Mothers’ intake of sugar-containing beverages during pregnancy and body composition of their children during childhood: the Generation R Study¹–³

Vincent Jen,⁴,⁵ Nicole S Erler,⁵,⁶,⁸ Myrte J Tielenmans,⁴,⁵,⁸ Kim VE Braun,⁵ Vincent WV Jaddoe,⁴,⁵,⁷ Oscar H Franco,⁵ and Trudy Voortman⁴,⁵*¹

⁴Generation R Study Group and Departments of ⁵Epidemiology, ⁶Biostatistics, and ⁷Pediatrics, Erasmus University Medical Center, Rotterdam, Netherlands

ABSTRACT

Background: High intake of sugar-containing beverages (SCBs) has been linked to increased risk of obesity. However, associations of SCB intake during pregnancy with child body composition have been unclear.

Objectives: We explored whether SCB intake during pregnancy was associated with children’s body mass index (BMI) and detailed measures of body composition. In addition, we examined different types of SCBs (i.e., fruit juice, soda, and concentrate).

Design: We included 3312 mother-child pairs of the Generation R Study, a prospective cohort from fetal life onward in the Netherlands. Energy-adjusted SCB intake was assessed in the first trimester with a food-frequency questionnaire. Anthropometric data of the children were collected repeatedly at 6 y of age, and BMI was calculated. At 6 y of age, we further measured fat mass index (FMI) and fat-free mass index with dual-energy X-ray absorptiometry. All outcomes were sex- and age-standardized. Associations of SCB intake with children’s BMI trajectories and body composition were analyzed with multivariable linear mixed and regression models.

Results: Results from linear mixed models showed that, after adjustment for confounders including the SCB intake of the child itself, mothers’ total SCB intake was positively associated with children’s BMI at 6 y of age [per serving per day: 0.04 SD score (SDS); 95% CI: 0.00, 0.07 SDS]. In addition, intakes of total SCBs and fruit juice, but not of soda or concentrate, were associated with a higher FMI [total SCBs: 0.05 SDS (95% CI: 0.01, 0.08 SDS); fruit juice: 0.04 SDS (95% CI: 0.01, 0.06 SDS)] of the 6-y-old children. These associations remained significant (P < 0.05) after additional adjustment for gestational weight gain, birth weight, and children’s insulin concentrations.

Conclusion: Our study suggests that maternal SCB intake during pregnancy is positively associated with children’s BMI during early childhood and particularly with higher fat mass. Am J Clin Nutr 2017;105:834–41.

Keywords: adiposity, body composition, childhood, children, cohort, epidemiology, fetal programming, nutrition, pregnancy

INTRODUCTION

The rapidly increasing prevalence of childhood overweight and obesity is of great concern because excess weight during childhood is associated with health problems over the child’s life course, including cardiometabolic disturbances (1). Intake of sugar-containing beverages (SCBs)⁹ has increased substantially during the past decades (2). Several studies have revealed that high intakes of SCBs by adults and children are related to overweight and obesity (2–4). Although this relation has been well established in the general population, the association of pregnant women’s SCB intake with their offspring’s growth and body composition has been unclear. Intake of SCBs during pregnancy may influence the intrauterine programming of the child toward obesity (5). Potential effects of SCB intake during pregnancy on child body composition may be hypothesized by several mechanisms including changes in the insulin response.

To our knowledge, only one study has prospectively investigated the association between intake of SCBs during pregnancy and child body weight (5). In a US cohort of 285 mothers and their infants, Phelan et al. (5) observed that intakes of soft drinks and fruit juice during pregnancy were not associated with child birth weight or weight at 6 mo of age. However, the later onset of childhood overweight and obesity was not explored. Also, more detailed measurements of body composition (i.e., fat mass and lean mass) were not explored in the study. Previous studies in the

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³Supplemental Tables 1–4 are available from the “Online Supporting Material” link in the online posting of the article and from the same link in the online table of contents at http://ajcn.nutrition.org.
⁴These authors contributed equally to this work.
*To whom correspondence should be addressed. E-mail: trudy.voortman@erasmusmc.nl.
⁹Abbreviations used: DXA, dual-energy X-ray absorptiometry; FMI, fat-free mass index; FFQ, food-frequency questionnaire; FMI, fat mass index; SCB, sugar-containing beverage; SDS, SD score.

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general population have suggested that higher intake of SCBs may be associated with a higher fat mass but not lean mass (6–8). Therefore, we hypothesized that mothers’ SCB intakes during pregnancy would be associated with higher BMI (in kg/m²) and, in particular, with higher fat mass in their children.

The aim of this study was to explore the associations of mothers’ SCB intakes during early pregnancy with BMI trajectories of their children at 6 y of age and with the children’s fat masses and fat-free masses at 6 y of age. In addition, we analyzed whether these associations differed by types of SCBs (fruit juice, concentrate, and soda).

METHODS

Study design

This study was embedded in the Generation R Study, which is an ongoing population-based prospective cohort from fetal life onwards in Rotterdam, Netherlands. Details of the study design and procedures have been described previously (9). The study was approved by the Medical Ethics Committee at Erasmus Medical Center. Pregnant women with an expected delivery date between 2002 and 2006 were included. Written informed consent was obtained for all participants. No measurements were performed when a child was not willing to participate.

Study population

The selection process of the population for analysis is shown in Figure 1. We restricted our analyses to 4545 women who were of Dutch origin. Of these women, 3558 individuals provided valid dietary data of whom 3478 had singleton live births. Of these children, 3312 had available information on BMI for ≥1 time point. More detailed body-composition outcomes were available for 2660 children at 6 y of age.

Dietary assessment of the mother

We assessed dietary intake in pregnant women at enrollment (median: 13.4 wk of gestation; 95% CI: 9.9, 22.8 wk of gestation) with the use of a self-administered semiquantitative food-frequency questionnaire (FFQ) (10). The FFQ covered intakes of 293 food items that were consumed in the preceding 3 mo and included questions about their consumption frequencies and portion sizes. We obtained information on the following 3 types of SCBs: soda (soft drinks, sports drinks, and energy drinks), fruit juice (fresh and boxed; 100% fruit juice only), and concentrate (juice and lemonades concentrates with added sugars). In this study, we defined total intake of SCBs as the sum of soda, fruit juice, and concentrate intakes, which were expressed as servings/d. We chose not to include sugar-containing milk products because of their different macronutrient composition (11). Daily energy and macronutrient intakes of the pregnant women were calculated with the use of the Dutch food-composition table (12).

Child anthropometric measures and body composition

Children visited Child Health Centers at the median (95% CI) ages of 1 mo (1, 2 mo), 2 mo (2, 3 mo), 3 mo (3, 4 mo), 4 mo

(4, 5 mo), 6 mo (5, 8 mo), 11 mo (10, 13 mo), 14 mo (14, 16 mo), 18 mo (17, 21 mo), 25 mo (23, 28 mo), 31 mo (29, 34 mo), 37 mo (35, 41 mo), and 46 mo (44, 48 mo). During all visits, heights and weights of the children were measured with the children not wearing shoes and heavy clothing. When children were a median age of 6 y (95% CI: 5.7, 6.8 y), a well-trained staff measured children’s anthropometric variables and body compositions in a dedicated research center of Sophia Children’s Hospital in Rotterdam (9). We measured height in a standing position to the nearest millimeter with the use of a Harpenden stadiometer (Holtain Ltd.). Weight was measured with the use of a mechanical personal scale (SECA). BMI was calculated for all time points.

In addition, to measure the body composition of children at 6 y of age, we used a dual-energy X-ray absorptiometry (DXA) scanner (iDXA; Ge-Lunar, 2008) (9). The DXA scanner measured fat mass, lean mass, and bone mass of the total body with the use of enCORE software (v.13.6; GE Healthcare). We calculated the fat mass index (FMI) as fat mass (kilograms) divided by the square of height (square meters) and the fat-free mass index (FFMI) as lean mass (kilograms) plus bone mass (kilograms) divided by the square of height (square meters). All outcomes were standardized for age and sex on the basis of the Generation R Study population. We used cutoffs that were recommended by Cole et al. (13) to determine the weight status of each child at 6 y of age as normal or as overweight or obese.

Covariates

At enrollment, we used self-administered questionnaires to collect information on maternal age, marital status (no partner compared with married or living together), education (low compared with high) (14), use of folate acid supplements (never, started during the first 10 wk, or started periconceptional), parity (nulliparous compared with multiparous), and net household income [<€2400 compared with ≥€2400/mo (equivalent to <$2770 and ≥$2770/mo)]. Maternal height and weight were measured at enrollment to calculate BMI, and a fetal ultrasound was performed to determine the gestational age. The maternal diet quality (range: 0 to 14) was scored on the basis of adherence to Dutch dietary guidelines with the use of the dietary intake data that were obtained from the FFQ at enrollment. This score included items on intakes of vegetables, fruit, legumes, whole grains, nut, fish, dairy, tea, soft fat and oils, red meat, alcohol, salt, and folic acid supplements (15). Psychiatric symptoms during pregnancy (Global Severity Index; range: 0 to 4) (16) and vomiting (≥1 compared with <1 time/wk) were also assessed with the use of questionnaires at enrollment but also during pregnancy.

With the use of questionnaires, we assessed smoking (never, until the pregnancy was known, or continued during pregnancy) and alcohol consumption (never, until the pregnancy was known, occasionally during pregnancy, or frequently during pregnancy). Body weight was measured in each trimester, and the total gestational weight gain was calculated by subtracting weight that was assessed at enrollment from weight that was measured in the third trimester (9).

After pregnancy, we obtained information on pregnancy-related diseases including pregnancy-induced hypertension, pre-eclampsia (17), and gestational diabetes from midwives and obstetricians. We collected information on child sex, gestational age, and birth weight from hospital medical records, and z scores were calculated for birth weight with the use of reference data (18). When a child was 6 y old, information on screen time (watching television and the use of the computer in hours per day), sports participation (yes or no), and intake of SCBs (servings per day) was obtained with the use of a questionnaire. In addition, nonfasting blood was collected at the research center, and insulin concentrations were analyzed with the use of enzymatic methods (Cobas 8000; Roche) (19).

Statistical analyses

To reduce the potential bias that might have been associated with missing data (≥22.8% for covariates), we used a fully Bayesian approach that allowed for the simultaneous imputation of missing covariates and an analysis of associations with multiple cross-sectional and longitudinal outcomes. A detailed description of this approach has been described elsewhere (20). Results of the main analyses were obtained directly from the Bayesian approach and are presented as posterior means and 95% credible intervals. To perform subsequent sensitivity analyses, 10 imputed data sets were created with the use of a random selection of imputed values from the Bayesian approach. These analyses were performed separately in each of the imputed data sets, and pooled effect estimates and 95% CIs are reported in this study. All decisions with regards to the structure of the final models were based on preliminary analyses.

Intake of SCBs was examined both with and without energy adjustment. Adjustment for energy intake was performed with the use of the residual method (21). We reported results from energy-adjusted SCBs as the main results in this study.

We specified linear mixed models to analyze associations of SCB intake during pregnancy with trajectories of children’s BMI between 1 mo and 6 y of age. To explore these associations, we constructed 3 models with a fixed-effects structure that included maternal SCB intake and possible confounders and a random-effects structure that including a random intercept and slope (for age). In model 1 (crude model), we adjusted for child sex and further included energy intake in the model. Model 2 (confounder model) was further adjusted for the following covariates: maternal parity, age, gestational age at enrollment, marital status, income, education, psychiatric symptoms during pregnancy, protein intake (percentage of energy intake), diet quality, smoking during pregnancy, alcohol intake during pregnancy, use of folic acid supplements, and child sports and screen times. The confounders were selected on the basis of previous literature and a ≥10% change in effect estimates (22). In model 3 (SCB child model), we adjusted for child SCB intake at age 6 y in addition to the confounders used in model 2 (4). We considered the possibility that SCB intake could modify the children’s BMI trajectories as well as the nonlinear effect of SCB intake with the use of interaction terms and natural cubic splines for SCB intake.

In addition, we specified linear regression models to examine the association between intake of SCBs during pregnancy and children’s FMI and FFMI at age 6 y. We used the previously mentioned models 2 and 3 to which we further added child age at the 6-y visit. The analyses for BMI trajectories, FMI, and FFMI were modeled jointly in the Bayesian analysis.
To study whether the associations differed by the type of SCB, the analyses were repeated for intakes of fruit juice, concentrate, and soda instead of total SCB intake.

For associations that were significant \( (P < 0.05) \) in model 3, we also examined the role of the potential mediators gestational weight gain, child birth weight, maternal BMI at enrollment (23), and child serum insulin concentrations at 6 y of age (24) by including them in the model. Also, we tested whether associations were modified by child sex (24) or by maternal BMI at enrollment by adding the product term of the potential effect modifier and maternal SCB intake to models 1 and 2. Main analyses were stratified if the interaction term was significant \( (P < 0.05) \).

To test the robustness of our findings, we performed 2 sensitivity analyses. First, we repeated our analyses by restricting them to women who vomited <1 time/wk because vomiting in pregnancy may alter dietary intake (25). Second, we restricted analyses to women who did not experience comorbidities during pregnancy (i.e., diabetes mellitus, gestational diabetes, or hypertensive disorders) because these comorbidities could alter the maternal diet during pregnancy and may affect child birth weight (26, 27). All statistical analyses were performed with the use of SPSS 21.0 software (IBM Corp.), R version 3.3.1 software (The R Foundation for Statistical Computing) (28), and JAGS software (version 4.2.0; http://mcmc-jags.sourceforge.net/) (29).

RESULTS

Subject characteristics

Characteristics of the 3312 mothers and their children are presented in Table 1. Median intake of total SCBs during pregnancy was 1.9 servings/d (95% CI: 0.1, 7.4 servings/d). Most intake came from fruit juices with median intake of 1.0 serving/d (95% CI: 0.0, 5.0 servings/d), whereas for both concentrate (95% CI: 0.0, 4.5 servings/d) and soda (95% CI: 0.0, 5.0 servings/d), median intake was only 0.1 serving/d. Most of the women who were included were highly educated (60.7%), had never smoked during pregnancy (75.2%), and used folic acid supplementation (88.8%). The mean ± SD birth weight of the children was 3488 ± 561 g. At 6 y of age, median BMI of the children was 15.7 (95% CI: 13.7, 19.3) with 9.2% of the children being classified as overweight or obese.

Maternal SCB intake and child BMI trajectory

In the linear mixed-model analyses, we observed no associations between energy-adjusted SCB intake during pregnancy and BMI trajectories of children from birth to ≥6 y of age in model 1 [0.01 SD score (SDS); 95% CI: −0.02, 0.04 SDS] and model 2 (0.03 SDS; 95% CI: 0.00, 0.07 SDS) (Table 2). After adjustment for child SCB intake, we observed that higher SCB intake during pregnancy was associated with higher BMI of children (model 3: 0.04 SDS; 95% CI: 0.00, 0.07 SDS) (Table 2). This association was not explained by specific intakes of fruit juice, concentrate, or soda during pregnancy (Table 2).

Maternal SCB intake and child body composition

In the linear regression analyses, we showed in model 1 that 1 additional daily serving of SCBs during pregnancy was associated with a 0.05-SDS higher FMI (95% CI: 0.02, 0.09 SDS) but not with FFMI of offspring at age 6 y (Table 3). This association remained after further adjustment for sociodemographic and lifestyle factors [model 2: 0.04 SDS (95% CI: 0.01, 0.07 SDS); model 3: 0.05 SDS (95% CI: 0.01, 0.08 SDS)]. To study fruit juice, concentrate, and soda intakes as exposures, we replaced total SCB intake for these types of beverages in the analyses. We observed an association between a higher daily serving of fruit juice, but not of concentrate or soda, during pregnancy and higher FMI (model 3: 0.04 SDS; 95% CI: 0.01, 0.06 SDS) but not higher FFMI (model 3: 0.02 SDS; 95% CI: −0.01, 0.05 SDS) (Table 3). These effect estimates remained similar after adjustment for the potential mediators gestational...
TABLE 2
Associations of SCB intake during pregnancy with child BMI trajectories
≥6 y of age

<table>
<thead>
<tr>
<th>Total, servings/d</th>
<th>BMI SDS (n = 3312)</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>0.01 (−0.02, 0.04)</td>
<td></td>
</tr>
<tr>
<td>Model 2 (confounder)</td>
<td>0.03 (0.00, 0.07)</td>
<td></td>
</tr>
<tr>
<td>Model 3 (SCB child)</td>
<td>0.04 (0.00, 0.07)*</td>
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<table>
<thead>
<tr>
<th>Fruit juice, servings/d</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>0.01 (−0.02, 0.03)</td>
</tr>
<tr>
<td>Model 2 (confounder)</td>
<td>0.02 (−0.01, 0.04)</td>
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<tr>
<td>Model 3 (SCB child)</td>
<td>0.02 (−0.01, 0.04)</td>
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<thead>
<tr>
<th>Concentrate, servings/d</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>0.00 (−0.02, 0.02)</td>
</tr>
<tr>
<td>Model 2 (confounder)</td>
<td>0.00 (−0.01, 0.02)</td>
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<tr>
<td>Model 3 (SCB child)</td>
<td>0.00 (−0.01, 0.02)</td>
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<tr>
<th>Soda, servings/d</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>−0.01 (−0.02, 0.01)</td>
</tr>
<tr>
<td>Model 2 (confounder)</td>
<td>0.00 (−0.02, 0.02)</td>
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<tr>
<td>Model 3 (SCB child)</td>
<td>0.00 (−0.01, 0.02)</td>
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</tbody>
</table>

1 Values reflect changes (95% CIs) in children’s BMI (sex and age adjusted) ≥6 y of age per 1 additional daily serving of either total maternal SCB intake or fruit juice, concentrate, or soda intake and were based on linear mixed models. Beverages were adjusted for total energy intake with the use of the residual method. Model 1 (crude model) was adjusted for maternal energy intake and child sex. Model 2 (confounder model) was adjusted as for model 1 and for maternal characteristics during pregnancy (parity, marital status, age, gestational age at enrollment, education, income, smoking, alcohol consumption, folic acid supplementation, psychiatric symptoms, protein intake, and diet quality) and child characteristics at 6 y of age (sports and screen time). Model 3 (SCB child model) was adjusted as for model 2 and for SCB intake of the child at 6 y of age. *Statistically significant, P < 0.05. SCB, sugar-containing beverage; SDS, SD score.

Interpretation and comparison with previous studies

In our study population, intake of SCBs during pregnancy was associated with trajectories of BMI in children during early childhood. This result is not in line with that of the previously mentioned study that was performed by Phelan et al. (5) in which they observed that intakes of soft drinks and fruit juice in 285 pregnant women were not associated with birth weight or weight after 6 mo of age. However, our findings suggest an association between maternal SCB intake and children’s BMI at a later age, which was not explained by a higher birth weight, thereby suggesting that an effect may be stronger later in childhood. Furthermore, BMI has several limitations as a marker of adiposity in children (30). First, BMI does not measure excess fat mass because of the many combinations of FMI and FFMI that result in the same BMI. Second, the amounts of both fat mass and fat-free mass vary within children (30). In our study population, we observed that higher intake of SCBs during pregnancy was associated with higher FMI, but not higher FFMI, of children at 6 y of age. This finding is in line with results from higher SCB intakes of mothers were associated with higher fat masses, but not higher fat-free masses, of their children, particularly in girls, and that this association was mainly explained by intake of fruit juice. These associations were independent of gestational weight gain, birth weight, child SCB intake, or child insulin concentration.

**TABLE 3**
Associations of SCB intake during pregnancy with child body composition at 6 y of age

<table>
<thead>
<tr>
<th>Total, servings/d</th>
<th>FMI SDS (n = 2660)</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>0.05 (0.02, 0.09)*</td>
<td>−0.01 (−0.05, 0.03)</td>
<td></td>
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<tr>
<td>Model 2 (confounder)</td>
<td>0.04 (0.01, 0.07)*</td>
<td>0.03 (−0.02, 0.07)</td>
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<tr>
<td>Model 3 (SCB child)</td>
<td>0.05 (0.01, 0.08)*</td>
<td>0.03 (−0.01, 0.07)</td>
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<tr>
<th>Fruit juice, servings/d</th>
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<tbody>
<tr>
<td>Model 1 (crude)</td>
<td>0.03 (0.00, 0.06)*</td>
</tr>
<tr>
<td>Model 2 (confounder)</td>
<td>0.03 (0.01, 0.06)*</td>
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<td>Model 3 (SCB child)</td>
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<tr>
<th>Soda, servings/d</th>
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<tbody>
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1 Values reflect changes (95% CIs) in children’s FMI and FFMI (sex and age adjusted) at 6 y of age per 1 additional daily serving of either total maternal SCB intake or fruit juice, concentrate, or soda intake and were based on linear mixed models. Beverages were adjusted for total energy intake with the use of the residual method. Model 1 (crude model) was adjusted for maternal energy intake and child sex. Model 2 (confounder model) was adjusted as for model 1 and for maternal characteristics during pregnancy (parity, marital status, age, gestational age at enrollment, education, income, smoking, alcohol consumption, folic acid supplementation, psychiatric symptoms, protein intake, and diet quality) and child characteristics at 6 y of age (sports and screen time). Model 3 (SCB child model) was adjusted as for model 2 and for SCB intake of the child at 6 y of age. *Statistically significant, P < 0.05. FMI, fat mass index; FFMI, fat-free mass index; SCB, sugar-containing beverage; SDS, SD score.
previous studies that have studied SCB intakes in children and the body compositions of these children (6, 31, 32).

Also, we observed associations between maternal intake of fruit juice, but not of other beverages, and higher FMI of their 6-y-old children. In our study population, intake of fruit juice was 10 times higher (median: 1.0 serving/d) than intakes of concentrate and soda. Consequently, intakes of concentrate and soda in our study may have been too low to detect potential associations with adverse body-composition outcomes of the children. Although fruit juice also provides vitamins and minerals (33), our results suggest that fruit juice could be harmful for a child’s body composition.

For FMI, but not for the other outcomes, we observed stronger associations in girls than in boys. We previously also observed stronger associations of early life nutrition with body fat in girls than in boys at ~6 y of age (4, 34). These associations have been suggested to be related to differences in insulin responses between boys and girls (19) or to differences in the timing of the adiposity rebound, which usually occurs between the ages of 5 and 7 y (35).

Potential mechanisms

We observed that SCB intake during pregnancy was positively associated with child BMI and FMI during early childhood. One possible mechanism that may explain this relation could be excessive energy intake from the SCBs themselves or from other food sources because caloric intake in a liquid form leads to a lower and shorter feeling of satiation (36–39). However, in our analyses, effect estimates were similar after adjustment for energy intake, and associations remained between SCB intake and child BMI and FMI, which suggested that the associations were due to other factors than energy intake.

Another possible mechanism could be that the epigenetics of the fetus changes when a mother has frequent intake of SCBs during pregnancy (40). These changes could lead to altered gene expression (41), which may result in children becoming more susceptible to having higher fat mass.

Also, because SCB intake leads to high peak concentration of insulin (42), the role of insulin should be further elucidated. Hyperinsulinemia during the development of the fetus could have long-lasting consequences to the central nervous systems that regulates body weight, possibly resulting in the stimulation of fat mass development (43). In addition, SCB intake during pregnancy might affect the insulin sensitivity of the child (24) with the subsequent stimulation of the development of fat mass in the child. However, our findings suggest that a child’s insulin concentration is not part of this pathway. Unfortunately, we had no information available on serum insulin during pregnancy.

Our results could also be explained by residual confounding because intake of SCBs is associated with other lifestyle factors (44). Although we had information available on several potential lifestyle confounders, including smoking, alcohol intake, and the overall diet quality during pregnancy, we had, e.g., no information on the physical activity of the mother (45). Furthermore, confounding that could have been due to child factors is difficult to take into account because lifestyle patterns may change during childhood (46). As part of these lifestyle patterns, intake of sweet foods, including SCBs, by the child could have partially determined the child’s body composition. Prenatal exposures such as flavors of the maternal diet can transmit to the amniotic fluid, which consequently may lead to greater acceptance by the child of these foods after birth (47). We attempted to take this potential confounding by child diet into account by adjusting for SCB intake of the child, and the association between SCB intake of the mother with her offspring’s fat mass remained.

Strengths and limitations

Strengths of this study are the prospective population-based design, the large sample size, and the available information on numerous confounders of the mothers and children. Also, the repeated measurement of child BMI was an important strength in this study. Furthermore, we had extensive measurements on child body composition at 6 y of age with the use of DXA. This method has been proven to measure fat mass accurately (48), which allowed us to distinguish the child’s body fat mass and fat-free mass. Another strength is that we also studied different types of SCBs rather than only examining overall intake. Finally, we applied the Bayesian approach with the use of all information that was available in the observed covariates. The use of this approach provides a better method to deal with bias that is associated with incomplete information on covariates than is achieved with the use of less-sophisticated missing-data methods (20).

This study also has several limitations. One limitation is that dietary intakes were estimated by self-report, which has been shown to be prone to measurement errors (49). However, we reduced the magnitude of the measurement errors by adjusting for total energy intake with the use of the residual method. Because all mothers included in our analyses were of Dutch origin and were, on average, highly educated, the generalizability of our findings to other ethnic or socioeconomic groups may be limited. Another limitation may be the single assessment of SCB intake during the first trimester. Repeated measurements of dietary intake would have been better to study whether there may have been an accumulative or trimester-specific effect of maternal SCB intake on child BMI and body composition. Although we adjusted the analyses for numerous sociodemographic and lifestyle factors related to both mother and child, residual confounding was still possible. An example was the absence of information on the energy expenditure or physical activity of the mother (50) or on the diet of the father (51), which might have influenced our results. Finally, although we had information that was available on total SCB intake of the child at 6 y, we did not collect information on different types of SCB intake, total energy intake, or other components of the diet of the child.

In conclusion, in this prospective cohort, we observe that higher intake of SCBs during pregnancy is associated with higher child BMI ≥6 y of age. Also, higher intakes of total SCBs and fruit juice, but not of soda or concentrate, are associated with higher FMI of the child at 6 y of age. These associations are stronger in girls than in boys. Future studies should further explore whether SCB intake during pregnancy is associated with child body composition, which should preferably be assessed repeatedly to observe whether changes occur in later stages during childhood.

The authors’ responsibilities were as follows—VJ, NSE, MJT, KVEB, and TV: analyzed the data; VJ, NSE, MJT, and TV: wrote the manuscript; VJ, MJT, and TV: designed the research; VJ and TV: had primary responsibility for the final content of the manuscript; VWVJ and OHF: were involved in the
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