Short-term Effects of School-Based Weight Gain Prevention Among Adolescents

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Objective: To determine whether a multicomponent health promotion intervention for Dutch adolescents would be successful in influencing body composition and aerobic fitness.

Design: Randomized controlled trial.

Setting: Ten intervention and 8 control prevocational secondary schools.

Participants: A total of 978 adolescents (mean age, 12.7 years).

Intervention: An interdisciplinary multicomponent intervention program with an adapted curriculum for 11 biology and physical education lessons and environmental change options, including additional lessons on physical education and advice on the school canteen selection.

Main Outcome Measures: Body height and weight, hip and waist circumference, 4 skinfold thickness measurements, and aerobic fitness.

Results: Multilevel analyses showed significant differences in changes after the 8-month intervention period in favor of the intervention group with regard to hip circumference (mean difference, 0.53 cm; 95% confidence interval, 0.07 to 0.98) and sum of skinfolds among girls (mean difference, −2.31 mm; 95% confidence interval, −4.34 to −0.28). In boys, the intervention resulted in a significant difference in waist circumference (mean difference, −0.57 cm; 95% confidence interval, −1.10 to −0.05). No significant intervention effects were found related to aerobic fitness.

Conclusions: The multicomponent Dutch Obesity Intervention in Teenagers program positively influenced several measures of body composition among both girls and boys. Our results indicate that secondary prevocational school curriculum changes may contribute to excessive weight gain prevention among adolescents.

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In the last decade, several international reports have addressed the significant increase in the prevalence of overweight and obesity among children and adolescents. Invariably, they underline the importance of developing effective, population-based preventive measures, specifically targeting the lower socioeconomic part of the population. It is generally accepted that both sides of the energy balance, that is, dietary and physical activity behavior, should be considered for a prevention program to have optimal effects. In addition, it is agreed that changing health behavior in the longer term requires intervention programs that focus not only on the individual but also on the environment. Still, results of school-based intervention programs have not enabled us to clearly distinguish effective interventions from those that are not effective.

Several characteristics of the adolescent life phase render it particularly appropriate for an intervention aimed at preventing overweight and obesity. First, treatment of overweight and establishing behavioral changes in adults are difficult and often not effective or feasible, especially in the longer term. Second, longitudinal data suggest that the probability of children and adolescents with a high body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) still being overweight in adulthood increases remarkably through adolescence and that overweight during adolescence is associated with increased morbidity and mortality in adulthood. Third, behavior and influences on behavior itself are both subject to important changes during adolescence. Adolescents, compared with younger children, may benefit more from health education because they possess the cognitive and behavioral...
competencies necessary to understand and act on health
and behavioral change instruction. Acquiring healthy diet-
y and physical activity habits during childhood and adol-
scence thus seems a more promising formula than alter-
ing ingrained unhealthy habits in adults.

Because low socioeconomic status in early life is associ-
ated with increased fatness in adulthood, we decided to
restrict our sample to schools of the lowest educational
evel (ie, prevocational education). Although some stud-
ies have demonstrated positive short-term effects on an-
thropometric measures, the underlying mechanisms of obe-
sity prevention are still not fully understood. Because the
number of well-designed trials in this field is small, ran-
domized controlled trials that use a range of objective mea-
sures of body composition are needed.

Drawing from promising effects of preventive ap-
proaches aimed at changing adolescent energy balance–
related behavior, we performed a randomized con-
trolled trial: the Dutch Obesity Intervention in Teenagers
(DOiT) study. We aimed to determine whether a school-
based multicomponent health promotion intervention for
Dutch adolescents would be successful in positively in-
fluencing body composition and aerobic fitness.

STUDY DESIGN AND PARTICIPANTS

A total of 18 prevocational secondary schools participated in
the study. Participating schools were requested to select 3 classes
of first-year students (aged 12-13 years), who received an in-
formational brochure about the study. No inclusion criteria were
set for students to take part in the study. Written informed con-
sent was obtained from all students and their parents. The Med-
ical Ethics Committee of the VU University Medical Center ap-
proved the study protocol.

After baseline measurements from September 15, 2003,
through October 13, 2003, the schools were randomly as-
signed to either the intervention or control group, using SPSS
statistical software (SPSS Inc, Chicago, Ill) for random selec-
tion of a sample. Randomization took place at the school level
or at location level (in case 2 schools were located in 1 city)
and was stratified by urbanization (urban vs rural). After ran-
domization, schools were informed about the group allocation.

OUTCOME MEASURES

We collected data at baseline at the start of the first school year
and after 8 months. Primary outcome measures were changes in
measures of body composition: waist and hip circumfer-
ence, skinfolds, and BMI class. The secondary outcome mea-
sure was change in aerobic fitness assessed by the shuttle run
test (adapted 18-m version).

All measurements were performed within a 6-week period
according to a standardized protocol by a trained research team,
which was not blinded to the group assignment. Before each mea-
surement period, we studied intrarater and interrater re-
liability of the skinfolds measurements, waist circumference,
and hip circumference. Values for intrarater reliability varied
from 0.82 to 0.95. Values for interrater reliability varied from
0.88 to 0.99.

Body height was measured and recorded with an accuracy
of 1 mm with a portable stadiometer (Seca 225; Seca Deutsch-
land, Hamburg, Germany). We attached a level to the stadi-
ometer to ensure that head posture was established correctly
for the measurement. Body weight was measured and re-
corded within 0.1 kg with a calibrated electronic flat scale (Seca
888; Seca Deutschland), leveled after each placement. Skin-
folds were measured on the right side of the body to the near-
est 0.2 mm, using a Harpenden skinfold caliper. We deter-
ned skinfold thickness by averaging 2 measurements. If the
2 measurements differed by more than 1 mm, a third measure-
ment was performed, and skinfold thickness was taken as the
average of the 3 measurements. Waist and hip circumferences
were measured and recorded with a flexible band (Seca 200:
Seca Deutschland) to an accuracy of 0.5 cm. The anatomical
landmark for the waist circumference was the trochan-
ter major, the maximum circumference over the buttocks.
During all measurements, students were dressed in under-
wear. We ensured adequate privacy during the measurements
by measuring 1 adolescent at a time in a separate room.

We conducted a group-administered shuttle run test to as-
sess aerobic fitness. Because of the limited size of the sports
hall at several schools, we changed the distance for 1 shuttle
test (adapted 18-m version).

INTERVENTION

We developed the DOiT program according to the Interven-
tion Mapping protocol, which facilitates a systematic pro-
cess of designing health promotion interventions and is based
on theory and empirical evidence. The DOiT program con-
Sisted of individual components and environmental compo-
nents (Figure 1). The individual component of the interven-
tion consisted of an educational program that covered 11 lessons
for the subjects of biology and physical education. Classroom
teachers implemented the program during 2 fixed periods in 1
school year. The program aimed to increase awareness and be-
havioral changes concerning energy intake and energy out-
put. Furthermore, we encouraged additional physical educa-
tion classes and changes at school canteens to facilitate behavioral
change. The development and content of the DOiT program
are described in more detail elsewhere. We aimed to fit
the DOiT program optimally into the regular curriculum in terms
of content and time to improve program feasibility and accept-
ability. Control schools were requested to maintain their regu-
lar curriculum.

STATISTICAL ANALYSIS

We used the nonparametric Kolmogorov-Smirnov test (all mea-
surements of body composition and physical fitness) and the
Pearson χ2 test (BMI class) to compare groups at baseline. Mul-
tilevel analysis was used to evaluate the effects of the interven-
tion on all anthropometric measures and aerobic fitness. Using
this technique, regression coefficients could be adjusted for the
clustering of observations within 1 school and/or class. We de-
defined 3 levels in our multilevel analysis: (1) student, (2) class,
and (3) school. Linear and logistic models were used to study
the effect of the intervention on the outcome values. The para-
eters of interest were the regression coefficients, indicating
the effect of the intervention compared with the control group.
In the crude model the outcome value at 8 months was ad-
justed for baseline value. Interaction effects for sex and age for
all outcome measures and for overweight for aerobic fitness only
were checked. All analyses were performed according to the
intention-to-treat principle.
Sample size calculation was based on changes in body weight. Assuming $\alpha=0.05$, power=$90\%$, and a 2-sided test, we needed 233 participants per group to show a mean $\pm$SD difference in weight of $0.5\pm1.5$ kg between the intervention and control groups. To perform multilevel analyses and taking into account the cluster randomization design, a sample size between 500 and 600 individuals from 16 schools was required. We increased the sample size to allow for dropout.

### RESULTS

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

In total, complete data were obtained in 978 students (Figure 2). Table 1 gives the baseline characteristics of our sample in terms of body weight, body height, and percentage of overweight and obesity. Mean baseline data stratified by sex revealed significant differences between control schools and intervention schools with regard to weight (boys) and body height (girls) (Table 1).

**EFFECTS ON BODY COMPOSITION AND AEROBIC FITNESS**

We conducted analyses separately for boys and girls because sex was found to be an effect modifier. In Table 2 and Table 3, we present the means for all outcome measures at baseline and follow-up and the results of the multilevel analyses (regression coefficients of the crude model) for girls and boys, respectively. After the 8-month intervention period, all measures had changed in favor of the intervention group among both girls and boys.

No significant intervention effects on BMI were found, although changes in BMI tended to be more favorable in the intervention group. This finding applied to both sexes. We found no between-group differences with regard to BMI class. In girls, 5 (2.8%) of 176 in the control group and 8 (2.9%) of 233 in the intervention group were classified as being of normal weight during baseline and as overweight after the 8-month intervention period. In boys, 5 (2.6%) of 196 in the control group and 10 (4.0%) of 249 in the intervention group were classified as being of normal weight during baseline and as overweight after the 8-month intervention period.

Changes in waist-hip ratio differed significantly in favor of the intervention group among boys and girls because of a smaller increase in waist circumference in boys and a larger increase in hip circumference in girls in the intervention group. Another significantly favorable intervention effect on the sum of skinfolds was found in girls. In girls, average triceps skinfold thickness increased in the control group, whereas it decreased in the intervention group. Average changes in the thickness of biceps (decrease), subscapular (decrease), and suprailliac (increase) skinfolds were also more favorable in the intervention group.

In boys, average suprailliac skinfold thickness increased in the control group, whereas it decreased in the intervention group. Average changes in skinfold thickness of the triceps (decrease), biceps (decrease), sub-

### COMMENT

The DOIT study was designed to evaluate the effectiveness of an interdisciplinary school-based program aimed at the prevention of overweight and obesity. The effects of this multicomponent intervention program were small but promising. In girls, we found significant intervention effects for 3 important measures of body composition after the 8-month intervention period: sum of skinfolds, waist circumference, and waist-hip ratio. In boys, we found significant differences with regard to waist circumference and waist-hip ratio. All changes in anthropometric outcome measures and aerobic fitness consistently favored the boys and girls of the intervention schools.

Our results suggest that the DOIT program was successful in altering body composition toward less fat mass in both sexes. The absence of significant differences with regard to BMI may be attributed to the failure of BMI to distinguish between fat and fat-free mass$^{23}$ and the fact that...
skinfold thickness is more sensitive to small changes in body composition. Our results are in line with the findings of Mcmurray et al., who also found a significant intervention effect on skinfold thickness but no effect on BMI. Findings of the New Moves study also illustrate a lack of effect on BMI after the 8-month intervention. The authors emphasize the need for more sensitive measures than BMI for assessing small changes in body composition.

Our findings do not exactly correspond with those of Gortmaker et al., who found a decrease in prevalence rates of obesity in girls after a school-based prevention program (ie, Planet Health). The discrepancy of the results between our study and that of Gortmaker and colleagues may be attributed to the difference with regard to the outcome measures used to determine effectiveness. Gortmaker and colleagues used a composite indicator to define prevalence rates of obesity, consisting of BMI and triceps skinfold thickness. We did not find significant effects on the isolated measures of BMI and triceps skinfold thickness, although our results are in favor of the intervention group on both outcome measures. Furthermore, considerable differences exist concerning program duration and intensity. The Planet Health intervention consisted of 32 lessons spread over 2 school years, whereas the DOiT program comprised 11 lessons spread over 1 school year.

Although waist circumference is considered to be an important risk factor for cardiovascular diseases and...
type 2 diabetes mellitus in adults\textsuperscript{25} and adolescents,\textsuperscript{26} to our knowledge no studies have evaluated the effectiveness of obesity prevention programs in adolescents on both waist and hip circumference. The DOiT program had significant beneficial effects on waist circumference in boys and hip circumference in girls. Data from several studies show that a larger hip circumference is a significant independent inverse risk factor for cardiovascular disease and diabetes in adults,\textsuperscript{27} independent of BMI and waist circumference. These facts, combined with the results we found, suggest that the DOiT program has led to favorable changes in waist circumference (decrease in visceral fat accumulation) in boys and hip circumference (increase in muscle mass in the gluteal region)\textsuperscript{28} in girls.

Our study comprised several strong elements. First, the study had a solid theoretical basis because we used the Intervention Mapping protocol\textsuperscript{29} for the development of the intervention and for the selection of evidence-based intervention elements, such as the introduction of additional lessons in physical education, computer-tailored individualized feedback,\textsuperscript{29} and simultaneous targeting of individual and environmental determinants of dietary and physical activity behavior.\textsuperscript{4} Another strength of our study is that the intervention is easy to implement and sustain as a whole because it requires only existing school staff, has low implementation costs, and includes lessons that fit the existing biology and physical education curriculum of the schools. We restricted our sample to schools of the lowest educational level because in many Western countries an inverse relationship between educational level or socioeconomic status and prevalence of obesity has been observed.\textsuperscript{30} To our knowledge, this is the first school-based obesity prevention program that specifically targets this segment of the adolescent population. Finally, we achieved a high participation rate, ensuring good representation of the general population of students of secondary prevocational education in the Netherlands.

The effect sizes in the present study were relatively small compared with the size of the obesity problem, an apparent drawback that we share with other studies.\textsuperscript{31}

### Table 2. Anthropometric Characteristics and Physical Fitness in Girls at Baseline and After the 8-Month Intervention and Mean Difference in Change Between the Intervention and Control Schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention Group</th>
<th>Control Group</th>
<th>Difference in Change Between the Intervention and Control Schools (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline 8 mo</td>
<td>Baseline 8 mo</td>
<td></td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>65.73 (6.80)</td>
<td>67.23 (6.04)</td>
<td>−0.49 (−0.75 to −0.23)</td>
</tr>
<tr>
<td>Hip circumference, cm</td>
<td>84.12 (7.79)</td>
<td>85.26 (8.38)</td>
<td>0.14 (−0.24 to 0.52)</td>
</tr>
<tr>
<td>Waist-hip ratio</td>
<td>0.78 (0.04)</td>
<td>0.79 (0.04)</td>
<td>0.01 (−0.01 to 0.03)</td>
</tr>
<tr>
<td>Triceps skinfold, mm</td>
<td>14.54 (4.85)</td>
<td>14.78 (5.31)</td>
<td>0.24 (−0.17 to 0.65)</td>
</tr>
<tr>
<td>Biceps skinfold, mm</td>
<td>8.87 (3.66)</td>
<td>9.14 (4.14)</td>
<td>0.27 (−0.06 to 0.59)</td>
</tr>
<tr>
<td>Subscapular skinfold, mm</td>
<td>13.11 (7.29)</td>
<td>13.65 (8.62)</td>
<td>0.54 (−0.74 to 1.82)</td>
</tr>
<tr>
<td>Suprailiac skinfold, mm</td>
<td>16.68 (8.76)</td>
<td>17.71 (10.32)</td>
<td>1.03 (0.24 to 1.82)</td>
</tr>
<tr>
<td>Sum of skinfolds, mm</td>
<td>53.14 (23.04)</td>
<td>55.14 (27.05)</td>
<td>2.00 (0.10 to 3.90)</td>
</tr>
<tr>
<td>BMI</td>
<td>19.0 (3.0)</td>
<td>19.48 (3.38)</td>
<td>0.48 (−0.18 to 0.10)</td>
</tr>
<tr>
<td>Shuttle run test, laps</td>
<td>7.24 (1.77)</td>
<td>7.19 (1.86)</td>
<td>0.05 (−0.14 to 0.24)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); CI, confidence interval.

*Data are presented as mean (SD).

†Changes in favor of the intervention group.

### Table 3. Anthropometric Characteristics and Physical Fitness in Boys at Baseline and After the 8-Month Intervention and Mean Difference in Change Between the Intervention and Control Schools

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention Group</th>
<th>Control Group</th>
<th>Difference in Change Between the Intervention and Control Schools (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline 8 mo</td>
<td>Baseline 8 mo</td>
<td></td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>66.08 (7.03)</td>
<td>68.02 (7.50)</td>
<td>−1.94 (−3.72 to −0.16)</td>
</tr>
<tr>
<td>Hip circumference, cm</td>
<td>80.04 (6.97)</td>
<td>82.27 (7.35)</td>
<td>2.23 (0.92 to 3.55)</td>
</tr>
<tr>
<td>Waist-hip ratio</td>
<td>0.82 (0.04)</td>
<td>0.83 (0.04)</td>
<td>0.01 (−0.01 to 0.03)</td>
</tr>
<tr>
<td>Triceps skinfold, mm</td>
<td>11.85 (4.64)</td>
<td>12.02 (4.57)</td>
<td>0.17 (−0.13 to 0.48)</td>
</tr>
<tr>
<td>Biceps skinfold, mm</td>
<td>6.53 (3.08)</td>
<td>6.75 (3.23)</td>
<td>0.22 (−0.38 to 0.82)</td>
</tr>
<tr>
<td>Subscapular skinfold, mm</td>
<td>8.21 (4.27)</td>
<td>9.26 (5.33)</td>
<td>1.05 (0.52 to 1.57)</td>
</tr>
<tr>
<td>Suprailiac skinfold, mm</td>
<td>12.57 (8.06)</td>
<td>13.70 (8.46)</td>
<td>1.13 (0.52 to 1.74)</td>
</tr>
<tr>
<td>Sum of skinfolds, mm</td>
<td>38.90 (18.53)</td>
<td>41.54 (20.51)</td>
<td>2.64 (0.82 to 4.47)</td>
</tr>
<tr>
<td>BMI</td>
<td>18.16 (2.64)</td>
<td>19.05 (2.86)</td>
<td>0.89 (0.11 to 1.66)</td>
</tr>
<tr>
<td>Shuttle run test, laps</td>
<td>8.93 (2.08)</td>
<td>8.61 (2.13)</td>
<td>0.32 (−0.18 to 0.83)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); CI, confidence interval.

*Data are presented as mean (SD).

†Changes in favor of the intervention group.
However, in interpreting the results of the present study, one should bear in mind that the aim of our intervention was prevention rather than treatment of obesity. Currently, no evidence has indicated that the small effects we found can make a difference in the long term. Nevertheless, our results suggest that from the perspective of public health and prevention of excessive weight gain, the DOiT program has the potential to effect change in the right direction. Effective interventions aimed at preventing excessive weight gain in adolescence are vital but may affect health in the longer term only if such approaches are implemented on a broad scale with public and governmental involvement.

The lack of significant between-group differences regarding changes in aerobic fitness is disappointing given the results of several other obesity prevention studies that found positive intervention effects on (proxy) measures of aerobic fitness.13-15,23 Although the shuttle run test is probably the most widely used test to assess aerobic fitness among children and adolescents and its reliability and validity have been proved,3,20 it may be less suitable for the age group of our study population. Confidence in the validity of our shuttle run findings is limited by the observations during the measurements, postulating the influence of motivation and peer pressure on the performance of the shuttle run test.

The fact that our study population consisted exclusively of students from the lower educational levels of the Dutch school system restricts the generalization of our results to this section of the adolescent population. In addition, a selection bias cannot be excluded given that the repeated measurements combined with the moderate changes in the curricula were rather demanding for the performance of the shuttle run test.

In summary, the results of our study showed that well-planned moderate physical activity and nutritional alterations to the school curricula may contribute to the prevention of excessive weight gain among adolescents. After an 8-month intervention period, sensitive measures of body composition, such as the sum of skinfolds and waist and hip circumference, significantly changed in favor of the intervention schools in both sexes. The results of several other obesity prevention studies that were implemented on a broad scale with public and governmental support. We also thank our research assistant, Judith van Leeuwen, MSc, for her help and enthusiasm during the data collection phase.

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Author Contributions: Ms Singh had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Singh, Chin A Paw, Brug, and van Mechelen. Acquisition of data: Singh. Analysis and interpretation of data: Singh, Chin A Paw, Brug, and van Mechelen. Drafting of the manuscript: Singh and Chin A Paw. Critical revision of the manuscript for important intellectual content: Singh, Chin A Paw, Brug, and van Mechelen. Administrative, technical, and material support: Singh. Study supervision: Chin A Paw, Brug, and van Mechelen.

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Sesame Street is best known for the creative geniuses it attracted, people like Jim Henson and Joe Raposo and Frank Oz, who intuitively grasped what it takes to get through to children. They were television’s answer to Beatrix Potter or L. Frank Baum or Dr Seuss. But it is a mistake to think of Sesame Street as a project conceived in a flash of insight. What made the show unusual, in fact, was the extent to which it was exactly the opposite of that—the extent to which the final product was deliberately and painstakingly engineered. Sesame Street was built about a single, breakthrough insight—that if you can hold the attention of children, you can educate them.

—From The Tipping Point by Malcolm Gladwell, 2000