RESEARCH
Original Research

Beverage Consumption Patterns at Age 13 to 17 Years Are Associated with Weight, Height, and Body Mass Index at Age 17 Years

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ABSTRACT

Background Sugar-sweetened beverages (SSBs) have been associated with obesity in children and adults; however, associations between beverage patterns and obesity are not understood.

Objective Our aim was to describe beverage patterns during adolescence and associations between adolescent beverage patterns and anthropometric measures at age 17 years.

Design We conducted a cross-sectional analyses of longitudinally collected data.

Participants/setting Data from participants in the longitudinal Iowa Fluoride Study having at least one beverage questionnaire completed between ages 13.0 and 14.0 years, having a second questionnaire completed between 16.0 and 17.0 years, and attending clinic examination for weight and height measurements at age 17 years (n=369) were included.

Exposure Beverages were collapsed into four categories (ie, 100% juice, milk, water and other sugar-free beverages, and SSBs) for the purpose of clustering. Five beverage clusters were identified from standardized age 13 to 17 years mean daily beverage intakes and named by the authors for the dominant beverage: juice, milk, water/sugar-free beverages, neutral, and SSB.

Outcomes Weight, height, and body mass index (BMI; calculated as kg/m^2) at age 17 years were analyzed.

Statistical analyses We used Ward's method for clustering of beverage variables, one-way analysis of variance and χ^2 tests for bivariable associations, and γ-regression for associations of weight or BMI (outcomes) with beverage clusters and demographic variables. Linear regression was used for associations of height (outcome) with beverage clusters and demographic variables.

Results Participants with family incomes <$60,000 trended shorter (1.5±0.8 cm; P=0.070) and were heavier (2.0±0.7 BMI units; P=0.002) than participants with family incomes ≥$60,000/year. Adjusted mean weight, height, and BMI estimates differed by beverage cluster membership. For example, on average, male and female members of the neutral cluster were 4.5 cm (P=0.010) and 4.2 cm (P=0.034) shorter, respectively, than members of the milk cluster. For members of the juice cluster, mean BMI was lower than for members of the milk cluster (by 2.4 units), water/sugar-free beverage cluster (3.5 units), neutral cluster (2.2 units), and SSB cluster (3.2 units) (all P<0.05).

Conclusions Beverage patterns at ages 13 to 17 years were associated with anthropometric measures and BMI at age 17 years in this sample. Beverage patterns might be characteristic of overall food choices and dietary behaviors that influence growth.
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OBESITY IS A DISEASE CHARACTERIZED BY EXCESSIVE adipose tissue and is a substantial risk factor for morbidity and premature mortality.[1,2] Using data from the National Health and Nutritional Examination Survey, Ogden and colleagues[3] reported that the prevalence of adolescent obesity increased from 10.5% (95% CI 8.8% to 12.5%) in 1988 to 1994 to 20.6% (95% CI 16.2% to 25.6%) in 2013 to 2014, with extreme obesity increasing from 2.6% (95% CI 1.7% to 3.9%) to 9.1% (95% CI 7.0% to 11.5%) during

the same time period. Because obesity is difficult to treat, understanding risk factors to facilitate development of preventive strategies is necessary to reduce the disease burden.

Diet is a potentially modifiable environmental risk factor for obesity; historic dietary recommendations have targeted foods high in fats and low in nutrients. More recently, sugar-sweetened beverages (SSBs), defined as beverages containing added sugars, have been associated with obesity in children, adolescents and adults.[4-9] The science linking SSBs with obesity is mostly observational in nature. In addition, SSBs are consumed in the context of the whole diet—an assortment of other foods and beverages. The relationships among foods and beverages within the diet might exacerbate or minimize the impact of a particular food or beverage item. In addition, the physical state (ie, solid vs liquid) of food and beverage items is thought to influence satiety with implications for obesity.[10,11]

Beverages (ie, 100% juice, water, milk, and SSBs) differ in both energy and nutrient density. The choice of beverage to consume in a given situation is likely influenced by flavor, perceived nutrient quality, and perceived health benefits. As a result, most individuals consume multiple beverages throughout the day. Individual associations between SSBs, milk, and 100% juice and obesity have been investigated; the majority of studies, particularly those of high quality, suggest a positive association between SSBs and weight gain, overweight, or obesity.[4-9,12-15] However, few investigations of beverage patterns and obesity in children or adolescents have been reported.[16] LaRowe and colleagues[16] reported that the body mass index (BMI; calculated as kg/m^2) of children aged 6 to 11 years was higher ($P<0.05$) in children with water (adjusted mean BMI=19.9), sweetened beverages (BMI=18.7), or soda (BMI=18.7) beverage patterns compared with mix/light (BMI=18.2) and high-fat milk (BMI=17.8) beverage patterns.[16] To our knowledge, the relationships among beverage patterns and growth measures during adolescence have not been reported. Therefore, the objective of this article was to describe beverage patterns during adolescence and the associations between the adolescent beverage patterns and anthropometric measures at age 17 years.

METHODS

Study Design

Secondary analyses of data collected as part of the longitudinal Iowa Fluoride Study and Iowa Bone Development Study, which investigated relationships among dietary exposures, fluoride exposures, oral health, and bone health, were conducted.[6,17-20] Food and beverage intakes, oral health behaviors, and systemic health information have been collected by questionnaire at approximately 6-month intervals since the children's birth. Dental examinations and/or dual-energy x-ray absorptiometry examinations were conducted during clinic visits when the children were approximately 5, 9, 13, and 17 years of age for assessment of oral and bone health. All components of the Iowa Fluoride Study and Iowa Bone Development Study were approved by the Institutional Review Board at the University of Iowa. Written informed consent was obtained from mothers at recruitment and from parents at clinic visits, while written assent was obtained from children beginning at 13 years of age.

Subjects

Mothers of newborn infants were recruited at the time of their child's birth between 1992 and 1995 for their child's participation in the Iowa Fluoride Study. A total of 1,382 mothers and newborns were originally in the study after recruitment and returned at least 1 questionnaire at 6 weeks, 3 months, or 6 months of age. Attrition averaged about 7% per year thereafter through dental examinations at age 17 years. Children who participated in the clinic examination at age 17 years (n=428), and returned at least one questionnaire completed between ages 13.0 and 14.0 years and a second questionnaire between ages 16.0 and 17.0 years were included in the current analyses (n=369). Of children who met the study's inclusion criteria, 97% (n=359) had data for mother's education, and 95% (n=352) had data for family income. Sex ($P=0.45$), mother's education ($P=0.58$), and income ($P=0.74$) did not differ between subjects meeting inclusion criteria and those excluded due to missing beverage data.

Parents whose children attended the clinic visit at age 5 years were invited to participate in the Iowa Bone Development Study; parental weight and height were measured and bone mineral density and content were assessed at that time. Of children who met the study's inclusion criteria, weight data were available for 64% (n=237) of mothers, height data for 64% (n=238), and both weight and height for 64% (n=236).

Data Collection

The Iowa Fluoride Study questionnaires queried information regarding family demographic characteristics, oral health behaviors, systemic health, and food and beverage intakes. Beverage frequency questionnaires, previously validated using 3-day diaries for reference in 9-year-old children, queried whether the beverage was consumed during the previous week and, if consumed, the frequency and quantity of consumption.[18] Individual beverage types (eg, 100% juice, milk, water, soda pop, sport drinks, ready-to-drink beverages, and reconstituted beverages) were queried. If a beverage was consumed, then the participant was asked to provide detailed product information, including the brand, type, and flavor. Beverages were collapsed into four categories: 100% juice, milk, water and other sugar-free beverages (SFB), and SSBs. Mean daily beverage intakes were averaged from all available surveys of subjects aged 13 to 17 years. The means of the four beverage categories were used for clustering.

Weight and height were measured at the clinic visit at age 17 years, with participants wearing lightweight clothing and without shoes. Weight was measured using a standard physician's scale; height was measured using a stadiometer. BMI was calculated from weight and height measures. Participants were categorized as normal weight (BMI <24.9), overweight (BMI=25.0 to 29.9), or obese (BMI >30) using Centers for Disease Control and Prevention adult guidelines.[21] Adult guidelines were used because the 85th and 95th percentiles used to define "at risk for overweight" and "overweight" for children overlap adult standards beginning at age 17 years.[21]

Statistical Analyses

Cross-sectional analyses of longitudinal beverage exposures and anthropometric measures at age 17 years were