CORRELATES OF BEVERAGE INTAKE IN ADOLESCENT GIRLS: THE NATIONAL HEART, LUNG, AND BLOOD INSTITUTE GROWTH AND HEALTH STUDY

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Objectives To examine longitudinal changes in consumption of 6 types of beverages (milk, diet and regular soda, fruit juice, fruit-flavored drinks, and coffee/tea) in girls and determine the relationship between beverage intake, body mass index (BMI), and nutrient intake.

Study design Three-day food diaries were included from black (1210) and white (1161) girls who participated in the National Heart, Lung, and Blood Institute Growth and Health Study. Diaries were recorded during annual visits beginning at ages 9 or 10 years until age 19 years. Mixed models estimated the association of (1) visit and race with average daily consumption of beverages and (2) beverage intake with BMI and average daily intake of total calories, sucrose, fructose, total sugars, and calcium.

Results For girls of both races, milk consumption decreased and soda consumption increased with time. Changes in beverage intake with time varied by race for all beverages except fruit juice. For all beverage categories, consumption was associated with caloric intake. Of all beverages, increasing soda consumption predicted the greatest increase of BMI and the lowest increase in calcium intake.

Conclusions Public health efforts are needed to help adolescents gain access to and choose healthful beverages and decrease intake of beverages of minimal nutritional value. (J Pediatr 2006;148:183-7)
changes with time in intake of milk, soda, diet soda, fruit juice, fruit drinks, and coffee or tea. We also estimated the association of each of these beverages with BMI and average daily intake of total calories, sucrose, fructose, total sugars, and calcium.

METHODS

Participants and Recruitment

As previously reported, the multi-site NGHS involved 2379 girls (9 or 10 years old at study entry) who identified themselves (by using United States census categories for race/ethnicity) as “black” or “white,” non-Hispanic, with racially concordant parents or guardians. The University of California at Berkeley recruited girls from public and parochial schools in the Richmond Unified School District; the University of Cincinnati/ Cincinnati Children’s Hospital Medical Center recruited girls from all public and parochial schools in Hamilton County; Westat, Inc./Group Health Association in Rockville, Maryland, randomly selected girls from families who were enrolled in a large Washington, DC-area health maintenance organization and, because of an insufficient number of white families with age-eligible girls, recruited girls from several local Girl Scout troops in the same geographic area. Child assent and parental consent was obtained. The study was approved by the institutional review boards of all participating institutions. Only instruments relevant to this report are described.

Measurements and Procedure

Girls participated in 10 approximately annual assessment “visits” at participating sites or, when the girl was unable to travel to the site, at her home. Retention was high at visits 2, 3, and 4 (96%, 94%, and 91%, respectively), declined to 82% at visit 5, and increased to 89% at visit 10. Data collection commenced in 1987 and ended in 1997. Demographic information was collected at study entry from girls and their parents (or guardians). Race (black or white) was defined by self-report, by using US Census categories. Participants’ age was recorded as their age at last birthday. BMI was calculated annually on the basis of the research staff’s measures of girls’ height and weight (weight in kilograms divided by height in meters squared).

Food Intake

Dietary assessment for this study included a 3-day food record that provided high reporting accuracy, as documented in the initial validation study. Three-day food records were collected annually for visits 1 to 5 and then again at visits 7, 8, and 10. A standardized procedure was used to record all food and beverage intake. More specifically, dietitians trained and certified by the University of Minnesota Nutrition Coordinating Center (NCC) and retrained in later years by staff at the Dietary Data Entry Center in Cincinnati, used age-appropriate materials to instruct girls to record all food and drink for 3 consecutive days (2 weekdays and 1 weekend day). Dietitians reviewed the completed food records individually with the girls, using standard probes to answer girls’ questions or clarify incomplete responses. Default values adapted from the NCC were used for missing information on food amounts or preparation methods. To minimize the use of defaults, staff had a notebook of labels and label pictures to help girls describe foods. Food records were coded and analyzed for nutrients using the Food Table version 19 of the NCC nutrient database initially, with updated versions being used as the study progressed.

The amount and type of beverages consumed were recorded in the food diaries. For this analysis, beverages were coded as: 1) “milk” (all kinds of cow’s milk, including flavored varieties); 2) “regular soda” (all non-diet carbonated beverages, except water); 3) “diet soda” (all diet carbonated beverages, excluding water); 4) “fruit juice” (fruit and vegetable juices); 5) “fruit drinks” (fruit-flavored drinks, punches, ades that contain <100% juice); and 6) “coffee/tea.” These 6 categories captured 88.2% of all beverages in the food diaries; water (tap or carbonated) comprised >90% of the excluded beverages. At each visit, for each beverage category, average grams consumed per day were determined by adding the daily amounts and dividing the total by the number of days associated with a visit.

Intake of total energy (kilocalories, kcal), sucrose (grams, g), fructose (g), total sugars (g, computed as the sum of sucrose, lactose, galactose, glucose, and fructose), and calcium (milligrams, mg) were computed by adding the nutrient values of all foods and beverages consumed during each day in the visit, then averaging across the 3 days.

Data Analysis

Visit number served as a proxy for age (mean ages at the visits are shown in Table I). To examine age- and race-related differences in average daily beverage consumption (in grams), a separate model was constructed for each type of beverage. The predictors were visit, race, and the visit-by-race interaction. All models adjusted for site differences and daily total caloric intake. Because these variables were not of substantive interest, their effects are not reported. Beverage consumption reports at different visits were not independent, therefore mixed models (PROC MIXED) were used to account for the within-girl correlation. The within-girl covariance structure was modeled as unstructured (type = UN in the REPEATED statement of PROC MIXED), on the basis of comparisons of the Akaike and Bayesian information criteria in models with different covariance structures but all else held constant. Main effects and interactions were evaluated by using likelihood ratio tests, which have a chi-square distribution.

Separate mixed models were used to estimate the relations between beverage consumption and each dependent variable: BMI, and average daily intake of total calories, sucrose, fructose, total sugars, and calcium. Consumption of different beverages might be related (eg, girls who drink diet sodas might tend to not drink regular sodas), therefore models
adjusted for all other beverages when evaluating the relation between consumption of a given beverage and the outcomes of interest. All models were adjusted for site, race, and (except when predicting total caloric intake) caloric intake.

RESULTS

Changes in Beverage Consumption Across Adolescence

In all, 2371 girls (1210 black and 1161 white; 99.7% of the NGHS participants) completed a food diary at 1 or more visits. Average daily consumption of each beverage among black and white girls during the course of the study is shown in Table I.

At each visit, black girls had consumed less milk than white girls did. White girls' milk intake did not change between visits 1 and 3 (ages 9.5-11.5 years), but decreased steadily after visit 3; from visit 3 until visit 7 (ages 11.5-15.5 years), black girls' milk consumption decreased at a greater rate than white girls' did. Regular soda consumption increased in a nearly linear fashion across visits. The rate of increase in regular soda consumption was greater among black girls than among white girls until visit 8 (age 16.5 years), when black girls' soda intake leveled off but white girls' soda intake continued to increase. Black girls' intake of diet soda remained uniformly low across all visits (≤11.5 grams per day, on average), whereas white girls' intake of diet soda increased steadily throughout the entire period. In both groups, intake of fruit juice changed little between visits 1 and 4 (ages 9.5-12.5 years), and then increased slightly after visit 5. At all visits, black girls consumed more fruit drinks than white girls drank. White girls' consumption of fruit drinks changed little during the course of the study, except for modest increases at visits 4 and 8; in contrast, black girls' intake of fruit drinks increased at a much greater rate between visits 3 and 10 (ages 11.5-18.6 years). On average, black girls consumed less coffee/tea than white girls did. White girls' intake of coffee/tea did not increase between visits 1 and 4 (ages 9.5-12.5 years), but it increased steadily after visit 4. Black girls' intake of coffee/tea also increased after visit 4, but to a lesser extent than among white girls.

Table II shows the estimated effects of beverage intake on each of the outcomes. Only soda intake was associated with BMI (chi-square(1) = 4.62, P <.05).

Consumption of beverages was associated with an increase in average daily caloric intake (chi-square(1) = 49.95-2072.68, P values <.0001).

Drinking milk, soda, fruit drinks, or coffee/tea was associated with increased average daily sucrose consumption (chi-square(1) = 5.85-469.34, P values <.05). In contrast, diet soda consumption was associated with a significant decrease in average daily sucrose intake (chi-square(1) = 6.63, P <.01). Fruit juice consumption was not associated with average daily sucrose intake. Drinking soda, fruit juice, or fruit drinks was strongly associated with increased average daily fructose consumption (chi-square(1) = 7809.30-13752.38, P values <.0001), whereas drinking milk or coffee/tea was associated with decreased average daily fructose intake (chi-square(1) = 22.79 and 8.25, respectively; P values <.05). Diet soda intake was not associated with average daily fructose. All beverages except diet soda were associated with increased intake of average daily total sugar intake (chi-square(1) = 213.98-5300.18, P values <.0001). Diet soda consumption was not associated with average daily total sugar intake.

Correlates Of Beverage Intake In Adolescent Girls: The National Heart, Lung, And Blood Institute Growth And Health Study

1Tap or bottled water and alcohol were excluded in the analyses.
2Artificially sweetened carbonated soft drinks, diet or low-calorie soft drinks.
3Regular soda; excludes artificially sweetened non-carbonated drinks, sports drinks.
4Sweetened carbonated soft drinks; excludes diet or low-calorie carbonated beverages or water.
5Sweetened non-carbonated fruit-flavored drinks, punches, or aces, bottled, canned, frozen; excludes artificially sweetened non-carbonated drinks, sports drinks.

### Table 1. Mean daily consumption (standard error) of each type of beverage (in grams), by race and visit

<table>
<thead>
<tr>
<th>Race</th>
<th>Beverage</th>
<th>1 (9.5)</th>
<th>2 (10.5)</th>
<th>3 (11.5)</th>
<th>4 (12.5)</th>
<th>5 (13.5)</th>
<th>7 (15.5)</th>
<th>8 (16.5)</th>
<th>10 (18.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>Regular soda</td>
<td>135.45 (8.29)</td>
<td>146.33 (8.54)</td>
<td>201.70 (8.63)</td>
<td>216.56 (9.32)</td>
<td>242.12 (9.13)</td>
<td>274.48 (9.74)</td>
<td>329.70 (9.90)</td>
<td>377.02 (9.09)</td>
</tr>
<tr>
<td></td>
<td>Diet soda</td>
<td>22.36 (4.52)</td>
<td>33.82 (4.66)</td>
<td>37.39 (4.71)</td>
<td>49.60 (5.09)</td>
<td>52.65 (4.99)</td>
<td>71.48 (5.32)</td>
<td>72.63 (5.41)</td>
<td>81.86 (4.96)</td>
</tr>
<tr>
<td></td>
<td>Milk</td>
<td>352.04 (7.22)</td>
<td>340.00 (7.44)</td>
<td>348.83 (7.52)</td>
<td>320.07 (8.12)</td>
<td>306.28 (7.96)</td>
<td>290.20 (8.49)</td>
<td>262.24 (8.63)</td>
<td>241.99 (7.92)</td>
</tr>
<tr>
<td></td>
<td>Coffee/tea</td>
<td>19.78 (3.45)</td>
<td>20.09 (3.55)</td>
<td>22.74 (3.59)</td>
<td>22.35 (3.88)</td>
<td>27.90 (3.80)</td>
<td>53.31 (4.06)</td>
<td>67.44 (4.12)</td>
<td>105.60 (3.78)</td>
</tr>
<tr>
<td></td>
<td>Fruit juice</td>
<td>110.46 (4.94)</td>
<td>106.70 (5.09)</td>
<td>111.64 (5.15)</td>
<td>103.80 (5.56)</td>
<td>120.58 (5.45)</td>
<td>124.81 (5.81)</td>
<td>119.38 (5.91)</td>
<td>128.68 (5.42)</td>
</tr>
<tr>
<td></td>
<td>Fruit drinks†</td>
<td>78.41 (4.39)</td>
<td>82.23 (4.53)</td>
<td>81.91 (4.57)</td>
<td>95.39 (4.94)</td>
<td>84.41 (4.84)</td>
<td>80.26 (5.17)</td>
<td>96.92 (5.25)</td>
<td>87.16 (4.82)</td>
</tr>
<tr>
<td>Black</td>
<td>Regular soda</td>
<td>134.53 (7.85)</td>
<td>173.15 (7.87)</td>
<td>210.44 (7.76)</td>
<td>244.96 (8.33)</td>
<td>299.41 (8.13)</td>
<td>326.06 (8.79)</td>
<td>377.02 (9.09)</td>
<td>383.48 (8.11)</td>
</tr>
<tr>
<td></td>
<td>Diet soda</td>
<td>7.20 (1.75)</td>
<td>11.53 (1.75)</td>
<td>8.38 (1.73)</td>
<td>10.28 (1.86)</td>
<td>8.59 (1.81)</td>
<td>10.21 (1.96)</td>
<td>8.65 (1.95)</td>
<td>9.46 (1.81)</td>
</tr>
<tr>
<td></td>
<td>Milk</td>
<td>244.13 (5.36)</td>
<td>237.99 (5.37)</td>
<td>214.83 (5.30)</td>
<td>180.44 (5.68)</td>
<td>160.30 (5.55)</td>
<td>150.45 (6.00)</td>
<td>147.57 (5.96)</td>
<td>144.62 (5.53)</td>
</tr>
<tr>
<td></td>
<td>Coffee/tea</td>
<td>19.50 (2.61)</td>
<td>18.94 (2.61)</td>
<td>17.55 (2.58)</td>
<td>18.66 (2.77)</td>
<td>23.03 (2.70)</td>
<td>29.08 (2.92)</td>
<td>41.11 (2.90)</td>
<td>46.84 (2.69)</td>
</tr>
<tr>
<td></td>
<td>Fruit juice</td>
<td>108.36 (4.86)</td>
<td>103.91 (4.87)</td>
<td>105.43 (4.81)</td>
<td>93.32 (5.16)</td>
<td>110.02 (5.03)</td>
<td>115.38 (5.44)</td>
<td>105.80 (5.41)</td>
<td>119.81 (5.02)</td>
</tr>
<tr>
<td></td>
<td>Fruit drinks‡</td>
<td>134.68 (6.78)</td>
<td>144.47 (6.80)</td>
<td>169.44 (6.71)</td>
<td>173.27 (7.19)</td>
<td>159.73 (7.02)</td>
<td>212.74 (7.59)</td>
<td>202.34 (7.54)</td>
<td>204.41 (7.00)</td>
</tr>
</tbody>
</table>

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1Tap or bottled water and alcohol were excluded in the analyses.
2Artificially sweetened carbonated soft drinks, diet or low-calorie soft drinks.
3Whole, low-fat, skin milk, non-fat dry milk from powder, buttermilk, chocolate milk or cocoa, evaporated milk, milkshakes; excludes chocolate-flavored drink, strawberry-flavored drink; Instant Breakfast, coconut milk, soy milk, yogurt drink.
4Coffee, caffeinated or decaffeinated, brewed or instant, cappuccino, postum, international coffees, tea, caffeinated or decaffeinated, brewed or instant tea mixtures with or without sugar or artificial sweetener, herbal tea; excludes chocolate-flavored breakfast or diet drinks.
5Coffee or vegetable juice; bottled, canned, fresh, frozen, sweetened or unsweetened; fruit nectars.
6Sweetened non-carbonated fruit-flavored drinks, punches, or aces, bottled, canned, frozen; excludes artificially sweetened non-carbonated drinks, sports drinks.
Milk consumption and, to a lesser extent, diet soda consumption were associated with increased average daily calcium intake (chi-squares(1) = 73.35 and 10000.65, respectively; P values <.0001). In contrast, consumption of regular soda, fruit drinks, or coffee/tea was associated with significant decreases in average daily calcium intake (chi-squares(1) = 6.46–94.17, P values <.05). Finally, fruit juice was not associated with average daily calcium intake.

**DISCUSSION**

Our study examined changes in beverage consumption from childhood (age 9/10 years) to late adolescence (age 18/19 years) in a large cohort of black and white girls. We found that beverage intakes changed considerably with time, although for all beverages except fruit juice the magnitude or specific timing of these age-related changes varied by race. In both black and white girls, consumption of milk decreased by >25% during the course of the study. The decline in milk intake during adolescence has been reported in previous studies and may reflect a decrease in breakfast consumption or increased intake of meals away from home. Lower milk intakes in black compared to white children have been found in other studies and may, in part, be a function of a higher prevalence of lactose intolerance in black children.

Consistent with previous studies, we found a very strong association between milk intake and calcium intake. That many girls drink less milk as they get older and, consequently, have reduced calcium intake, is highly problematic, because adolescence is a critical period for accumulating peak bone mass. Moreover, calcium intake has a protective effect of reducing risk for hypertension.

By far the greatest changes with time were found for soda intakes (both regular and diet). Consumption of regular soda increased almost 3-fold during the course of this 10-year study. In both groups, regular soda intake moved from second place at the youngest age level (albeit in a virtual tie with fruit juice among black girls) to first place at the oldest age level. Other studies have shown that in adolescent girls, regular soda intake is considerable and may be the result of sodas often being served with fast foods. Our data showed that for every 100 g of soda consumed, the average daily total caloric intake increased by about 82 calories. Although 100 g of soda has only 41 kcal, this finding suggests consumption of soda may be related to other eating habits resulting in additionally higher caloric intake than the intake attributable to soda. Efforts to decrease soda intake may be most successful when they are undertaken in the context of efforts to decrease consumption of fast-food meals.

Soda consumption also was associated with a considerably decreased intake of calcium, as has been shown in some studies but not all studies. Decreased calcium intake, in turn, may contribute to the risk for obesity through the effects of calcium on fat absorption or the regulation of lipogenesis and lipolysis within adipocytes.

Finally, BMI increased by 0.01 unit for every 100 g of regular soda consumed. This represents a small increase in BMI; however, this increase was above and beyond the impact of total caloric intake on BMI. Other studies also have shown positive associations between sugar-added drink (combining sodas, fruit drinks, and sweetened tea or coffee) intake or intake of regular soda and weight gain. The longer-term effect of soda consumption in adolescence on BMI and weight requires further study, because emerging evidence suggests that increased consumption of high-fructose corn syrup in beverages may influence obesity risk through increased energy intake and hepatic lipogenesis.

Across all ages, white girls consumed more diet soda than black girls, and black girls consumed more fruit drinks than white girls. We speculate that the choice of diet soda in white girls may reflect their greater drive for thinness, relative to black girls. The unexpected finding of a positive association between diet soda consumption and calcium intake possibly reflects that girls who drank diet soda were diet-conscious, which may have led them to consume more calcium in a variety of forms (not just milk or fruit juices containing calcium, because the models controlled for other beverages).

Overall, coffee/tea intake was very low, suggesting that these are not widely chosen beverages among adolescent girls. Drinking tea or coffee was associated with

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**Table II. Relationship among beverage consumption (in units of 100 g/day) and outcomes of body mass index and average daily intake of total energy, sucrose, fructose, total sugars, and calcium**

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Beverage parameter estimate (Standard Error)</th>
<th>Milk</th>
<th>Regular soda</th>
<th>Diet soda</th>
<th>Fruit juice</th>
<th>Fruit drinks</th>
<th>Coffee/tea</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td></td>
<td>-0.002 (0.006)</td>
<td>0.011 (0.005)*</td>
<td>-0.010 (0.013)</td>
<td>0.005 (0.007)</td>
<td>0.009 (0.007)</td>
<td>0.005 (0.013)</td>
</tr>
<tr>
<td>Daily energy (kcal)</td>
<td></td>
<td>96.4 (2.2)*</td>
<td>81.5 (1.7)*</td>
<td>29.1 (4.1)*</td>
<td>81.3 (2.7)*</td>
<td>81.3 (2.3)*</td>
<td>46.3 (4.3)*</td>
</tr>
<tr>
<td>Daily sucrose (g)</td>
<td></td>
<td>0.2 (0.1)*</td>
<td>0.6 (0.1)*</td>
<td>-0.5 (0.2)*</td>
<td>0.2 (0.1)</td>
<td>2.3 (0.1)*</td>
<td>3.8 (0.2)*</td>
</tr>
<tr>
<td>Daily fructose (g)</td>
<td></td>
<td>-0.15 (0.03)*</td>
<td>3.99 (0.03)*</td>
<td>-0.01 (0.06)</td>
<td>4.89 (0.04)*</td>
<td>3.43 (0.03)*</td>
<td>-0.18 (0.06)*</td>
</tr>
<tr>
<td>Daily total sugar (g)</td>
<td></td>
<td>4.3 (0.1)*</td>
<td>7.8 (0.1)*</td>
<td>-0.3 (0.2)</td>
<td>9.4 (0.1)*</td>
<td>8.9 (0.1)*</td>
<td>3.4 (0.2)*</td>
</tr>
<tr>
<td>Daily calcium (mg)</td>
<td></td>
<td>103.1 (0.8)*</td>
<td>-7.0 (0.7)*</td>
<td>13.7 (1.6)*</td>
<td>1.7 (1.1)</td>
<td>-2.3 (0.9)*</td>
<td>-0.67 (1.7)*</td>
</tr>
</tbody>
</table>

Parameter estimates were derived from mixed models with outcomes as the dependent variable, controlling for the consumption of the other types of beverages, site, visit, race, and total caloric intake (in all models except that with caloric intake as the dependent variable).

The estimates are interpreted as the predicted change in the outcome for each additional 100 g of a given beverage consumed per day.

Likelihood ratio test: *P < .05, †P < .01, ‡P < .001, ¶P < .0001 (H1: parameter estimate = 0).
increased average daily sucrose and total sugar intake, perhaps because sugar enhances the palatability of these beverages. Coffee/tea intake also was associated with greater average daily total energy intake, an effect that may have been driven by consumption of popular coffee beverages (eg, latte), which are high in calories.

Several limitations need to be considered. As is typical for epidemiological studies, dietary information was based on self-report and may therefore be subject to recall errors or under-reporting. Before data entry, food was reduced into main ingredients, making it impossible to relate beverage to consumption of specific foods or type of meals (eg, fast food). Because the NGHS started out with a limited age range of 9- to 10-year-old children and did not collect food diaries in every year, it was not possible to report beverage consumption for each age. Finally, although demographically diverse in terms of geographic location and socioeconomic status, the NGHS is not a national sample of girls. Therefore, no information was available on ethnic minority groups such as Hispanic populations. These limitations are offset by several strengths, such as the large number of black girls, low dropout rate, and availability of 3 days of food intake data.

Our findings suggest that public health efforts are needed to promote healthful beverage choices and decreased soda consumption in adolescent girls to positively influence health outcomes. A concerted effort will be required by governmental institutions, schools, parents, and producers of nutritional beverages to counteract the strong influence of the “toxic food environment” in promoting sugar-sweetened and diet beverages.


REFERENCES