Effects of Consuming Dietary Fructose versus Glucose on de novo Lipogenesis in Overweight and Obese Human Subjects

Permalink
https://escholarship.org/uc/item/7vv7z7zw

Journal
Berkeley Scientific Journal, 15(2)

ISSN
1097-0967

Author
Lam, Patrick

Publication Date
2011

Peer reviewed|Undergraduate
Effects of Consuming Dietary Fructose versus Glucose on de novo Lipogenesis in Overweight and Obese Human Subjects

Patrick H. Lam1,5, Kelley Ng1,5, Kimber L. Stanhope3,4, Jean Marc Schwarz5,6, Nancy L. Keim7, Steven C. Griffen8, Andrew A. Bremer9, James L. Graham3,4, Bonnie Hatcher4, Chad L. Cox, Artem Dyachenko5, Wei Zhang8, John P. McGahan10, Anthony Seibert10, Ronald M. Krauss11, Sally Chiu11, Ernst J. Schaefer12, Masumi Ai12, Seiko Otokozawa12, Katsuyuki Nakajima12, Takamitsu Nakano13, Carine Beysen14, Marc K. Hellerstein14, Lars Berglund8,16, and Peter J. Havel3,4, J.M. Schwarz1 and A. Dyachenko1

1Department of Molecular Environmental Biology, College of Natural Resources, UCB, Berkeley, USA.
2Department of Integrative Biology, College of Letters and Science, UCB, Berkeley, USA.
3Department of Molecular Biosciences, School of Veterinary Medicine, Davis, California, USA
4Department of Nutrition, UCD, Davis, California, USA.
5College of Osteopathic Medicine, Touro University, Vallejo, California, USA.
6UCSF, San Francisco, California, USA.
7United States Department of Agriculture, Western Human Nutrition Research Center, Davis, California, USA.
8Department of Integrative Biology, College of Letters and Science, UCB, Berkeley, USA.
9Department of Pediatrics, School of Medicine, UCD, Sacramento, California, USA.
10Department of Radiology, UCD Medical Center, Sacramento, California, USA.
11Children’s Hospital Oakland Research Institute, Oakland, California, USA.
12Lipid Metabolism Laboratory, Jean Mayer United States Department of Agriculture Human Nutrition Research Center on Aging at Tufts University, and Tufts University School of Medicine, Boston, Massachusetts, USA.
13Diagnostic Division, Otsuka Pharmaceutical Co., Tokyo, Japan.
14KineMed, Emeryville, California, USA.
15Nutritional Sciences and Toxicology, University of California, Berkeley, California, USA.
16Veterans Affairs Northern California Health Care System, Sacramento, California, USA.

Keywords: fructose vs. glucose, de novo lipogenesis (DNL), very low density lipoproteins (VLDL), methyl palmitate, gas chromatography/mass spectrometry (GC/MS), mass isotopomer distribution analysis (MIDA), obesity

ABSTRACT

The effects of consuming a diet high in fructose, compared to a diet high in glucose, on the rate of hepatic de novo lipogenesis (DNL) in overweight and obese individuals were studied. These subjects were given a diet in which either glucose or fructose was substituted for 25% of their energy requirements for 10 weeks. During the fasted state, subjects’ DNL for those on a glucose and fructose diet were similar. However, in the fed state, DNL was increased significantly in subjects given a fructose diet. This suggests that consuming a diet from fructose-sweetened beverages increases DNL.

INTRODUCTION

Not many studies have been conducted on humans to prove the consumption of fructose increases de novo lipogenesis (DNL). Glucose and fructose are the two most popular simple sugars in one’s diet today; their effects on hepatitis DNL were compared. Most, if not all, of the fructose from one’s diet is metabolized in the liver (90-100%); on the other hand, glucose is mostly metabolized in extra-hepatic tissues (80%) (Figure 1). Also, fructose is metabolized faster than glucose because it bypasses the early steps of glycolysis.

1Corresponding author: for questions, contact Patrick H. Lam. Phone number: (408) 887-7898 E-mail: patricklam@berkeley.edu
MATERIALS AND METHODS

Subjects were admitted to the UC Davis School of Medicine/Sacramento Veterans Affairs Medical Center General Clinical Research Center (GCRC) for a double-blinded diet intervention study to evaluate lipid metabolism. The study was divided into three phases – inpatient baseline (2 weeks), outpatient intervention (8 weeks), and inpatient intervention (2 weeks). For the 2-week inpatient baseline phase, subjects were fed an energy-balanced, high-complex carbohydrate (CHO) diet (55% energy from CHO, 30% fat, 15% protein) for the first two weeks. During the 8-week outpatient intervention, subjects consumed either glucose- (n=3) or fructose-sweetened (n = 7) beverages providing 25% of daily energy requirements in addition to their ad libitum diet. After 2 outpatient weeks, the subjects returned to the clinic for an inpatient study and blood draw and then finished the remaining 6 weeks outside. In the final 2 weeks of inpatient intervention, subjects consumed an energy-balanced diet where 25% of daily energy requirements came from glucose- or fructose-sweetened beverages. During all inpatient stays, blood was collected. Other procedures during the inpatient stays included a postprandial postheparin blood sampling, oral glucose tolerance test (OGTT), gluteal adipose biopsy, stable isotope tracer infusion to determine fractional DNL (the percent of newly synthesized fat from the liver in the fasted and fed states), and CT scan of the abdomen.

RESULTS

The baseline parameters and characteristics of the 10 subjects were similar (Figure 4). Fasting fractional hepatic DNL from the baseline to intervention phases for both glucose and fructose diets showed a similar negative trend and decreased about 2.5%. A negative trend also appeared for postprandial DNL during glucose consumption, decreasing 5.8%. However, postprandial DNL during fructose consumption showed a positive trend, increasing about 6% (Figure 5).

MAterIALs And MetHods

Subjects were admitted to the UC Davis School of Medicine/Sacramento Veterans Affairs Medical Center General Clinical Research Center (GCRC) for a double-blinded diet intervention study to evaluate lipid metabolism. The study was divided into three phases – inpatient baseline (2 weeks), outpatient intervention (8 weeks), and inpatient intervention (2 weeks). For the 2-week inpatient baseline phase, subjects were fed an energy-balanced, high-complex carbohydrate (CHO) diet (55% energy from CHO, 30% fat, 15% protein) for the first two weeks. During the 8-week outpatient intervention, subjects consumed either glucose- (n=3) or fructose-sweetened (n = 7) beverages providing 25% of daily energy requirements in addition to their ad libitum diet. After 2 outpatient weeks, the subjects returned to the clinic for an inpatient study and blood draw and then finished the remaining 6 weeks outside. In the final 2 weeks of inpatient intervention, subjects consumed an energy-balanced diet where 25% of daily energy requirements came from glucose- or fructose-sweetened beverages. During all inpatient stays, blood was collected. Other procedures during the inpatient stays included a postprandial postheparin blood sampling, oral glucose tolerance test (OGTT), gluteal adipose biopsy, stable isotope tracer infusion to determine fractional DNL (the percent of newly synthesized fat from the liver in the fasted and fed states), and CT scan of the abdomen.

RESULTS

The baseline parameters and characteristics of the 10 subjects were similar (Figure 4). Fasting fractional hepatic DNL from the baseline to intervention phases for both glucose and fructose diets showed a similar negative trend and decreased about 2.5%. A negative trend also appeared for postprandial DNL during glucose consumption, decreasing 5.8%. However, postprandial DNL during fructose consumption showed a positive trend, increasing about 6% (Figure 5).
**DISCUSSION AND CONCLUSIONS**

Two diets with the same macronutrient composition but different types of carbohydrate (fructose vs. glucose) affect hepatic DNL differently. Fructose consumption but not glucose consumption increases fractional hepatic DNL, elevating triglyceride levels in blood. It makes sense because fructose metabolism is independent of phosphofructose kinase regulation, unlike glucose metabolism (Mayes, 1993). It has also been shown that fructose may activate a sterol receptor binding protein which activates genes in DNL (Matsuzaka, 2004). In addition, hepatic lipids may increase because increased DNL supplies more endogenous fatty acids and hepatic DNL limits fatty acid oxidation in the liver via production of malonyl-CoA, which reduces the entry of fatty acids into the mitochondria (McGarry, 1995). Nonetheless, additional studies on dose-responses are necessary to evaluate the different amounts of fructose in one's diet and their effect on hepatitis DNL and lipids. Also, a follow-up study may be needed because the 25% of daily energy being provided by the sweetened beverages may be too high compared to the average intake of added sugars by Americans (Guthrie and Morton, 2000).

**LITERATURE CITED**