Dutch Obesity Intervention in Teenagers

Effectiveness of a School-Based Program on Body Composition and Behavior

Amika S. Singh, PhD; Marijke J. M. Chin A Paw, PhD; Johannes Brug, PhD; Willem van Mechelen, MD, PhD

Objective: To determine whether a multicomponent health promotion intervention for Dutch adolescents (defined as persons between 12 and 14 years of age) would be successful in influencing body composition and dietary and physical activity behavior in both the short and long terms.

Design: Randomized controlled trial.

Setting: Ten intervention and 8 control prevocational secondary schools.

Participants: A total of 1108 adolescents (mean age, 12.7 years).

Intervention: An interdisciplinary program with an adapted curriculum for 11 lessons in biology and physical education and environmental change options.

Main Outcome Measures: Body height and weight, waist circumference, 4 skinfold thickness measurements, and dietary and physical activity behavior data.

Results: Multilevel analyses showed that the intervention remained effective in preventing unfavorable increases in important measures of body composition after 20-month follow-up in girls (biceps skinfold and sum of 4 skinfolds) and boys (triceps, biceps, and subscapular skinfolds). Consumption of sugar-containing beverages was significantly lower in intervention schools both after intervention (boys: −287 mL/d; 95% confidence interval [CI], −527 to −47; girls: −249; −400 to −98) and at 12-month follow-up (boys: −233; −371 to −95; girls: −271; −390 to −153). For boys, screen-viewing behavior was significantly lower in the intervention group after 20 months (−25 min/d; 95% CI, −50 to −0.3). No significant intervention effects on consumption of snacks or active commuting to school were found.

Conclusion: The Dutch Obesity Intervention in Teenagers program resulted in beneficial effects on the sum of skinfold thickness measurements in girls and consumption of sugar-containing beverages in both boys and girls in both the short and long terms.


To curb the obesity epidemic, population-based preventive approaches are required that affect multiple behaviors.1 Related to the reduced opportunities for being physically active and the increased availability and accessibility of high-energy foods—the obesogenic environment2—there is consensus that changes in lifestyle are driving the obesity epidemic.3 Adolescence is an important transition period in the life course in which lifestyle, including energy balance–related behaviors (EBRBs), is subject to important changes4 (eg, levels of physical activity decrease5,6 and food choices become more autonomous7 and less healthy).8 Unfavorable behavioral patterns established during this period of life may be vital in the development of adult health behaviors,9 and health behaviors in youth may track to a certain extent into adulthood.10 The most promising interventions focus on improving dietary and physical activity patterns11 and combine educational and environmental elements.12 Since schools can provide valuable opportunities to influence the lifestyles of adolescents in a collective setting,13,14 recent research within the field of obesity prevention among youth has therefore focused on interventions in the school setting. Most school-based interventions were able to show improvements in dietary or physical activity patterns; however, hardly any study could demonstrate significant effects on indicators of adiposity.15 There is an urgent need for more scientific evidence about intervention programs that effectively contribute to prevention of excessive weight gain in
adolescents, especially in the long term. Unless intervention programs and the theoretical models on which they are based are identified and described more accurately, it will be difficult to conclude which programs are effective and whether they have a solid theoretical basis.\textsuperscript{10,17}

We performed a randomized controlled trial, the Dutch Obesity Intervention in Teenagers (DOiT), to evaluate the effectiveness of a school-based multicomponent health promotion intervention aimed at preventing excessive weight gain. The DOiT program was developed, implemented, and evaluated systematically, applying the Intervention Mapping protocol.\textsuperscript{18} Short-term results of our trial showed that the DOiT intervention was associated with lower skinfold thickness in girls and lower waist circumference in boys.\textsuperscript{19} In this article, we describe the short-term and long-term effects on the anthropometric and behavioral outcome measures.

**METHODS**

**STUDY DESIGN AND PARTICIPANTS**

A total of 18 prevocational secondary schools participated in the randomized controlled trial. Participating schools were asked to select 3 classes of first-year students (aged 12-14 years). The selection of classes was based on practical reasons (eg, similar timetables for lessons in physical education). No inclusion criteria were set for students to take part in the study. Written informed consent was obtained from all students and their parents. The Medical Ethics Committee of the VU University Medical Center approved the study protocol.

Schools were randomly assigned to either the intervention or control group. Randomization took place at the school level or at the location level (in case 2 schools were located in the same city) and was stratified by degree of urbanization, using SPSS statistical software (SPSS Inc, Chicago, Illinois). We collected data at baseline (at the start of the first school year of secondary school) and after 8 months (immediately after intervention), 12 months (4 months after intervention), and 20 months (12 months after intervention).

Sample size calculation was based on changes in body weight. Assuming an $\alpha$ of .05, power of 90%, and a 2-sided test, we needed 233 participants per group to show a mean (SD) difference in body weight of 0.5 (1.5) kg between the intervention and control groups. To be able to perform multilevel analyses and at the same time take into account the cluster randomization design, a sample size between 500 and 600 in-
tions were equal for all EBRBs (cTable; http://www.archpediatrics.com). The questionnaire was pretested for clarity and length among adolescents not participating in the study by means of cognitive interviewing. 27

Frequency and quantity of the reported items were multiplied to obtain estimates of mean daily consumption. Behavior reported above the 95th percentile was recoded as the value of the 95th percentile because these unrealistically high values are probably due to overreporting.

STATISTICAL ANALYSES

We used the nonparametric Kolmogorov-Smirnov test (for all measurements of body composition, physical fitness, and EBRBs) and the Pearson χ2 test (BMI class) to compare groups at baseline. The effects of the intervention on all anthropometric measures were evaluated by multilevel analysis, using a software package (MLwiN, version 2.0; Centre for Multilevel Modeling at the University of Bristol, England). With the use of this technique, regression coefficients could be adjusted for the clustering of observations within 1 school and/or class. We defined 3 levels in our multilevel analysis: (1) student, (2) class, and (3) school. The parameters of interest are the regression coefficients of the linear regression models, indicating the effect of the intervention compared with the control group. In the crude model, the outcome value at 8, 12, or 20 months was adjusted for baseline value. We checked for possible effect modification by sex or ethnicity by including group × sex and group × ethnicity interaction terms in the regression analyses. All analyses were performed according to the intention-to-treat principle. Missing values were not imputed.

RESULTS

PARTICIPATION, COMPLETION RATE, AND BASELINE CHARACTERISTICS OF THE STUDY SAMPLE

In total, we obtained data from 1108 students (ie, anthropometric or behavioral data at baseline and at least 1 follow-
up measurement) \( (\text{Figure}) \). Table 1 presents the baseline characteristics of our sample. Mean baseline data stratified by sex revealed significant differences between intervention and control schools with regard to body weight (boys), body height (girls), and screen-viewing behavior (girls).

### EFFECTS ON BODY COMPOSITION

We present the means for all anthropometric outcome measures at baseline, the 3 follow-up measurements, and the results of the multilevel analyses (regression coefficients of the crude model) in Table 2 and Table 3 for girls and boys, respectively. Because no significant group × ethnicity interactions were found, analyses were not stratified for ethnicity. Sex was found to be an effect modifier. Therefore, analyses were conducted separately for boys and girls.

At the 20-month follow-up, we found a significant intervention effect on biceps skinfold thickness among girls (\(-0.7\ mm; 95\%\ confidence\ interval [CI], \(-1.3\ to\ -0.3\ mm\) ). Another significant intervention effect was found with regard to the sum of skinfold thickness: the sum of skinfold thickness was lower in the girls of the intervention schools at both 8-month (\(-2.3\ mm; 95\%\ CI, \(-4.3\ to\ -0.3\ mm) \) and 20-month follow-ups (\(-2.0; -3.9\ to\ -0.1\ mm) \).

For boys, waist circumference was significantly lower in the intervention group at 8-month follow-up (\(-0.6\ cm; 95\%\ CI, \(-1.7\ to\ -0.1\ cm) \). At 20-month follow-up, waist circumference was significantly lower in the control group. For the 20-month follow-up, we found a significant intervention effect on the triceps (\(-0.7\ mm; 95\%\ CI, \(-1.2\ to\ -0.1\ mm) \), biceps (\(-0.4\ mm; -0.8\ to\ -0.1\ mm) \), and subscapular skinfold thickness (\(-0.5\ mm; -1.0\ to\ -0.1\ mm) \).
Table 3. Anthropometric Characteristics in Boys at Baseline and After 8-, 12-, and 20-Month Follow-ups and the Mean Differences in Change Between the Intervention and Control Schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline Mean (SD)</th>
<th>8-Month Follow-up Mean (SD)</th>
<th>Difference in Change Between Groups After 8 Months (95% CI)</th>
<th>12-Month Follow-up Mean (SD)</th>
<th>Difference in Change Between Groups After 12 Months (95% CI)</th>
<th>20-Month Follow-up Mean (SD)</th>
<th>Difference in Change Between Groups After 20 Months (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triceps skinfold, mm</td>
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<tr>
<td>Intervention group</td>
<td>11.9 (4.6)</td>
<td>11.1 (4.9)</td>
<td>-0.3 (-0.7 to 0.1)</td>
<td>10.6 (4.9)</td>
<td>-0.3 (-0.8 to 0.3)</td>
<td>9.8 (4.9)</td>
<td>-0.7 (-1.2 to -0.1)</td>
</tr>
<tr>
<td>Control group</td>
<td>12.0 (4.6)</td>
<td>11.6 (4.8)</td>
<td></td>
<td>10.8 (4.6)</td>
<td></td>
<td>10.3 (4.7)</td>
<td></td>
</tr>
<tr>
<td>Biceps skinfold, mm</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>6.5 (3.1)</td>
<td>6.1 (3.1)</td>
<td>-0.4 (-0.4 to 0.2)</td>
<td>6.9 (3.7)</td>
<td>-0.4 (-0.8 to -0.1)</td>
<td></td>
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</tr>
<tr>
<td>Control group</td>
<td>6.7 (3.2)</td>
<td>6.3 (3.0)</td>
<td></td>
<td>7.1 (3.6)</td>
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<tr>
<td>Subscapular skinfold, mm</td>
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<tr>
<td>Intervention group</td>
<td>8.2 (4.3)</td>
<td>8.4 (5.1)</td>
<td>-0.8 (-0.8 to 0.3)</td>
<td>8.9 (6.0)</td>
<td>-0.3 (-1.1 to 0.6)</td>
<td>8.5 (4.9)</td>
<td>-0.5 (-1.0 to -0.1)</td>
</tr>
<tr>
<td>Control group</td>
<td>9.3 (5.3)</td>
<td>9.4 (5.8)</td>
<td></td>
<td>9.5 (5.7)</td>
<td></td>
<td>9.2 (4.0)</td>
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<tr>
<td>Suprailiac skinfold, mm</td>
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<tr>
<td>Intervention group</td>
<td>12.6 (8.1)</td>
<td>12.4 (8.4)</td>
<td>-0.9 (-0.9 to 0.4)</td>
<td>13.1 (9.6)</td>
<td>-0.1 (-1.4 to 0.3)</td>
<td>16.6 (11.1)</td>
<td>-0.9 (-3.1 to 0.3)</td>
</tr>
<tr>
<td>Control group</td>
<td>13.7 (8.5)</td>
<td>14.0 (9.3)</td>
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<td>14.1 (9.7)</td>
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<td>17.1 (10.9)</td>
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<tr>
<td>Sum of skinfolds, mm</td>
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<tr>
<td>Intervention group</td>
<td>38.9 (18.5)</td>
<td>38.0 (20.5)</td>
<td>-2.4 (-2.4 to 0.5)</td>
<td>38.4 (22.4)</td>
<td>-1.1 (-3.0 to 0.9)</td>
<td>41.9 (22.4)</td>
<td>-1.1 (-4.4 to 0.2)</td>
</tr>
<tr>
<td>Control group</td>
<td>41.5 (20.5)</td>
<td>41.1 (21.8)</td>
<td></td>
<td>40.5 (21.9)</td>
<td></td>
<td>43.7 (22.0)</td>
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<tr>
<td>Waist circumference, cm</td>
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</tr>
<tr>
<td>Intervention group</td>
<td>66.1 (7.0)</td>
<td>66.9 (6.8)</td>
<td>-0.6 (-1.1 to -0.1)</td>
<td>68.3 (7.7)</td>
<td>0.3 (-0.6 to 1.1)</td>
<td>71.9 (7.8)</td>
<td>1.1 (0.1 to 2.0)</td>
</tr>
<tr>
<td>Control group</td>
<td>68.0 (7.5)</td>
<td>68.9 (7.2)</td>
<td></td>
<td>69.7 (7.5)</td>
<td></td>
<td>72.8 (8.1)</td>
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<tr>
<td>BMI</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>18.2 (2.6)</td>
<td>18.6 (2.8)</td>
<td>-0.2 (-0.1 to 0.2)</td>
<td>19.1 (3.0)</td>
<td>0.1 (-0.2 to 0.4)</td>
<td>19.4 (2.9)</td>
<td>0.2 (-0.1 to 0.4)</td>
</tr>
<tr>
<td>Control group</td>
<td>19.0 (2.9)</td>
<td>19.4 (2.9)</td>
<td></td>
<td>19.8 (3.0)</td>
<td></td>
<td>20.0 (2.7)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: See Table 2.

*Unstandardized regression coefficients.

Table 4. Energy Balance-Related Behaviors in Girls at Baseline and After 8-, 12-, and 20-Month Follow-ups and the Mean Differences in Change Between the Intervention and Control Schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline, Mean (SD)</th>
<th>8-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 8 Months (95% CI)*</th>
<th>12-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 12 Months (95% CI)*</th>
<th>20-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 20 Months (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen-viewing behavior (television viewing and computer use), min/d</td>
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<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>212 (130)</td>
<td>209 (138)</td>
<td>-22 (-55 to 2)</td>
<td>217 (119)</td>
<td>-16 (-46 to 15)</td>
<td>258 (129)</td>
<td>-2 (-9 to 5)</td>
</tr>
<tr>
<td>Control group</td>
<td>250 (138)</td>
<td>250 (149)</td>
<td></td>
<td>258 (130)</td>
<td></td>
<td>248 (121)</td>
<td></td>
</tr>
<tr>
<td>Active commuting to school, min/d</td>
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</tr>
<tr>
<td>Intervention group</td>
<td>385 (29)</td>
<td>44 (28)</td>
<td>-1 (-9 to 7)</td>
<td>45 (32)</td>
<td>-3 (-10 to 5)</td>
<td>46 (32)</td>
<td>-2 (-10 to 5)</td>
</tr>
<tr>
<td>Control group</td>
<td>34 (27)</td>
<td>45 (26)</td>
<td></td>
<td>43 (30)</td>
<td></td>
<td>42 (28)</td>
<td></td>
</tr>
<tr>
<td>Consumption of sugar-sweetened beverages, soft drinks, and fruit juices, mL/d</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>1044 (764)</td>
<td>761 (579)</td>
<td>-249 (-400 to -98)</td>
<td>629 (544)</td>
<td>-271 (-390 to -153)</td>
<td>689 (538)</td>
<td>-88 (-203 to 28)</td>
</tr>
<tr>
<td>Control group</td>
<td>1120 (795)</td>
<td>993 (680)</td>
<td></td>
<td>900 (669)</td>
<td></td>
<td>714 (589)</td>
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</tr>
<tr>
<td>Consumption of snacks (sweet and savory), portions/d</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>1.9 (1.3)</td>
<td>2.0 (1.4)</td>
<td>0.1 (-0.3 to 0.4)</td>
<td>1.8 (1.3)</td>
<td>-0.1 (-0.3 to 0.2)</td>
<td>1.9 (1.2)</td>
<td>0.1 (-0.2 to 0.4)</td>
</tr>
<tr>
<td>Control group</td>
<td>1.9 (1.3)</td>
<td>1.9 (1.3)</td>
<td></td>
<td>1.8 (1.3)</td>
<td></td>
<td>1.5 (1.1)</td>
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</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

*Unstandardized regression coefficients.

EFFECTS ON EBRBs

The means for all behavioral outcome measures at baseline, the 3 follow-up measurements, and the results of the multilevel analyses (regression coefficients of the crude model) are given in Table 3 for boys and Tables 4 and 5 for girls, respectively. No significant group × ethnicity interactions were found, and the analyses were thus not stratified for ethnicity.

Consumption of sugar-containing beverages was significantly lower among boys and girls of the intervention schools both at the 8-month (boys: -287 mL/d; 95% CI, -527 to -47; girls: -249; -400 to -98) and 12-month follow-ups (boys: -233; -371 to -95.1; girls: -271;
We found no significant between-group differences at the 20-month follow-up. Differences in screen-viewing behavior consistently favored the boys and girls from the intervention schools at all follow-up measurements, with statistically significant differences in favor of the boys of the intervention group after 20 months (−25 min/d; 95% CI, −50 to −0.3 min/d). No significant intervention effect on consumption of snacks or active commuting to school was found.

**COMMENT**

The DOiT program had significant beneficial effects on body composition in girls and consumption of sugar-containing beverages in boys and girls, compared with the regular curriculum in a sample of prevocational education students. Hence, our results do not show consistently positive findings on all anthropometric and behavioral outcome measures. Our findings are important, especially when considering the need for evidence on the long-term effectiveness of interventions in the field of obesity prevention.

**BMI VS SKINFOLD THICKNESS MEASUREMENTS**

Our intervention was successful in influencing skinfold thickness in the short and long terms. In comparison between BMI and measurement of skinfold thickness, the latter is known to be a more sensitive alternative for determining body fatness, especially in youth, because it discriminates better between lean mass and fat mass. A recent review also recommended the use of skinfold measures when interventions aim to improve physical activity patterns. The fact that we found between-group differences in skinfold thickness but not in BMI might therefore indicate that BMI in children and adolescents represents body build rather than body fatness.

**COMPARISON WITH PREVIOUS STUDIES**

Our findings are in line with those of McMurray et al, who found significant between-group differences in skinfold thickness but not in BMI. In the study by McMurray et al, the school-based intervention aimed at increasing the aerobic component of the school's physical activity program and at improving knowledge about the relationship of weight control and blood pressure to body fat in early adolescents. This intervention was shorter when compared with the DOiT intervention, although more intensive. Gortmaker et al found a decrease in the prevalence of obesity in the girls of the intervention group, as indicated by a composite measure of obesity (ie, BMI and triceps skinfold thickness measurements). However, they assessed the effectiveness of a school-based program of a longer duration and higher frequency (ie, 2 school years with 32 lessons [Planet Health] compared with 1 school year with 11 lessons [DOiT]).

We tried to develop an intervention that is relatively easy to implement (ie, no additional school staff required, low implementation cost, and good fit with existing curriculum, meaning that intervention program lessons could partly replace regular biology lessons). Nevertheless, our process evaluation among teachers indicated that implementation required more time than expected and was perceived as being demanding (A.S.S. unpublished data, presented at the Amsterdam/Cambridge/Ghent Meeting in Ghent, the Netherlands, January 28-30, 2007). Time constraints are a commonly expressed problem in the school setting in general and are related to health promotion projects as indicated by other com-

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**Table 5. Energy Balance-Related Behaviors in Boys at Baseline and After 8-, 12-, and 20-Month Follow-ups and the Mean Differences in Change Between the Intervention and Control Schools**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline, Mean (SD)</th>
<th>6-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 8 Months (95% CI)</th>
<th>12-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 12 Months (95% CI)</th>
<th>20-Month Follow-up, Mean (SD)</th>
<th>Difference in Change Between Groups After 20 Months (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screen-viewing behavior (television viewing and computer use), min/d</td>
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</tr>
<tr>
<td>Intervention group</td>
<td>268 (154)</td>
<td>248 (151)</td>
<td>−14 (−44 to 7)</td>
<td>261 (134)</td>
<td>−9 (−38 to 10)</td>
<td>258 (129)</td>
<td>−25 (−50.0 to −0.3)</td>
</tr>
<tr>
<td>Control group</td>
<td>294 (150)</td>
<td>261 (142)</td>
<td></td>
<td>272 (126)</td>
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<td>278 (146)</td>
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</tr>
<tr>
<td>Active commuting to school, min/d</td>
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<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>39 (31)</td>
<td>45 (29)</td>
<td>1 (−4 to 6)</td>
<td>47 (35)</td>
<td>5 (−0.3 to 9)</td>
<td>46 (32)</td>
<td>1 (−6 to 8)</td>
</tr>
<tr>
<td>Control group</td>
<td>33 (27)</td>
<td>39 (26)</td>
<td></td>
<td>41 (30)</td>
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<td>40 (28)</td>
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</tr>
<tr>
<td>Consumption of sugar-sweetened beverages, soft drinks, and fruit juices, mL/d</td>
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<tr>
<td>Intervention group</td>
<td>1124 (918)</td>
<td>825 (786)</td>
<td>−287 (−527 to −47)</td>
<td>740 (675)</td>
<td>−233 (−371 to −95)</td>
<td>689 (538)</td>
<td>−75 (−198 to 47)</td>
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<tr>
<td>Control group</td>
<td>1183 (922)</td>
<td>1126 (834)</td>
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<td>981 (767)</td>
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<td>763 (594)</td>
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<td>Consumption of snacks (sweet and savory) snacks, portions/d</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Intervention group</td>
<td>2.0 (1.4)</td>
<td>2.0 (1.5)</td>
<td>−0.0 (−0.4 to 0.2)</td>
<td>2.0 (1.3)</td>
<td>0.3 (−0.0 to 0.5)</td>
<td>1.9 (1.2)</td>
<td>0.2 (−0.0 to 0.5)</td>
</tr>
<tr>
<td>Control group</td>
<td>2.0 (1.4)</td>
<td>1.9 (1.3)</td>
<td></td>
<td>1.7 (1.3)</td>
<td></td>
<td>1.8 (1.1)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

a Unstandardized regression coefficients.
parable studies in this field. This problem suggests that a more intensive intervention would be less feasible in the current Dutch school system.

The DOIT intervention resulted in significantly lower self-reported consumption of sugar-containing beverages after 8 and 12 months (boys and girls). The difference between the intervention and control groups was approximately 250 mL/d. We are aware of 1 other comparable study that reported successfully reducing consumption of sugar-containing beverages. James et al studied the effectiveness of an intervention aimed at reducing consumption of carbonated drinks among preschool children. James et al reported changes of 150 mL during 3 days, which indicates that their study aim and methods are similar to ours. Although the magnitude of the effects of the study by James et al was smaller compared with our results, one should bear in mind that the difference in magnitude of the effects might partly be attributed to the difference in the absolute consumption of drinks of all types between preschoolers and adolescents.

With regard to screen-viewing behavior, a statistically significant difference after 20 months was found for boys. This finding is in line with findings of several other studies that have reported beneficial intervention effects on television viewing and body composition. However, the fact that we found no differences with regard to screen-viewing behavior after 8 and 12 months may be because of the lack of sensitivity of our questionnaire. Bearing in mind that our intervention was aimed at small behavioral changes, a plausible explanation for the lack of effect, besides the absence of effect of the intervention, could be that the questionnaire used was not sensitive enough to detect such small changes as those that occurred between the groups in our study.

We found no significant differences between the intervention and control groups with regard to active commuting to school, neither in the short nor long term. Bicycling is common in the Netherlands, and 95.0% of the adolescents in our baseline sample reported bicycling to school 5 days a week. Thus, our intervention may not have been able to considerably improve this behavior. The intervention program encouraged active commuting not only to school but also during leisure time (eg, the use of a bicycle to visit friends or to go to a sports club). Because our measurements included only active commuting to school, we were not able to measure possible intervention effects on active commuting during leisure time.

Our results indicate no significant intervention effect on consumption of high-energy snacks. A systematic review that reported estimates of the prevalence of being overweight in school-aged youth showed a significant negative relationship between the intake of sweet snacks and the probability of being overweight as do our baseline data (Spearman ρ for sum of skinfold thickness measurements and consumption of sweet snacks: boys = −0.15, P = .002; girls = −0.16, P = .001). Although these are cross-sectional data, this finding indicates that weight control behavior may moderate the relationship between EBRBs and body composition. This complicates the ability to find the effects of intervention on behaviors that are already well-known weight control strategies. Another explanation for the lack of effect may be a possible lack of sensitivity on the part of the questionnaire in the detection of small behavioral changes.

STUDY STRENGTHS AND LIMITATIONS

Body Composition

Because research assistants were involved in arranging to take measurements, conducting the measurements, and delivering the intervention materials, they were not blinded to the group assignment. The remainder of the research team, which consisted of students who were helping with measurements, were not informed about the group assignment. The performance of all measurements according to a standardized protocol minimized the potential for observation bias.

As previously mentioned, the sum of skinfold thickness measurements best reflects body composition, and effects on this measurement are therefore most important. We have presented differences in the sum of skinfold and separate skinfold thickness measurements. Because these separate analyses increase type I error, the results for the separate skinfold thickness measurements should be interpreted with caution.

Energy Balance–Related Behaviors

The use of self-report questionnaires to assess behavioral change is subject to limitations, a drawback our study shares with many studies in the field. Hence, doubt remains as to whether observed changes in self-reported measures reflect behavioral changes. We used an extensive questionnaire that took students approximately 60 minutes to complete. The order in which specific behaviors were assessed was as follows: consumption of sugar-containing beverages, screen-viewing behavior, active commuting to school, and consumption of snacks. We find small but significant between-group differences with regard to the first (consumption of sugar-containing beverages) and second (screen-viewing) questioned behaviors but failed to pick up differences in the third (active commuting to school) and last (snack consumption) questioned behaviors. Confidence in the adequacy of the assessment of behavioral change via questionnaire was somewhat diminished based on observations during the measurements that suggested that some students (especially ones with dyslexia) had difficulties with the length of the questionnaire, which may have caused less adequate completion of the latter parts. On the other hand, it has already been considered unlikely that our intervention would change active commuting behaviors in a country where bicycles are frequently used for transportation.

The fact that we found no differences with regard to screen-viewing behavior after 8 and 12 months contrasts with our findings after 20 months and forces us to question the sensitivity of our questionnaire. As with most questionnaires, we used a tool that was designed to assess actual behavior. Bearing in mind that our intervention was aimed at small behavioral changes, a plausible explanation for the lack of effect could be that the questionnaire used was not sensitive enough to detect such small changes between groups as those that occurred in our study.
The participating schools clearly represented a highly motivated group. This self-selection bias was unavoidable but reflected the reality that only interested schools would participate in evaluation studies such as ours. The compliance rate among adolescents was relatively high and possibly in part due to the motivation of the participating schools and teachers.

Common problems that are likely to have an effect on the intervention effects found on body composition were relatively small but statistically significant. In theory, altering the energy gap by as little as 100 kcal/d (eg, a reduction of intake of approximately 0.2 L of sugar-containing beverages per day or an additional 15 minutes of bicycling [20 km/h] per day) is considered to prevent weight gain.\(^3\) On a population level, this would mean that no major changes in body composition and behavior among normal weight youth would be required to prevent excessive weight gain in the long term. Therefore, the DOiT intervention has provided promising evidence that interdisciplin ary school-based interventions, developed on a solid theoretical basis, can make a significant contribution to obesity prevention in adolescents on a public health level. To achieve more sustained changes with regard to anthropometry and all targeted behaviors, our intervention might benefit from improvements with regard to parental involvement and more focus on environmental changes. Future interventions might consider the possibility or the need for a booster component (beyond the 11 lessons given) and the maintenance of the environmental changes in the schools to produce greater benefit. Health and population effects can only be expected if interventions are maintained, as has been shown by the implementation of the Planet Health intervention.\(^33\)

**CONCLUSIONS**

The DOiT intervention resulted in some beneficial effects on the sum of skinfold thickness measurements in girls and consumption of sugar-containing beverages in boys and girls in the short and long terms. Reducing intake of sugar-containing beverages should therefore be considered a good behavioral target for future interventions aimed at the prevention of overweight among adolescents.

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**ADDITIONAL INFORMATION**

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