlying performance enhancement could be mostly attributed to ergogenic effect of caffeine. Ergogenic potential of caffeine has been studied extensively, with most of data supporting the ingestion of caffeine to augment endurance for long term exercise activities. In addition, studies that have examined pre-exercise caffeine's ingestion effects on endurance in short-term exercise reported considerable variability within studies, with general finding that caffeine either has positive effects or causes a nonsignificant improvement in exercise time (Mohr *et al.*, 2008; Graham, 2001; Cox *et al.*, 2002; Meyers & Cafarelli, 2005; Slivka *et al.* 2008). Limited data considering caffeine ingestion effects on progressive exercise protocol performance have been published. Perkins *et al.* (1975) reported no effects of caffeine ingestion on time to exhaustion. However, several authors, (Dodd *et al*., 1991; Powers *et al.*, 1983; Flinn *et al*., 1990), showed small (0.3 and 0.5 minutes) or significant (from 14.9 to 17.5 minutes) increase in endurance time after caffeine intake.

Caffeine has been proposed to improve exercise performance by 1) increasing mobilization of fat and possible sparing of muscle glycogen, 2) affecting calcium release from the sarcoplasmic reticulum, and 3) increasing excitatory neurontransmitter activity as a consequence of adenosine receptor antagonism. (Spriet, 2002). Considering that exercise performance in this study is not limited by carbohydrate availability, other mechanisms must explain its ergogenic effect. Caffeine administration could influence high intensity short term performance by increasing intracellular calcium concentration (Doherty *et al*., 2004). It should be noted, however, that these effects occurred during in vitro (James *et al*. 2004) or in vivo experiments (Powers *et al*., 1983) with either above toxic level caffeine doses, or caffeine concentrations that are not regularly observed in high energy drinks (> 7 mg/kg). Thus it is likely that ergogenicity of caffeine in this study is the result of its role as an adenosine receptor antagonist (Graham, 2001). Recent researches imply that caffeine affects endurance performance largely through its antagonist effect on adenosine receptors in the brain (Davis *et al*., 2003) modulating central fatigue and ratings of perceived exertion (RPE). Indeed, one consistent outcome of caffeine ingestion during exercise testing, regardless of intensity, or duration of exercise, is an alteration in participants' perceptual response. A recent study (Doherty &

Smith 2005) revealed that caffeine appears to reduce rates of perceived exertion (RPE) during exercise, by an average of 7%. Althouth RPE was not monitored in our study, it could be hypothesized that reduction in RPE at all levels of intensity enables experimental group–subjects to sustain higher power outputs and consequently improve time to exhaustion during pseudo ramp test protocol. Finally, results across studies suggest that caffeine dose found in high energy drink used in this study (150 mg/l) could be effective for increasing exercise performance in recreationally active subjects. Although caffeine is the main purported ergogenic ingredient this commercially available energy drink also contains other potential ergogenic compounds. For example, taurine supplementation has been shown to increase exercise time-to-exhaustion, with doses of 2-6 g/day for one week suggested to be beneficial (Zhang *et al*., 2004). For the present study, the amount of taurine (500 mg) with just pre-exercise administration, may have been too low to elicit an improvement in endurance performance. No studies appear to have examined the effect of glucuronolactone ingestion on exercise performance. However, when ingested with taurine and caffeine, it has been shown to improve cognitive function, alertness, and physical performance (Alford *et al*., 2001). In addition, the B vitamins are known to play an important role in energy metabolism (Manore, 1994). Additional researches are warranted to determine the contributions of each ingredient to exercise performance.

Conclusion

The results of this study support the use of high energy drink before exercise in order to improve endurance performance in recreationally active subjects There are several possible mechanisms that could account for this improvement, with suggested high energy compound effect on CNS most likely responsible. In effort to substantiate or refute the findings of this research, additional studies are warranted.

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