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[1-3] 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.[4] 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.[5] Still, results of school-based intervention programs have not enabled us to clearly distinguish effective interventions from those that are not effective.[6]

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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.[7] 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[8] and that overweight during adolescence is associated with increased morbidity and mortality in adulthood.[9] 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.[10] Acquiring healthy dietary and physical activity habits during childhood and adolescence thus seems a more promising formula than altering ingrained unhealthy habits in adults.

Because low socioeconomic status in early life is associated with increased fatness in adulthood,[11] we decided to restrict our sample to schools of the lowest educational level (ie, prevocational education). Although some studies[12-15] have demonstrated positive short-term effects on anthropometric measures, the underlying mechanisms of obesity prevention are still not fully understood. Because the number of well-designed trials in this field is small,[16] randomized controlled trials that use a range of objective measures of body composition are needed.

Drawing from promising effects of preventive approaches aimed at changing adolescent energy balance–related behavior, we performed a randomized controlled 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 influencing body composition and aerobic fitness.

METHODS

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 informational brochure about the study. 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.

After baseline measurements from September 15, 2003, through October 13, 2003, the schools were randomly assigned to either the intervention or control group, using SPSS statistical software (SPSS Inc, Chicago, Ill) for random selection 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 randomization, 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 circumference, skinfolds, and BMI class.[17] The secondary outcome measure 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 measurement period, we studied intrarater and interrater reliability 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 Deutschland, Hamburg, Germany). We attached a level to the stadiometer to ensure that head posture was established correctly for the measurement. Body weight was measured and recorded within 0.1 kg with a calibrated electronic flat scale (Seca 888; Seca Deutschland), leveled after each placement. Skinfolds were measured on the right side of the body to the nearest 0.2 mm, using a Harpenden skinfold caliper.[18] We determined skinfold thickness by averaging 2 measurements. If the 2 measurements differed by more than 1 mm, a third measurement 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 laterally midway between the lowest portion of the rib cage and iliac crest. The anatomical landmark for the hip circumference was the trochanter major, the maximum circumference over the buttocks. During all measurements, students were dressed in underwear. 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 assess aerobic fitness.[19] Because of the limited size of the sports hall at several schools, we changed the distance for 1 shuttle to 18 m. The shuttle run test was always explained and conducted by the same researcher (A.S.).

INTERVENTION

We developed the DOiT program according to the Intervention Mapping protocol,[4,20] which facilitates a systematic process of designing health promotion interventions and is based on theory and empirical evidence. The DOiT program consisted of individual components and environmental components (**Figure 1**). The individual component of the intervention 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 behavioral changes concerning energy intake and energy output. Furthermore, we encouraged additional physical education classes and changes at school canteens to facilitate behavioral change. The development and content of the DOiT program are described in more detail elsewhere.[21] We aimed to fit the DOiT program optimally into the regular curriculum in terms of content and time to improve program feasibility and acceptability. Control schools were requested to maintain their regular curriculum.

STATISTICAL ANALYSIS

We used the nonparametric Kolmogorov-Smirnov *z* test (all measurements of body composition and physical fitness) and the Pearson χ^2 test (BMI class) to compare groups at baseline. Multilevel analysis was used to evaluate the effects of the intervention 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 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 parameters 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 adjusted 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 α = .05, power = 90%, and a 2-sided test, we needed 233 participants per group to show a mean ± SD difference in weight of 0.5 ± 1.5 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 273 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 suprailiac (increase) skinfolds were also more favorable in the intervention group.

In boys, average suprailiac 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), subscapular (increase), and sum of skinfolds (decrease) were also more favorable in the intervention group.

The increase in aerobic fitness was somewhat larger in the intervention group among both boys and girls, but this finding was not statistically significant. A significant interaction between group allocation and age was found in girls. The interaction indicated that with increasing age the effect of the intervention on aerobic fitness was more favorable.

5 Risk Behaviors Targeted:
- Reduction in consumption of sugar-sweetened beverages
- Reduction in consumption of high-sugar, high-fat-content snacks
- Reduction in sedentary behavior
- Increase in active transport behavior
- Maintenance of level of sports participation

Classroom-Based, Individual Part of the Intervention (Teachers received a manual describing the structure of each lesson and goals for the distinctive parts of the lessons:
- Educational program, covering 11 biology and physical education lessons:
  - First part (BALANCEiT, consisting of 6 lessons) aimed at raising awareness and information processing with regard to energy balance–related behaviors
  - Second part (CHOOSEiT) aimed at facilitation of choice to improve 1 of the risk behaviors

Supportive Material for the Educational Program:
- Individually computer-tailored advice via Internet or CD-ROM (TESTiT)
- Pocket-sized diary (CHECKiT)
- Pedometer
- Supportive video material

Environmental Part of the Intervention:
- School-specific advice on the selection of the school canteen and possible change options
- Posters for the school canteen
- Financial encouragement of schools to offer additional physical activity options

Behavior Change Methods Used:
- Self-monitoring
- Self-evaluation
- Reward
- Increasing skills
- Goal setting
- Environmental changes
- Social encouragement
- Social support
- Information regarding behavior
- Personalized messages

Figure 1. Dutch Obesity Intervention in Teenagers program. BALANCEiT, CHOOSEiT, TESTiT, and CHECKiT indicate the different parts of the intervention.

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[22] and the fact that

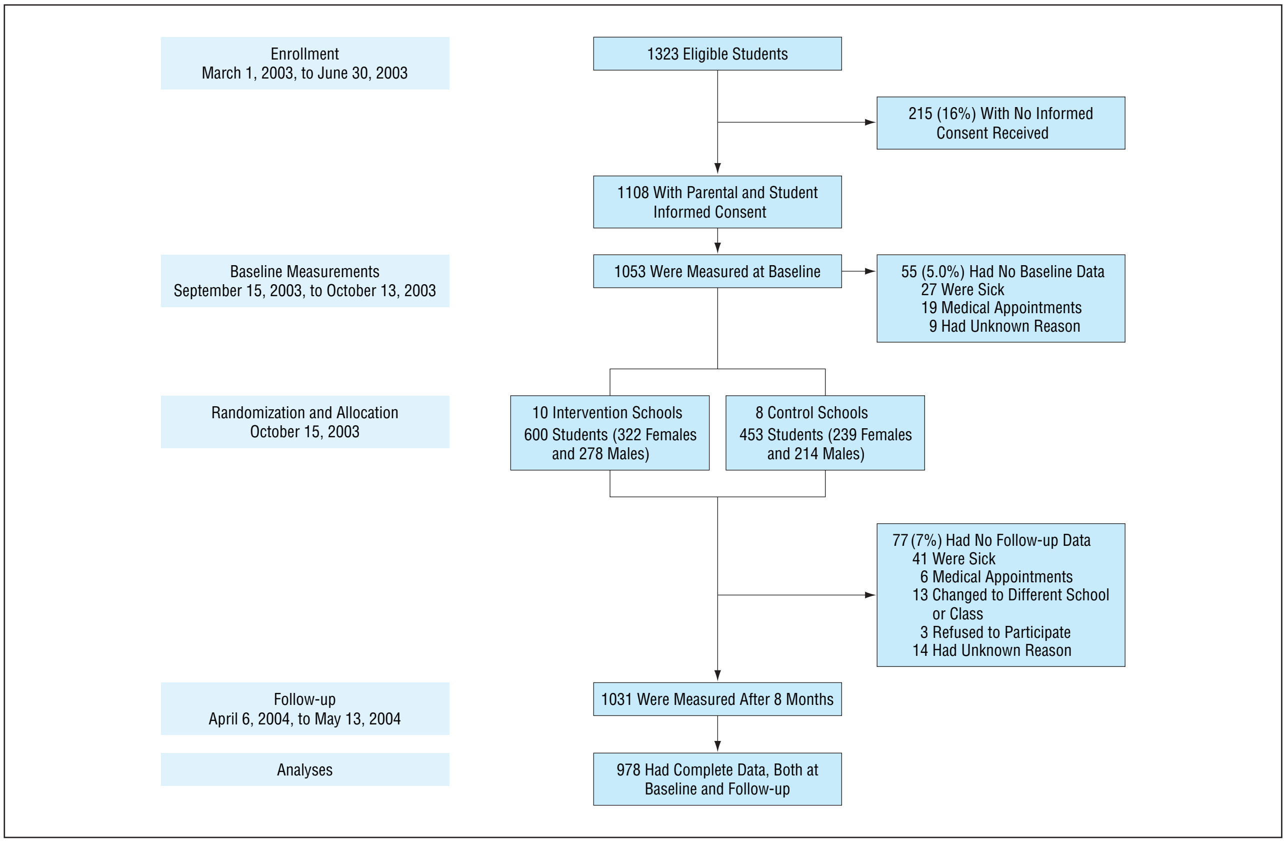

Figure 2. Flow of the participants through the trial.

Table 1. Characteristics at Baseline in the Intervention and Control Schools*

	Boys (n = 517)			Girls (n = 536)		
Characteristic	**Intervention Group (n = 278)**	**Control Group (n = 214)**	***P* Value†**	**Intervention Group (n = 322)**	**Control Group (n = 239)**	***P* Value†**
Age, y	12.72 (0.47)	12.83 (0.51)	.09	12.61 (0.44)	12.69 (0.51)	.23
Body height, cm	158.55 (8.20)	159.62 (8.22)	.26	157.38 (7.58)	158.80 (6.75)	.01
Weight, kg	45.93 (9.22)	48.86 (9.99)	.00	47.27 (9.28)	49.42 (10.62)	.10
Overweight, No. (%)‡	26.0 (9.4)	40.0 (16.7)	.08	43.0 (13.4)	31.0 (14.5)	.56
Obese, No. (%)‡	3.0 (1.1)	3.0 (1.3)		6.0 (1.9)	7.0 (3.3)	

*Data are presented as mean (SD) unless otherwise indicated.
†Comparing intervention and control schools at baseline, using the Kolmogorov-Smirnov *z* test (age, body height, and weight) and the Pearson χ^2 test (percentage overweight/percentage obese).
‡Using cutoff values described by Cole et al.[17]

skinfold thickness is more sensitive to small changes in body composition. Our results are in line with the findings of Mcmurray et al,[23] who also found a significant intervention effect on skinfold thickness but no effect on BMI. Findings of the New Moves study[24] also illustrate a lack of effect on BMI after the 8-month intervention. The authors[24] 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,[12] 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[12] 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

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*

Variable	Intervention Group Baseline	Intervention Group 8 mo	Control Group Baseline	Control Group 8 mo	Difference in Change Between Groups (95% CI)
Waist circumference, cm	65.73 (6.80)	67.05 (6.74)	67.23 (8.04)	68.80 (8.01)	−0.34 (−0.82 to 0.15)†
Hip circumference, cm	84.12 (7.79)	87.28 (7.64)	85.26 (8.38)	88.05 (8.80)	0.52 (0.07 to 0.98)
Waist-hip ratio	0.78 (0.04)	0.77 (0.04)	0.79 (0.04)	0.78 (0.04)	−0.009 (−0.02 to −0.003)†
Triceps skinfold, mm	14.54 (4.85)	14.42 (5.29)	14.78 (5.31)	14.87 (5.66)	−0.23 (−0.71 to 0.26)†
Biceps skinfold, mm	8.87 (3.66)	7.856 (3.61)	9.14 (4.14)	8.45 (3.93)	−0.27 (−0.71 to 0.18)†
Subscapular skinfold, mm	13.11 (7.29)	12.47 (7.07)	13.65 (8.62)	12.66 (7.62)	−0.52 (−1.17 to 0.12)†
Suprailiac skinfold, mm	16.68 (8.76)	18.25 (10.13)	17.71 (10.32)	19.99 (11.14)	−1.02 (−2.31 to 0.28)†
Sum of skinfolds, mm	53.14 (23.04)	53.19 (24.81)	55.14 (27.05)	56.02 (26.84)	−2.31 (−4.34 to −0.28)†
BMI	19.0 (3.0)	19.46 (3.05)	19.48 (3.38)	20.00 (3.47)	−0.05 (−0.18 to 0.08)†
Shuttle run test, laps	7.24 (1.77)	7.65 (1.93)	7.19 (1.86)	7.44 (1.83)	0.10 (−0.44 to 0.64)†

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*

Variable	Intervention Group Baseline	Intervention Group 8 mo	Control Group Baseline	Control Group 8 mo	Difference in Change Between Groups (95% CI)
Waist circumference, cm	66.08 (7.03)	66.83 (6.79)	68.02 (7.50)	68.97 (7.17)	−0.57 (−1.10 to 0.05)†
Hip circumference, cm	80.04 (6.97)	82.18 (7.18)	82.27 (7.35)	84.38 (7.32)	0.005 (−0.52 to 0.53)
Waist-hip ratio	0.82 (0.04)	0.81 (0.04)	0.83 (0.04)	0.82 (0.04)	−0.006 (−0.01 to −0.000)†
Triceps skinfold, mm	11.85 (4.64)	11.13 (4.87)	12.02 (4.57)	11.61 (4.81)	−0.28 (−0.70 to 0.13)†
Biceps skinfold, mm	6.53 (3.08)	6.08 (3.08)	6.75 (3.23)	6.26 (3.05)	−0.10 (−0.38 to 0.17)†
Subscapular skinfold, mm	8.21 (4.27)	8.36 (5.11)	9.26 (5.33)	9.41 (5.84)	−0.22 (−0.75 to 0.31)†
Suprailiac skinfold, mm	12.57 (8.06)	12.44 (8.43)	13.70 (8.46)	14.01 (9.34)	−0.25 (−0.94 to 0.44)†
Sum of skinfolds, mm	38.90 (18.53)	37.99 (20.53)	41.54 (20.51)	41.16 (21.83)	−0.98 (−2.42 to 0.45)†
BMI	18.16 (2.64)	18.61 (2.76)	19.05 (2.86)	19.43 (2.92)	−0.02 (−0.11 to 0.16)†
Shuttle run test, laps	8.93 (2.08)	9.33 (2.03)	8.61 (2.13)	9.0 (2.23)	0.14 (−0.18 to 0.46)†

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.

type 2 diabetes mellitus in adults[25] and adolescents,[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,[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)[28] in girls.

Our study comprised several strong elements. First, the study had a solid theoretical basis because we used the Intervention Mapping protocol[20] 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,[29] and simultaneous targeting of individual and environmental determinants of dietary and physical activity behavior.[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.[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.[31]

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,[32] 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 participating schools.

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 DOiT study thus emphasizes the need for low-intensity population-wide studies.

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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