Journal of Adolescent Health 56 (2015) 352–359

ELSEVIER

JOURNAL OF ADOLESCENT HEALTH

www.jahonline.org

Original article

Usual Intake of Added Sugars and Lipid Profiles Among the U.S. Adolescents: National Health and Nutrition Examination Survey, 2005–2010

Zefeng Zhang, M.D., Ph.D. [a,*], Cathleen Gillespie, M.S. [a], Jean A. Welsh, Ph.D., M.P.H., R.N. [b,c], Frank B. Hu, M.D., Ph.D. [d,e], and Quanhe Yang, Ph.D. [a]

[a] Division for Heart Disease and Stroke Prevention, Centers for Disease Control and Prevention, Atlanta, Georgia
[b] Department of Pediatrics, Emory University School of Medicine, Atlanta, Georgia
[c] Wellness Department, Children's Healthcare of Atlanta, Atlanta, Georgia
[d] Department of Nutrition, Harvard School of Public Health, Boston, Massachusetts
[e] Department of Epidemiology, Harvard School of Public Health, Boston, Massachusetts

Article history: Received July 22, 2014; Accepted December 2, 2014
Keywords: Usual percentage of calories; Added sugars; Lipid profiles; Dyslipidemia

A B S T R A C T

Purpose: Although studies suggest that higher consumption of added sugars is associated with cardiovascular risk factors in adolescents, none have adjusted for measurement errors or examined its association with the risk of dyslipidemia.
Methods: We analyzed data of 4,047 adolescents aged 12–19 years from the 2005–2010 National Health and Nutrition Examination Survey, a nationally representative, cross-sectional survey. We estimated the usual percentage of calories (%kcal) from added sugars using up to two 24-hour dietary recalls and the National Cancer Institute method to account for measurement error.
Results: The average usual %kcal from added sugars was 16.0%. Most adolescents (88.0%) had usual intake of ≥10% of total energy, and 5.5% had usual intake of ≥25% of total energy. After adjustment for potential confounders, usual %kcal from added sugars was inversely associated with high-density lipoprotein (HDL) and positively associated with triglycerides (TGs), TG-to-HDL ratio, and total cholesterol (TC) to HDL ratio. Comparing the lowest and highest quintiles of intake, HDLs were 49.5 (95% confidence interval [CI], 47.4–51.6) and 46.4 mg/dL (95% CI, 45.2–47.6; $p = .009$), TGs were 85.6 (95% CI, 75.5–95.6) and 101.2 mg/dL (95% CI, 88.7–113.8; $p = .037$), TG to HDL ratios were 2.28 (95% CI, 1.84–2.70) and 2.73 (95% CI, 2.11–3.32; $p = .017$), and TC to HDL ratios were 3.41 (95% CI, 3.03–3.79) and 3.70 (95% CI, 3.24–4.15; $p = .028$), respectively. Comparing the highest and lowest quintiles of intake, adjusted odds ratio of dyslipidemia was 1.41 (95% CI, 1.01–1.95). The patterns were consistent across sex, race/ethnicity, and body mass index subgroups. No association was found for TC, low-density lipoprotein, and non-HDL cholesterol.
Conclusions: Most U.S. adolescents consumed more added sugars than recommended for heart health. Usual intake of added sugars was significantly associated with several measures of lipid profiles.
Published by Elsevier Inc. on behalf of Society for Adolescent Health and Medicine.

IMPLICATIONS AND CONTRIBUTION

Studies examining the association between added sugars intake and lipid profiles among adolescents have not taken into account the measurement error. We used the method developed by the National Cancer Institute and found usual intake of added sugars was significantly associated with several measures of lipid profiles and risk of dyslipidemia among adolescents.

Conflicts of Interest: The authors have no conflicts of interest to report.
Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

* Address correspondence to: Zefeng Zhang, M.D., Ph.D., Division for Heart Disease and Stroke Prevention, Centers for Disease Control and Prevention, Mailstop F-72, 4770 Buford Highway NE, Atlanta, GA 30341.
E-mail address: zzhang3@cdc.gov (Z. Zhang).

1054-139X/Published by Elsevier Inc. on behalf of Society for Adolescent Health and Medicine.
http://dx.doi.org/10.1016/j.jadohealth.2014.12.001

Dyslipidemia is a modifiable risk factor for cardiovascular disease, which is a leading cause of morbidity and mortality among the U.S. adults. The dramatic increase in the prevalence of childhood obesity since the 1980s has coincided with an increased prevalence of dyslipidemia among children and adolescents [1]. Studies have shown that dyslipidemia in childhood is a strong predictor of the disorder in adulthood [2–4], and there is also a strong association between adverse lipid profiles and the early onset of atherosclerosis in children and young adults [5,6]. Risk factors and risk behaviors that accelerate the development of atherosclerosis begin in childhood, such as unhealthy dietary habits and physical inactivity [1]. Reductions in risk factors and risk behaviors delay the progression toward clinical disease [1], which indicates the importance of early prevention to reduce cardiovascular disease risk later in life.

Eating a healthy diet, including limiting intake of added sugars, plays an important role in lowering the risk of cardiovascular disease. Although the consumption of added sugars in the United States has decreased among all age groups recently, adolescents continue to be the highest consumers [7]. Studies among adults have consistently shown an association between the high consumption of added sugars—especially sugar-sweetened beverages (SSBs) and weight gain, obesity, type 2 diabetes, and increased cardiovascular disease risk, including lipid disorders [8–10].

A few population-based studies also have examined the association of added sugars with lipid profiles among adolescents [11–14]. Welsh et al. [12] examined added sugars from one 24-hour dietary recall from the National Health and Nutrition Examination Survey (NHANES), 1999–2004, and found a statistically significant correlation between added sugars and high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides (TGs) among 2,157 U.S. adolescents aged 12–18 years, after adjusting for covariates. Ambrosini et al. [11] reported a prospective association between SSBs and increased TG in both boys and girls aged 14–17 years, independent of body mass index (BMI) and an association with HDL cholesterol in boys among 1,433 adolescent offspring from the Western Australia Pregnancy Cohort Study. Kell et al. [14] used the average of added sugars from two 24-hour dietary recalls and found significant association between the higher consumption of added sugars and elevated TG among 322 children aged 7–12 years. In a 10-year cohort study of 2,379 non-Hispanic, Caucasian, and African-American girls aged 9 years and 10 years at baseline, Lee et al. [15] used multiple 3-day food records and reported that low added sugars consumption (0%–<10% of total energy) compared with high added sugars consumption (≥10% of total energy) was associated with a .26 mg/dL greater annual increase in HDL levels. However, these studies were limited by the use of intake estimates on the basis of a single or the average of two 24-hour dietary recalls without explicitly taking into account individual day-to-day variability in consumption, which represents a type of measurement error. This intraindividual variation generally leads to the biased estimates of the nutrient–health outcome association [16,17]. Although one study [11] used food frequency questionnaire which can be interpreted as assessing a person's long-term intake, the number of foods reported in food frequency questionnaire is usually very limited, and therefore, these data might not capture complete added sugars intake. Furthermore, no studies have examined the association between added sugars intake and the risk of dyslipidemia among adolescents. In the present study, we used the methods developed by the National Cancer Institute (NCI) that estimate the usual intake of added sugars from up to two 24-hour dietary recalls, which adjusted for the measurement error due to the intraindividual variations in intake. We examined the associations between the estimated usual intake of added sugars and lipid profiles and risk of dyslipidemia among the U.S. adolescents using 2005–2010 data from the NHANES, a nationally representative, cross-sectional survey.

Subjects and Methods

Study participants

Study participants included the U.S. adolescents aged 12–19 years who participated in the 2005–2010 NHANES. The NHANES uses a complex, stratified, multistage probability cluster sampling, cross-sectional design to collect health and nutritional data from a representative sample of the noninstitutionalized U.S. population. The design and operation of the NHANES has been described previously [18–20]. There were 4,536 NHANES participants aged 12–19 years who provided at least one 24-hour dietary recall. The dietary recalls were completed by the adolescents, rather than a proxy, and were included in this study if the recall was deemed reliable and complete [21]. A reliable recall was determined if all relevant dietary recall variables associated with the 24-hour dietary recall contain a value. For the dietary intake and lipid profile study, we excluded participants who had missing total cholesterol (TC) data (n = 447) or were pregnant (n = 42), leaving 4,047 adolescents for the analysis. For the association study, we further excluded adolescents who were on restricted diets, such as low-sugar, low-calorie, or low-carbohydrates (n = 282) or whose total calorie intake was <500 or >5,000 kcal/day (n = 113) because restricted diets or extreme calorie intakes might not represent the adolescents' usual dietary intakes. Because they would be more likely to have underlying health conditions, such as digestive or eating disorders or thyroid disease, we excluded underweight participants (defined as BMI <5th percentile based on the CDC 2000 growth charts; n = 106). Finally, we excluded participants with missing covariate data (n = 213), yielding a sample of 3,333 participants for analyses. Study protocols for the NHANES were approved by the National Center for Health Statistics Ethics Review Board. Signed informed consent was obtained from all participants or their parent or guardian.

Lipid profiles

Outcome variables include levels of TC, HDL cholesterol, non-HDL cholesterol, LDL cholesterol, TG, TG-to-HDL cholesterol ratio, and TC-to-HDL cholesterol ratio. The standardized laboratory procedures to measure lipid levels have been described elsewhere [22]. Values for LDL cholesterol were calculated using the Friedewald calculation for TG levels ≤400 mg/dL:

$$\text{LDL cholesterol} = \text{TC} - \text{HDL cholesterol} - (\text{TG}/5)$$ [23].

Non-HDL cholesterol was calculated as TC − HDL cholesterol. Because the TG level can increase up to 20%–30% after a meal, which would throw off the equation, LDL cholesterol, TG, and TG-to-HDL cholesterol ratio analyses were limited to those who had fasted 8 hours or more before the physical examination. Dyslipidemia was defined according to the National Cholesterol