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Effects of XS® Energy Drink on Aerobic Exercise Capacity of Athletes

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ABSTRACT

Int J Exerc Sci 4(2) : 152-163, 2011. A small increase in performance is often the difference between winning and losing for athletes, and energy supplements are marketed to give them a competitive edge. One such supplement is XS® Energy Drink which contains B vitamins, caffeine, taurine, and an herbal adaptogen blend. XS® Energy Drink is primarily designed and marketed as an alertness stimulus; however, it is also marketed to athletes as a performance enhancing supplement. The hypothesis of this investigation was that the consumption of XS® Energy Drink before exercise would increase aerobic capacity (an increase in Vo₂max) and time to fatigue, and would decrease time for recovery from the exercise bout. Twelve 18-24 year old athletes performed two Vo₂max tests following a modified Ellestad Treadmill protocol. Prior to testing, a double-blind cross-over method was used to administer the energy supplement or the placebo. Vo₂max (p=0.99), time to muscle fatigue (p=0.48), maximum heart rate (p=0.66), VEmax (p=0.10), time at which R is greater than 1 (p=0.50), or recovery time to one half Vo₂max (p=0.67) were not significantly different with ingestion of XS® Energy Drink over placebo. The second trial was significantly longer than the first (p=0.01) likely due to the desire to improve exercise time or familiarization with the testing procedures. Results showed no physiological effects of XS® Energy Drink; however, there is a possibility of psychological advantage. Supported by a Wright State University undergraduate research fellowship and a Wright State University Honors Program grant to KMS.

KEY WORDS: Dietary supplement, ergogenic aids, maximal oxygen consumption, double blind

INTRODUCTION

A variety of factors limit athletic endurance performance. One of the most important factors is that performance is limited by the amount of oxygen that reaches the bloodstream and eventually muscle tissue [19]. Oxygen is the final electron acceptor in the electron transport chain that rephosphorylates ADP and produces the majority of adenosine triphosphate (ATP) during oxidative phosphorylation [11].

During endurance exercise ATP is being generated primarily by means of oxidative phosphorylation [10]. Therefore, if more oxygen reaches the muscle tissue, more ATP will be produced and the muscle will have greater ability to generate or maintain the tension needed to contract [19]. Unfortunately increasing the amount of bound oxygen in the bloodstream at any given time is difficult and can only be done by increasing the amount of hemoglobin in the blood through high altitude training or

administration of exogenous erythropoietin (blood doping) [19]. However, blood doping and altitude training are not available or are illegal for many athletes. Therefore, supplements such as XS® Energy Drink are an alternative strategy to increase aerobic exercise performance. Another problem facing an endurance athlete's performance is the onset of muscle fatigue. Fatigue usually results from increasingly intense and prolonged exercise. There are many causes of muscle fatigue. One of the causes is the depletion of energy sources available to be broken down to provide ATP to working muscles [5]. Another cause is the onset of central fatigue, or the fatigue perceived by the central nervous system [6].

Many sports performance beverages attempt to increase the limits of endurance performance. Some sports beverages contain glucose and electrolytes in an attempt to prevent dehydration and improve endurance performance. It is clear that these types of supplements are effective at improving endurance performance in comparison to a placebo [13]. Although beverages containing glucose and electrolytes have been well researched, a newer class of sports performance beverages, energy drinks, has not been studied extensively in regards to exercise capacity. Some current research supports the idea that energy drinks are ergogenic. Ivy et al. (2009) found that a popular energy drink had an ergogenic effect on exercise capacity. It is also possible that consuming an energy drink may improve performance by enhancing the psychological aspect of endurance competition. Although there is some evidence of ergogenicity, there is currently insufficient research to make any

conclusions about energy drinks' effect on exercise capacity.

XS® Energy Drink is mainly marketed as an energy drink designed to stimulate the central nervous system and create feelings of alertness; however, it is also marketed to endurance athletes to help them increase their performance. XS® Energy Drink contains a variety of ingredients including B vitamins, caffeine, taurine, and an adaptogen blend (summarized in Table 1). All of these ingredients have different ways by which they provide the body with more energy for longer periods of time.

The hypothesis of this investigation was that consuming the XS® Energy Drink before exercise would increase aerobic capacity and, thereby, increase the time until muscle fatigue. This hypothesis was tested using Vo₂ max tests as indicators of aerobic exercise capacity [19]. The duration of exercise during the test was used to estimate time until muscle fatigue. Each individual was subjected to two Vo₂ max tests using a randomized double-blind cross over testing method. One test was done after consuming XS® Energy Drink and another test was done after consuming a placebo allowing participants to be their controls.

The sub-hypothesis of this investigation was that consuming XS® Energy Drink before exercise would also decrease the time of recovery. Recovery was estimated by assessing the time it took for each participant to recover to 50 percent of his or her VO₂MAX.

Table 1. Components of XS® Energy Drink with known functions and purported effects on exercise.

Ingredient	Function	Ways it may Increases Exercise Capacity
Vitamin B ₁₂ [14]	Acts as a catalyst in reaction that breaks down fats and proteins to generate ATP	Makes ATP more readily available to be used for exercise
Vitamin B ₆ [16]	Acts as a coenzyme in reaction that releases glucose from glycogen stores Acts as coenzyme in reaction that generates glucose from amino acids	Makes glucose more readily available to be broken down to generate ATP
Caffeine [8]	Stimulates central nervous system and causes the release of fatty acids from adipose tissue	Makes fatty acids more readily available to be broken down to generate ATP
Taurine [25]	Cytoprotection and antioxidation	Prevents DNA damage caused by exercise-induced oxidative stress to maintain normal cell function
<i>Eleutherooccus senticosus</i> [15]	Adaptogenic function	Has anti-fatigue and anti-stress properties
<i>Panax ginseng</i> and <i>Panax quinquefolium</i> [2,20]	Adaptogenic function	Increases total workload and V _{O2} max, has anti-stress properties
<i>Schisandra</i> [2]	Adaptogenic function	Has anti-stress properties

METHODS

Participants

Twelve endurance trained volunteers (9 males, 3 females) ages 18-24 participated in the research study (Table 2). Sample size was based on previously published studies on exercise capacity and potential performance enhancing supplements [Ivy et al. (n=12), Zhang et al. (n=11), Thomas et

al. (n=9)] [13,23,25]. Informed consent was understood and signed by all participants before any testing began. The study protocol and consent form were approved by the Wright State University Institutional Review Board. A questionnaire was administered to obtain background information: gender, age, level of physical fitness, and determination of the safety of exercise testing on the individual. Before the test was administered the participant’s resting heart rate, resting blood pressure, and body composition were assessed (Table 2).

Table 2. Participant Demographics.

	Age (yrs)	HR (bpm)	SBP (mmHg)	DBP (mmHg)	Body Fat Percent
Male (n=9)	21 ± 1.6	70.0 ± 9.4	134.8 ± 9.4	81.4 ± 7.2	14.4 ± 9.1
Female (n=3)	19.3 ± 1.2	77.8 ± 18.3	118.3 ± 1.2	77.1 ± 6.3	26.9 ± 6.0
Combined	20.6 ± 1.6	72.0 ± 11.7	130.7 ± 11.0	80.3 ± 7.0	17.5 ± 8.3

Protocol

An automatic cuff was used to measure blood pressure (Riester Ri-Champion N-Digital BP Monitor, Jungingen, Germany) and body composition was assessed using air displacement plethysmography (Life Measurement Inc., BOD POD®, Concord, CA). Heart rate was monitored using a chest strap with a remote receiver (Polar FS1, Kempele, Finland). Incremental maximum oxygen consumption treadmill (Life Fitness 9500 HR, Schiller Park, IL) tests using a modified Ellestad protocol were used as indicators of aerobic capacity [19,3]. The protocol was modified to be more intense due to the high level of physical fitness of the participants. The first stage of the protocol in this study was the same as the second stage in the Ellestad protocol; however this stage (3 mph, 10% grade) was

completed for 3 minutes to allow adequate time to reach a steady state. The remainder of the stages followed the Ellestad protocol with the third, fourth, fifth, and sixth stage in the Ellestad protocol representing the second, third, fourth, and fifth stage, respectively, in the modified protocol. A sixth stage at 7 mph and unchanged grade was added for athletes that were not fatigued at the end of the 6 mph stage. An alternative protocol (Bruce, Stanford, etc.) was not used due to the limitations of treadmill equipment. The participant wore a mouthpiece (Hans Rudolph Inc., Kansas City, MO) connected to a flow meter and gas analyzer. The fraction of expired oxygen was measured with an S-3A/I oxygen analyzer (AEI Technologies, Naperville, IL), and the rate of air flow was measured with a pneumotachograph (Hans Rudolph, Inc., Kansas City, MO). These measurements were integrated by the MOXUS computer program (AEI Technologies, Naperville, IL) to calculate relative and absolute oxygen consumption (VO_2), carbon dioxide expired (VCO_2), minute ventilation (VE), respiratory exchange ratio (RER), tidal volume (VT), and respiratory frequency (fR). The metabolic cart was calibrated before each test using a 4 % CO_2 , 16% O_2 , nitrogen balanced gas mixture (Weiler, Dayton, OH) and a 3 liter calibration syringe (Hans Rudolph Inc. Series 5530, Kansas City, MO). Blood pressure was not assessed during exercise due to limitations of the blood pressure device.

Each participant completed two $\text{VO}_{2\text{MAX}}$ tests with at least 48 hours between each test to allow muscle glycogen to be restored to normal levels [3]. The second test was completed within a maximum of two weeks of the first test to ensure that the participant

was in approximately the same physical condition for each test. Participants were asked not to perform any rigorous exercises or activities the day of or day before each test, to get 7-8 hours of sleep the night before each test, and to wear exercise clothing for the test. One test was done 30 minutes after consuming a placebo and the other was done 30 minutes after consuming the XS® Energy Drink. The test was done 30 minutes after consumption because caffeine levels peak in the blood 30-60 minutes after consumption [13]. The participants consumed 250 ml of Cherry Blast XS® Energy Drink (XS® Gear, LLC, Redmond, WA) consisting of 1.5 g taurine, 6.0 mg Vitamin B6, 294 μg Vitamin B12, 10 mg Vitamin B5, 20 mg Vitamin B3, 0 g carbohydrate [4]. The participants also consumed a placebo that was composed of 1.25 grams sugar-free Cherry Kool-Aid (Kraft Foods Global, Inc., Glenview, IL), 5 μl blue food coloring (Kroger Co., Cincinnati, OH), and 250 ml carbonated water (Canada Dry, Dr. Pepper/Seven Up Inc., Plano, TX). The placebo was in the same type of container, had the same volume, was the same color, and had a similar flavor to the XS® Energy Drink. Participants were randomly assigned to drink either XS® Energy Drink or the placebo before the tests. An unbiased third party identified each substance with a six-digit code that was recorded and later used to determine whether the participant consumed the placebo or the XS® Energy Drink.

During each test the participant's relative and absolute VO_2 , heart rate, RER, VE, VCO_2 , breathing frequency, and VT were recorded every 30 seconds. The recorded data were averaged between minutes 3 and 8 to determine resting values for each

parameter. Measurements preceding the third minute were not used in calculation of resting data to allow the participant to return to resting levels after walking to the testing area. At minute 8 participants stood up to prepare for the incremental test. At minute 10 the incremental test began with stage 1 of the protocol.

All maximum values were determined by taking the mean of the three highest recorded values taken at 30 second intervals. Time until fatigue was determined by measuring and recording the time from the beginning of the exercise test to the time that the participant voluntarily stopped that test. Ventilatory threshold (VT) was figured as the point when RER was greater than one. Sue et al. (1988) determined that an RER of about 1.0 was observed at work rates below VT and RER values above 1.0 were observed when work rates were above VT indicating that the point at which RER exceeds one can be described as the VT [1]. Vo₂ max measurements were also compared between genders, differing fitness levels, and differing body composition categories. The fitness level comparisons were based on the category each participant subjectively placed themselves on the pre-exercise questionnaire. The body composition categories were based on those outlined in Gallagher D, Heymsfield SB, Heo M, et al. (2000) [7]. Tests were terminated voluntarily by the participant upon muscle fatigue. Vo₂ max was considered to be achieved if the participant could no longer continue the test because of fatigue, the respiratory exchange ratio had reached a value of 1.15 or higher, or the heart rate was within 10 beats per minute of predicted values based on age [3].

Once exercise had ceased, the participant was observed until resting ventilation, blood pressure, and VO₂ had been re-established. These variables indicated that the participant was recovered from the exercise.

Statistical Analysis

Statistically significant differences between XS® Energy Drink and Placebo and between first and second trials were determined for reported variables using paired t-tests where a-priori level of significance was determined for $p < 0.05$. The effects of XS® Energy Drink and Placebo on Vo₂ max were compared for each gender, body fat percentage category, and subjective fitness category using Analysis of Variance (ANOVA) where a-priori level of significance was determined for $p < 0.05$ (GraphPad InStat, version 3.06, GraphPad Software, San Diego California USA, www.graphpad.com).

RESULTS

There was no significant difference between maximal oxygen consumption after consuming XS® Energy Drink and after consuming a placebo. There were also no statistically significant differences between XS® Energy Drink and Placebo on parameters of time to muscle fatigue, recovery time to 50 percent Vo₂ max, maximum VE, maximum heart rate, time until RER was above one, RER at VO₂MAX, maximum VCO₂, maximum frequency of breaths per minute, and maximum VT (Table 3). There was, however, a significant difference between the first trial and the second trial in time until muscle fatigue (Figure 1). There were no other statistical

differences between the first and second trials in any other parameters (Table 3).

Table 3. Maximal Exercise Comparisons: XS® Energy Drink v. Placebo and Trial 1 vs. Trial 2.

Parameter	XS® Energy Drink	Placebo	P value	Trial 1	Trial 2	P value
VO ₂ max (ml/kg/min)	61.6	61.5	0.99	60.9	62.2	0.29
Time to Fatigue (s)	703	695	0.48	687	712	0.01 *
HR max (bpm)	193.1	194.0	0.66	193.1	194.1	0.64
V _E max (L/min)	129.7	134.1	0.10	130.5	133.3	0.31
Time R > 1(s)	661	647	0.50	639	668	0.15
Recovery Time - 50 % VO ₂ max(s)	83	86	0.67	88	80	0.28
V _T (ml)	2743	2778	0.72	2769	2752	0.87
f _R max	47.8	48.4	0.72	47.3	48.9	0.39
VO ₂ max (ml/min)	4475	4460	0.89	4406	4529	0.23
V _{CO2} (ml/min)	4096	4225	0.11	4125	4195	0.41
RER	0.93	0.95	0.35	0.94	0.94	0.89

Significant effects (p<0.05) are indicated with an asterisk (*).

XS® Energy Drink did not have a significant effect on maximum oxygen consumption with differing genders, body fat percentages, and subjective fitness ratings (Table 4).

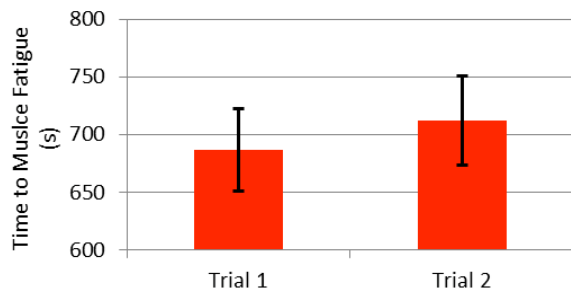


Figure 1. Effect of trial on the time to muscle fatigue. Significant effects (p<0.05) are indicated with an asterisk (*).

Table 4. Comparison of VO₂max (mL kg⁻¹ min⁻¹) with XS® Energy Drink vs. Placebo on Gender, Body Fat Percentage Category, and Subjective Fitness Category.

Category	Parameter	XS® Energy Drink	Placebo	P value
Gender	Female	51.4	52.2	0.52
	Male	64.9	64.7	0.87
Body Fat % Category	< 8 % males or < 21 % females	64.6	67.2	0.59
	8-19 % males or 21-32 % females	61.3	61.1	0.59
	20-24 % males or 33-38 % females	57.9	54.7	0.59
Subjective Fitness Category	Excellent	57.1	59.1	0.22
	Good	59.1	58.0	0.22
	Fair	76.7	77.6	0.22

Body fat percentage classification categories from Gallagher D, Heymsfield SB, Heo M, et al. (2000) [7].

Consumption of XS® Energy Drink did not have an effect on resting values either (Table 5). However, resting relative Vo₂, absolute VO₂, VCO₂, and VE were significantly elevated in the second trial in comparison to the first (Table 5).

DISCUSSION

The results of this study did not support the hypotheses that consuming XS® Energy Drink before exercise would increase aerobic capacity or increase time to muscle fatigue. These results suggest that consuming XS® Energy Drink before physical activity or an athletic event will not physiologically increase aerobic endurance performance. This research shows that XS® Energy Drink is ineffective across the genders, body compositions, and fitness levels tested in this study. Although

some participants had slight gains in maximum oxygen consumption during the XS® Energy Drink trial, others had no difference or even a decrease in VO₂ after consuming the supplement. These results also indicated that XS® Energy Drink does not increase time until muscle fatigue. The fact that XS® Energy Drink does not increase time until the RER is greater than one showed that the supplement does not prolong time before reaching ventilatory threshold. This means that the supplement does not increase the intensity at which you can still rely primarily on aerobic energy pathways [1]. XS® Energy Drink also does not decrease time of recovery as evidenced by a lack of significant difference between the time it takes to reach 50 percent VO_{2MAX} between XS® Energy Drink and the placebo. There were also no gains in maximum VE or maximum heart rate after consuming XS® Energy Drink versus the placebo. From this research it appears that a single can of XS® Energy Drink has little or no physiological effect on aerobic endurance performance.

Table 5. Resting Comparisons: XS® Energy Drink v. Placebo and Trial 1 vs. Trial 2.

Parameter	XS® Energy Drink	Placebo	P value	Trial 1	Trial 2	P value
HR (bpm)	68.3	70.9	0.096	69.4	69.9	0.76
V _{O2} (ml/kg/min)	5.0	4.8	0.43	4.7	5.1	0.02*
V _E (L/min)	10.8	9.9	0.07	9.9	10.8	0.05*
V _I (ml)	725	711	0.46	716	719	0.85
RER	0.76	0.74	0.41	0.74	0.75	0.82
V _{O2} (ml/min)	356	346	0.50	336	366	0.03*
V _{CO2} (ml/min)	271	256	0.12	252	275	0.01*
f _R	15.2	14.4	0.25	14.1	15.5	0.06

Significant effects (p<0.05) are indicated with an asterisk (*).

Although this research did not find any physiological advantages in consuming

XS® Energy Drink before aerobic exercise, there were some additional factors that may need to be taken into account in future research. Although participants were given instructions to not perform vigorous exercise the day of or before the test and to get 7-8 hours of sleep, the subjects were not monitored. The subjects were also not given instructions as to what to eat and when to eat before the tests. Prior coffee or soda consumption before tests may have played a role in VO_{2MAX} achievement. Also, the time of day that participants performed exercise tests was not consistent for all participants. Individual differences in energy levels at differing points in the day may have also affected physiological measurements.

Although it was necessary to have a protocol with the potential for high intensity, a more gradual increase in intensity may have provided more accurate maximum measurements. A ramping treadmill protocol may be the most appropriate because of the consistent, gradual increases in intensity and physiological responses [22]. The drink was consumed 30 minutes prior to exercise due to the amount of time it takes caffeine to peak in the blood [13]. However, due to the blend of ingredients in XS® Energy Drink it is difficult to determine when the substances in the supplement would be most active. Perhaps consuming the drink at a shorter or longer period before exercise would produce evidence of physiological advantages.

Even with all sources of error taken into account it is still not likely that acute consumption of XS® Energy Drink, in the amount used in this experiment, has an advantageous performance effect. As

shown in the results, VO_{2MAX} values similar after consuming the placebo compared to XS® Energy Drink.

Although XS® Energy Drink contains substances that are claimed to enhance performance or prolong onset of central or muscle fatigue, these claims may not apply to all individuals and/or may be exaggerated. For example, promoted components of XS® Energy Drink are large doses of B vitamins, especially vitamin B12. XS® Energy Drink contains 4900 % of the Daily Value of Vitamin B12, which equates to 294 μ g. Although Vitamin B12 is a necessary cofactor in the mechanism to breakdown fats and proteins to produce ATP, excessive amounts of vitamin B12 have not been shown to speed up this process or provide additional energy resources [17]. According to a review by Herbert people store approximately 2.5 mg of vitamin B12 and vitamin B12 has a long half-life (480 – 1360 days). Therefore, most individuals can go more than a year without consuming Vitamin B12 and still have enough for necessary functions because of the large amount stored. The mechanism by which vitamin B12 helps breakdown macromolecules is also saturated at any given time by only 1-1.5 μ g of Vitamin B12, therefore it can be assumed that taking large amounts of vitamin B12 will not provide an increase in energy availability in those consuming the average diet [12]. It is possible, however, that vitamin B12 supplementation may provide performance increases if a person is vitamin B12 deficient.

Similarly, XS® Energy Drink has 300 percent of the daily value of Vitamin B6, which equates to 6.0 mg. Vitamin B6 is a necessary cofactor in glycogen breakdown

and protein metabolism. Although it has been theorized that vitamin B6 supplementation will increase ATP generation and improve exercise performance, this theory has not been supported by research. Like Vitamin B12, exceeding the Daily Value (2.0 mg) of Vitamin B6 has not shown improvements in exercise or physiological performance. In a study that provided cyclists with 20 mg per day vitamin B6 supplementation, cycling time to exhaustion was not increased in those with the supplement compared to those without the supplement [18]. This lack of performance increase with vitamin B6 supplementation may be because most individuals consume enough vitamin B6 to fully metabolize the protein they consume. About 0.016 mg vitamin B6 is necessary to metabolize every gram of protein. Since most people consume 60-100 g of protein per day, 100 percent of the Daily Value of vitamin B6 is sufficient for protein metabolism [18]. Therefore, a surplus of vitamin B6 would not provide any additional ATP from protein metabolism. Although it appears that having a surplus of B vitamins provides no physiological advantage, performance may increase with B vitamin supplementation if the participant has Vitamin B12 or B6 deficiency [12,18].

Another major component of XS® Energy Drink is caffeine. Caffeine has been shown to cause increases in maximal oxygen consumption and aerobic performance in several studies [8]. Caffeine increases stimulation of the sympathetic nervous system, increasing the release of epinephrine. This response may reduce central fatigue by decreasing the perception of fatigue and result in prolonged exercise [6]. Caffeine also causes an increase in the

release of fatty acids that can be broken down and used as an energy source [8]. However, XS® Energy Drink may not have a sufficient concentration of caffeine to see a significant increase in performance. XS® Energy Drink contains 83 mg of caffeine, which is less than the minimum amount shown to improve aerobic performance, 160 mg [9]. Future research must be done to determine whether drinking two cans of XS® Energy Drink provides the necessary caffeine to improve aerobic performance.

Another ingredient added to XS® Energy Drink for the purpose of performance enhancement is taurine. Taurine is an amino acid that has been shown to have cytoprotective and antioxidative functions. Although taurine administration has been shown to increase Vo_2 max and time to exhaustion in cyclists, these participants were administered 6 grams of taurine, which is much more than the 1.5 grams of taurine in a can of XS® Energy Drink. The cyclists were also administered taurine for seven consecutive days [25]. This suggests that a more regular administration and larger dose of taurine may be necessary to observe any physiological performance advantages.

Similarly, the adaptogen, *Eleutherococcus senticosus* may need to be supplemented more regularly to observe improved performance. *Eleutherococcus senticosus* increased swimming time in rats after nine consecutive days of administration of root *Eleutherococcus senticosus* [15]. There are also different versions, stem and root *Eleutherococcus senticosus*, which may have different effects on exercise physiology [15]. Since there is not much known about this adaptogen, there is research needed to determine the type,

dose, and frequency of administration of *Eleutherococcus senticosus* to maximize its performance enhancing effects.

Positive performance effects seen with other adaptogens were also seen under specific conditions, such as repeated dosage, large doses, and in combinations with other herbs. For example *Panax ginseng* requires a daily dose of at least 2000 mg to improve performance [2]. McNaughton et al. (1989) found that improvements in aerobic performance were only seen after 6 weeks of supplement administration [2]. Other adaptogens found in XS® Energy Drink like *Schisandra*, have only caused aerobic improvements when in combination with other herbs such as *Eleutherococcus senticosus*, *Aralia*, *Rhaponticum*, and *Rhodiola* [2]. It is clear that the individual advantages reported with the ingredients found in XS® Energy Drink are on a conditional basis. Many of these substances may not provide physiological advantages unless they are consumed in higher doses, over a period of days or weeks, or by a person who is deficient in a nutrient.

Although no significant differences among physiological parameters were found between XS® Energy Drink and the placebo (Table 3), participants exercised significantly longer during the second trial compared to the first trial (Figure 1). This increase in time until fatigue may have been caused by familiarization with testing procedures and the participant's desire to improve exercise duration. This finding suggests that participants should be less aware of the duration of the test to decrease the desire for improvement with the second test. It may also be advantageous to have a baseline VO_{2MAX} measurement so that the

participant is familiarized with testing procedures before completing either the placebo or XS® Energy Drink trial.

Resting relative $\dot{V}O_2$, absolute $\dot{V}O_2$, $\dot{V}CO_2$, and VE were elevated during the second trial compared to the first (Table 4). It is typical to see an increase in these parameters with increasing metabolic demand. However, it is difficult to explain why resting parameters were elevated during the resting portion of the second trial with the negative feedback mechanism because there was no increase in metabolic demand. Poon and colleagues theorize that this mechanism for exercise hyperpnea is much more complex than a typical chemoreflex or homeostatic regulatory mechanism [21]. It is likely that there is an internal process occurring in the cerebral cortex or other area of the brain that actually predicts that the metabolic demand will be increased. Therefore, the cerebral cortex may be providing information before exercise to increase oxygen consumption to prepare for exercise. Since the participants had already completed one $\dot{V}O_{2MAX}$ test, they may have learned that the activity would require greater oxygen consumption. The cerebral cortex may have responded by elevating resting oxygen consumption and ventilation in preparation for the bout of exercise. Poon explained that associative learning, such as that described previously, may help explain why resting respiratory levels are elevated before exercise [21].

Individuals ages 18-24 were tested for this study due to the marketing strategies of XS® Energy Drink. Further research will need to be done to determine whether XS® Energy Drink improves performance in older or younger individuals. All

participants in this study had high levels of maximal aerobic capacity with all males scoring in the 90th percentile or better and all females scoring within the 85th percentile or better for individuals 20-29 years old [24]. Therefore, it is not yet known what XS® Energy Drink's effect is on less fit individuals. Further research is needed to determine if XS® Energy Drink and similar substances have any ergogenic properties that may benefit a competitive or recreational endurance athlete. Further research is also needed to determine if consuming an energy supplement, like XS® Energy Drink gives an individual a psychological advantage thereby decreasing central fatigue and increasing aerobic endurance performance.

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REFERENCES

1. Bischoff MM & Duffin J. An Aid to the Determination of the Ventilatory Threshold. *Eur J Appl Physiol* 71: 65-70, 1995.
2. Bucci LR. Selected Herbals and Human Exercise Performance. *Am J of Clin Nutr* 72: 624S-636S, 2000.
3. Byars A, Greenwood M, Greenwood L, et al. The Effectiveness of a Pre-Exercise Performance Drink (PRX) on Indices of Maximal Cardiorespiratory Fitness. *J Int Soc Sports Nutr* 3: 56-59, 2006.
4. Clark, Joshua. The XS® Energy Drink Advantage. Billimoria Global - Amway Global 1-18, 2008. Retrieved 10 April 2010 from <http://billimoriaglobal.net/1XSPresentation.htm>.
5. Costill DL, Hargreaves M. Carbohydrate Nutrition and Fatigue. *Am J Sports Med* 13: 86-92, 1992.
6. Dempsey JA, McKenzie DC, Haverkamp HC, et al. Update in the Understanding of Respiratory Limitations to Exercise Performance in Fit, Active Adults. *Chest* 134: 613-22, 2008.
7. Gallagher D, Heymsfield SB, Heo M, et al. Healthy Percentage Body Fat Ranges: An Approach for Developing Guidelines Based on Body Mass Index. *Am J Clin Nutr* 72: 694-701, 2000.
8. Graham TE, Battram DS, Dela F, et al. Does Caffeine Alter Muscle Carbohydrate and Fat Metabolism During Exercise? *Appl Physiol Nutr Metab* 33: 1311-8, 2008.
9. Graham, TE & Spriet LL. Metabolic, Catecholamine, and Exercise Performance Responses to Various Doses of Caffeine. *J Appl Physiol* 78: 867-874, 1995.
10. Grassi, B. Oxygen Uptake Kinetics: Old and Recent Lessons from Experiments on Isolated Muscle in situ. *Eur J Appl Physiol* 90: 242-9, 2003.
11. Hatefi Y. The Mitochondrial Electron Transport and Oxidative Phosphorylation System. *Annu Rev Biochem* 54: 1015-69, 1985.
12. Herbert V. Recommended Dietary Intakes of Vitamin B-12 in Humans. *Am J Clin Nutr* 45: 671-8, 1987.
13. Ivy JL, Kammer L, Ding Z, et al. Improved Cycling Time-Trial Performance after Ingestion of a Caffeine Energy Drink. *Int J Sport Nutr Exerc Metab* 19: 61-78, 2009.
14. Kapadia CR. Vitamin B12 in Health and Disease: Part I--Inherited Disorders of Function, Absorption, and Transport. *Gastroenterologist* 3: 329-44, 1995.
15. Kimura Y & Sumiyoshi M. Effects of Various *Eleutherococcus Senticosus* Cortex on Swimming Time, Natural Killer Activity and Corticosterone Level in Forced Swimming Stressed Mice. *J Ethnopharmacol* 95: 447-453, 2004.
16. Livanova NB, Chebotareva NA, Eronina TB, et al. Pyridoxal 5' Phosphate as a Catalytic and Conformational Cofactor of Muscle Glycogen Phosphorylase b. *Biochemistry (Moscow)* 67: 1089-98, 2002.
17. Lukaski, HC. Vitamin and Mineral Status: Effects on Physical Performance. *Nutrition* 20: 632-644, 2004.
18. Manore MM. Vitamin B6 and Exercise. *Int J Sport Nutr* 4: 89-103, 1994.
19. Maughan RJ. The Limits of Human Athletic Performance. *Ann Transplant* 10: 52-54, 2005.
20. Pieralisi G, Ripari P, Vecchiet L. Effects of a Standardized Ginseng Extract Combined with Dimethylaminoethanol Bitartrate, Vitamins, Minerals, and Trace Elements on Physical Performance During Exercise. *Clin Ther* 13: 373-82, 1991.
21. Poon CS, Chung T, & Yu Y. Homeostasis of Exercise Hyperpnea and Optimal Sensorimotor Integration: The Internal Model Paradigm. *Respir Physiol Neurobiol* 159: 1-13, 2007.
22. Porszasz J, Casaburi R, Somfay A, et al. A Treadmill Ramp Protocol Using Simultaneous Changes in Speed and Grade. *Med Sci Sports Exerc* 35: 1596-603, 2003.
23. Thomas K, Morris P, & Stevenson E. Improved endurance capacity following chocolate milk

consumption compared with 2 commercially available sport drinks. *Appl Physiol Nutr Metab* 34: 78-82, 2009.

24. Thompson WR, Gordon NF, Pescatello LS (eds.). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). American College of Sports Medicine 84-87, 2010.

25. Zhang M, Izumi I, Kagamimori S, et al. Role of Taurine Supplementation to Prevent Exercise-Induced Oxidative Stress in Healthy Young Men. *Amino Acids*. 26: 203-207, 2004.