Research

Preliminary Comparison of Gatorade G2® to Red Bull® on Maximal Cycle Ergometer Performance

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Abstract

Background: Gatorade G2® (G2) and Red Bull® (RB) are two common sport and energy drinks athletes consume. The difference between the two beverages on performance is not known.

Purpose: The purpose of this study was to compare G2 to RB on a maximal cycle ergometer (bike) test.

Methods: Thirty healthy college students were randomly divided into three comparative groups that engaged in an Åstrand maximal cycle ergometer test twice, with one week of rest in between test sessions. Participants in each group consumed a designated beverage and then engaged in the cycle ergometer test 30 minutes later. Group 1 consumed G2 during week one and RB during week two. Group 2 consumed RB during week one and G2 during week two. Group 3 consumed water during both weeks. Data from this group were used as a control to measure test-retest variability. Electrocardiogram measurements and Rating of Perceived Exertion (RPE) were recorded at baseline and after each stage of the exercise test. Cycle time to exhaustion and blood lactate were recorded at the conclusion of the exercise test. A between-within analysis of variance (ANOVA) was used to analyze electrocardiogram and RPE data. A one-way ANOVA was utilized to analyze blood lactate and cycle time to exhaustion.

Results: No statistically significant differences were noted between RB and G2. However, participants in the G2 group were able to cycle 17 seconds longer to exhaustion and reported less abdominal discomfort.

Conclusions: Preliminarily, this research suggests that consumption of RB or G2 prior to sustained aerobic exercise result in similar performance.

Introduction

The energy drink market has grown rapidly in recent years compared to the more established sports drink industries.[1-4] More and more adolescents and athletes are consuming energy drinks, with a significant relationship between daring behavior and energy drink consumption.[5-10] The differing impact of energy drinks compared to alternatives like sports drinks should be studied further. Chiropractors work with athletes often and this topic is an area of concern for this profession.[11-12]

Gatorade and similar sports drinks like Powerade are designed to provide electrolytes (sodium, potassium, calcium, and magnesium), carbohydrates (usually at 6-8 grams/100 ml), and improve hydration.[13, 14] Gatorade has been shown to be superior to placebo at improving exercise performance in an exhausted state.[15] Research indicates that when Gatorade is consumed in hot/humid environments it can reduce dehydration and improve aerobic endurance.[16-18] Although these sports drinks are intended to increase hydration they often are actually hypertonic drinks in relation to intracellular fluid and thus a period of time is required for them to be assimilated into body cells.[19] Another negative attribute of many sports drinks is that they have a low pH which is believed to increase dental erosion rates.[19-23]

There are many flavors of Gatorade, each with different osmolarities.[19] One of the newer products from Gatorade is Gatorade G2(G2), It was originally sold in 2010 and has not been studied extensively in research literature .[24] Thus its review is warranted as many athletes may be consuming this beverage in an attempt to improve exercise performance.

Contrary to sports drinks, energy drinks market their ability to enhance mental alertness and improve exercise performance more so than impact hydration. [1,5,14,25,26] Red Bull(RB) is one of the leading energy drink companies in the US.[3] Studies have demonstrated that RB has some capability of enhancing aerobic and anaerobic exercise performance. [27-29] A 16 oz can of RB has 54 g of carbohydrates, 160 mg of caffeine, 2000 mg taurine, 40 mg B3, 10 mg B5, 10 mg B6, and 10 µg B12.[30] Energy drinks typically include more caffeine than a cup of coffee.[31-32] Caffeine has been shown to act as an ergogenic aid for endurance exercise and, in the past, was a substance banned by the International Olympic Committee.[33] Caffeine can induce muscle to use fat as a fuel source and spare glycogen, which can lead to prolonged exercise.[34-36] The small amount of Taurine found in energy drinks, like RB, is not believed to be enough to yield ergogenic benefits.[31] The B vitamins in RB are intended to aid in the rapid conversion of the carbohydrates in RB to ATP.[37]

Another issue to consider regarding choosing a sports drink versus an energy beverage is that energy beverages have been associated with undesirable physiologic side effects in some individuals that consume them. This is particularly due to their high level of caffeine which has been correlated with central nervous system, cardiovascular, gastrointestinal, and renal dysfunction.[10] Additionally, researchers have shown that energy beverage consumption has been positively correlated with smoking, drinking, and illicit prescription use, particularly among White male college students.[25]

The purpose of this study was to compare G2 to RB on maximal cycle ergometer performance. It was hypothesized that individuals utilizing RB would perform better on the maximal exercise test due primarily to the caffeine content of RB.

Methods

This study was reviewed and approved by the Institutional Review Board for human subjects at the sponsoring university in accordance with the Declaration of Helsinki. All subjects were provided a written and oral explanation of the study procedures prior to participation.

Study Design and Setting

This was a randomized, controlled study of the impact that G2 and RB had on maximal cycle ergometer performance. This study's specific aims were to determine if one beverage was superior to the other in its impact on aerobic exercise performance.

As shown in **Fig. 1** thirty participants were divided into three comparative study groups that consumed assigned beverages and then engaged in maximal cycle ergometer testing (**Fig. 2**) after 30 minutes. Thirty-minutes was chosen due to research demonstrating peak plasma caffeine concentration 29.8 minutes post-ingestion. [38] Group 1 consumed G2 during week one and RB during week two. Group 2 consumed RB during week one and G2 during week two. The purpose of the AB:BA design structure of groups #1 and #2 was to reduce exercise test acclimation as a covariate between the two compared main groups. Group 3 acted as a control and consumed water during both weeks and was used to monitor test-retest performance variability. Electrocardiogram measurements and Rating of Perceived Exertion (RPE) were recorded at baseline and after each stage of the test. Cycle time to exhaustion and blood lactate were recorded at the conclusion of each test.

Fig 1. Experimental design. G2= Gatorade G2®, RB= Red Bull®, and W= water.

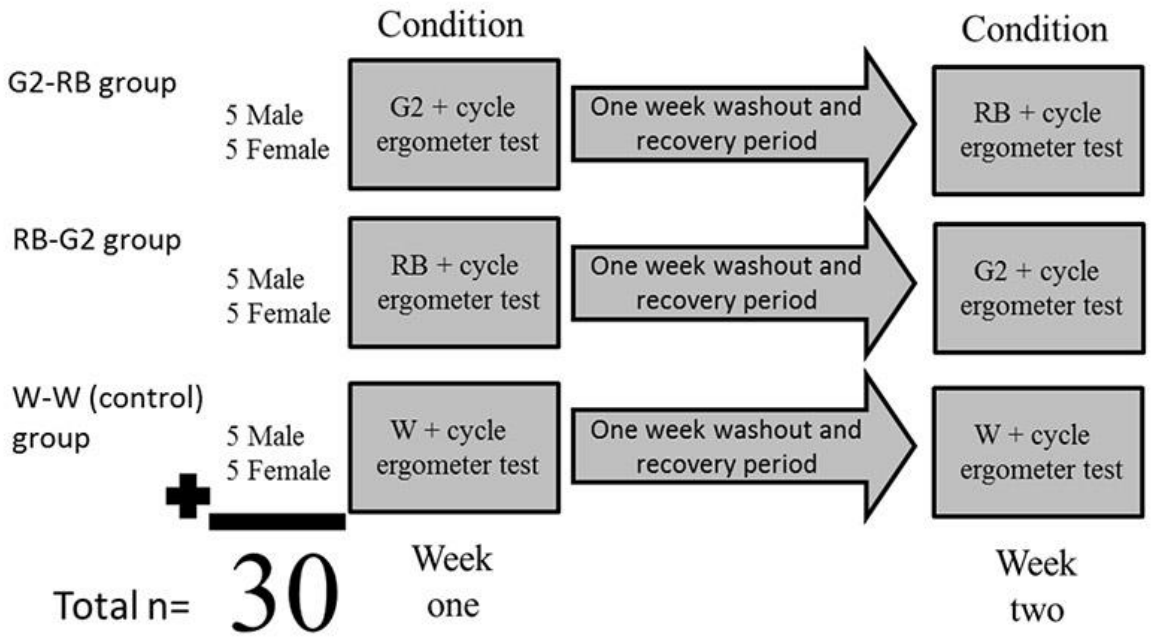


Fig 2. Åstrand cycle ergometer test and data collection protocol. Min= minutes, Kp= kilopond, rpm= revolutions per minute.

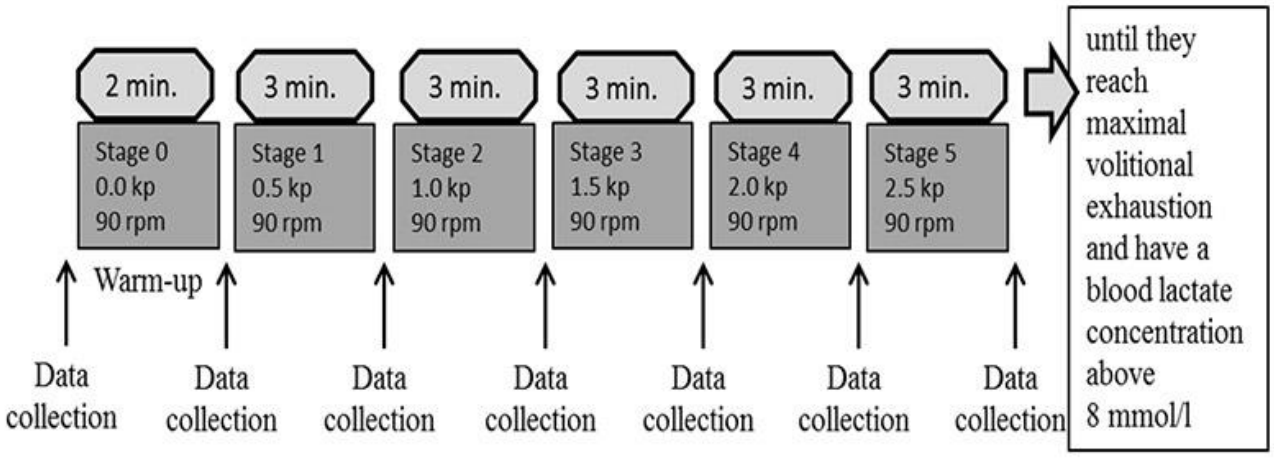
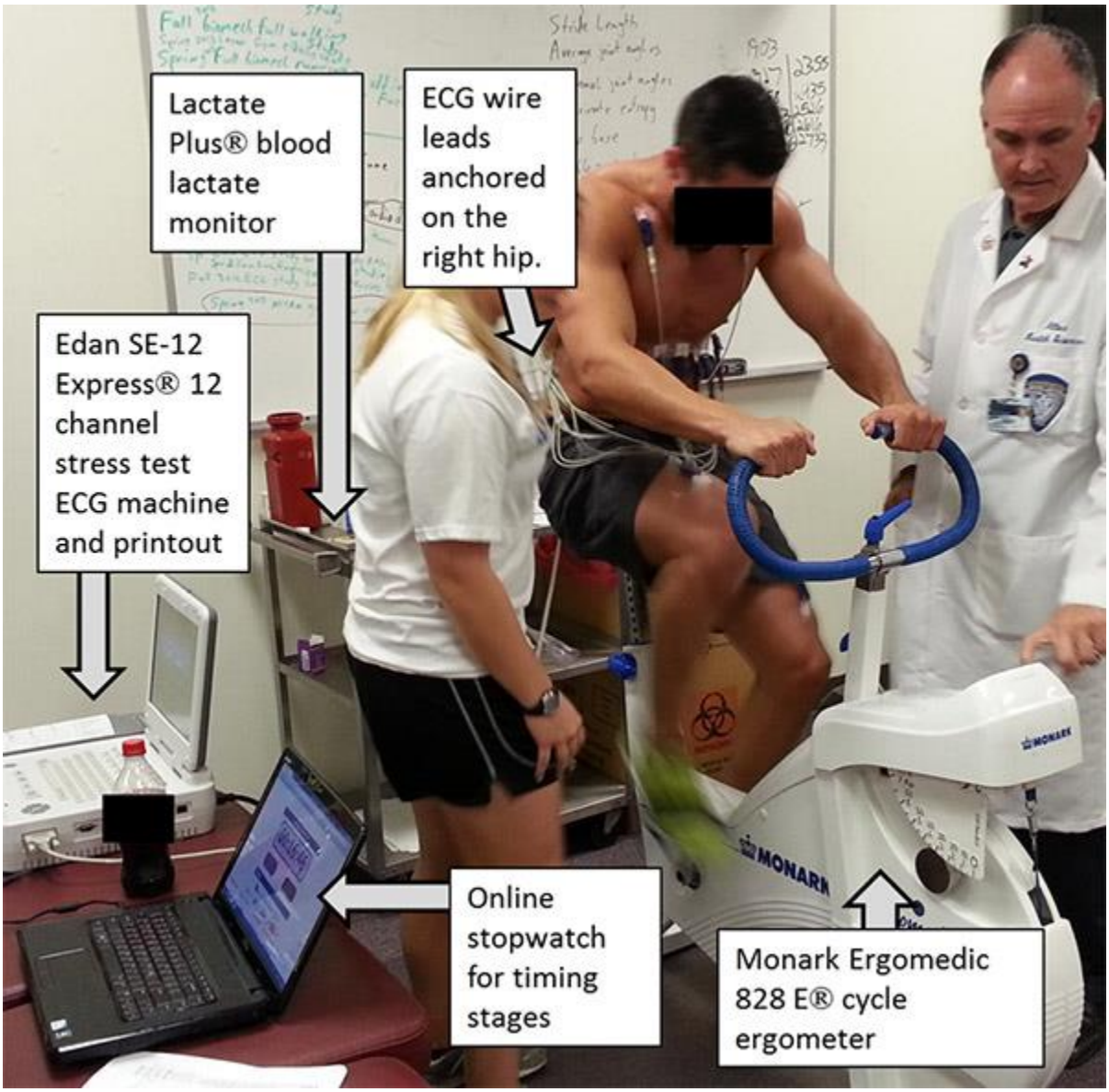


Fig 3. Sample participant engaged in the Åstrand maximal cycle ergometer test.



Participants and Randomization

Asymptomatic graduate college student volunteers were recruited via word-of-mouth from the college campus where this study took place. All study applicants provided an informed written consent on college-approved documents. They were then screened against inclusion and exclusion criteria. Thirty apparently healthy students (age= 26.6 ± 3.8 yrs, height= 1.73 ± 0.1 m, body mass= 75.5 ± 15.7 kg, age

range= 22-36 yrs) that met the inclusion/exclusion criteria participated in this study (**Table 1**). Three participants were excluded from this study due to violating the exclusionary criteria. A computer-generated randomization list was created before the study began to determine which group participants would be assigned.

Table 1. Baseline study participant attributes. G2= Gatorade G2®, RB= Red Bull®, and W= water.

	RB-G2 group	G2-RB group	W-W group
Participant number (M/F)	5/5	5/5	5/5
Age (y)	27.1 ± 4.2	25.5 ± 3.7	27.0 ± 3.5
Body Mass (kg)	71.0 ± 12.6	77.6 ± 13.7	77.9 ± 20.4
Height (m)	1.73 ± 0.11	1.76 ± 0.10	1.71 ± 0.10
Body Mass Index (kg/m^2)	23.7 ± 2.9	24.8 ± 2.8	26.5 ± 5.0
Data listed as mean ± SD.			

Inclusion/exclusion criteria

Inclusion criteria were: 1) a body mass index under 30, 2) between the ages of 18-40 years of age, 3) answering "no" to all exercise contraindication sections on a Physical Activity Readiness-Questionnaire (PAR-Q), and 4) they provided their informed written consent. Study participants with any of the following were excluded from the study: 1) diagnosis of any sacral, hip, or lower limb pathology that would prevent them from engaging in a cycle ergometer test, 2) possessing lower limb surgeries, 3) presence of severe pain in their lower limbs that they would rate greater than a 3 on a 0 to 10 Numeric Rating Scale (NRS), 4) use of tobacco products, 5) diagnosis of a chronic obstructive or restrictive respiratory disease, 6) history of cardiovascular drug use, 7) pregnancy, or 8) possessing high blood pressure. Participants were additionally asked to avoid caffeine consumption on the day of their test due to its half-life in the blood.[39]

Intervention

Thirty minutes prior to their exercise test participants were provided their assigned beverage in a disposable cup with a 19 fl oz. mark annotated on it. Each participant received 19 fluid ounces of their assigned beverage at room temperature. This value was chosen because G2 (20.0 fl oz., Gatorade Inc., Chicago, IL) and RB (19.2 fl oz., Red Bull GmbH, Austria) are both sold at almost this exact quantity in the US. Participants were not told the name of their beverage; however, they likely could differentiate them due to their distinct taste. Drinks were poured from plastic bottles in the case of G2 (as opposed to using powder mixed with water) and water, and aluminum cans in the case of RB out of visual site of participants. This study occurred between the hours of 4-6 PM. Participants were asked to eat similar meals for lunch during their test days one week apart.

Assessments

Participants were all given a verbal description of the procedures prior to testing to reduce anxiety during the test. Upon arrival to the session participants changed into appropriate exercise clothing. This consisted of shorts for males, and shorts and a sports bra for females, in addition to shoes.

Electrocardiogram recordings, RPE, blood lactate, and cycle time to exhaustion were chosen as outcome measures to track the study participants' capacity to engage in sustained strenuous exercise. These variables are all effective markers of exercise performance difficulty that have been used in many exercise science studies.[40-42]

Electrocardiogram recordings were measured using the Edan SE-12 Express® 12 channel stress test ECG machine (Edan, Nanshan Shenzhen, China). Leads were affixed to the chest, anterior shoulders, and mid-thighs as described by the manufacturer. Surgical tape was used to anchor the leads in place to avoid slipping as participants would sweat. Electrode lead wires were taped on the right hip during the cycle ergometer test to avoid contact with the lower limbs (e.g., knees). Study participants were not allowed to view the ECG machine's display. This was done to reduce the chance of biofeedback acting as a covariate. Exercise heart rate, PR interval (the duration of atrial contraction), and QT interval (duration of ventricular contraction) were extracted from ECG printouts to be used as measures of cardiovascular exercise intensity.[40-42]

RPE was measured using a Borg RPE scale that was positioned facing the participant on the body of the cycle ergometer. At the prescribed times, participants self-reported their exertion level in relation the scale. The Borg scale is a commonly used scale to measure subjective interpretation of exercise intensity.[40-42] The intent of measuring this variable was to later compare it to objective study data (e.g., heart rate and blood lactate) and see how well it correlates if statistically significant differences were found.

Blood lactate was measured using the Lactate Plus® blood lactate monitor (Nova Biomedical, Waltham, MA, USA) and test strips. Universal safety precautions were utilized when taking finger-prick blood samples. Samples were taken from the right index finger tip using a disposable lancet. Prior to taking each sample an alcohol pad was used to clean the sample location on the index finger. Blood lactate was measured as a marker of cardiovascular exercise intensity. The more hypoxic muscle cells become with strenuous exercise the greater the quantity of lactate that will be measured in the bloodstream. As a result, blood lactate measurements are an important indicator of exercise intensity.[40-42] Blood lactate had to be above 8 mmol/l, which is correlated with maximal to near maximal exertion, for data inclusion in analysis.[40] All participants reached this level of exertion during all tests.

Åstrand maximal cycle ergometer test

Participants engaged in the Åstrand maximal cycle ergometer test on a Monark Ergomedic 828E cycle (Monark AB, Sweden) until they reached maximal volitional exhaustion. Maximal exhaustion was defined as an inability to maintain 90 rpm at a given stage's intensity level for 3 consecutive seconds. The test began by having the participants cycle at 0 kp at 90 rpm for 2 minutes as a warm-up. Subsequently, the participants then engaged in three-minute stages where the resistance increased by 0.5 kp per stage until the participant reached maximal exhaustion.[40] At the conclusion of the cycle ergometer test blood lactate and seconds to volitional exhaustion were recorded. Participants were also asked to report if they developed an upset stomach during the study.

Statistical Analysis

A between-within (mixed) analysis of variance (ANOVA) was used to analyze HR, PR interval, QT interval, and RPE. Factors were groups (assigned beverage) and trials (exercise test stage from baseline to stage 3 of the exercise test). The repeated measures analysis stopped at stage 3 because many participants were not able to continue past this level of the exercise test. The water only group was compared with only its' week 1 data for the mixed ANOVA. Sphericity was observed with Mauchly's test. The Greenhouse-Geisser correction was used in instances of sphericity violation. Blood lactate and maximal cycle ergometer time (for the entire test duration including all stages) were each analyzed individually with a one-way ANOVA between all three groups. Hochberg's GT2 post-hoc test was utilized due to the sample size variance of the water group compared to the other two groups (10 W baseline sample size versus 20 G2 and 20 RB) as recommended by Field.[43] The W-W group underwent a within-group paired samples *t*-test for the purpose of acting as a control for week-to-week performance should statistically significant findings be discovered for the G2 and RB groups. The significance level was set to $p<0.05$ and the data were analyzed using SPSS 20.0 (SPSS Inc., Chicago, IL, USA). Results were reported as mean $\pm$ standard deviation (SD) unless otherwise specified.

Results

Preliminarily, the results for the study demonstrated that there were no statistically significant differences between the groups in terms of exercise heart rate (p=0.97), PR interval (p=0.48), QT interval (p=0.28), and RPE (p=0.06) throughout the maximal exercise test. For blood lactate (p=0.64) and cycle time to exhaustion (p=0.68) there were also no statistically significant differences between groups. However, a direct comparison between the RB to G2 groups demonstrated that the G2 group was able to marginally cycle 17 seconds longer to exhaustion than the RB group and demonstrated higher blood lactate. The W-W control group demonstrated week-to-week variation in seconds cycled to exhaustion of 4.6 seconds. Participants in the G2 group cycled 821 $\pm$ 227 seconds to exhaustion and had 17.9 $\pm$ 3.0 mmol/l blood lactate. Participants in the RB group cycled 804 $\pm$ 260 seconds to exhaustion and had 16.9 $\pm$ 3.1 mmol/l blood lactate. Comparing only week one water data, the water only group cycled 878 $\pm$ 173 seconds to exhaustion and had 17.1 $\pm$ 4.2 mmol/l blood lactate. Within-groups exercise data changed for all three groups as would be expected during incrementally challenging exercise.

Discussion

The data preliminarily demonstrate that G2 and RB are equivalent in aerobic performance outcomes. This was surprising considering that a primary ergogenic ingredient in RB is caffeine. Caffeine has been shown to improve exercise time to exhaustion in some studies.[14,44-48] A negative interaction associated with caffeine consumption is that it has been found to act as a diuretic.[49] However, this action appears to primarily impact individuals that abstain from caffeine. Participants that regularly consume caffeine adapt to caffeine ingestion and have blunted diuresis.[39] Also studies suggest this diuresis action may not occur or be necessarily harmful during exercise.[39] Another concern with consuming caffeine at high levels is that it can negatively impact insulin sensitivity and it may contribute to the development of diabetes over time.[50] The impact this can have on athletes long-term should be studied. Additionally, research has demonstrated that increased caffeine consumption can lead to symptoms of abdominal discomfort, muscle soreness, tachycardia, and insomnia.[51-53] Throughout this study four participants that consumed RB complained of abdominal discomfort out of all twenty participants that consumed RB in this study. No participants in the G2 group complained of abdominal discomfort. The fact that 20% of all participants consuming RB in this study demonstrated abdominal discomfort is concerning and should warrant caution by athletes and their coaches. Abdominal discomfort likely would reduce athletic performance in a myriad of sports.

Similar to the findings of Rahnama *et al.* the researchers from this study found minimal difference in blood lactate or heart rate between the control beverage and G2 and RB.[14] In relation to the findings of this study it seems that consumption of G2 versus RB by an athlete is more an issue of personal preference, provided of course that the athlete does not suffer from preventricular contractions (caffeine consumption can exacerbate symptoms).

Participants who consumed only water were able to cycle longer to exhaustion compared to the other two study groups. This was a surprising finding of the study which may have been due to the higher osmolality of the other two beverages that were used, G2 and RB, in relation to water. Higher osmolality beverages cause slower gastric emptying.

Limitations

This study only speaks to the impact G2 and RB on acute maximal exercise performance through a graded exercise test (GXT). These results would not apply to weight lifting performance, sprint performance or other mostly non-aerobic tasks.

In this study reasonably healthy graduate college students were utilized as test participants. The findings of this study cannot be extrapolated to competitive athletes who likely would have been able to exercise for longer durations and they may have reacted differently.

Also these participants consumed their assigned beverage 30 minutes prior to engaging in the cycle ergometer test. This time frame was chosen because it would likely be associated with maximal levels of caffeine in the bloodstream post-ingestion associated with energy drinks. The researchers did not know the optimal time G2 could be assimilated into the bloodstream and thus the researchers utilized the only time guide that was available.

Another limitation of this study is that energy drinks are labelled as nutritional supplements instead of food products (through the 1996 DSHEA). As a result, they are able to vary the exact quantities of ingredients in them. Due to this, the exact quantities listed of various ingredients in this study, regarding energy drinks, possibly could have varied slightly.

Researchers did not recruit a set number of participants based on a power analysis. As a result, type II statistical error is possible. Future larger studies should follow a power analysis and recruit a larger sample size for comparison. As a result, trends seen in this study must be seen as preliminary.

Lastly, there are differences in habitual caffeine users compared to novice caffeine users in the impact caffeine has on their cardiovascular system. The researchers did not survey participants to see if they regularly consumed caffeinated beverages. If they did consume caffeinated beverages often it may have had a blunted stimulatory effect on them.

Conclusions

There is minimal research investigating how sports beverages compare to energy drinks in terms of exercise performance. The focus of this experiment was to compare G2 and RB to one another regarding their capability to improve maximal aerobic exercise performance. The findings from this study were that G2 preliminarily extended cycle time to exhaustion by approximately 17 seconds longer

than RB and raised blood lactate (by 1 mmol/l) if consumed 30 minutes before exercise. Future research should focus on the impact these beverages have on different sports activities (e.g., concentration during archery, weight lifted during power lifting, repeated sprint performance).

Funding sources and potential conflicts of interest

This study was supported by an internal grant from the college where the study took place. The researchers report no conflicts of interest.

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