Journal of Nutrition & Intermediary Metabolism 12 (2018) 8–13

Contents lists available at ScienceDirect

Journal of Nutrition & Intermediary Metabolism

journal homepage: http://www.jnimonline.com/

Non-fat milk attenuates acute hypertriglyceridemia in obese individuals who consume a high fat diet: A randomized control trial

Miriam P. Leary*, Jisok Lim, Wonil Park, Rodrigo Ferrari, Jared Eaves, Stephen J. Roy, Daniel R. Machin, Hirofumi Tanaka

Cardiovascular Aging Research Laboratory, Department of Kinesiology and Health Education, The University of Texas at Austin, Austin, TX, 78712, United States

ARTICLE INFO

Article history:
Received 12 February 2018
Received in revised form
29 May 2018
Accepted 30 May 2018
Available online 31 May 2018

Keywords:
Milk
Dairy products
Postprandial lipemia
Triglycerides
Hemodynamics
Flow-mediated dilation

ABSTRACT

Background: Repeated exposure to elevated postprandial triglycerides, as seen with typical Western diets, contributes to atherosclerosis and vascular disease. We determined if a single serving of non-fat milk added to a high fat tolerance test could attenuate postprandial hypertriglyceridemia in individuals who consume a high fat diet.

Methods: In this placebo-controlled, randomized, crossover experimental study, 30 overweight/obese adults consumed a high-fat tolerance test meal combined with either non-fat milk, carbohydrate control drink, or caloric control drink.

Results: Plasma triglycerides increased over time with no significant differences between interventions. Peak plasma triglyceride levels during HFTT were significantly related to dietary fat intake ($r = 0.30$, $p < 0.05$). When participants were divided into tertiles based on habitual dietary fat intake, the higher fat diet group exhibited reduced triglyceride net integrated area under the curve when supplemented with non-fat milk. No significant differences in hemodynamic measures (brachial flow-mediated dilation and femoral vascular conductance) were observed between the milk and caloric control trials for either the low fat or high fat diet groups.

Conclusions: A single serving of non-fat milk may attenuate acute hypertriglyceridemia in individuals who chronically consume a high fat diet, offering a simple and easily implemented option for managing elevations in postprandial triglycerides.

1. Introduction

Atherosclerosis is responsible for over 40% of deaths in the U.S [1]. Traditionally, fasting plasma triglyceride has been used as an important risk factor for atherosclerosis. However, as most individuals spend the majority of their day in a postprandial state, acute responses in plasma triglycerides following a meal have been shown to be a better predictor of relative cardiovascular disease (CVD) risk [2,3]. Indeed, postprandial lipemia is associated with reduced vascular reactivity and impaired endothelial function [4–6]. The magnitude of increase in postprandial plasma triglycerides is directly proportional to the fat content in meals [7–9]. As such, multiple high fat meals throughout the day exemplified by typical Western diets results in the prolonged presence of elevated plasma triglycerides. Repeatedly exposing the vasculature to hypertriglyceridemia causes endothelial dysfunction, which may increase the risk of developing atherosclerosis.

Epidemiological studies suggest that chronically high consumption of milk and dairy products are inversely associated with the overall risk of atherosclerosis [10–12]. A potential mechanism underlying how dairy products reduce the risk of atherosclerosis may be through the attenuation in the postprandial rise in triglyceridemia when milk and milk products are consumed with a high fat meal [13–16]. However, the available evidence is inconclusive and highly controversial. For example, the postprandial appearance of triglycerides was decreased with the consumption of large doses of milk-derived proteins [15]. In contrast, no difference was found

* Corresponding author. Department of Kinesiology and Health Education, The University of Texas at Austin, 2109 San Jacinto Blvd, D3700, Austin, TX, 78712, United States.

E-mail addresses: miriampearmanleary@gmail.com (M.P. Leary), jslim4599@gmail.com (J. Lim), voguse0403@utexas.edu (W. Park), rod.ferrari84@gmail.com (R. Ferrari), jeaves825@yahoo.com (J. Eaves), sjr07130@utexas.edu (S.J. Roy), danielrmachin@gmail.com (D.R. Machin), htanaka@austin.utexas.edu (H. Tanaka).

https://doi.org/10.1016/j.jnim.2018.05.003

in postprandial triglycerides between milk, a carbohydrate control, and a caloric control [16].

Milk proteins demonstrate an insulinotropic effect upon absorption in the gut that may induce the rapid release of insulinotropic amino acids and gastric inhibitor polypeptide (GIP), which in turn augments insulin secretion [17]. As insulin-mediated vasodilation is achieved through a nitric oxide dependent mechanism, postprandial hyperinsulinemia and the resultant vasodilation could be a mechanism underlying the potential effect of milk protein on postprandial hypertriglyceridemia [18]. However, hemodynamic studies have not been performed in conjunction with the effects of milk and milk proteins to confirm this possibility.

Thus, the primary aim of the present study was to determine if a single serving of non-fat milk could attenuate postprandial hypertriglyceridemia induced by a high fat tolerance test in individuals who chronically consume a high fat diet. Overweight and obese individuals who consume high fat diets are at an increased risk of developing atherosclerosis [19] and often present with sub-optimal metabolic profiles. These individuals may be the biggest beneficiaries of the proposed dietary regimen. Accordingly, participants were ranked and divided into tertiles based on habitual dietary fat intake. As secondary outcomes, we also evaluated whether these improvements would be associated with hyperinsulinemic and/or vasodilatory effects, including endothelial-dependent vasodilation and whole limb perfusion. Moreover, employing a carbohydrate control and a macronutrient/caloric control allowed us to determine whether milk, independent of its protein content, was capable of attenuating postprandial triglyceride response.

2. Methods

Participants. A total of 30 young adults with a mean (±SEM) age of 26 ± 1 y were studied. They were recruited via advertisements and fliers from the local community. Inclusion criteria were as follows: healthy, sedentary (physical activity <3 d/wk), overweight or obese (BMI $\geq$ 25.0 kg/m^2), nonsmoking, no overt signs of chronic diseases as assessed by physical examination and/or medical health history, normal blood chemistry as assessed by fasting glucose and lipid panel, no cardiovascular-acting medications, and no pregnancy. Participants who were lactating or reported dairy allergies, lactose intolerance, and/or alcohol abuse were excluded from the study. Participants were required to maintain their normal routine diet and exercise habits for the duration of the study participation. After being informed about the study verbally and in writing, all participants gave their informed consent. All procedures were reviewed and approved by the Internal Review Board at the University of Texas at Austin (IRB #2014-04-0017). This study was registered at clinicaltrials.gov (NCT02894112).

Study Design. A placebo-controlled, randomized, crossover experimental design was used for the present dietary intervention trials. Each participant underwent a high fat tolerance test (HFTT) with a non-fat milk, a carbohydrate control, and a total caloric control. Each treatment was preceded by two consecutive days of strict dietary and physical activity controls. Treatment interventions were randomized and separated by a washout period of at least 1 week.

Experimental Protocol. Dietary intake was reported with a 3-day, self-report food log and analyzed by a registered dietician with Nutrition Pro Software (Axxya Systems, Woodinville, WA). Standardized meals were matched for energy/calorie content (isocaloric; 60% carbohydrate, 15% protein, and 25% fat) and were provided to participants to consume on Days 1–2. The participants were provided with a dietary record log and instructed to consume the same meals and record the timing of the meals on both days to better replicate the dietary controls prior to the other treatments. Alcohol and caffeine intake were prohibited starting in the evening before Day 1. Further, participants were instructed to maintain their normal physical activity, but refrain from both formal and recreational exercises. To confirm this, participants were provided with and required to wear pedometers during the waking hours of Days 1–2.

Participants reported to the laboratory on the morning of Day 3. Following the resting measurements of vascular functions, an intravenous catheter was inserted into the antecubital vein, and fasting blood samples were collected. Next, participants were given 20 min to consume a high fat meal consisted of corn chips (H.E.B., San Antonio, TX), which were 68% fat/serving. To normalize the high fat load, participants were given 1 g of dietary fat/kg of body weight. This high fat meal was provided with 8 oz. of non-fat milk (227 g liquid weight), 8 oz. of carbohydrate (CHO) control drink (12 g lactose + 215 g water), or 8 oz. of the caloric (CAL) control drink (12 g lactose + 8 g whey protein +207 g water). The carbohydrate control drink was identical to non-fat milk in carbohydrate content, and the caloric control drink was identical to non-fat milk in macronutrient and calorie contents. Participants remained sedentary in the quiet, temperature-controlled laboratory during the 4-h postprandial period.

Measurements. During each treatment, blood samples were collected at baseline, 30, 60, 90, 120, 180, and 240 min. These samples were later analyzed for plasma glucose, insulin, glucagon, glucagon-like peptide-1 (GLP-1), and GIP concentrations. Due to financial constraint, GLP-1 and GIP concentrations were analyzed only for baseline, 30, 60, and 120 min. These time points were selected because significant changes in these hormones were expected to occur early in the postprandial phase. Commercially available assay kits were used to determine triglyceride and glucose concentrations (Point Scientific, Canton, MI). Enzyme-linked immunosorbent assays were used to assess plasma concentrations of GIP and GLP-1 (RayBiotech, Inc., Norcross, GA) and insulin (Mercodia, Uppsala, Sweden). Glucagon concentrations were determined by radioimmunoassay (EMD Millipore, Darmstadt, Germany) [20]. The net incremental area under the curve (iAUC) for plasma triglycerides was calculated using the trapezoidal method [20].

Vascular function was measured at baseline, midway (120 min), and end of the postprandial period (240 min). As an index of vascular endothelium-dependent vasodilation, flow-mediated dilation (FMD) was measured as previously described [21]. Briefly, brachial artery diameter and blood flow velocity were assessed from images derived from an ultrasound machine (iE33, Philips Medical, Bothel, WA) equipped with a high-resolution linear-array transducer. A longitudinal image of the brachial artery was acquired 5–10 cm proximal to the antecubital fossa. A blood pressure cuff, placed on the forearm 3–5 cm distal to the antecubital fossa, was inflated to 50 mmHg above resting systolic blood pressure or a maximum of 200 mmHg for 5 min. After cuff deflation, ultrasound-derived measurements of the brachial artery diameters and blood velocity were taken for 3 min. FMD was calculated as a percent increase in brachial artery diameter at the post-blood flow occlusion compared with the pre-blood flow occlusion.

Blood flow and vascular conductance were measured in the common femoral artery using the ultrasound machine (iE33, Philips Medical, Bothel, WA) as previously described [22,23]. To minimize turbulence from the bifurcation, the measurements were performed below the inguinal ligament, approximately 2–3 cm above its bifurcation into the profundus and superficial branch. Mean blood velocity measurements were performed with the lowest possible insonation angle that was always <60°. Blood flow was calculated using the following formula: (mean blood velocity)