


Sugar-sweetened beverages and BMI in children and adolescents: reanalyses of a meta-analysis

Dear Sir:

In a recent issue of the Journal, Forshee et al (1) reexamined current epidemiologic and clinical trial evidence on the relation between sugar-sweetened beverages (SSBs) and body mass index (BMI; kg/m²) in children and adolescents. The conclusion of their meta-analysis, which was supported by the beverage industry, contradicts those drawn from several other reviews (2–4). A previous systematic review and meta-analysis on the same topic reported “clear associations of soft drink intake with increased caloric intake and body weight” (4). We believe that the reasons for the discrepant results between Forshee et al and others stem from analytic errors in their meta-analysis.

We were alerted to a potential problem because the percentage weights for several studies in the Forshee analysis, as shown in their forest plot, appeared to be incorrect. For example, the weights for studies by Blum et al (5) and Newby et al (6) were suspiciously high compared with other much larger studies, such as those by Ludwig et al (7) and Berkey et al (8). Because study weights are related to the inverse of the variance of the coefficients, larger studies generally have smaller variances and are thus expected to have larger weights. Because Forshee et al expressed their results as the change in BMI units per 12-oz serving of change of SSB, scaling factors were applied to estimates from some studies to obtain unit consistency. However, estimates from Blum and Newby, both of which are expressed as change per I-oz serving of SSB in their original publications, were not scaled. We conducted a meta-analysis on the same data using scaled coefficients and SEs and found greatly reduced study weights, larger estimates, and wider CIs for these studies compared with analyses by Forshee et al (Figure 1A). Because the methods used to transform the estimates by Phillips to the required units for the meta-analysis were unclear, we used those reported by Forshee et al. In addition, our weights are summarized using random-effects analysis, which is the preferred method compared with the fixed-effects analysis in the presence of study heterogeneity. Forshee et al reported study weights from the inverse variance fixed-effects analysis, despite having a high degree of heterogeneity between studies ($I^2 = 73.9\%$). In our analysis, where available, we also used coefficients that were not adjusted for total energy intake. Because the association between SSB consumption and BMI is mediated in part by overall energy intake, adjusting for energy will tend to underestimate the effect of these beverages on body weight. Forshee et al used results in their analysis that were adjusted for energy and mention that the impact of using unadjusted values on their overall effect estimate was minimal. However, if analyzed separately and weighted properly, studies with energy-adjusted estimates (5, 6, 9, 10) show a nonsignificant inverse trend ($-0.03; 95\% CI: -0.11, 0.04$), whereas those with unadjusted estimates (7, 8, 11–13) show a positive association (0.08; 95\% CI: 0.03, 0.13), suggesting the presence of bias in Forshee et al’s analysis. Results from a meta-regression that used adjustment for energy as a predictor of effect confirm these findings ($P = 0.048$) and provide statistical rationale for using unadjusted estimates in the analysis.

Overall, our findings, in contrast to those by Forshee et al, clearly suggest a positive association between SSB consumption and BMI among children. The analyses without adjustment for total energy as shown in Figure 1B are more likely to reflect the true association, although this will still be underestimated because of measurement error in

![FIGURE 1. A: Forest plot of studies of sugar-sweetened beverage consumption and BMI (kg/m²) in children and adolescents. Random-effects estimate (DerSimonian and Laird method). B: Forest plot of studies of sugar-sweetened beverage consumption and BMI in children and adolescents with estimates that are not adjusted for total energy intake. ES, reported estimate for the predicted change in BMI per change in 12-oz serving of sugar-sweetened beverage.](https://academic.oup.com/ajcn/article-abstract/89/1/438/4598275)
diagnostic assessment. However, the studies in this literature are heterogeneous by nature, with varying lengths of duration, age of participants, methods of exposure and outcome assessment, design (intervention compared with observational), and units of expression. For these reasons, to fully understand the relation between SSB intake and BMI, particularly among children and adolescents who are still growing, studies need to be examined individually with greater emphasis placed on higher quality studies that are adequately powered, with appropriately long periods of follow-up, and use of robust assessment methods (eg, a single 24-h recall provides a poor assessment of an individual’s diet). As discussed in previous systematic reviews (3, 4), discouraging consumption of sugary beverages is an important way to achieve and maintain a healthy body weight in children and adults.

No conflicts of interest were declared.

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REFERENCES


Reply to VS Malik et al

Dear Sir:

We appreciate the opportunity to respond to the letter from Malik et al regarding our recently published meta-analysis (1) of the relation between sugar-sweetened beverage consumption and body mass index (BMI; in kg/m²) in children and adolescents. Malik et al correct that the studies published by Blum et al (2) and Newby et al (3) should have been scaled by a factor of 12, because they estimated their models using 1 oz as the unit of analysis for beverage consumption. Both of these studies estimated a small negative association between sugar-sweetened beverage consumption and BMI that was not statistically significant. Scaling these 2 studies by a factor of 12 results in an overall estimate of 0.03 (95% CI: –0.01, 0.07) BMI unit change per serving compared with the original estimate of 0.02 (95% CI: –0.01, 0.04). Although we regret the scaling error, this does not affect any of the substantive conclusions of the article. An erratum, featuring corrected versions of Figures 1 and 2 and a corrected version of the online-only data set (see “Supplemental Data” in the current online issue), also appears in this issue of the Journal (4).

We respectfully disagree with the other points raised in the letter. First, we used the correct weights in our analysis and reported both the fixed-effects and random-effects estimates and the test for heterogeneity. Anyone can verify this by checking the code we provided [see the option “second(random)” under Supplemental Data in the current online issue]. The forest plot we used simultaneously displayed both the fixed- and random-effects estimates so that readers could compare the 2 results. Second, Phillips et al (5) presented the most challenges for scaling, because it used a unique combination of methods and units. We contacted the corresponding author to request additional information, but we did not receive any more information on the study. We considered excluding the study from the quantitative analysis and discussing it qualitatively, but we were concerned that excluding a statistically significant study would be inappropriate. As part of our overall sensitivity tests for influential studies, we estimated a model excluding the Phillips et al study, and the overall random-effects estimate changed from 0.02 to 0.01. In the corrected data, the random-effects estimate changed from 0.03 to 0.02 when Phillips et al’s study was excluded.

After careful consideration of the options that were available and assessment of the impact they would have on our results, we used the coefficient and SE (calculated from the P value using p2ci) for those females who consumed the largest percentage of calories from soda in the BMI z-score model (Table 3). We also explored an alternative scaling that converted the BMI z-score for that difference to BMI units using the LMS method (6) and then divided by the estimated number of servings based on the percentage of calories from soda data (Table 1). This alternative scaling was very close to the original—0.121 compared with the original 0.178—and did not affect the estimate of the overall effect size. We were uncomfortable with the number of assumptions used in the scaling, particularly because the percentage-of-calories-from-soda variable could be affected by either the numerator (energy from soft drinks) or the denominator (total energy). We believe that we exhausted all options to put the Phillips et al study in a common scale.