

# Short- and Long-Term Beneficial Effects of a Combined Dietary–Behavioral–Physical Activity Intervention for the Treatment of Childhood Obesity

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**ABSTRACT.** *Background.* Obesity has become the most common pediatric chronic disease in the modern era. Early prevention and treatment of childhood and adolescent obesity is mandated. Surprisingly, however, only a minor fraction of obese children participate in weight reduction interventions, and the longer-term effects of these weight-reduction interventions among children have not been elucidated.

*Objective.* To examine prospectively the short- and long-term effects of a 3-month, combined dietary-behavioral-physical activity intervention on anthropometric measures, body composition, dietary and leisure-time habits, fitness, and lipid profiles among obese children.

*Methods.* In this randomized prospective study, 24 obese subjects completed the 3-month intervention and were compared with 22 obese, age- and gender-matched, control subjects.

*Results.* At 3 months, there were significant differences in changes in body weight ( $-2.8 \pm 2.3$  kg vs  $1.2 \pm 2.2$  kg), BMI ( $-1.7 \pm 1.1$  kg/m<sup>2</sup> vs  $-0.2 \pm 1.0$  kg/m<sup>2</sup>), body fat percentage (from skinfold tests;  $-3.3 \pm 2.6\%$  vs  $1.4 \pm 4.7\%$ ), serum total cholesterol level ( $-24.6 \pm 15.1$  mg/dL vs  $0.8 \pm 18.7$  mg/dL), low-density lipoprotein cholesterol level ( $-23.3 \pm 15.2$  mg/dL vs  $-3.7 \pm 17.3$  mg/dL), and fitness ( $215 \pm 107$  seconds vs  $50 \pm 116$  seconds) in the intervention group versus the control group. After a 1-year follow-up period, there were significant differences between the intervention group ( $n = 20$ ) and the control group ( $n = 20$ ) in body weight ( $0.6 \pm 6.0$  kg vs  $5.3 \pm 2.7$  kg), BMI ( $-1.7 \pm 2.3$  kg/m<sup>2</sup> vs  $0.6 \pm 0.9$  kg/m<sup>2</sup>), and body fat percentage. There was a significant increase in leisure-time physical activity among the intervention participants, compared with a decrease among the control subjects.

*Conclusions.* Our data demonstrate the short- and longer-term beneficial effects of a combined dietary-behavioral-physical activity intervention among obese children. These results highlight the importance of multidisciplinary programs for the treatment of childhood obesity and emphasize their encouraging long-term effects. *Pediatrics* 2005;115:e443–e449. URL: [www.pediatrics.org/cgi/doi/10.1542/peds.2004-2172](http://www.pediatrics.org/cgi/doi/10.1542/peds.2004-2172)

[pediatrics.org/cgi/doi/10.1542/peds.2004-2172](http://pediatrics.org/cgi/doi/10.1542/peds.2004-2172); *obesity, multidisciplinary treatment, childhood, exercise.*

ABBREVIATIONS. LDL, low-density lipoprotein; TG, triglyceride; HDL, high-density lipoprotein.

Childhood obesity has reached epidemic proportions worldwide, despite major efforts to promote weight reduction. The mechanisms responsible for the increasing prevalence of childhood obesity are not understood completely, but lifestyle changes associated with increased caloric intake and decreased energy expenditure play probably critical roles.<sup>1,2</sup>

Childhood obesity is associated with increased risk of hyperlipidemia, hypertension, insulin resistance, diabetes mellitus, and arteriosclerosis later in life.<sup>3,4</sup> In addition, long-term follow-up results indicate that obese children and adolescents tend to become obese adults.<sup>5</sup> Moreover, adults who were obese children have increased morbidity and mortality rates independent of their adult weight.<sup>6</sup> Therefore, prevention and treatment of obesity must start during childhood. It is surprising that relatively few intervention programs are available for obese children and adolescents and that treatment is initiated for <20% of obese children.<sup>7</sup> Moreover, current data on the long-term effects of weight management programs for childhood obesity are limited.

We previously reported the favorable immediate effects of a 3-, 6-, and 12-month multidisciplinary (nutritional, behavioral, and exercise) intervention on BMI and physical fitness among children and adolescents.<sup>8,9</sup> The aim of the present study was to examine prospectively the long-term (1-year) effects of a brief (3-month), combined dietary-behavioral-physical activity intervention on body weight, BMI, BMI percentile, body composition, habitual physical activity, fitness, and serum lipids among obese Israeli children and adolescents.

## METHODS

### Power Analysis

The sample size calculation for this study was based on the previously reported intervention changes in body weight and BMI percentile among children.<sup>8</sup> With a 2-sided, .05 significance level ( $\alpha = .05$ ), with weight change as the primary variable, 18 subjects in each group would allow us to detect a significant difference at 90% power. For BMI percentile, 11 subjects per group would be

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required to detect a significant difference with 90% power. We chose to use the larger, weight change-based, sample size, which would provide adequate power for detecting both differences. To account for the expected dropout and loss of follow-up rates, assuming a higher dropout rate for the intervention group, we added 10 subjects to the intervention group and 6 subjects to the control group. We allocated intentionally an unequal number of participants to each group, on the basis of our previous experience.<sup>8</sup> In most cases, dropouts from our program (20%) were attributable to difficulties with transportation to our training facility, whereas losses to follow-up monitoring (20%) were attributable to relocation.

Fifty-four obese self-referred children and adolescents (6–16 years of age) participated in the study, with informed consent, from January 2002 to May 2003. The study was approved by the institutional review board of the Meir General Hospital. After recruitment, all participants were examined by the attending physician at the Child Health and Sports Center. None of the subjects had an organic cause for his or her obesity, and none of the subjects received any medication that might interfere with growth or weight control (eg, corticosteroids or thyroid hormone).

Thirty children and adolescents were assigned randomly, with a computerized, random number generator, to participate in our 3-month, combined dietary and exercise program for the treatment of childhood obesity, at the Child Health and Sports Center, Meir General Hospital, Tel Aviv University. During the intervention period, 6 subjects (20%) withdrew from the program (mainly because of difficulties with transportation to the exercise training facility). Twenty-four subjects completed the 3-month program, and 20 of them returned for evaluation 1 year later.

Twenty-four obese children and adolescents were assigned to serve as control subjects and were monitored in our pediatric obesity clinic. Control subjects were referred to an ambulatory nutritional consultation at least once and were instructed to perform physical activity 3 times per week on their own. Twenty-two control subjects completed the 3-month evaluation, and 20 of them returned for evaluation after 1 year.

### Intervention Design

Subjects and parents in the intervention group were invited together for a series of 4 evening lectures (on childhood obesity, general nutrition, a therapeutic nutritional approach for childhood obesity, and exercise and childhood obesity) during the 3 months of the program. The lectures were given by the physicians and dietitian of the Child Health and Sports Center.

### Dietary Intervention

The participants met with the dietitian 6 times during the 3-month program. The participants in these meetings differed according to the age of the patients. For children 6 to 8 years of age, only the parents were invited for the first 2 meetings, and the children joined the meetings thereafter. Children >8 years of age were invited, with both parents, to all meetings. Pubertal subjects were invited to the first meeting with both parents and then, alternately, the adolescent and his or her parents met the dietitian separately. Each family was instructed to come to the first meeting with a 24-hour dietary recall. The first appointment, which was 45 to 60 minutes long, was dedicated to becoming acquainted, learning about the reasons for childhood obesity, receiving information about food choices and dietary and cooking habits, understanding the motivation for weight loss, and trying to enroll the whole family in the “battle” against overweight. The subsequent appointments, which were 30 to 45 minutes each, were devoted mainly to nutritional education (eg, food pyramid, food choices, food labels, food preparation and cooking, eating habits, regular meals, and controlling environments that stimulate overeating). In addition, children received dietary information through worksheets and flyers on important nutritional issues such as the food pyramid, fruits and vegetables, calcium intake and needs, special dietary consideration during holidays, and how to deal with food during a big celebration, on vacations, and at restaurants.

Subjects received a balanced hypocaloric diet. The diet consisted of 5021 to 8368 kJ (depending on the age and weight of the child), a caloric deficit of ~30% from the reported intake, or intake 15% less than the estimated daily required intake.

### Exercise Program

All intervention subjects participated in a twice-weekly training program (1 hour per training session). Training was directed by professional youth coaches at the Child Health and Sports Center training center. The intervention was designed to mimic the type and intensity of exercise that elementary school and high school children perform normally. These activities varied in duration and intensity throughout the program and were designed primarily as games to encourage enthusiasm and participation of the subjects. Endurance-type activities accounted for most of the time spent in training (~50% team sports and 50% running games), with attention to coordination and flexibility skills. The physicians who worked in the program (former members of the Israeli national track and field team) participated regularly in the training sessions, to encourage the children and provide examples.

To encourage personal responsibility among the participants, subjects were instructed to add an extra 30 to 45 minutes of walking or other weight-bearing sport activities at least once per week. These activities were reported to the coach at the end of the last training session each week. Subjects were encouraged throughout the program, by the physicians, nutritionist, and coaches, to reduce sedentary activities (eg, reduce television viewing and video game use, use stairs instead of elevators, and play outside instead of inside).

### Anthropometric Measurements

Standard calibrated scales and stadiometers were used to determine height, weight, and BMI. Because BMI changes with age, BMI-for-age percentiles were calculated according to the Centers for Disease Control and Prevention growth charts,<sup>10</sup> with the following equation:  $C = M(1 + LSZ)^2(1/L)$ , where  $C$  represents the age (in months)-adjusted percentile for a given measurement (eg, BMI),  $M$  represents the age-related median,  $S$  represents the age-related SD,  $L$  represents the age-related power in the Box-Cox transformation, and  $Z$  represent the  $z$  score.

The age-adjusted  $z$  score corresponding to the exact percentile for a given measurement was calculated with the following equation:  $Z = [(X/M)^2L - 1]/LS$ , where  $X$  represents the physical measurement (eg, weight, length, head circumference, stature, or calculated BMI value) and the  $L$ ,  $M$ , and  $S$  values were again collected from the appropriate table corresponding to the age (in months) of the child. Measurements were performed weekly throughout the 3-month program and again 1 year after the intervention.

Triceps and subscapular skinfold values were measured to the nearest 0.1 mm, with Holtain skinfold calipers (CMS Weighing Equipment, Crymych, United Kingdom). Measurements were made on the right side of the body. All measurements (baseline, 3 months, and 1 year) were performed by the same trained individual. Calculations of percentage body fat were performed with standard equations.<sup>11</sup>

### Nutritional Assessment

All subjects were instructed on how to keep a 2-day food record and were evaluated for understanding and accuracy through administration of a 24-hour recall before initiation of the study. Subjects kept three 2-day food records (at baseline, at the end of the 3-month program, and 1 year later). The food record data were reviewed by the project nutritionist and checked for omissions (for example, whether dressing was used on a salad listed as ingested with no dressing) and errors (for example, inappropriate portion size). This approach was validated by Crawford et al<sup>12</sup> for children and adolescents. All subjects completed the baseline, 3-month, and 1-year food records.

Food records were analyzed with the Israeli Ministry of Health tables. A computer algorithm based on these tables calculated the total energy intake and the proportions of the total energy intake derived from protein, fat, and carbohydrates.

### Habitual Activity Assessment

Habitual physical activity was assessed with a physical activity questionnaire.<sup>13</sup> Each type of activity was scored according to an estimated metabolic equivalent score, and a final weighted score was calculated.

## Fitness Assessment

Fitness was assessed with a progressive treadmill exercise test, to determine exercise endurance.<sup>8</sup> Subjects performed an exercise test before the program, at the end of the 3-month program, and 1 year after the program, with the same protocol. All subjects were familiarized with the treadmill for 5 minutes and performed a warm-up of 1 minute at a speed of 2.2 miles per hour, with no incline. Exercise started at a speed of 2.2 miles per hour, with an incline of 10 degrees. The exercise intensity was enhanced every 2 minutes by increasing the elevation of the treadmill by 2.5 degrees (up to an incline of 22.5 degrees). Then the treadmill speed was increased by 0.6 miles per hour every 2 minutes. All subjects were encouraged throughout the test by the staff members and exercised to the limit of their tolerance. Endurance time was measured from the end of the warm-up period to exhaustion.

## Evaluation of Serum Lipid Levels

Early-morning blood samples were collected for all subjects after a fast of  $\geq 12$  hours. Samples were collected at baseline and after the 3-month intervention. Serum total cholesterol, triglyceride (TG), and high-density lipoprotein (HDL) cholesterol levels were analyzed with an automated instrument (Hitachi 747; Boehringer Mannheim, Mannheim, Germany). Low-density lipoprotein (LDL) cholesterol levels were calculated for samples containing TG levels of  $<400$  mg/dL, with the following equation:  $LDL = \text{total cholesterol} - HDL - (TG/5)$ . Cholesterol levels of  $<170$  mg/dL were defined as acceptable, 170 to 199 mg/dL as borderline, and  $>200$  mg/dL as elevated. LDL cholesterol levels of  $<110$  mg/dL were defined as acceptable, 110 to 129 mg/dL as borderline, and  $>130$  mg/dL as elevated.<sup>14</sup>

## Statistical Analyses

Two-sample *t* tests were used to determine baseline differences between the control and intervention groups. Two-way, repeated-measures, analyses of variance were used to compare effects on body weight, BMI, percentage body fat (from skinfold measurements), habitual physical activity, fitness, and body lipid levels between the intervention subjects and the control subjects, with time serving as the within-group factor and intervention as the between-group factor. Statistical significance was taken at  $P < .05$ . Data are presented as mean  $\pm$  SD.

## RESULTS

### Subject Characteristics

Subject characteristics are summarized in Table 1. No significant differences in age, gender, pubertal status (overall and gender specific), BMI, body fat, television viewing, habitual physical activity, fitness, and parental obesity were found between the groups before the combined dietary and exercise intervention (Table 1).

## Three-Month Intervention

After the 3-month intervention, there were significant decreases in body weight (from  $63.8 \pm 19.1$  kg to  $61.0 \pm 18.3$  kg), BMI (from  $28.5 \pm 4.1$  kg/m<sup>2</sup> to  $26.8 \pm 3.9$  kg/m<sup>2</sup>), and body fat percentage (from  $40.2 \pm 7.3\%$  to  $36.9 \pm 8.0\%$ ) among the intervention participants (Fig 1). In contrast, there were significant increases in body weight (from  $63.4 \pm 22.8$  kg to  $64.5 \pm 24.1$  kg) and body fat percentage (from  $40.7 \pm 7.9\%$  to  $42.2 \pm 9.9\%$ ) among the control subjects, whereas BMI was not changed (from  $27.8 \pm 5.0$  kg/m<sup>2</sup> to  $27.6 \pm 5.6$  kg/m<sup>2</sup>).

Changes in habitual physical activity, screen time (television and computer), and fitness among the intervention participants and control subjects are summarized in Table 2. There was a significant increase in the habitual physical activity index after the intervention, compared with a small decrease among the control subjects. Endurance time increased significantly in both groups, but the increase in the intervention group was significantly greater. Screen time did not change significantly for the intervention and control subjects.

Changes in daily energy intake and relative intake from carbohydrates, protein, and fat among the intervention participants and control subjects are summarized in Table 3. Both groups reported significant decreases in daily energy intake, but there was no significant difference between the groups.

After the 3-month intervention, there were significant decreases in total cholesterol and LDL cholesterol levels (Table 4). There was no significant difference in the changes in serum TG and HDL cholesterol levels between the intervention participants and the control subjects.

## Long-Term (1-Year) Effects

Twenty subjects in each group completed the 1-year follow-up evaluation. Changes in anthropometric measurements, energy intake, leisure-time activities, and fitness are summarized in Table 5. One year after the combined dietary-behavioral-physical activity intervention, there were significant decreases in BMI and body fat percentage among the intervention participants, compared with increases among the control subjects. Body weight was maintained

TABLE 1. Characteristics of the Study Participants

	Control Subjects (n = 22)	Intervention Subjects (n = 24)
Age, y	11.3 $\pm$ 2.8	10.9 $\pm$ 1.9
Gender, male/female	12/10	14/10
Pubertal status, Tanner stage	2.6 $\pm$ 2.0	2.2 $\pm$ 1.5
Male/female Tanner stage	2.1 $\pm$ 1.7/3.0 $\pm$ 1.6	2.0 $\pm$ 1.3/2.4 $\pm$ 1.6
Height, m	1.485 $\pm$ 0.16	1.477 $\pm$ 0.12
Weight, kg	63.4 $\pm$ 22.8	63.8 $\pm$ 19.1
BMI, kg/m <sup>2</sup>	27.8 $\pm$ 5.0	28.5 $\pm$ 4.1
Body fat (skinfold), %	40.7 $\pm$ 7.9	40.2 $\pm$ 7.3
Caloric intake, kJ/d	8335 $\pm$ 1741	7519 $\pm$ 1569
Screen time, h/d	4.6 $\pm$ 4.2	4.8 $\pm$ 1.6
Habitual activity, units	24.3 $\pm$ 20.1	22.5 $\pm$ 12.5
Endurance time, s	597 $\pm$ 128	660 $\pm$ 184
Parental obesity, both/single/none, no	7/11/4	8/10/6

No significant differences were found between the groups before the intervention.



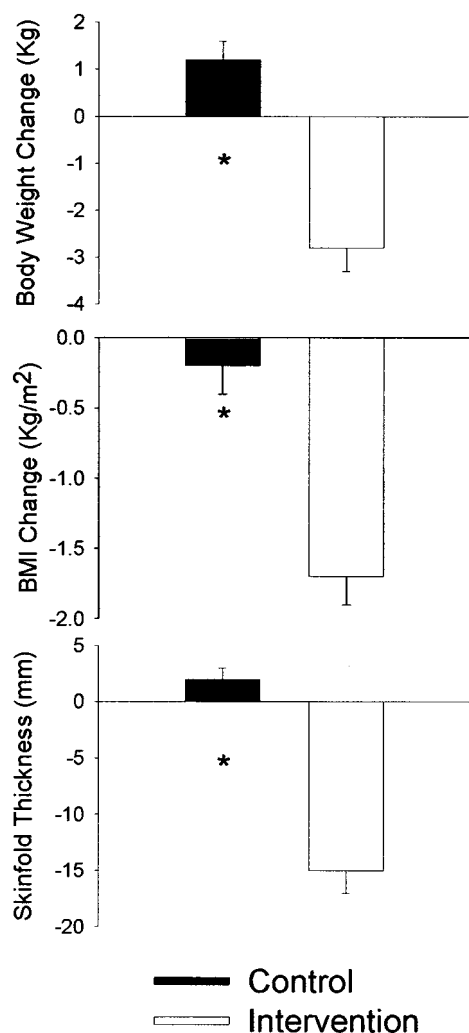


Fig 1. Short-term (3-month) body weight, BMI, and skinfold thickness changes in the intervention and control groups. There were significant differences in all 3 outcome variables (\* $P < .05$ ).

among the intervention participants, compared with a significant increase among the control subjects.

Habitual physical activity was significantly increased among the intervention participants. There was a greater increase in fitness level among the intervention participants; however, this difference did not reach statistical significance ( $P = .056$ ). Both groups reported decreased screen time, but there was no between-group difference. No adverse events were noted during the intervention.

#### DISCUSSION

This study demonstrates the short-term (3 months) and long-term (1 year) beneficial effects of a combined nutritional-behavioral-exercise intervention for childhood obesity. Our intervention was associated with significant weight loss, reduced BMI, reduced body fat, increased habitual physical activity, and improved fitness, as well as reduced total and LDL cholesterol levels, among obese children and adolescents. In contrast, obese children who did not participate in the intervention program gained weight, increased their body fat percentage, did not change their habitual physical activity level, and had

a lesser improvement in fitness. Favorable effects on body weight, BMI, body fat, and habitual physical activity were maintained among the intervention participants, compared with the control subjects, after a 1-year follow-up period.

Childhood obesity has reached epidemic proportions in recent years, and the prevalence of childhood obesity in Israel is among the highest, compared with European countries and the United States.<sup>15</sup> Despite the increased prevalence, very few treatment programs for childhood obesity are available, and <20% of obese children initiate treatment. Treatment programs for childhood obesity require a multidisciplinary approach and should include dietary changes, nutritional education, changes in physical activity patterns, behavioral modification, and parental involvement.<sup>16,17</sup> Pediatric weight management programs should emphasize realistic goals. Weight loss should be encouraged only in severe obesity, whereas maintenance of body weight with continued linear growth, accompanied by development of a healthier lifestyle, should be the goal for the majority of obese children. Moreover, because BMI increases naturally with age (eg, the 95th percentile for girls is 20.6 kg/m<sup>2</sup> at the age of 8 years and 28.9 kg/m<sup>2</sup> at the age of 16 years,<sup>18</sup> maintenance of BMI, and in some cases even attenuation of the increase in BMI, could be considered a success. In this study, 90% of the intervention participants reduced their BMI, whereas BMI kept increasing for 68% of the control subjects.

Today's children's sedentary lifestyle and the increased inactivity in western societies are among the major contributors to the increased prevalence of childhood obesity.<sup>19,20</sup> Therefore, exercise training and education represented the major focus of our intervention. As a result, leisure-time physical activity increased significantly and fitness improved for all intervention participants. It is interesting to note that the 3-month program was not associated with a significant decrease in television viewing or computer game time. It can be assumed that an additional decrease in physical inactivity among the intervention participants is possible and may lead to greater weight loss and better improvement in physical fitness.

We and others demonstrated previously<sup>21</sup> that elevated total and LDL cholesterol levels are relatively common among obese children and adolescents. This suggests that obesity should be considered a risk factor for pediatric hypercholesterolemia and that obese children should be screened for abnormal lipid profiles. The clinical implications of hypercholesterolemia among obese children and adolescents are becoming better understood. It is now known that elevated cholesterol levels during childhood are associated with hypercholesterolemia in adult life.<sup>22,23</sup> Moreover, lipid abnormalities among children and adolescents are related to higher risks of insulin resistance and hypertension later in life and play an important role in the development of heart disease. Therefore, one of the most important findings of this study was the significant decrease in serum cholesterol and LDL cholesterol levels among the interven-

**TABLE 2.** Short-Term (3-Month) Changes in Habitual Physical Activity, Screen (Television and Computer) Time, and Fitness Among the Intervention Participants and Control Subjects

	Control Group		Intervention Group	
	Before	After	Before	After
Screen time, h/d	4.5 ± 4.2	4.2 ± 1.6	4.8 ± 1.6	4.1 ± 1.7
Habitual activity, units	24.3 ± 20.1	22.1 ± 16.9	22.5 ± 12.5	45.7 ± 12.6*
Endurance time, s	597 ± 128	642 ± 148	660 ± 184	821 ± 110*

Data are presented as mean ± SD.

\*  $P < .05$  for between-group difference.

**TABLE 3.** Short-Term (3-Month) Changes in the Daily Caloric Intake and the Relative Contributions of Carbohydrates, Protein, and Fat Among the Intervention Participants and Control Subjects

	Control Group		Intervention Group	
	Before	After	Before	After
Caloric intake, kJ/d	8335 ± 1741	6602 ± 1439*	7519 ± 1569	5887 ± 1305*
Carbohydrate, g	271 ± 68	218 ± 47*	224 ± 48	171 ± 40*
Protein, g	72 ± 15	62 ± 19	74 ± 21	75 ± 20
Fat, g	80 ± 22	62 ± 21*	74 ± 21	59 ± 22*

Data are presented as mean ± SD.

\*  $P < .05$  for within-group difference.

**TABLE 4.** Short-Term (3-Month) Changes in Serum Lipid Levels Among the Intervention Participants and Control Subjects

	Control Group		Intervention Group	
	Before	After	Before	After
TGs, mg/dL	109.8 ± 42.4	104.3 ± 52.7	93.6 ± 29.5	79.7 ± 32.5
Cholesterol, mg/dL	165.2 ± 29.2	167.1 ± 20.4	170.1 ± 22.5	147.8 ± 19.3*
HDL cholesterol, mg/dL	44.1 ± 10.7	45.5 ± 12.0	43.6 ± 7.2	44.8 ± 8.4
LDL cholesterol, mg/dL	101.9 ± 26.7	99.9 ± 18.0	106.5 ± 20.0	89.7 ± 17.0*

Data are presented as mean ± SD.

\*  $P < .05$  for between-group difference.

**TABLE 5.** Long-Term Changes in Anthropometric Measurements, Leisure Time Activities, and Fitness After 1 Year of Follow-Up Monitoring

	Control Group ( $n = 20$ )		Intervention Group ( $n = 20$ )	
	Before	12 Months	Before	12 Months
Height, m	1.476 ± 0.16	1.520 ± 0.15*	1.445 ± 0.11	1.490 ± 0.10*
Weight, kg	63.4 ± 23.6	68.6 ± 24.8	59.1 ± 15.4	59.7 ± 17.7†
BMI, kg/m <sup>2</sup>	28.0 ± 5.2	28.6 ± 5.8	27.7 ± 3.6	26.1 ± 4.7†
BMI percentile	97.2 ± 0.7	96.1 ± 1.4	98.2 ± 0.3	92.3 ± 3.0†
Body fat, %	40.9 ± 9.5	44.4 ± 9.7	40.6 ± 6.7	38.3 ± 12.5†
Caloric intake, kJ/d	8318 ± 1661	7736 ± 3088	7878 ± 1778	5908 ± 1573
Screen time, h/d	4.7 ± 1.7	3.4 ± 1.7*	4.6 ± 1.7	3.3 ± 1.2*
Habitual activity, units	26.2 ± 20.0	18.9 ± 14.4	25.0 ± 12.4	34.1 ± 21.1†
Endurance time, s	629.0 ± 128.1	669.3 ± 157.8	614.7 ± 184.2	799.8 ± 167.2†

Data are presented as mean ± SD.

\*  $P < .05$  for within-group difference.

†  $P < .05$  for between-group difference.

tion participants. This highlights the importance of multidisciplinary programs for the treatment of childhood obesity, not only for weight reduction and changes in body composition but also for improvement of lipid profiles and reduction of risk factors for atherosclerosis.

An interesting finding of this study was that both control and intervention participants reported a decrease of ~1674 kJ/day after the 3-month observation period. However, the intervention participants lost weight but the control subjects kept gaining weight during the observation period. The explanation for this discrepancy is not completely clear. No

concomitant decrease in the habitual activity levels for the control group was reported during the intervention period; therefore, reduced activity could not account for this weight increase. It is possible that the subjectivity of the food-recording techniques was a source of error. A number of investigators think that under-recording of self-reported food intake occurs often<sup>24,25</sup> and that participation in a weight management study (even if "only" as control subjects) leads to subconscious underestimation/underreporting of the daily total energy intake.

Adult studies indicate that the long-term effects of weight reduction programs have been very disap-

pointing.<sup>26</sup> In this study, the favorable short-term effects of the combined dietary-behavioral-physical activity intervention remained significant 1 year after the intervention. The intervention participants demonstrated remarkable decreases in BMI, age-adjusted BMI percentile, and body fat and substantial increases in habitual activity and fitness level 1 year after the end of active intervention.

A mean decrease in age-adjusted BMI percentiles of 5% to 6% is very impressive and indicates that some of the obese children and adolescents were not categorized as obese after the 1-year follow-up period, whereas many with marked obesity (BMI of >95th percentile) were reclassified as overweight (BMI of 85th to 95th percentile). Moreover, obesity is frequently complicated by abnormal lipid profiles, insulin resistance, and hypertension.<sup>27</sup> Many of these associated complications can be reversed with a 5% decrease in age-adjusted BMI percentile.<sup>28</sup> Unfortunately, the majority of our intervention participants refused to undergo blood testing at the 1-year follow-up evaluation; therefore, we were unable to assess whether the short-term positive effects of the intervention on body lipids lasted.

Interestingly, the decreases in BMI percentile at the 1-year follow-up evaluation after the 3-month intervention were very similar to the changes we reported recently for a different group of obese children and adolescents who participated in 12 consecutive months of a similar structured program<sup>9</sup> (Fig 2). Our brief program focuses mainly on exercise training, nutritional education, and behavioral changes and therefore can be implemented easily in the daily lives of children. Once the children gained the basic knowledge and health-related skills (presumably after 3 months), they were able to maintain their achievements on their own after 1 year.

Finally, the fitness improvement of the intervention participants 1 year after the intervention was greater than that of the control subjects; this difference almost reached statistical significance ( $P < .056$ ). The improved fitness resulted probably from the greater habitual activity of the intervention par-

ticipants, compared with the control group subjects. This might be very important because increased physical fitness, even without weight loss, can improve insulin sensitivity and lipid profiles, reduce blood pressure, and reduce the risk of heart disease later in life.<sup>29</sup>

## CONCLUSIONS

Our brief multidisciplinary intervention resulted in significant positive effects on body weight, BMI, body fat, habitual activity, fitness, and body lipids. Moreover, the participants' ability to incorporate easily the intervention principles into their daily activities helped them to maintain most of their achievements at the 1-year follow-up evaluations. Additional studies are needed to assess longer-term (eg, 5-year) effects of this intervention. Encouragingly, however, multidisciplinary pediatric programs seem to be more successful than adult programs in maintenance of weight loss for 5 or 10 years.<sup>30,31</sup>

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## REFERENCES

1. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *Lancet*. 2004;364:257-262
2. Dietz WH. Overweight in childhood and adolescence. *N Engl J Med*. 2004;350:855-857
3. Berenson GS, Srinivasan SR, Bao W, Newman WP III, Tracy RE, Wattigney WA. Association between multiple cardiovascular risk factors and atherosclerosis in children and young adults: the Bogalusa Heart Study. *N Engl J Med*. 1998;338:1650-1656
4. Mossberg HO. 40-year follow-up of overweight children. *Lancet*. 1989;2:491-493
5. Whitaker RC, Wright JA, Pepe MS, Seidel KD, Dietz WH. Predicting obesity in young adulthood from childhood and parental obesity. *N Engl J Med*. 1997;337:869-873
6. Must A, Jacques PF, Dallal GE, Bajema CJ, Dietz WH. Long-term morbidity and mortality of overweight adolescents: a follow-up of the Harvard Growth Study of 1922 to 1935. *N Engl J Med*. 1992;327:1350-1355
7. Denen ME, Hennessey JV, Markert RJ. Outpatient evaluation of obesity in adults and children: a review of the performance of internal medicine/pediatrics residents. *J Gen Intern Med*. 1993;8:268-270
8. Eliakim A, Kaven G, Berger I, Friedland O, Wolach B, Nemet D. The effect of a combined intervention on body mass index and fitness in obese children and adolescents: a clinical experience. *Eur J Pediatr*. 2002;161:449-454
9. Eliakim A, Friedland O, Kowen G, Wolach B, Nemet D. Parental obesity and higher pre-intervention BMI reduce the likelihood of a multidisciplinary childhood obesity program to succeed: a clinical observation. *J Pediatr Endocrinol Metab*. 2004;17:1055-1061
10. Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC Growth Charts for the United States: methods and development. *Vital Health Stat* 11. 2002;(246):1-190
11. Slaughter MH, Lohman TG, Boileau RA, et al. Skinfold equations for estimation of body fatness in children and youth. *Hum Biol*. 1988;60:709-723
12. Crawford PB, Obarzanek E, Morrison J, Sabry ZI. Comparative advantage of 3-day food records over 24-hour recall and 5-day food frequency validated by observation of 9- and 10-year-old girls. *J Am Diet Assoc*. 1994;94:626-630
13. Godin G, Shephard RJ. A simple method to assess exercise behavior in the community. *Can J Appl Sport Sci*. 1985;10:141-146
14. Shamir R, Lerner A, Fisher EA. Hypercholesterolemia in children. *Isr Med Assoc J*. 2000;2:767-771
15. Lissau I, Overpeck MD, Ruan WJ, Due P, Holstein BE, Hediger ML.

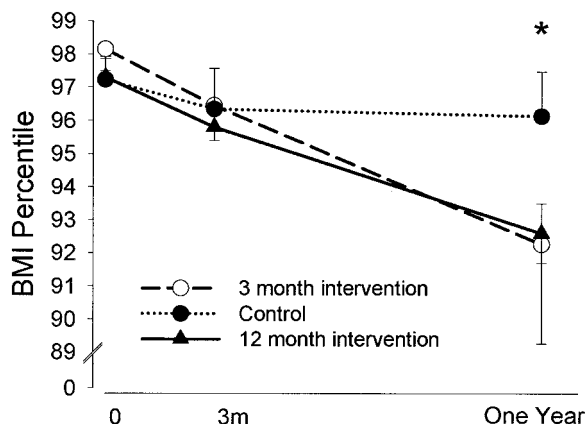


Fig 2. Changes in BMI percentiles among study participants. Data were compared with a different group of obese children who participated in a 1-year combined program in our center.<sup>9</sup> There was a significant decrease in BMI percentiles in intervention versus control subjects.

- Body mass index and overweight in adolescents in 13 European countries, Israel, and the United States. *Arch Pediatr Adolesc Med.* 2004;158:27–33
16. Goran MI, Reynolds KD, Lindquist CH. Role of physical activity in the prevention of obesity in children. *Int J Obes Relat Metab Disord.* 1999;23(suppl 3):S18–S33
  17. Williams CL, Campanaro LA, Squillace M, Bollella M. Management of childhood obesity in pediatric practice. *Ann NY Acad Sci.* 1997;817:225–240
  18. Rosner B, Prineas R, Loggie J, Daniels SR. Percentiles for body mass index in U.S. children 5 to 17 years of age. *J Pediatr.* 1998;132:211–222
  19. Sothorn MS. Obesity prevention in children: physical activity and nutrition. *Nutrition.* 2004;20:704–708
  20. Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. *Int J Obes Relat Metab Disord.* 2004;28:1238–1246
  21. Friedland O, Nemet D, Gorodnitsky N, Wolach B, Eliakim A. Obesity and lipid profiles in children and adolescents. *J Pediatr Endocrinol Metab.* 2002;15:1011–1016
  22. Belay B, Belamarich P, Racine AD. Pediatric precursors of adult atherosclerosis. *Pediatr Rev.* 2004;25:4–16
  23. Lauer RM, Lee J, Clarke WR. Factors affecting the relationship between childhood and adult cholesterol levels: the Muscatine Study. *Pediatrics.* 1988;82:309–318
  24. Ambler C, Eliakim A, Brasel JA, Lee WN, Burke G, Cooper DM. Fitness and the effect of exercise training on the dietary intake of healthy adolescents. *Int J Obes Relat Metab Disord.* 1998;22:354–362
  25. Bingham SA. Limitations of the various methods for collecting dietary intake data. *Ann Nutr Metab.* 1991;35:117–127
  26. Crawford D, Jeffery RW, French SA. Can anyone successfully control their weight? Findings of a three year community-based study of men and women. *Int J Obes Relat Metab Disord.* 2000;24:1107–1110
  27. Steinberger J, Daniels SR. Obesity, insulin resistance, diabetes, and cardiovascular risk in children: an American Heart Association scientific statement from the Atherosclerosis, Hypertension, and Obesity in the Young Committee (Council on Cardiovascular Disease in the Young) and the Diabetes Committee (Council on Nutrition, Physical Activity, and Metabolism). *Circulation.* 2003;107:1448–1453
  28. Reinehr T, Andler W. Changes in the atherogenic risk factor profile according to degree of weight loss. *Arch Dis Child.* 2004;89:419–422
  29. Carnethon MR, Gidding SS, Nehgme R, Sidney S, Jacobs DR Jr, Liu K. Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. *JAMA.* 2003;290:3092–3100
  30. Epstein LH, Valoski AM, Kalarchian MA, McCurley J. Do children lose and maintain weight easier than adults: a comparison of child and parent weight changes from six months to ten years. *Obes Res.* 1995;3:411–417
  31. Epstein LH. Methodological issues and ten-year outcomes for obese children. *Ann NY Acad Sci.* 1993;699:237–249

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