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Original Research

Physiological and Glycemic Responses Following Acute Ingestion of a Popular Functional Drink in Patients with Type 1 Diabetes

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ABSTRACT

Objective: To determine the physiologic and glycemic responses to energy drinks by people with type 1 diabetes.
Methods: In a double-blind randomized comparison of Red Bull, Red Bull Light and a control drink, 16 adults (11 females; average age 31.5 years) with type 1 diabetes and an average glycated hemoglobin (A1C) of 68 mmol/mol were given 750 mL of Red Bull, Red Bull Light and Suso Orange in a random order. During 3 hours, comparisons were made of blood pressure and blood glucose and caffeine levels; 4-choice reaction time (4CRT) and a digit symbol substitution test were used to assess cognitive performance. Mood was measured using the University of Wales Institute of Science and Technology mood adjective checklist.
Results: Consumption of Red Bull and Suso Orange were associated with an early sustained rise in blood glucose, which was augmented by Red Bull ($p=0.02$). A transient rise in systolic blood pressure (115.9 mm Hg to 124.5 mm Hg and 115.8 mm Hg to 125.9 mm Hg, respectively, both $p<0.01$) followed consumption of Red Bull and Red Bull Light. There were less consistent changes in diastolic blood pressure and heart rate. Consumption of both energy drinks resulted in modest improvement in performance on the digit substitution test but had no effect on 4CRT. Energy arousal and hedonic tone were influenced transiently only, following the consumption of Suso Orange.
Conclusions: Consumption of energy drinks can result in a significant carbohydrate load for people with diabetes, and patients must consider the need to adjust their insulin regimens appropriately. Caffeine-containing energy drinks can cause a rise in blood pressure, which may be an important consideration for individuals at risk for diabetes-related complications.

Mots clés :
diabète de type 1
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boissons sucrées contenant de la caféine
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boissons énergétiques sans sucre contenant de la caféine
pression artérielle
épreuve de temps de réaction
épreuve de substitution de codes
Mood Adjective Cheklist

RÉSUMÉ

Objectif : Déterminer les réponses physiologiques et glycémiques des boissons énergétiques chez les personnes souffrant du diabète de type 1.
Méthodes : Dans une comparaison aléatoire et à double insu sur les boissons Red Bull, Red Bull Light et des boissons témoins, 16 adultes (11 femmes; âge moyen de 31,5 ans) souffrant du diabète de type 1 et ayant une hémoglobine glyquée (A1c) de 68 mmol/mol ont absorbé 750 ml de Red Bull, de Red Bull Light et de Suso Orange selon un ordre aléatoire. Durant 3 heures, des comparaisons de la pression artérielle, de la glycémie et des concentrations de caféine ont été effectuées; l'épreuve de temps de réaction à 4 choix (TR4C) et l'épreuve de substitution des codes ont été utilisées pour évaluer la performance cognitive. L'humeur a été mesurée par la Mood Adjective Checklist de l'UWIST (University of Wales Institute of Science and Technology).
Résultats : La consommation de Red Bull et de Suso Orange a été associée à une augmentation précoce soutenue de la glycémie, qui a pour sa part été augmentée par la Red Bull ($p = 0,02$). La consommation de

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Red Bull et de Red Bull Light a été suivie d'une augmentation transitoire de la pression artérielle systolique (de 115,9 mm Hg à 124,5 mm Hg et de 115,8 mm Hg à 125,9 mm Hg, respectivement, p<0,01pour les deux). Il y a eu moins de modifications constantes de la pression artérielle diastolique et du rythme cardiaque. La consommation des deux breuvages énergétiques a entraîné une amélioration modeste de la performance à l'épreuve de substitution des codes, mais n'a eu aucun effet sur la TR4C. Le gain d'énergie et le caractère hédonique après avoir consommé la Suso Orange ont été influencés de manière transitoire seulement.

Conclusions : La consommation de boissons énergétiques peut entraîner une surcharge importante en glucides chez les personnes souffrant de diabète. Les patients doivent tenir de compte de la nécessité d'ajuster convenablement leur posologie d'insuline. Les boissons énergétiques contenant de la caféine peuvent causer une augmentation de la pression artérielle, ce qui peut avoir une grande considérable chez les individus exposés à un risque de complications liées au diabète.

Introduction

Since first appearing in Austria in 1987, the so-called functional beverage Red Bull has become an iconic global brand. This type of soft drink is popular, particularly among the 11- to 35-year age group, and there is no evidence that young people living with type 1 diabetes are any less likely to use these types of energy drinks (1). On the Red Bull website, the manufacturer claims that its products "have been developed to increase performance and improve concentration, increase alertness and contribute to mental performance" (2). In sharp contrast, consumption of these types of energy drinks has also been associated with high-risk behaviours, including illicit drug use, smoking and alcohol abuse as well as adverse effects (3–5).

In physiologic terms, there have been reports of transient increases in heart rate, blood pressure and cardiac contractility following acute ingestion of energy drinks (6). More alarmingly, there have also been case reports of acute psychiatric illness, seizures and cardiac arrest associated with such consumption (1). In addition, a common constituent of energy drinks is caffeine (80 mg per 250 mL serving). The American Psychiatric Association recognizes 4 caffeine-induced psychiatric disorders: caffeine intoxication, caffeine-induced anxiety disorder, caffeine-induced sleep disorder and a general caffeine-related disorder together with a withdrawal syndrome of unpleasant and perplexing symptoms following acute cessation after a period of regular caffeine consumption (7). Caffeine has measurable physiologic effects following acute ingestion. Under normal circumstances, ingestion of caffeine can have acute pressor effects and cause reduction of cerebral blood flow, although incomplete tolerance develops with continued use (8). Regular consumption of caffeine-containing beverages has also been associated with insulin resistance (9).

To date, there has been no study of the physiologic and metabolic effects of consuming energy drinks in young people with type 1 diabetes. However, the consequences for this group may be clinically important, given the potential for hyperglycemia and also the fact that any effect on the cardiovascular system may be relevant for individuals at risk for premature cardiovascular disease (10). Therefore, the aim of this study was to determine the acute physiologic and psychological effects following ingestion of Red Bull in people with type 1 diabetes.

Methods

People older than 18 years of age who were living with type 1 diabetes and managing on either a basal bolus or a continuous subcutaneous insulin regime were eligible for inclusion in the study. Potential volunteers were identified from our departmental diabetes database. The study information sheet and letter of invitation were sent to them by mail. The study was also advertised in the diabetes centre, and eligible people were approached directly in the outpatient clinic. Potential volunteers were excluded if they were known to have hypoglycemia unawareness, coronary heart disease, cardiac arrhythmia, structural heart lesions, autonomic neuropathy, psychiatric illness, epilepsy, migraine or caffeine intolerance. This was a prospective study conducted between February 2010 and July 2011. The Wiltshire Research Ethics Committee approved the study, and all participants gave written informed consent prior to participation.

Three drinks were compared: 1) drink A, Red Bull Energy (28 g carbohydrate, 80 mg caffeine per 250 mL); drink B, Red Bull Light (carbohydrate free, 80 mg caffeine per 250 mL); drink C, Suso Orange (caffeine free, 21 g carbohydrate per 250 mL, adjusted to give an equal volume and carbohydrate content).

All participants were asked to abstain from caffeine-containing beverages and medications and alcohol for 3 days preceding the studies and during the study days. Participants were asked to have breakfast and their regular insulin dose on the day of the study. Their blood glucose levels were checked on arrival at the study centre, and blood was taken for baseline caffeine levels. The study was postponed if there was biochemical evidence of hypoglycemia (<3.5 mmol/L). Participants then had multiple practises of the cognitive function tests that were to be used in the study to reduce the likelihood of experience bias.

Participants consumed 750 mL of each drink, in random order, over 10 to 15 minutes, 1 week apart. Heart rate; blood pressure; cognitive function (the 4 Choice Reaction Time [4CRT] test and the digit symbol substitution test); mood (University of Wales Institute of Science and Technology [UWIST] mood adjective checklist); glucose levels and caffeine levels were measured at baseline and every 30 minutes for 3 hours. Participants were asked to report any adverse effects experienced during the study period.

Heart rate and blood pressure were measured by the OMRON 5-I Blood Pressure Monitor (Omron Healthcare, Lake Forest, IL). Plasma glucose and caffeine samples were analyzed using the Roche Cobas 6000 analyzer (Roche Diagnostics, Burgess Hill, UK). Cognitive function was assessed using the 4CRT test and the digit symbol substitution test.

In the 4CRT test, the subject is presented with a computer screen divided into 4 quadrants. A computer-generated signal appears randomly in 1 quadrant at a time, and the subject has to clear it by pressing a corresponding button on a box. Up to 500 signals are presented in 5 minutes. The mean times of the reactions and the accuracy are recorded.

The digit symbol substitution test consists of 9 paired digits and symbols, and participants are asked to match a list of digits with their corresponding symbols as fast as possible over 90 seconds. This test assesses memory and speed of processing.

The UWIST mood adjective checklist (11) was used to document changes in mood experienced by the participants. There are 3 main bipolar scales supported by item factor analysis states: energetic arousal, tense arousal and hedonic tone.

The sample size of 16 participants detected standardized effect sizes of 0.75 within-subject standard deviations at the 5%, 2-sided significance level with 80% power. Comparisons within drinks were made using area-under-curve measurements, with individual