Original article:

Effect of pre-exercise energy drink on the exercise endurance in young active adults

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ABSTRACT:

The effect of a pre-exercise energy sport drink on the exercise performance was examined in twenty recreationally active 1st yr medical students. A single-blind, case-controlled research study design was conducted. Subjects underwent two testing session separated by 7 days, consisted of VO2max, RPE scale, HRmax as well as incremental test to exhaustion on motorized treadmill. Before the second trial, they were provided with Pre-exercise energy drink supplement (commercially marketed as RED BULL energy drink). Statistical analysis by student's paired t test revealed significant difference was observed in VO2max, RPE scale, Exhaustion time and HRmax ($p<0.05$) after ingestion of Pre-Exercise energy drink. The present study indicate that a high energy drink consumed 30 minutes before exercise can enhance exercise performance by increasing the total time to fatigue during incremental testing.

Keywords: *Endurance, Exhaustion time, Vo2 max*

1. Introduction

The prospect of increased performance drives athletes to discover ways to gain that peak performance. The fastest and most widely used method of gaining increased performance is through performance enhancing substances. Not all of these substances are illegal and some of them are actually very natural. Three examples of legal substances that could help improve endurance performance are water, Gatorade, and Red Bull energy drink. The basic physiological effect created by these three drinks acts to help cool down the body during exercise (among other effects), making it work longer than it normally would at the continually increasing temperature. Red Bull alone has two final ingredients which could further extend the time an athlete could exercise: caffeine and taurine.**(l)**

There have been numerous reports that caffeine is an ergogenic aid; ingestion of the drug has been shown to increase endurance, particularly in prolonged exercise lasting 30-120 min **(11)**. Nutritional ergogenic aids are substances which enhance the athletic performance by influencing physiological as well as psychological process. Caffeine is one of the most common ergogenic supplements in endurance sports**(2)**. Ingestion of 3-6 mg of caffeine per kg of body weight exerts an equivalent ergogenic effect to its higher doses **(3)**. A dose of 5 mg caffeine per kg of body weight has been shown to provide most consistent effect to improve endurance performance **(5)**. According to the Medical Council of International Olympic Committee (IOC), caffeine is allowed in sports as long as its urinary excretion level is below 12 µ*g/ml* **(6)**,Thus it has been recommended that caffeine dose should be limited to 7 mg per kg of body weight or less to avoid a positive drug test because there may be individual variations in caffeine clearance. (**6,7,8)**

V02 max or the ability of the human body to use or consumes oxygen for aerobic metabolism during exercise is an important predictor of athletic performance in endurance activities. The ability of an individual to reduce or tolerate more lactate production or the metabolic end product caused by the excessive metabolism of carbohydrates (CHO) is an important factor in the performance of endurance athletes as well as other sports that rely heavily upon aerobic metabolic pathways. Therefore, it is generally accepted that by using less CHO and more fat during activity with a concomitant decrease in lactate, aerobic performance of the individual should therefore be enhanced. Previously, research has demonstrated that CHO ingestion during aerobic exercise can improve performance during exercise sessions lasting longer that 90 minutes performed at intensities greater than 70% V02 max by preventing a decline in blood glucose concentration and facilitating glucose oxidation late, whereas the timing and type of CHO ingestion following exercise influences muscle glycogen, restoration **[9-11]**. This information is especially important for endurance athletes since CHO type and blood glucose response is important in order to optimize CHO intake either pre or post exercise. For example, CHO ingestion immediately prior to exercise has been reported to have a negative effect on exercise performance **[12]**.

Currently there are many sport drinks that help the body replenish CHO levels during exercise including p -e-exercise formulas whose purpose is to promote the sparing of CHO by facilitating fat substrate utilization during exercise. Athletes, in particular those participating in sports requiring aerobic power, commonly use pre-exercise drinks (PRX) and/or other ergogenic aids prior to training workouts and competition.

Taurine or L-Taurine is an amino acid that is considered to be the second most abundant in the body's muscle after glutamine. However, with new research scientists are beginning to think that taurine is the most abundant in the body's Type II muscle fibers, even more so than glutamine ..which has led to much speculation for power athletes **(14)** . Taurine has been known to increase muscle mass, muscle strength, power, reduces muscle damage caused by exercise, accelerate recovery between workout~), and may also have an insulin-like effect in the body. it appears that taurine has several critical functions and can act similarly to creatine in that it expands the body's cells by helping the muscle cell itself hold more water, thus increasing cell volume. It has been theorized that all these may be very important to high performance athletes as it helps in protein synthesis and thus muscle hypertrophy. Additionally, another theory is that taurine enhances structural contractile capabilities in the muscle itself and thus may aid the lifter in handling heavier weights. High muscle concentrations of taurine also seem to be of the utmost importance in aiding high performance athletes.

Therefore, the purpose of this study was to examine the effects of Pre-Exercise energy drink i.e. RED BULL energy drink contains 107 calories with 193 mg Na and 26 gm sugar also including significant amount of niacin (93% RDA),vitamin B6 (240%RDA),vitamin B12 (80% RDA) and

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Pantothenic acid (47% RDA) along with Taurine and Caffiene (based on Red Bull can label).

2. Material and Method

2.1 Subjects

20 male 1st year MBBS students, who are actively participating in various sports in college annual sports activity (aged: 18±5.0 yr) were recruited in this study. The study was conducted at the Exercise Laboratory, Department of Physiology, JNMC, Sawangi(M). The descriptive 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 with hypertension, asthma, diabetes, bronchitis, anaemia, heart problems, kidney or liver diseases and or any other major diseases are excluded from the study. For assessment of physical fitness in subjects, the HARVARD STEP TEST was used. All research procedures were approved by the institutional ethical committee.

2.2 Procedure : The athlete steps up and down on the plateform at a rate of 30 steps per minute (every two seconds) for 5 minutes or until exhaustion. Exhaustion is defined as when the athlete can not maintain the stepping rate for 15 seconds. The athlete immediately sits down on completion of the test, and the total number of heart beats are counted between 1 to 1.5 mins, 2 to 2.5 mins and 3 to 3.5 mins after finishing the test.

Fitness index (long form) = (100 x test duration in seconds) divided by (2 x sum of heart beats in the recovery periods).

Rating	Fitness index (long form)
Excellent	>90
Good	80-89
High average	65-79
Low average	55-64
Poor	<55

2.3 Preparation of subjects :- To minimize variation in pre-exercise muscle glycogen status, subjects are requested to record their food intake for 3 consecutive days prior to the first trial and repeat the same diet over 3 days prior to consecutive trials. Subjects are asked to refrain from heavy exercise for 24 hours before all the experimental trials.

Table 1: Descriptive statistics for age, height, Weight, BMI,SBP and DBP

Parameters	Mean	SD	Minimum	Maximum
Age(yrs)	18.65	0.74	18.00	20.00
Weight(kg)	70.15	3.09	65.00	75.00
Height(m)	1.73	0.04	1.66	1.82
BMI(kg/m2)	23.24	0.68	21.83	24.56
SBP(mmHg)	119.80	3.03	116.00	126.00
DBP(mmHg)	70.50	2.23	66.00	74.00
Fitness index(%)	83.7	2.93	79	88

2.4 Experiment procedure :-

The study was single blind case control design. Each subject will come to the laboratory three times. During the first visit to laboratory, weight and height were measured for each subject. Fitness index was measured with the help of Harvard step test. The remaining 2 visits were for 2 identical experimental testing sessions at the same time of day and the same day of the week, one week apart to nullify the effect of the supplement. Total participation time for each testing session was approximately 1 hour. During second visit to the laboratory subjects were arrived to the lab 30 minutes prior to each trial and be seated for 10 minutes. Following this resting period, subjects required to perform maximal effort exercise test on a motor-driven treadmill. The exercise intensity began at a low level and was advanced every three minutes by increasing the speed and incline of the treadmill belt using Bruce protocol. Incremental protocol was applied until volitional fatigue. During the test, heart rate and time were measured continuously while the ratings of perceived exertion (RPE) **[15]** were measured toward the end of each three minute stage. The highest heart rate (HR) at the end of the test was recorded as HRmax. In addition, time to exhaustion and maximal oxygen uptake (VO2max) were obtained. During third visit subjects were provided with Pre -exercise energy drink (PRX) i.e. RED BULL energy drink . The supplement is provided according to the manufacturer's serving recommendation (250 ml per serving). During the trials - Heart rate, rate of perceived exertion or RPE , Time to exhaustion and HRmax were monitored. Time to exhaustion is determined as· the time that the subject could no longer maintain exercise intensity and *or* reached volitional exhaustion.

Prior to test participation, subjects were asked to adhere to the following pre-test instructions: 1) Wear comfortable, loose-fitting clothing 2) Drink plenty of fluids over the 24-hour period preceding the test 3) Avoid food, tobacco, alcohol, and caffeine for 3 hours prior to taking the test 4) Avoid exercise or strenuous physical activity the day of the test 5) Get an adequate amount of sleep (6 to 8 hours) the night before the test.

2.5 Estimation of VO2 max :

The estimation of VO2 max was calculated by following equation :

VO2 max = resting component (1 MET [3.5 ml O_2 /kg/min]) + Horizontal component (speed [m/min] × oxygen consumption of horizontal movement) + Vertical component (% grade × speed [m/min] × oxygen consumption of vertical movement). **[16]**

3. Statistical analysis:

The data are expressed as means (SD). Statistical significance was assessed using Student’s paired *t* test for correlated samples. Statistical significance was set at $p < 0.05$.

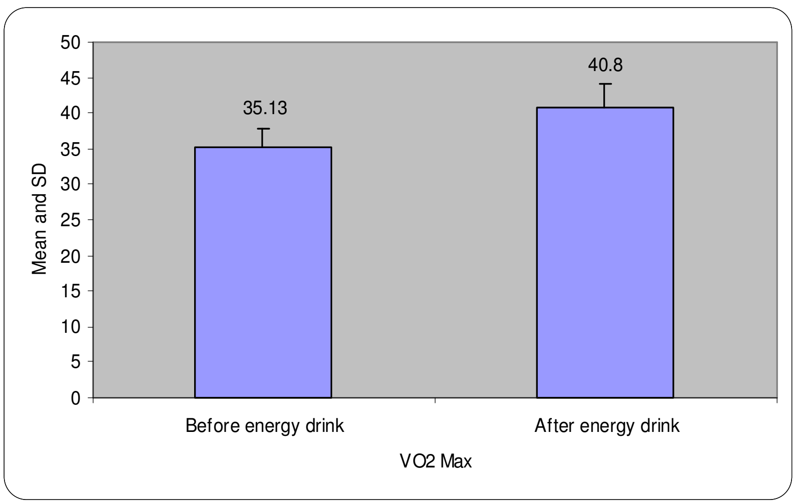
4. Results :

All results are shown in Table 2. Significant difference in VO2max ($p<0.05$) was observed after energy drink ingestion as compared before energy drink ingestion with mean change of 5.66 ml/kg/min. Exhaustion time significantly increased after energy drink ingestion ($p<0.05$) as compared with initial results with mean change of 108 sec. Similarly there was significant difference in RPE scale and HRmax after ingestion of energy drink ($p<0.05$) with mean change of 2 and 2.25 beats per min respectively as compared to before energy drink ingestion. Finally, significant difference between groups over time was observed in VO2max, Exhaustion time, RPE scale and HRmax. There were no side effects reported from the exercise testing or high energy drink ingestion.

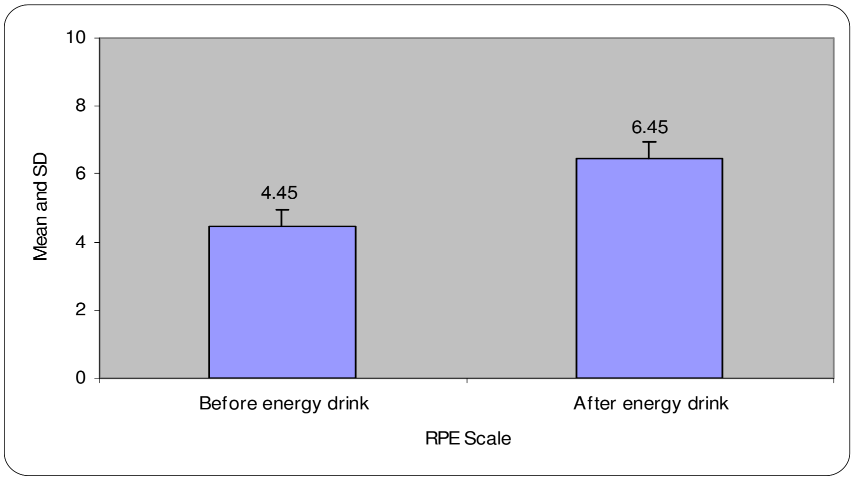
Table no. 2

Variables(n=20)	Before energy drink(Mean±SD)	After energy drink(Mean±SD)	95% C.I.
VO2 max(ml/kg/min)	35.13±2.70	40.80±3.43	(-6.57) -- (-4.53)
RPE scale	4.45±0.51	6.45±0.51	(-2.15) -- (-1.84)
Exhaustion time(sec)	551.40±38.78	659.50±40.06	(-114.55) -- (-101.64)
HRmax(beats/min)	176.50±6.01	178.75±5.79	(-2.96) – (-1.53)

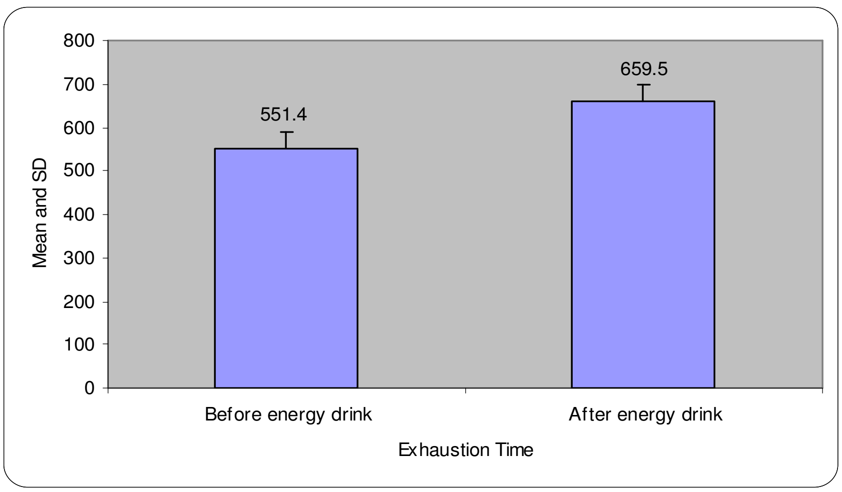
Graph 1: Comparison of VO2 Max before and after energy drink (Student's paired t test)



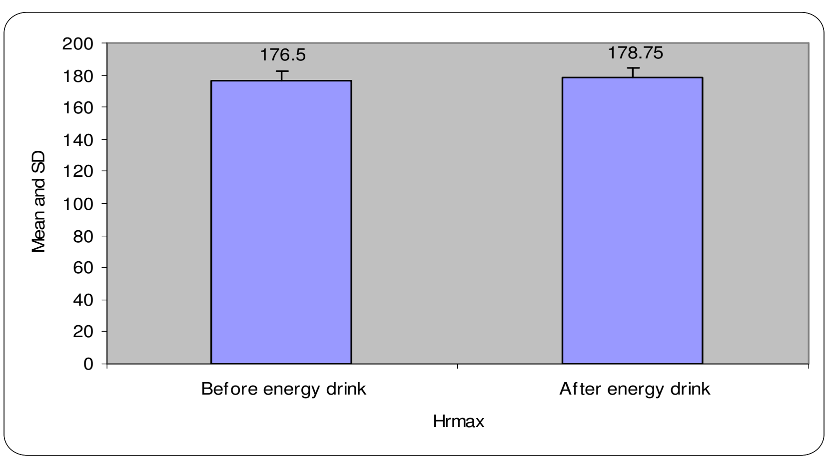
Graph 2: Comparison of RPE Scale before and after energy drink (Student's paired t test)



Graph 3: Comparison of Exhaustion Time before and after energy drink (Student's paired t test)



Graph 4: Comparison of Hrmax before and after energy drink (Student's paired t test)



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5. 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. In addition, there is increase in higher maximal heart rate (HRmax), anaerobic performance indices (VO2 max) and subjective feeling of fatigue (RPE scale) after ingestion of pre-exercise energy drink.

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. One key ingredient in Red Bull that should decrease fatigue is carbohydrates. Winnick et al. (2005) **[17]** tested athletes using basketball style testing, running 20m sprints and using maximal vertical leap. After four quarters of play the athletes who ingested carbohydrates had faster sprint times as well as significantly higher leaps. Jeukendrup (2004) **[18]** also provides many examples of how carbohydrates increase endurance performance. Carbohydrates are a necessary ingredient in muscle contraction, helping provide metabolic fuel and while they may act to increase the active temperature of the body through these continued muscle contractions. The water that is in the drinks helps to decrease core temp through sweating, expiration, and other normal cooling methods (von Duvillard et al. 2004).**[19]**

Since carbohydrates are a natural source of energy for all living organisms it would make sense that an overabundance would continue to provide athletes with more energy. The biggest problem with carbohydrate absorption during exercise is the actual amount of carbohydrates that are absorbed in the small intestine do not equal that which was initially ingested. Lang et al. (2006)**[20]** experimented on glucose absorption during exercise and found that both active and passive intestinal absorption is significantly decreased. This is due to the loss of blood flow and thus performance throughout the gastrointestinal system.

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 ($\geq$ 1 hour), with substrate availability unlikely to play a significant role in exercise performance lasting $\geq$30 minutes (Kuipers et al., 1999)

The most commonly used ingredient in energy drinks is caffeine. Caffeine has been shown to be an effective ergogenic agent by delaying fatigue and increasing time to exhaustion during endurance exercise . This is thought to be related to caffeine's ability to enhance reliance on fat oxidation preserving muscle glycogen content. Caffeine itself is only a mild central nervous system stimulator **[21].**

Forbes et al., (2007) **[22]** used Red Bull to elicit a significant increase in upper body muscle endurance. In their research they allowed an hour after ingestion for the full effects of caffeine to occur. Wiles et al., (2006) **[23]** used 76.5 minutes with 60 minutes of rest and 15 minutes of warm up time and an additional 90 seconds of stretching before their cycle test. These were twice as long as the research done by Alford et al., (2001) **[24]** in which they stated that a significant amount of caffeine was absorbed into the body after 30 minutes. Wiles et al. (2006) found that caffeine significantly increased short term, high intensity exercise verses a placebo (71.1+2.0 vs 73.4+2.3) and Alford et al. (2001) had similar findings ($P < 0.05$). Forbes et al. (2007) had a positive mention for upper body muscle endurance but no significance for average or peak power output with a Wingate cycle test.

Caffeine has a similar physiological effect on the body to other stimulants, but runs some unique pathways. Caffeine increases glucose absorption in the intestines (Van Nieuwenhoven et al. 2000) **[25].** With this increased glucose absorption, along with the increased carbohydrates (including glucose) present in the Red Bull, the caffeine should increase the available amount of glucose to the body, specifically making it more available to the muscles to increase output. Because of decreased gastrointestinal flow during exercise from sympathetic nerve regulation (Van Nieuwenhoven et al. 2000) the increased absorption of glucose aids in keeping glucose levels more even. While not increasing output it could extend the normal functioning levels of the body, thus increasing endurance while keeping max performance at normal levels.

Recent researches imply that caffeine affects endurance performance largely through its antagonist effect on adenosine receptors in the brain (Davis et al., 2003) **[26]** 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) **[27]** revealed that caffeine appears to reduce rates of perceived exertion (RPE) during exercise, by an average of 7%.

The taurine that is included in Red Bull also has an increased effect on endurance. Many researchers have found a link between decreasing taurine levels and fatigue (Hamilton et al. 2006, Zhang et al. 2003, Miyazaki et al. 2004) **[28,29,30]**. Taurine provides fuel for skeletal muscle contraction which then decreases with exertion like other nutrients. When the sarcoplasmic reticulum releases Ca^{+2} into the muscle filament to bind to troponin, taurine increases the amount of Ca^{+2} released and causes the cells to be more sensitive to the Ca^{+2} which would further increase contractibility (Hamilton et al. 2006). Taurine's contribution to increasing Ca^{+2} then increases the availability for continued stimulation.

Taurine also has many properties that help the body continue functioning at optimum levels. Some of the properties are being an antioxidant, helping with detoxification and osmoregulation, and helping maintain membrane stabilization (Zhang et al. 2003). The body produces its own amount of taurine but with taurine supplementation such as that in Red Bull the endurance effects should be observably significant.

6. 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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