Microvascular Research 115 (2018) 8–11

Contents lists available at ScienceDirect

Microvascular Research

journal homepage: www.elsevier.com/locate/ymvre

Short Communication

Transient endothelial dysfunction induced by sugar-sweetened beverage consumption may be attenuated by a single bout of aerobic exercise

Pia Varsamis[a], Guillaume Walther[a,b], Bianca Share[a], Frances Taylor[c], Simon Stewart[d], Christian Lorenzen[a], Jordan Loader[a,b,c,*]

[a] School of Exercise Science, Australian Catholic University, Melbourne, Australia
[b] Avignon University, LAPEC EA4278, F-84000, Avignon, France
[c] Centre of Research Excellence to Reduce Inequality in Heart Disease, Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia
[d] The Mary MacKillop Institute for Health Research, Australian Catholic University, Melbourne, Australia

ARTICLE INFO

Keywords:
Sugar-sweetened beverages
Acute hyperglycemia
Endothelial dysfunction
Microcirculation
Aerobic exercise

ABSTRACT

Background: This study assessed whether aerobic exercise would attenuate microvascular endothelial dysfunction induced by commercial sugar-sweetened beverage (SSB) consumption.

Methods: Eleven healthy males participated in this randomized, single-blind crossover study. Cutaneous microvascular endothelial function was assessed using laser speckle contrast imaging coupled with post-occlusive reactive hyperemia before and after **a)** consumption of water; **b)** consumption of a commercial SSB; **c)** 30 min of aerobic exercise followed by water consumption; and **d)** 30 minutes of aerobic exercise followed by SSB consumption. Blood glucose and arterial pressure responses were also monitored. Volumes of water and SSB consumed (637.39 ± 29.15 mL) were individualized for each participant, ensuring SSB consumption delivered 1 g of sucrose per kg of body weight. Exercise was performed at 75% of the maximal oxygen uptake heart rate.

Results: Compared to water consumption, the commercial SSB elevated blood glucose concentrations in both sedentary (4.69 ± 0.11 *vs.* 7.47 ± 0.28 mmol/L, $P < 0.05$) and exercised states (4.95 ± 0.13 *vs.* 7.93 ± 0.15 mmol/L, $P < 0.05$). However, the decrease in microvascular endothelial function observed following sedentary SSB consumption, expressed as the percentage increase from baseline (208.60 ± 22.40 *vs.* 179.83 ± 15.80%, $P = 0.01$) and the change in peak hyperemic blood flux from basal to post-intervention assessments (− 0.04 ± 0.03 *vs.* − 0.12 ± 0.02 ΔCVC, $P = 0.01$), was attenuated following 30 min of aerobic exercise.

Conclusions: To our knowledge, this is the first study to provide evidence that a single bout of aerobic exercise may prevent transient SSB-mediated microvascular endothelial dysfunction.

1. Introduction

Commercial sugar-sweetened beverages (SSB) are one of the most prominent sources of added sugar in the modern diet and are linked to an increased incidence of cardiovascular disease (CVD) (Malik et al., 2010). Our research group has reported that endothelial dysfunction, one of the earliest markers of CVD, is transiently induced by the consumption of a single commercial SSB; even in those considered healthy (Loader et al., 2017). Previous research has demonstrated that exercise, performed prior to excess sugar consumption, improves post-prandial macrovascular function (Zhu et al., 2007). However, considering that microvascular disease may explain myocardial ischemia, heart failure and CVD mortality following myocardial infarction without apparent macrovascular disease (Jzerman et al., 2003), this present study assessed whether a single bout of aerobic exercise would prevent SSB-mediated microvascular endothelial dysfunction.

2. Methods

Eleven healthy Caucasian, non-smoking males (age, 22.18 ± 0.94 years; body mass index, 23.62 ± 0.95 kg/m2; fasting blood glucose, 4.41 ± 0.14 mmol/L; maximal oxygen uptake [VO2max], 44.37 ± 1.76 mL/kg/min), free from medications and chronic cardiovascular or metabolic disease, completed this randomized, single blind crossover study. The Australian Catholic University Human Research Ethics Committee approved this study protocol, conducted according to the ethical guidelines of the 1975 Declaration of Helsinki, and all participants provided written informed consent.

* Correspondence to: J. Loader, Mary MacKillop Institute for Health Research, Level 5, 215 Spring St, Melbourne, VIC 3000, Australia.
E-mail address: jordan.loader@acu.edu.au (J. Loader).

http://dx.doi.org/10.1016/j.mvr.2017.07.003
Received 8 June 2017; Received in revised form 24 July 2017; Accepted 24 July 2017

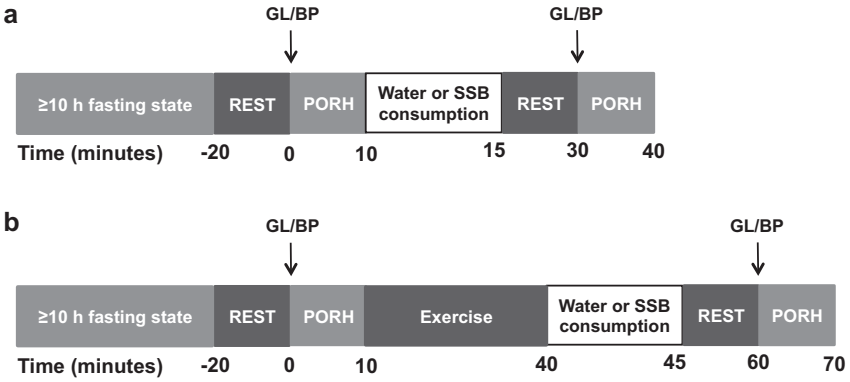

Fig. 1. Study design: sequence of testing for the **a)** sedentary and **b)** exercise interventions. BP, blood pressure; GL, blood glucose concentration; PORH, post-occlusive reactive hyperemia; SSB, sugar-sweetened beverage.

Table 1
The nutrient composition of each test beverage.

	Water (per 100 mL)	SSB (per 100 mL)
Energy, kJ	0	200
Protein, g	0	0.05
Fat		
Total, g	0	0
Saturated, g	0	0
Carbohydrate, g	0	14.48
Sugars, g	0	14.48
Calcium, mg	3	N/A
Magnesium, mg	1	N/A
Sodium, mg	4	18
Zinc, mg	0.01	N/A
Ingredients	Tap water	Carbonated water, sugar, reconstituted lemon juice (5%), food acids (330,331), natural flavor, preservatives (211, 223), natural colour (safflower extract)

Nutrient composition of water was obtained from the United States Department of Agriculture Nutrient Database Standard Reference Release 27 (United States Department of Agriculture, 2016). Nutrient composition for the commercial SSB was obtained from the nutrition information label on packaging.

In four trials, randomized by an online sequence generator, each participant's blood glucose, blood pressure and cutaneous microvascular endothelial function were assessed before and after a) sedentary water consumption; b) sedentary consumption of a commercial SSB; c) 30 min of aerobic exercise followed by water consumption; and d) 30 min of aerobic exercise followed by SSB consumption (Fig. 1). The nutritional content of the commercial sugary drink primarily sweetened with sucrose, a disaccharide comprised of glucose and fructose (Varsamis et al., 2017), is detailed in Table 1. The volume of water ingested was equivalent to the volume of commercial SSB consumed (637.39 ± 29.15 mL), which was individualized for each participant to ensure administration of 1 g of sucrose per kg of body weight; and each participant was instructed to consume the beverage within 5 min from the conclusion of exercise or from the beginning of consumption during the sedentary intervention. To standardize each trial, participants fasted overnight (≥ 10 h) and were instructed to refrain from caffeine and alcohol consumption for 18 h, as well as strenuous exercise for 24 h prior to each visit. No less than 48 h and no more than 72 h separated each trial. Exercise was performed on a cycling ergometer (Monark 828E, Sweden) at an exercise intensity set at 75% of the VO2max heart rate. Blood glucose concentrations and blood pressure were assessed using a handheld blood glucose monitoring system (Freestyle Optium, Abbott Diabetes Care Ltd., UK) and a digital sphygmomanometer (Dinamap, GE Medical Systems, Milwaukee, USA), respectively.

Prior to beginning the four trials, changes in blood glucose concentrations in response to SSB consumption were assessed in a cohort of eight healthy males (age, 21.40 ± 0.72 years) to confirm in which time period the maximal, SSB-mediated, acute hyperglycemic plateau occurs. In this test, participants were instructed to consume an individualized volume of SSB, delivering 1 g of sucrose per kg of bodyweight, within 5 min; with blood glucose concentrations being assessed before and every 5 min after the beginning of consumption, for 50 min. Post-SSB consumption vascular assessments were performed in this acute hyperglycemia plateau in the following trials. Assessments of microvascular endothelial function performed following water consumption were also conducted in the same time period to allow for comparison between all trials. Cutaneous microvascular endothelial function was assessed on the ventral surface of each participant's right forearm using laser speckle contrast imaging (PeriCam PSI System®, PeriMed, Sweden) in conjunction with post-occlusive reactive hyperemia (PORH). In brief, PORH involved laser measurement of basal cutaneous blood flux for 2 min before a sphygmomanometer cuff, positioned on the upper right arm, was inflated to 50 mmHg above resting systolic blood pressure, occluding the forearm circulation for 3 min. The cuff was then rapidly deflated inducing reactive hyperemia that was recorded for a period of 5 min. Participants remained in a supine position throughout all vascular assessments, as well as during 15–20 min of acclimatization before both pre- and post-intervention vascular assessments. Blood glucose concentrations and blood pressure were measured at the end of each acclimatization period, immediately before vascular assessments: confirming that acute hyperglycemia had been induced following SSB consumption.

2.1. Data and statistical analyses

The sample size was based on power calculations from a previous study (Birk et al., 2013); and it was estimated that a minimum of 10 participants would be needed to detect a difference between trials, with a two-tailed α of 0.05 and a 1-β of 0.80. Cutaneous blood flux values were averaged for the 30 s immediately prior to the occlusion period and for 3 s at the peak response during reactive hyperemia. Microvascular data were reported as the percentage increase from the baseline measurement, as well as the peak blood flux response to PORH and as the change in the peak blood flux response to PORH between basal and post-intervention microvascular assessments; expressed as cutaneous vascular conductance. Given that all data were normally distributed, differences between assessments for variables of blood glucose, blood pressure and cutaneous microvascular function were assessed using one-way, repeated measures, analysis of variance (ANOVA) for pre-intervention data and two-way, repeated measures, ANOVA for post-intervention data. Statistical analyses were conducted using SPSS (Version 22.0, IBM Corp, Armonk, NY, USA) and $P < 0.05$ was considered statistically significant. All data are reported as mean ± SEM.