Does an Energy Drink Modify the Effects of Alcohol in a Maximal Effort Test?

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Background: There are popular reports on the combined use of alcohol and energy drinks (such as Red Bull® and similar beverages, which contain caffeine, taurine, carbohydrates, etc.) to reduce the depressant effects of alcohol on central nervous system, but no controlled studies have been performed. The main purpose of this study was to verify the effects of alcohol, and alcohol combined with energy drink, on the performance of volunteers in a maximal effort test (cycle ergometer) and also on physiological indicators (oxygen uptake, ventilatory threshold, respiratory exchange rate, heart rate, and blood pressure), biochemical variables (glucose, lactate, insulin, cortisol, ACTH, dopamine, noradrenaline, and adrenaline), and blood alcohol levels.

Methods: Fourteen healthy subjects completed a double-blind protocol made up of four sessions: control (water), alcohol (1.0 g/kg), energy drink (3.57 ml/kg Red Bull®), and alcohol + energy drink, each 1 week apart. The effort test began 60 min after drug or control ingestion, and the dependent variables were measured until 60 min after the test.

Results: Heart rate at the ventilatory threshold was higher in the alcohol and alcohol + energy drink sessions in comparison with control and energy drink sessions. Although in comparison to the control session, the peak oxygen uptake was 5.0% smaller after alcohol ingestion, 1.4% smaller after energy drink, and 2.7% smaller after the combined ingestion, no significant differences were detected. Lactate levels (30 min after drug ingestion, 30 and 60 min after the effort test) and noradrenaline levels (30 min after the effort test) were higher in the alcohol and alcohol + energy drink sessions compared with the control session.

Conclusions: The performance in the maximal effort test observed after alcohol + energy drink ingestion was similar to that observed after alcohol only. No significant differences between alcohol and alcohol + energy drink were detected in the physiological and biochemical parameters analyzed. Our findings suggest that energy drinks, at least in the tested doses, did not improve performance or reduce alterations induced by acute alcohol ingestion.

Key Words: VO₂, alcohol, energy drinks, caffeine, taurine.

RECENTLY, THE COMBINED ingestion of alcoholic beverages and “energy drinks” has increased in many countries. There are popular reports that energy drinks can delay the depressant effects of alcohol on the central nervous system, prolonging its excitatory effects. Most energy drinks are a mixture of caffeine, taurine, carbohydrates, B complex vitamins, and gluconolactone. It is possible that energy drinks could interfere with the metabolism and/or organic effects of alcohol.

There are few scientific studies on the effects of energy drinks and particularly on their combined ingestion with alcoholic beverages. According to Seidl et al. (2000), the ingestion of the main ingredients of energy drinks enhances cognitive performance and improves mood status. Horne and Reyner (2001) observed an improvement in reflex time in a driving simulator when comparing energy drink to a control ingestion of a mix of carbohydrates, this effect being more evident in the first hour after ingestion. Alford et al. (2001) also observed an improvement in physical performance after energy drink ingestion. Riesselmann et al. (1996) suggested that the use of a mixture of energy drinks and alcoholic beverages could induce erroneous judgments while driving, increasing the chances of provoking accidents.

Studies using laboratory animals have demonstrated an interaction between alcohol and some of the components of energy drinks, especially taurine (Aragon et al., 1992; Dahchour et al., 1996; Martin-Algarra et al., 1998; Narahashi et al., 2001) and caffeine (Hannigan, 1995; Koo, 1999; Kunin et al., 2000; Kuribara et al., 1992; Liguori and Robinson, 2001). However, the amount of caffeine (80 mg or less) present in most of the commercial energy drinks is not...
considered enough to justify its putative antagonist effect in acute alcoholic intoxication. There is no scientific evidence to indicate whether this amethyest effect exists or whether it is just a placebo effect.

Given the paucity of studies on the effects of the simultaneous ingestion of alcoholic beverages and energy drinks, this study aimed to verify the effects of alcohol, and alcohol combined with energy drink, on the performance of volunteers in a maximal effort test (cycle ergometer) and also on physiological indicators [oxygen uptake (VO2), ventilatory threshold, respiratory exchange rate, heart rate and blood pressure], biochemical variables (glucose, lactate, insulin, cortisol, ACTH, dopamine, noradrenaline and adrenaline), and blood alcohol levels.

METHODS

Subjects

Fourteen male volunteers (age, 24 ± 3 years; body mass index, 23 ± 1 kg/m²; schooling, 13 ± 1 years) were invited to participate in the study. Initially they were submitted to a standardized medical examination and an electrocardiogram of effort. Blood and urine samples were collected and analyzed for levels of uric acid, creatinine, urea, Na+, K+, triglycerides, cholesterol, glucose, insulin, cortisol, T3, T4, TSH, bilirubins, lipase, alkaline phosphatase, aspartate aminotransferase, alanine aminotransferase, and γ-glutamyltransferase. Serological tests for HIV and hepatitis A, B, and C were also performed. All volunteers were physically active but not athletes, as defined by the Questionnaire of Habitual Physical Activity (Baecke et al., 1982). All of them were moderate users of alcohol (defined as less than 14 standard doses per week (1 dose = 13.6 g of ethanol), according to the Daily Drink Questionnaire (Collins et al., 1985)) and moderate users of energy drinks (less than 10 cans of 250 ml in the last 6 months).

All volunteers were interviewed and, after an explanation of the aims and procedures of the study, signed an informed consent. The Ethics Committee of the Federal University of Sao Paulo approved this study (394/00).

Drugs

A mixed solution of alcohol and energy drink was prepared containing 3.57 ml/kg of the energy drink (equivalent to one 250 ml can given to a 70 kg person) and 1.0 g/kg of alcohol (vodka Smirnoff®—37.5% v/v). The volume was completed with a commercial diet peach juice (Clight®—20% v/v of the volume of the aspirate solution of alcohol and energy drink). Similar solutions were also prepared containing only alcohol and juice or only energy drink and juice. The energy drink used was Red Bull®, containing by 100 ml a mixture of sucrose and glucose (11.3 g), taurine (400 mg), caffeine (32 mg), glucoronolactone (240 mg), inositol (20 mg), niacin (7.2 mg), pantenol (2.4 mg), B3 (0.64 mg), B6 (0.8 mg), B12 (0.4 μg), citric acid, caramel coloring, artificial flavoring, and sparkling water.

Procedures

Each volunteer was tested four times. In the first trial (control), the volunteers ingested water. In the other trials (separated by 1-week intervals), the volunteers ingested the drug solutions in a randomized order. The subjects arrived at the laboratory at 12:00 PM and rested, lying on a bed, for 30 min in order for us to evaluate their metabolism at rest. The Vista Mini-CPX Metabolic System (Vacu Med, Inc., Ventura, CA) was used to evaluate the oxygen consumption, ventilation, and respiratory exchange rate during the rest. Following this, a standardized meal of 1000 calories was served (1 Big Mac®, 1 medium portion of fried potatoes, and a 500 ml soft drink). Sixty minutes after the meal, the volunteers ingested the drug solution.

A catheter was installed in the antecubital vein to collect blood samples at the following times: immediately after the installation, 30 min after the drug ingestion, immediately after the effort test, and 30 and 60 min after the effort test. The samples were immediately prepared to be sent to the lab, to determine glucose, lactate, insulin, ACTH, cortisol, and catecholamines levels. Glucose and lactate levels were determined by colorimetric method (Vitros, Johnson & Johnson, Rochester, NY); insulin and cortisol levels by competitive immunoassay (Tosoh, ALA System Analyzer, Tokyo, Japan); ACTH levels by solid-phase sandwich immunoassays that use chemiluminescence for signal generation (Immulate, DPC, Los Angeles, CA), and catecholamines by HPLC with electrochemical detection (column Shim-pack CLC-ODS, Shimadzu, Tokyo, Japan).

Sixty minutes after the ingestion of the solution, the volunteers were tested in a cycle ergometer (Cateyergociser Ec 1600, Tokyo, Japan) using a ramp protocol. The test followed the sequence of 2 min of rest on the cycle ergometer, 3 min of warming up at 50 W, followed by increments of 25 W every 2 min. The test continued until either the maximum heart rate was reached or the volunteer asked to stop. The ergospirometric variables (VO2, ventilatory threshold, ventilation, and respiratory exchange rate) were measured using the Vista Mini-CPX Metabolic System (Vacu Med, Inc). A heart monitor (Polar® Advantage, Lake Success, NY) continuously monitored the heart rate, and the blood pressure was monitored by a semi-automated sphygmomanometer (Omron, Inc, Vernon Hills, China). The blood alcohol concentration was evaluated using a breath analyzer (Alco-Sensor IV®, Intoximeters, Inc.) before drug ingestion and 15, 30, 60, 90, 120, and 150 min afterward.

Statistical Analysis

The variables were analyzed using a one-way ANOVA followed by Newman-Keuls post hoc comparisons, using the software Statistica (StatSoft, Inc., Sao Paulo, Brazil). The significance level was set at 5% (p < 0.05). The results are presented as mean ± standard deviation.

RESULTS

Table 1 shows that in comparison with the control trial, the maximal oxygen uptake (VO2 Peak) and the oxygen uptake at the ventilatory threshold were not significantly different among the different trials, although in all of them there was a tendency toward a reduction of the VO2 Peak (5.0% smaller after alcohol ingestion, 1.4% smaller after energy drink, and 2.7% smaller after alcohol + energy drink). During the effort test, no significant differences in the maximal heart rate were detected among the trials.

<table>
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<th>Table 1. Oxygen Uptake (VO2 Peak and at Ventilatory Threshold in ml·kg · min⁻¹) and Heart Rate (Maximal and at Ventilatory Threshold in Beats/min), After Control (Water), Energy Drink (3.57 ml/kg), Alcohol (1.0 g/kg), and Alcohol + Energy Drink (1.0 g/kg + Energy Drink 3.57 ml/kg) Ingestion</th>
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* Higher than control and energy drink trials [F(3,39) = 11.18, p < 0.01].
However, the heart rate was significantly higher at the ventilatory threshold in the alcohol and alcohol + energy drink trials than in the control and energy drink trials \([F(3,39) = 11.18, p < 0.01]\).

Figure 1 shows that the energy expenditure (metabolic equivalents) was higher in the alcohol trial than in the control trial both 30 min \([+17\%, F(3,39) = 2.92, p < 0.05]\) and 60 min \([+14\%, F(3,39) = 2.97, p < 0.05]\) after ingestion. Although there was a tendency to increase, no significant alterations in the energy expenditure were observed in the alcohol + energy drink (12% after 30 min and 8% after 60 min) and energy drink trials (6% after 30 min and 3% after 60 min). The respiratory exchange rate (Fig. 1) was smaller in the alcohol and alcohol + energy drink trials than in the control and energy drink trials both 30 min after ingestion \([F(3,39) = 8.43, p < 0.01]\) and 60 min after the effort test \([F(3,39) = 9.78, p < 0.01]\).

Figure 2 shows that blood lactate levels were higher in both the alcohol and alcohol + energy drink trials in comparison with either the control or energy drink trials 30 min after the ingestion \([F(3,39) = 8.85, p < 0.01]\) and 30 \([F(3,39) = 19.48, p < 0.01]\) and 60 min after the effort test \([F(3,39) = 54.10, p < 0.01]\). Alcohol + energy drink ingestion significantly increased blood lactate levels immediately after the effort test in comparison with control, energy drink, and alcohol ingestion \([F(3,39) = 3.90, p < 0.02]\). In comparison with the control and energy drink trials, a significant increase in noradrenaline levels was observed 30 min after the effort test in the alcohol and alcohol + energy drink trials \([F(3,39) = 3.62, p < 0.02]\).

No significant differences among the trials were observed in blood alcohol concentration, blood pressure, glucose, insulin, dopamine, adrenaline, ACTH, and cortisol levels.

No effect due to the order of the trials was detected.

**DISCUSSION**

As far as we are aware, this is the first controlled study on the combined effects of alcohol and an energy drink. There are popular reports on the effects of energy drinks reducing the depressant effects of alcohol, such as fatigue, sleepiness, and impairment of motor coordination and increasing physical performance (Ferreira et al., 2004). Considering the pharmacological properties of caffeine and taurine (the main components of energy drinks), a reduction of some symptoms of alcoholic intoxication could be expected (Aragon et al., 1992; Dahchour et al., 1996; Kunin et al., 2000; Liguori and Robinson, 2001; Quertemont et al., 1998).

However, in the present study, the findings on physical...
to the acute increase in the production of energy from lipid and increased the blood lactate levels and energy expenditure. However, in most studies an increase in metabolic demand after alcohol ingestion has been observed, independently of its effects on physical performance. According to the American College of Sports Medicine, alcohol does not possess an ergogenic effect. However, it may be used to reduce anxiety or tremor before competition. (Wagner, 1991). Nevertheless, the putative positive effects of alcohol on physical performance, its effect increasing the metabolic demand (Borg et al., 1990), decreasing exercise performance (Montoye et al., 1980; Ohmiya et al., 1992; Wang et al., 1995), or delaying the recovery process (Mahmoud, 2002; Mahmoud et al., 2000), could counter indicate its use as an ergogenic source.

In this study, alcohol ingestion produced no significant reduction in the maximal oxygen uptake, confirming other studies (Bond et al., 1984; Kendrick et al., 1993), although there are some reports of significant reductions (Montoye et al., 1980; Ohmiya et al., 1992; Wang et al., 1995). In relation to the maximal effort test, higher heart rates at the ventilatory threshold were observed after alcohol (alone or with energy drink) than in the trials in which only water or energy drink was administered. These differences could be due to the increase in the release of catecholamines provoked by alcohol. No differences were observed between the alcohol and alcohol + energy drink trials. Borg et al. (1990) and Ohmiya et al. (1992) observed similar results. Borg et al. (1990) reported a higher cardiac demand after the ingestion of a moderate dose of alcohol (1.0 g/kg) but no alteration in the perception of effort. Ohmiya et al. (1992) observed a significant decrease in performance as a consequence of the increase in the cardiac demand after the ingestion of 0.7 g/kg of alcohol.

In agreement with Wang et al. (1995), our results suggest that during the effort test, acute alcohol ingestion may affect energy metabolism. Alcohol increased the demands of the cardiovascular system, reducing physical performance. This was confirmed by the fact that in the trials where alcohol was administered (alone and with energy drink), the total time and workload (watts) achieved were a little smaller than in the control sessions, although these differences were not significant.

During the rest moments, alcohol ingestion (alone or with energy drink) reduced the respiratory exchange rate and increased the blood lactate levels and energy expenditure in comparison with the control trial. This could be due to the acute increase in the production of energy from lipid sources provoked by alcohol (Kalant and Le, 1983; Siviy et al., 1987).

Two studies have reported an increase in psychomotor performance (motor reaction time, concentration, memory, and subjective perception of vigor and alertness) as well as mood status and physical performance after Red Bull® ingestion (Alford et al., 2001; Seidl et al. 2000). Both these studies attributed the effects to the “compound” but they did not test the different components of the mixture. Horne and Reyner (2001) observed that energy drink ingestion improved performance in a car driving simulator, increasing reflex time when compared with a carbohydrate mix solution used as control. This improvement was reported as being more evident in the first hour of the 2 hr evaluation period. These authors tested undiluted energy drink, whereas in our study the concentration of energy drink was lower because water was added to control the alcohol volume administered in the other trials. The different dilutions and/or test duration could provide explain the different findings observed in our study and those mentioned previously.

Summarizing, the ingestion of alcohol with an energy drink did not provoke different effects in the observed variables than those provoked by the ingestion of alcohol alone. At least in the tested doses, the possible beneficial effects of the energy drinks could be just a placebo effect. Therefore, these results do not confirm the popular reports on the efficacy of energy drinks in antagonizing the harmful effects of alcohol. However, due to the increasing popular use of this combination and the small number of studies on its effects, other studies are still needed.

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REFERENCES


