Efficacy of Maintenance Treatment Approaches for Childhood Overweight
A Randomized Controlled Trial

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Context No trials for childhood overweight have examined maintenance interventions to augment the effects of initial weight loss programs.

Objectives To determine the short-term and long-term efficacy of 2 distinct weight maintenance approaches vs no continued treatment control following standard family-based behavioral weight loss treatment for childhood overweight, and to examine children's social functioning as a moderator of outcome.

Design, Setting, and Participants A parallel-group, randomized controlled trial conducted between October 1999 and July 2004 in a university-based weight control clinic. Participants were 204 healthy 7- to 12-year-olds, 20% to 100% above median body mass index (BMI) for age and sex, with at least 1 overweight parent. Children enrolled in 5 months of weight loss treatment and 150 were randomized to 1 of 3 maintenance conditions. Follow-up assessments occurred immediately following maintenance treatments and 1 and 2 years following randomization.

Interventions Maintenance conditions included the control group or 4 months of behavioral skills maintenance (BSM) or social facilitation maintenance (SFM) treatment.

Main Outcome Measures BMI *z* score and percentage overweight.

Results Children receiving either BSM or SFM maintained relative weight significantly better than children assigned to the control group from randomization to post-weight maintenance ($P \leq .01$ for all; effect sizes $d = 0.72$-0.96; mean changes in BMI *z* scores = –0.04, –0.04, –0.05, and 0.05 for BSM alone, SFM alone, BSM and SFM together, and the control group, respectively). Active maintenance treatment efficacy relative to the control group declined during follow-up, but the effects of SFM alone ($P = .03$; $d = 0.45$; mean change in BMI *z* score = –0.24) and when analyzed together with BSM ($P = .04$; $d = 0.38$; mean change in BMI *z* score = –0.22) were significantly better than the control group (mean change in BMI *z* score = –0.06) when examining BMI *z* score outcomes from baseline to 2-year follow-up. Baseline child social problem scores moderated child relative weight change from baseline to 2-year follow-up, with low social problem children in SFM vs the control group having the best outcomes.

Conclusions The addition of maintenance-targeted treatment improves short-term efficacy of weight loss treatment for children relative to no maintenance treatment. However, the waning of effects over follow-up, although moderated by child initial social problems, suggests the need for the bolstering of future maintenance treatments to sustain effects.

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CHILDHOOD OVERWEIGHT prevalence in the United States has tripled in recent decades[1] and related health care costs have nearly quadrupled.[2] Childhood overweight significantly increases risk for adult obesity and for greater severity of obesity in adulthood.[3] Lifestyle interventions[4-8] remain the most well-established interventions for overweight 7- to 12-year-olds.[4,6,8] Although some evidence supports long-term efficacy,[7] maintaining weight loss remains a challenge, with most interventions marked by considerable relapse.[4,9]

Adult interventions address weight loss maintenance by extending treatment contact[10] and content.[11] To our knowledge, no childhood overweight intervention study has examined the impact of treatment extended beyond 6 months. The present study evalu-

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ated the effects of extending intervention following standard family-based behavioral weight loss treatment. Two theoretically and procedurally distinct family-based maintenance approaches were tested: (1) a behavioral skills maintenance (BSM) and (2) a social facilitation maintenance (SFM) intervention.

The BSM approach builds on the behavioral approach of the initial weight loss treatment program but assumes that the skills needed to lose weight are different from those required for weight maintenance. Accordingly, BSM takes a cognitive-behavioral approach to weight maintenance adapted from adult weight maintenance programs[11,12] and other evidence-based programs for children with anxiety[13,14] and substance use disorders,[15] emphasizing self-regulation behaviors and relapse-prevention strategies. In contrast, social-ecological–based SFM uses empirically supported techniques[16] to help parents facilitate child peer networks that support healthy eating and physical activity. The SFM approach also targets peer (eg, teasing) and self-perceptual (eg, body image) factors identified as barriers to overweight children's physical activity.[17] Friend support increases success in long-term weight maintenance control in adults[18] and, even when not targeted, in children.[7] The SFM approach may result in more readily sustainable maintenance relative to BSM because it focuses more on a child's developmental context,[19,20] specifically reducing perceptual and environmental barriers to weight maintenance,[21,22] and promoting social support for healthy behaviors. The SFM approach also includes more novel content than BSM relative to weight loss treatment, perhaps better holding children's attention and, thus, improving treatment adherence.[23]

We hypothesized that children randomized to an extended treatment condition would better maintain weight loss in the short-term and long-term compared with children assigned to only standard-length weight loss treatment. We further posited that SFM would yield better weight maintenance than BSM. Finally, given prior research,[24] social functioning as a treatment-specific moderator of long-term outcome was examined.

METHODS

Children aged 7 to 12 years who were 20% to 100% overweight and had at least 1 parent with a body mass index (BMI, calculated as weight in kilograms divided by height in meters squared) of more than 25 were recruited through media announcements or advertisements and physician referrals. At least 1 parent or guardian participated with the child. Families were excluded if either the child or parent was currently involved in psychological or weight loss treatment, was using appetite or weight-affecting medications, or had a psychiatric condition (eg, eating disorder, psychosis) that would interfere with participation. Participants were unpaid volunteers and provided written informed consent (participating parent) and assent (child).

This parallel-group, randomized controlled trial was conducted between October 1999 and July 2004, with participants randomized into the 3 conditions within 3 cohorts starting in 2000, 2001, and 2002. Random assignment was conducted by using computer-generated random numbers. Assessments were conducted at baseline (month 0) and at months 5 (randomization), 9 (postweight maintenance), 17 (1-year follow-up), and 29 (2-year follow-up) after the start of weight loss treatment. Following completion of standard 5-month state-of-the-art weight loss treatment, children were stratified by sex and ordered by a combination of percentage overweight change during weight loss treatment and randomization levels of social problems. They were then randomly assigned, in groups of 3, to 1 of 3 conditions: (1) BSM, (2) SFM, or (3) control, a usual-care[25,26] condition (discontinued contact after the weight loss program). Treatment sessions were conducted at San Diego State University. The institutional review boards of San Diego State University and Southern California Kaiser Permanente (a referral source) approved the study.

All weight loss, BSM, and SFM sessions included 20-minute family treatment and 40-minute separate child and parent groups. Individual family treatment reinforced the content of group session topics and provided opportunities for individualized behavior therapy. Group session content was tailored to be age-appropriate yet similar for children and parents, with an added parenting skills component for the latter. One parent was scheduled to consistently attend sessions.

Family-Based Weight Loss Intervention

The weight loss treatment focused on dietary modification, physical activity increases, and behavior change skills.[26] Children and parents were taught how to improve dietary quality and reduce caloric intake to approximately 1200 to 1500 calories per day to facilitate weight loss of one-half to 1 pound per week. Families were encouraged to choose healthy foods consistent with individual, familial, and cultural preferences from food lists classified by the *Traffic Light Diet*.[26] The physical activity component was mastery based with a maximum goal of 90 minutes of at least moderate-intensity activity per day for children at least 5 days per week, while also encouraging decreased sedentary activities (eg, television watching). Other behavior change skills included using self-monitoring (food and physical activity logs) to set and evaluate behavior change goals and a family-based reinforcement system that allowed children to earn rewards for meeting program goals.

Weight Maintenance Interventions

There was no weight loss criterion for continuation into the weight maintenance phase. The small number (19 of 150 [12.7%]) of randomized children in BSM or SFM who gained weight during the weight loss phase were encouraged to lose weight at the beginning of

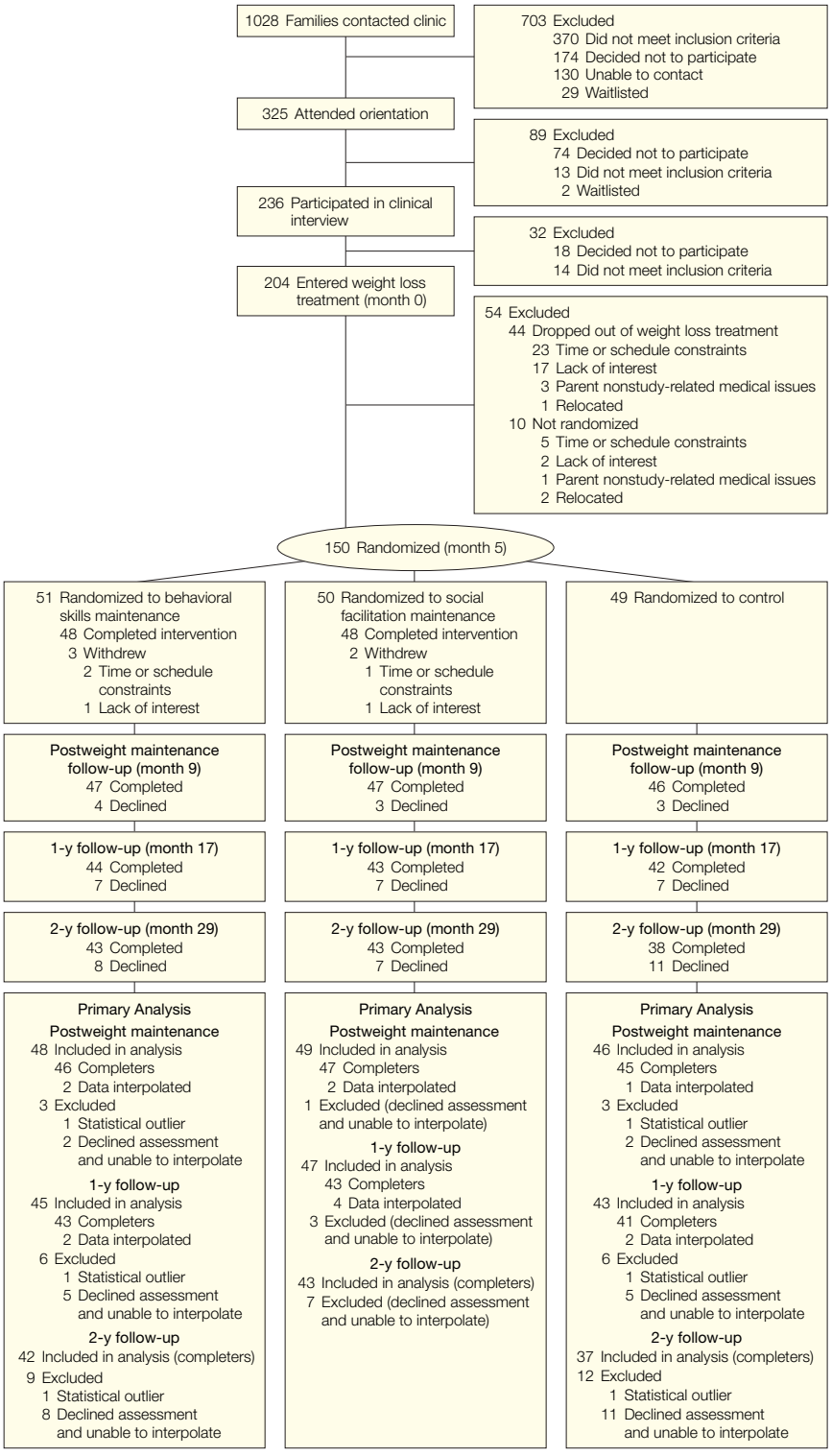
the maintenance intervention to reach their baseline weight. This weight then formed their 3-lb (1.35-kg) maintenance range.

The active maintenance intervention conditions were identical in duration and amount of contact (16 weekly sessions). Parents and children in both BSM and SFM were encouraged to (1) modify their caloric intake from weight loss treatment levels to an individualized level consistent with weight maintenance; (2) participate in the frequency, duration, and intensity of physical activity necessary to bring about energy balance, which was increased from the weight loss phase and individualized to partially compensate for increased caloric intake; and (3) maintain a 3-lb (1.35-kg) weight range, 1.5 lb (0.675 kg) above or below their absolute weight at the outset of the weight maintenance treatment. Our approach during the weight maintenance phase was targeted toward maintaining absolute weight, not weight loss. Children and parents in BSM and SFM continued to self-monitor, but the behaviors tracked were treatment-specific.

The BSM approach is based on the premise that specific strategies are needed for weight loss maintenance. Phase 1 (weeks 1-5) focused on enhancing motivation and promoting small changes in eating and physical activity to support weight maintenance. Phase 2 (weeks 6-11) taught children and parents to (1) identify high-risk situations for overeating or missing physical activity, (2) preplan to avoid these situations or problem solve to cope more effectively with them, and (3) use cognitive restructuring and positive self-talk to decrease the likelihood that behavioral slips would result in full relapse. In phase 3 (weeks 12-16), families reassessed their eating and physical activity behaviors and developed plans for permanent lifestyle change.

The SFM approach is based on the premise that relapse results from the absence of a social environment support-

Figure 1. Study Participant Flow



Follow-up numbers listed as completed indicate the number of observed data points analyzed; 2 outliers, who completed all 3 follow-up time points, were excluded from all primary weight outcome analyses.

Table 1. Baseline Family Characteristics for the 2 Maintenance and Control Groups

Variable	Behavioral Skills Maintenance (n = 51)	Social Facilitation Maintenance (n = 50)	Control (n = 49)	*P* Value
Age, mean (SD), y				
Child	9.9 (1.4)	9.9 (1.4)	9.8 (1.2)	.88
Parent	42.0 (6.1)	43.3 (5.9)	42.7 (6.9)	.55
Child weight, mean (SD)				
BMI	27.1 (3.3)	28.2 (3.3)	27.3 (3.7)	.23
BMI percentile	96.7 (0.7)	96.8 (0.8)	96.5 (1.8)	.24
Parent weight, mean (SD)				
BMI[a]	35.2 (5.9)	35.2 (5.9)	34.6 (7.2)	.89
Percentage overweight[b]	60.0 (28.1)	59.5 (26.7)	58.1 (33.1)	.94
Scores, mean (SD)				
Socioeconomic status	47.9 (9.7)	47.0 (9.7)	47.0 (13.8)	.89
Social problems	62.9 (9.0)	61.7 (10.0)	62.4 (9.3)	.81
Child demographics, No. (%)				
Female	37 (72.5)	35 (70.0)	32 (65.3)	.73
Race/ethnicity[c]				
Black	5.9 (3)	14.0 (7)	2.0 (1)	.29
White, non-Hispanic	70.6 (36)	64.0 (32)	77.6 (38)	
White, Hispanic	21.6 (11)	16.0 (8)	18.4 (9)	
Other race	2.0 (1)	6.0 (3)	2.0 (1)	
Parent demographics, No. (%)				
Female	38 (74.5)	40 (80.0)	43 (87.8)	.32
Married	42 (82.4)	37 (74.0)	40 (81.6)	.49
Maternal education college or higher	26 (51.0)	28 (56.0)	22 (44.9)	.59

Abbreviation: BMI, body mass index, calculated as weight in kilograms divided by height in meters squared.
[a] A total of 74.5% of participating parents had a BMI of at least 30.
[b] For calculating parent percentage overweight, adult median BMI values at age 20 years were used.
[c] For child race/ethnicity, each cell is expressed as percentage of the column (frequency number) (ie, the percentage within the treatment condition) and the *P* value is based on Fisher exact test. The SAS statistical program used the network algorithm developed by Mehta and Patel[40] to compute the Fisher exact test *P* value. Family demographic variables were self-reported at baseline and parents classified their child's race/ethnicity using options provided.

ive of continued weight control. Phase 1 (weeks 1-5) guided parents to encourage children to form friendships with physically active peers and/or ensure that children's playdates with existing friends involved physical activity and healthful eating. Phase 2 (weeks 6-11) addressed body image concerns (eg, fear of body exposure) that might limit overweight children from engaging in peer-related physical activity. Families also learned effective strategies to curtail weight-related teasing or criticism. Phase 3 (weeks 12-16) focused on solidifying children's social support network to maximize its efficacy in promoting long-term behavioral changes.

Therapists' Training and Treatment Fidelity

All therapists were trained before leading group and family sessions. The same therapists were involved in weight loss and both maintenance approaches. Ongoing supervision, including review of audiotaped sessions, ensured treatment consistency with the respective manuals. Randomly selected treatment audiotapes (approximately 10% of parent group, child group, and family sessions) across cohorts and interventionists were evaluated by 2 independent raters blind to study design. Raters completed integrity checklists assessing the unique topic domains of both active maintenance interventions; ratings then formed indices assessing use of BSM and SFM content. The BSM group indices assessed discussion of problem-solving, goal-setting, and relapse prevention; the SFM group indices assessed discussion of the use of social support skills, coping with teasing, and body esteem. For both raters, BSM and SFM indices were significantly different, and in the expected direction, across all 3 types of sessions ($P \leq .003$ for all), suggesting that the maintenance treatments were distinct and delivered with high treatment fidelity.

Outcome Measures

All outcome measures, except demographics, were administered at all assessment time points. It was not possible to keep assessors blind to treatment condition; however, a standard protocol was used to facilitate objective and reliable measurement of height and weight. Additional protection from assessment bias was achieved by blinding assessors to group differences and to each participant's prior height and weight values. Participants in the control condition did not receive any intervention following the initial weight loss treatment but were contacted to complete their assessments in the clinic at all 3 follow-up time points.

Body mass index was calculated from weight, which was measured to the nearest one-fourth pound on a Detecto balance-beam scale (Cardinal Scale Manufacturing, Webb City, Missouri), and height, which was measured to the nearest one-eighth inch with a stadiometer. The BMI *z* scores of the children were determined using the age-specific and sex-specific median BMI, generalized coefficient of variation (S), and the power of the Box-Cox transformation (L) by the following formula: $\{[(\text{BMI}/\text{median BMI})^{L}]-1\}/(L \times S)$, based on US Centers for Disease Control and Prevention growth curves.[27] Percentage overweight was defined as percentage above median BMI. These 2 primary outcomes were selected because they are the most frequently reported relative weight outcomes[28,29] for the age range studied herein.

The Child Dietary Self-efficacy Scale[30] evaluated children's self-efficacy in choosing healthy, low-fat foods. The Self-efficacy Scale for Children's Physical Activity[31] examined children's perceived self-efficacy in overcoming bar-

riers to achieving weight goals and developing positive alternatives to unhealthy habits. The Child Eating Disorder Examination[32] assessed weight and shape concerns. The Coping with Teasing Scale[33] measured the adequacy of children's responses to teasing. Peer support for diet and physical activity was measured using the Social Support for Eating Habits/Exercise Survey.[34] The levels of social problems of the children were evaluated by using the social problems subscale of the Achenbach Child Behavior Checklist-Parent Version.[35]

Family demographic variables were self-reported at baseline and used to compute the Hollingshead Socioeconomic Status Index.[36] Parents classified their child's race/ethnicity using options provided, allowing us to monitor sample representativeness relative to the study's local geographic area.

Table 2. Child Weight Outcomes by Time Point and Treatment Condition[a]

	Mean (SD)			
	Behavioral Skills Maintenance (n = 50)[b,c]	Social Facilitation Maintenance (n = 50)[b]	Pooled Maintenance Treatment Conditions (n = 100)[b]	Control (n = 48)[b,c]
BMI *z* score				
Baseline	2.17 (0.28)	2.26 (0.27)	2.22 (0.28)	2.17 (0.34)
Randomization	1.94 (0.34)	2.03 (0.42)	1.98 (0.38)	1.99 (0.39)
Postweight maintenance	1.90 (0.35)	1.99 (0.48)	1.95 (0.42)	2.04 (0.37)
1-y follow-up	1.99 (0.39)	2.03 (0.51)	2.01 (0.45)	2.07 (0.38)
2-y follow-up	1.98 (0.48)	2.02 (0.50)	2.00 (0.49)	2.11 (0.36)
Percentage overweight				
Baseline	61.8 (17.4)	68.1 (17.6)	65.0 (17.7)	63.3 (20.8)
Randomization	49.7 (16.2)	56.5 (20.1)	53.1 (18.5)	54.2 (20.3)
Postweight maintenance	49.1 (16.9)	56.2 (21.8)	52.7 (19.8)	57.9 (21.2)
1-y follow-up	57.0 (21.5)	61.2 (24.5)	59.1 (23.1)	61.6 (23.3)
2-y follow-up	59.6 (24.1)	62.6 (25.9)	60.5 (24.9)	64.8 (22.9)

Abbreviation: BMI, body mass index.
[a] Statistics are based on the sample available at each assessment, except for the 2 outliers. The follow-up observed data across time points comprised 393 of a possible 450 assessment points (87%), indicating a high retention rate with no differential assessment completion rate across groups.
[b] The sample sizes reflect those at baseline and randomization.
[c] The sample sizes of the behavioral skills maintenance and control groups each exclude 1 outlier.

Statistical Analysis

A total sample size of 150 was selected, based on effect-size estimates from a representative childhood overweight treatment study,[37] to provide statistical power of at least 80% to test the omnibus interaction of maintenance group × time across all time points. A sample size of 40 per group would yield statistical power of more than 90% from baseline to 2-year follow-up to test the planned contrast between the control and each active maintenance treatment, with power dropping to 70% when comparing the 2 active interventions.

Analyses were performed by using SAS version 9.1 (SAS Institute Inc, Cary, North Carolina). Tests of baseline differences in demographic and other participant characteristics were conducted by using analysis of variance, χ^2 tests, and Fisher exact test. The primary outcome measures were change in children's BMI *z* score and percentage overweight, and secondary outcome measures included treatment-specific psychosocial targets of BSM and SFM. For the primary analyses, a mixed-model, repeated-measures analysis of variance was used, which considers the correlation between repeated observations and uses all available subsequent observations for all participants with values at randomization, regardless of further assessment completion. Planned contrasts tested for differences in outcomes between each maintenance treatment and the control group from randomization to postweight maintenance, randomization to 1-year follow-up, randomization to 2-year follow-up, and baseline to 2-year follow-up. For the anthropometric measures, we also compared the pooled maintenance treatment groups with the control group. Models contained terms for condition, time point, and condition-by-time point interactions. For secondary outcomes, only significant comparisons are reported. Effect sizes were calculated for change in relative weight status using Cohen *d*.[38] Preplanned moderator analyses were conducted to examine the impact of baseline levels of social problems and their interaction with treatment group on weight outcomes. Potential outliers were defined as cases in which both BMI *z* scores and percentage overweight were more than 3 SDs from the mean change of the overall sample for a given time point comparison.

In all weight outcome analyses, missing data at postweight maintenance (n=4), 1-year follow-up (n=7), or both time points (n=1) were linearly interpolated based on observed values at immediately preceding and subsequent time points. Results did not change when analyses were repeated without these interpolated values. The remaining 10% of missing postrandomization data points (44 of 450 potential assessment points) could not be interpolated because the subsequent time point was not available.

Thus, for the primary analyses, data points were either observed (n=393), linearly interpolated (n=13), or they remained missing (n=44). Outliers (n=2) were removed from the primary weight outcome analyses. This deviation from the intention-to-treat (ITT) principle was chosen out of concern that retention of these outliers would distort statistical inference and lead to a misestimation of the magnitude of the treatment effect. To ensure that

the primary analyses were robust, 3 additional ITT analyses were conducted, all of which included the 2 outliers and the interpolated values (n=13) described above, but handling the 44 additional missing data points as follows: (1) with all randomized participants, with no replacement values for additional missing data; (2) with baseline (month 0) values carried forward for additional missing data; and (3) with additional missing data multiply imputed[39] using SAS PROC MI and MIANALYZE (SAS Institute Inc). $P \leq .05$ was considered statistically significant.

RESULTS

Of the 204 participants who entered weight loss treatment, 54 were not randomized to a maintenance condition, the majority of whom had withdrawn from weight loss treatment. No child or parent adverse events were reported or led to any study withdrawals. FIGURE 1 summarizes screening, participation, and retention of participants. Randomized and nonrandomized children did not significantly differ on most demographic or baseline variables, although randomized children were more likely to be female ($P=.01$), and randomized participating parents were older ($P=.008$) and more likely to be married ($P=.04$). Characteristics of the 150 randomized families are shown in TABLE 1; participants closely matched the racial and ethnic composition of the population of San Diego County at the time of recruitment (http://venus.census.gov/cdrom/lookup/908824497).

Demographics, baseline variables, and degree of weight change during the weight loss phase did not differ across the 3 experimental conditions. Randomized participants had attended a median 17 of 20 weight loss sessions (85%), with no significant differences across maintenance conditions. Families in the BSM and SFM groups did not significantly differ in median maintenance session attendance (12 of 16 [75%] and 11 of 16 [68.8%], respectively).

Two outliers were identified and removed from the primary weight outcome analysis, 1 in the BSM group and 1 in the control group who were 3.8 and 3.2 SDs, respectively, from the overall mean change on BMI *z* score and 3.1 SDs each from the overall mean change on percentage overweight. Based on indicators of statistical influence (studentized residuals and DFFITS statistic), both excluded cases were also identified as highly influential across multiple time points.

Table 3. Treatment Effects for Primary Child Weight Outcome Measures (n = 148)[a]

Time Point	*df*	Treatment Effect (95% CI)[b]	Effect Size (Cohen *d*)	*P* Value
Mean BMI *z* score				
Randomization to postweight maintenance				
BSM vs control	391	−0.09 (−0.16 to −0.02)	−0.73	.01
SFM vs control	391	−0.09 (−0.16 to −0.02)	−0.72	.009
Pooled vs control	391	−0.09 (−0.15 to −0.03)	−0.73	.003
Randomization to 1-y follow-up				
BSM vs control	391	−0.06 (−0.16 to 0.03)	−0.34	.19
SFM vs control	391	−0.09 (−0.19 to 0.00)	−0.47	.06
Pooled vs control	391	−0.08 (−0.16 to 0.01)	−0.40	.07
Randomization to 2-y follow-up				
BSM vs control	391	−0.04 (−0.16 to 0.08)	−0.20	.51
SFM vs control	391	−0.08 (−0.20 to 0.04)	−0.26	.17
Pooled vs control	391	−0.06 (−0.16 to 0.04)	−0.23	.25
Baseline to 2-y follow-up				
BSM vs control	119	−0.10 (−0.23 to −0.03)	−0.32	.14
SFM vs control	119	−0.14 (−0.27 to −0.01)	−0.45	.03
Pooled vs control	119	−0.12 (−0.24 to −0.01)	−0.38	.04
Mean percentage overweight				
Randomization to postweight maintenance				
BSM vs control	391	−5.2 (−8.7 to −1.8)	−0.96	.003
SFM vs control	391	−4.9 (−8.3 to −1.4)	−0.83	.006
Pooled vs control	391	−5.0 (−8.1 to −2.0)	−0.90	.001
Randomization to 1-y follow-up				
BSM vs control	391	−3.2 (−8.1 to 1.7)	−0.32	.19
SFM vs control	391	−4.3 (−9.2 to 0.5)	−0.43	.08
Pooled vs control	391	−3.7 (−8.0 to 0.5)	−0.37	.08
Randomization to 2-y follow-up				
BSM vs control	391	−0.1 (−6.1 to 5.9)	−0.11	.97
SFM vs control	391	−3.5 (−9.5 to 2.5)	−0.21	.25
Pooled vs control	391	−1.8 (−7.0 to 3.4)	−0.16	.50
Baseline to 2-y follow-up				
BSM vs control	119	−3.5 (−10.3 to 3.3)	−0.22	.31
SFM vs control	119	−6.2 (−13.0 to 0.6)	−0.37	.07
Pooled vs control	119	−4.9 (−10.8 to 1.1)	−0.29	.11

Abbreviations: BMI, body mass index; BSM, behavioral skills maintenance; CI, confidence interval; Pooled, pooled maintenance treatment conditions; SFM, social facilitation maintenance.

[a] Analyses include assessment completers except for 2 outliers. The follow-up observed data across time points comprised 393 of a possible 450 assessment points (87%), indicating a high retention rate with no differential assessment completion rate across groups.

[b] Treatment effects (intervention minus control) are presented as model estimates based on mixed-model, repeated-measures analysis of variance. Negative values for treatment effects and effect sizes indicate that the treatment groups did better than the control group.

Impact of the Standard Weight Loss Intervention

Overall, children's relative body weight significantly decreased from baseline to randomization (mean [SD] change, −0.22 [0.17]; $P<.001$ for BMI *z* score; mean [SD] change, −10.9 [7.9]; $P<.001$ for percentage overweight). TABLE 2 shows the mean for each maintenance condition across all assessment time points. Of the 150

children randomized following weight loss treatment, only 19 of 150 (12.7%) did not show a decrease in BMI *z* score and 11 of 150 (7.3%) did not show a decrease in percentage overweight. Success in weight loss appeared unrelated to success during the weight maintenance phase (point biserial $r=-0.04$, $P=.28$ for BMI *z* score; point biserial $r=-0.09$, $P=.66$ for percentage overweight).

Maintenance Intervention Effects

Weight Outcomes. *Interventions vs Control*. For short-term results, analyses of the BSM, SFM, or pooled active maintenance treatment groups indicated these children maintained their BMI *z* score and percentage overweight significantly better than those assigned to the control group (Table 2 and TABLE 3 and FIGURE 2). For long-term results, from baseline to 2-year follow-up, BMI *z* score maintenance was significantly better in the SFM and pooled active maintenance treatment groups than in the control group, although BSM and the control group did not significantly differ. For percentage overweight, the SFM vs control group contrast was similar but only approached statistical significance ($P=.07$), and neither the BSM ($P=.31$) nor pooled treatment groups ($P=.11$) significantly differed from the control group.

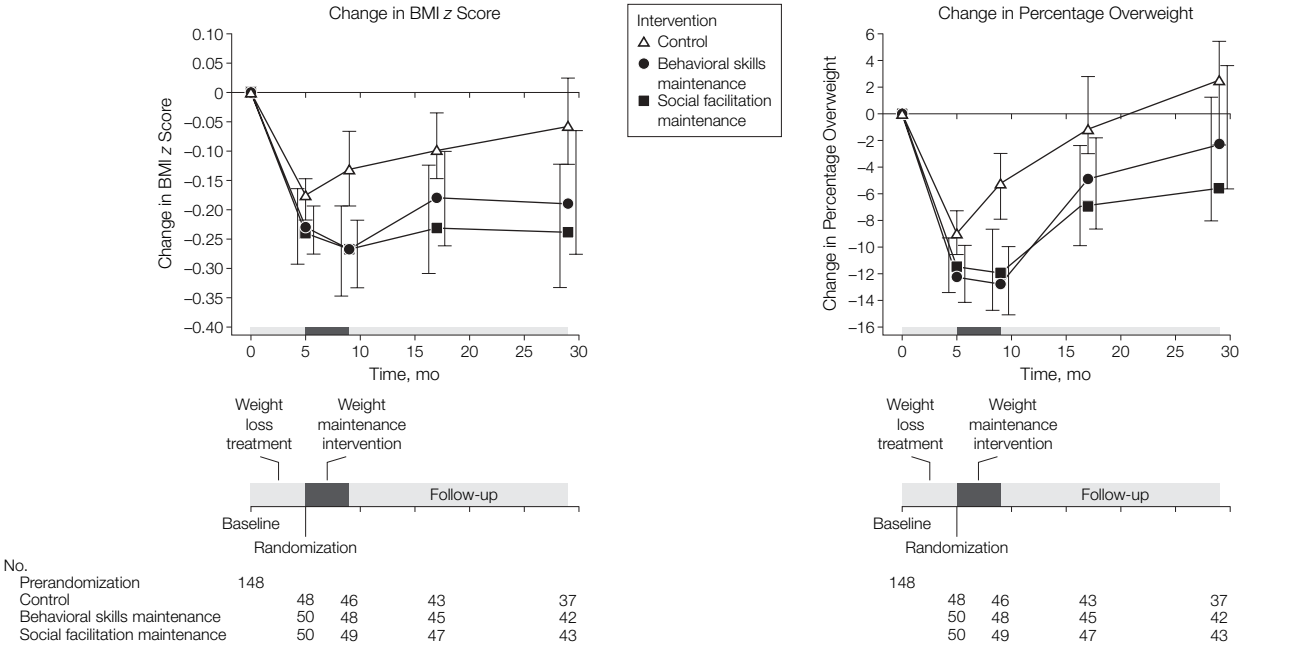
BSM vs SFM. For both weight outcomes, results for BSM and SFM were not significantly different from each other across any time points.

ITT Analyses. For each ITT analysis (all randomized participants without replacement values for missing data, with baseline values carried forward [TABLE 4], and with multiple imputation [TABLE 5]), short-term findings were significant, similar to the primary analysis findings. Each ITT analysis reduced the previously significant long-term SFM and pooled treatment group vs control group comparisons to nonsignificance ($P>.05$), while minimally impacting the long-term effect sizes, whose values remained similarly modest to those of the primary analyses (decreases in effect size ranged from 0.01 to 0.23).

BSM Psychosocial Targets. Over the long-term, children receiving BSM compared with controls significantly increased their perceived self-efficacy in adhering to a low-fat diet ($d=0.45$, $P=.04$, randomization to 1-year follow-up) and their perceived ability to overcome barriers to physical activity ($d=0.49$, $P=.05$, baseline to 2-year follow-up) (TABLE 6).

Children receiving SFM compared with controls significantly improved their perceived self-efficacy in adhering to a low-fat diet, over the short-term ($d=0.66$, $P=.004$, randomization to postweight maintenance) and long-term ($d=0.42$, $P=.05$, randomization to 2-year follow-up; and $d=0.42$, $P=.04$, baseline to 2-year follow-up) (Table 6). Additional long-term benefits of SFM relative to control included a greater perceived ability to overcome barriers to physical activity ($d=0.41$, $P=.02$,

Figure 2. Change in Child Weight Over Time by Treatment Condition



Error bars indicate 95% confidence intervals, which are staggered for presentation purposes, with social facilitation maintenance values left of the data point and behavioral skills maintenance values to the right of the data point. See Figure 1 for observed number analyzed for each condition by time point. Analyses also include 13 additional interpolated data points.

baseline to 2-year follow-up) and seek healthy alternatives to situations promoting inactivity (d=0.39, P=.02, randomization to 2-year follow-up).

No significant differences were found between BSM and SFM (Table 6).

SFM Psychosocial Targets. For any time point comparisons, SFM did not significantly differ from control on changes in weight/shape concerns (Table 6). Children in the SFM group compared with controls had significantly greater improvements in their ability to effectively use problem-focused coping with teasing over the long-term (d=0.83, P=.007, randomization to 2-year follow-up; and d=0.40, P=.008, baseline to 2-year follow-up). Children in the SFM group compared with controls also received more peer encouragement of healthy eating over the short-term (d=0.43, P=.03, randomization to postweight maintenance) and long-term (d=0.41, P=.05, randomization to 1-year follow-up), and were significantly better able to enlist support through friend participation in physical activity over the short-term (d=0.85, $P<.001$, randomization to postweight maintenance) and long-term (d=0.46, P=.05, randomization to 1-year follow-up).

No significant differences were found between BSM and control (Table 6).

There were no significant differences between active maintenance intervention groups on change in weight/shape concerns across any time points (Table 6). However, children in the SFM group compared with BSM showed significantly greater improvement in their ability to effectively use problem-focused coping with teasing over the long-term (d=0.47, P=.05, randomization to 2-year follow-up). The SFM group was better than the BSM group on increasing friend participation in physical activity over the short-term (d=0.47, P=.02, randomization to postweight maintenance) and long-term (d=0.44, P=.03, randomization to 2-year follow-up; and d=0.55, P=.006, baseline to 2-year follow-up).

Child Social Problems as a Moderator of Weight Outcome. Analyses of children's baseline level of social problems as a moderator of weight outcome indicated no short-term moderation effect. However, there was a significant long-term moderation effect of baseline social problems on change in BMI z score ($F_{2,114}$=6.56, P=.002) and percentage overweight ($F_{2,114}$=5.65, P=.005) from baseline to 2-year follow-up, and on change in BMI z score ($F_{2,114}$=2.16, P=.05) and percentage overweight ($F_{2,114}$=2.43, P=.03) from randomization to 2-year follow-up. To explore these significant interactions, level of baseline social problems was dichotomized, based on a median split (median=62). Post hoc simple effects analyses were then conducted, in which change in weight outcomes was examined by condition within the low and high social problems groups (FIGURE 3). From baseline to 2-year follow-up, children with low social problems in the SFM group relative to the control group showed significantly greater decreases in percentage overweight

Table 4. Treatment Effects for Primary Child Weight Outcome Measures, Intention-to-Treat With Baseline Values Carried Forward (N = 150)[a]

Time Point	*df*	Treatment Effect (95% CI)[b]	Effect Size (Cohen *d*)	*P* Value
Mean BMI *z* score				
Randomization to postweight maintenance				
BSM vs control	441	−0.07 (−0.14 to 0.02)	−0.50	.06
SFM vs control	441	−0.07 (−0.15 to −0.01)	−0.58	.03
Pooled vs control	441	−0.07 (−0.13 to −0.01)	−0.54	.02
Randomization to 1-y follow-up				
BSM vs control	441	−0.02 (−0.12 to 0.07)	−0.11	.63
SFM vs control	441	−0.08 (−0.17 to 0.03)	−0.34	.18
Pooled vs control	441	−0.05 (−0.13 to 0.04)	−0.22	.29
Randomization to 2-y follow-up				
BSM vs control	441	−0.03 (−0.14 to 0.09)	−0.09	.65
SFM vs control	441	−0.04 (−0.16 to 0.07)	−0.17	.45
Pooled vs control	441	−0.04 (−0.14 to 0.06)	−0.13	.49
Baseline to 2-y follow-up				
BSM vs control	147	−0.09 (−0.20 to 0.04)	−0.26	.21
SFM vs control	147	−0.14 (−0.22 to 0.03)	−0.31	.15
Pooled vs control	147	−0.12 (−0.19 to 0.02)	−0.29	.12
Mean percentage overweight				
Randomization to postweight maintenance				
BSM vs control	441	−4.2 (−7.8 to −0.7)	−0.71	.02
SFM vs control	441	−4.2 (−7.8 to −0.7)	−0.68	.02
Pooled vs control	441	−4.2 (−7.3 to −1.2)	−0.70	.007
Randomization to 1-y follow-up				
BSM vs control	441	−0.2 (−6.5 to 3.3)	−0.15	.52
SFM vs control	441	−1.3 (−7.9 to 1.8)	−0.29	.22
Pooled vs control	441	−0.6 (−6.6 to 1.9)	−0.22	.28
Randomization to 2-y follow-up				
BSM vs control	441	−0.1 (−5.7 to 6.0)	0.01	.95
SFM vs control	441	−3.5 (−7.2 to 4.5)	−0.10	.83
Pooled vs control	441	−1.8 (−5.6 to 4.5)	−0.04	.66
Baseline to 2-y follow-up				
BSM vs control	147	−2.4 (−8.4 to 3.7)	−0.16	.44
SFM vs control	147	−3.5 (−9.5 to 2.6)	−0.23	.26
Pooled vs control	147	−2.9 (−8.2 to 2.3)	−0.20	.28

Abbreviations: BMI, body mass index; BSM, behavioral skills maintenance; CI, confidence interval; Pooled, pooled maintenance treatment conditions; SFM, social facilitation maintenance.
[a] All analyses include outliers. Baseline (month 0) values are carried forward to replace all missing values.
[b] Treatment effects (intervention minus control) are presented as model estimates based on mixed-model, repeated-measures analysis of variance. Negative values for treatment effects and effect sizes indicate that the treatment groups did better than the control group.

(d=–0.86; 95% confidence interval [CI], –22.60 to –3.60; t_{65}=–2.75; P=.008) and BMI z score (d=–0.99; 95% CI, –0.50 to –0.10; t_{65}=–2.91; P=.005); whereas for corresponding children in the BSM group, decreases were significantly greater than control for BMI z score (d=–0.72; 95% CI, –0.4 to –0.002; t_{65}=–2.01; P=.05) but not for percentage overweight. The effect sizes for the SFM vs control group comparisons among children with low social problems were large (d=–0.99 and d=–0.86 for BMI z score and percentage overweight, respectively), whereas effect sizes for the BSM vs control group comparisons among these children were moderate (d=–0.72 and d=–0.55 for BMI z score and percentage overweight, respectively). There were no treatment group differences in change for either weight outcome among children with high baseline social problems. The moderator effect from baseline to 2-year follow-up remained significant with the inclusion of the 2 weight outliers (P=.02 for both BMI z score and percentage overweight) and with baseline values carried forward (P=.03 for percentage overweight and P=.02 for BMI z score). With missing data estimated by multiple imputation, SAS does not provide an overall P value but only P values for the simple contrasts (for percentage overweight, P=.06 for BSM vs control and P=.009 for SFM vs control; and for BMI z score, P=.04 for BSM vs control and P=.009 for SFM vs control). Post hoc analyses exploring the long-term moderator effect from randomization to 2-year follow-up revealed a similar pattern.

COMMENT

To our knowledge, this is the first large-scale study to test the efficacy of maintenance approaches for childhood overweight. Active maintenance treatments administered after weight loss treatment resulted in significantly improved child weight control during the 4-month maintenance contact period compared with no maintenance treatment in both the primary and ITT analyses. Consistent with adult maintenance studies, treatment effects declined from postweight maintenance through the 2-year follow-up in which there was no treatment contact for any condition. Based on the primary outcome analysis, children who had received SFM treatment evidenced attenuated BMI z score rebound vs the control group through this long-term follow-up period, although ITT analyses decreased effect magnitudes. There were no significant differences in child weight outcomes between BSM and SFM in either the short-term or long-term.

The BSM efficacy, the SFM efficacy, or both may have been compromised by artificially eliminating key procedures from each to minimize procedural overlap (eg, omission of self-regulatory skills in SFM such as detailed food monitoring). It is also possible that the treatment-specific effects of SFM relative to BSM are partially due to the presentation of new material in SFM, whereas BSM represents a continua-

Table 5. Treatment Effects for Primary Child Weight Outcome Measures, Intention-to-Treat With Multiple Imputation (N = 150)[a]

Time Point	*df*	Treatment Effect (95% CI)[b]	Effect Size (Cohen *d*)	*P* Value
Mean BMI *z* score				
Randomization to postweight maintenance				
BSM vs control	441	–0.08 (–0.16 to –0.01)	–0.63	.03
SFM vs control	441	–0.08 (–0.16 to –0.01)	–0.62	.03
Pooled vs control	441	–0.08 (–0.15 to –0.02)	–0.62	.01
Randomization to 1-y follow-up				
BSM vs control	441	–0.06 (–0.17 to 0.05)	–0.27	.29
SFM vs control	441	–0.07 (–0.18 to 0.03)	–0.35	.18
Pooled vs control	441	–0.07 (–0.16 to 0.30)	–0.31	.16
Randomization to 2-y follow-up				
BSM vs control	441	–0.04 (–0.17 to 0.09)	–0.14	.51
SFM vs control	441	–0.06 (–0.19 to 0.07)	–0.20	.38
Pooled vs control	441	–0.05 (–0.16 to 0.06)	–0.17	.37
Baseline to 2-y follow-up				
BSM vs control	147	–0.10 (–0.24 to 0.04)	–0.29	.18
SFM vs control	147	–0.10 (–0.24 to 0.03)	–0.33	.14
Pooled vs control	147	–0.10 (–0.22 to 0.02)	–0.31	.10
Mean percentage overweight				
Randomization to postweight maintenance				
BSM vs control	441	–4.9 (–8.6 to –1.2)	–0.85	.009
SFM vs control	441	–4.5 (–8.2 to –0.7)	–0.70	.02
Pooled vs control	441	–4.7 (–7.9 to –1.5)	–0.78	.004
Randomization to 1-y follow-up				
BSM vs control	441	–3.4 (–8.8 to 1.9)	–0.31	.21
SFM vs control	441	–3.6 (–8.8 to 1.6)	–0.33	.18
Pooled vs control	441	–3.5 (–8.1 to 1.1)	–0.32	.13
Randomization to 2-y follow-up				
BSM vs control	441	–0.6 (–7.0 to 5.8)	–0.04	.86
SFM vs control	441	–2.4 (–8.7 to 3.9)	–0.16	.46
Pooled vs control	441	–1.5 (–6.9 to 4.0)	–0.10	.60
Baseline to 2-y follow-up				
BSM vs control	147	–3.1 (–10.1 to 3.8)	–0.19	.38
SFM vs control	147	–4.5 (–11.4 to 2.3)	–0.27	.20
Pooled vs control	147	–3.8 (–9.8 to 2.1)	–0.23	.21

Abbreviations: BMI, body mass index; BSM, behavioral skills maintenance; CI, confidence interval; Pooled, pooled maintenance treatment conditions; SFM, social facilitation maintenance.
[a] All analyses include outliers.
[b] Treatment effects (intervention minus control) are presented as model estimates based on mixed-model, repeated-measures analysis of variance. Negative values for treatment effects and effect sizes indicate that the treatment groups did better than the control group. These values reflect outcomes across multiple imputations.

tion of the same principles taught in weight loss treatment. The general decline in effects following extended treatment suggests the need for the development of continuous care models for children, as in the adult weight loss field, which finds that longer ongoing contact helps maintain initial weight loss and improves health outcomes.[41,42]

A subset of children in both maintenance groups, those with lower social problems, evidenced better long-term weight loss maintenance compared with children in the control group, although the effects were larger and statistically significant for both weight outcomes in the SFM group. In fact, at 2-year follow-up, the children receiving SFM who had lower social problems achieved average weight status changes similar to those observed immediately following the initial weight loss intervention, which were comparable with the average changes found immediately after treatment ends in other studies of lifestyle interventions.[8]

Contrary with a priori hypotheses, there were no condition-based differences among children with higher social problems. Based on evidence[24] that high social problems are associated with poor treatment outcomes following weight loss treatment alone, and the SFM focus on social support, we had predicted a better effect of SFM compared with BSM and the control group for children with higher social problems. Perhaps our counterintuitive findings reflect that SFM was not designed to teach basic child social skills, but rather to help children refine existing skills to improve physical activity and diet by seeking peer support. The so-

Table 6. Child Secondary Outcome Measures by Time Point and Treatment Condition

	Mean (SD)															
	BSM					SFM					Control					Significant Time Point × Treatment Condition Interactions[a]
Outcome Measure	Baseline	Randomization	Postweight Maintenance	1-y Follow-up	2-y Follow-up	Baseline	Randomization	Postweight Maintenance	1-y Follow-up	2-y Follow-up	Baseline	Randomization	Postweight Maintenance	1-y Follow-up	2-y Follow-up	
BSM-Specific Treatment Targets																
CDSS: total self-efficacy	5.0 (4.8)	6.9 (3.4)	6.8 (4.6)	7.4 (3.4)	6.8 (4.0)	5.2 (4.3)	6.9 (3.8)	7.9 (3.3)	7.2 (3.4)	8.2 (3.3)	6.5 (4.1)	7.6 (3.3)	6.8 (3.7)	6.9 (3.5)	7.3 (4.0)	BSM vs control[b] SFM vs control[c,d,e]
SESCPA: barriers	2.6 (1.3)	2.8 (1.1)	2.8 (1.2)	2.9 (1.3)	3.0 (1.3)	2.3 (1.3)	2.7 (1.3)	2.7 (1.3)	2.8 (1.3)	2.8 (1.3)	2.7 (1.1)	2.8 (1.2)	2.3 (1.3)	2.7 (1.4)	2.3 (1.3)	BSM vs control[e] SFM vs control[e]
SESCPA: positive alternatives	5.1 (1.2)	5.5 (0.9)	5.5 (1.2)	5.4 (1.2)	5.3 (1.1)	5.2 (1.3)	5.4 (1.0)	5.6 (0.9)	5.5 (1.1)	5.7 (0.9)	4.8 (1.4)	5.5 (1.1)	5.5 (1.1)	5.2 (1.5)	5.0 (1.6)	SFM vs control[d]
SFM-Specific Treatment Targets																
CEDE: weight/shape concerns	1.4 (0.9)	1.0 (0.7)	0.8 (0.7)	0.9 (0.8)	0.9 (0.9)	1.4 (0.9)	1.0 (0.9)	0.7 (0.7)	0.7 (0.8)	0.7 (0.6)	1.6 (1.2)	1.2 (1.1)	0.9 (0.7)	1.0 (0.8)	0.9 (0.8)	No significant findings
CTS: problem-focused coping	4.7 (1.4)	4.3 (1.8)	4.7 (1.9)	4.9 (1.9)	4.0 (1.3)	4.6 (1.7)	4.3 (1.9)	4.7 (2.0)	5.1 (1.8)	5.0 (1.9)	4.8 (1.4)	4.2 (1.9)	4.0 (1.8)	3.6 (1.6)	3.4 (1.4)	SFM vs control[d,e] SFM vs BSM[d]
SSEH/ES: friend encouraged healthy eating	7.8 (3.8)	8.0 (3.6)	7.8 (4.0)	6.3 (1.9)	6.8 (3.0)	7.2 (2.8)	7.9 (3.5)	8.9 (4.2)	7.6 (3.8)	7.6 (3.9)	8.6 (4.9)	8.4 (4.0)	7.8 (3.8)	6.5 (2.0)	8.2 (4.7)	SFM vs control[b,c]
SSEH/ES: friend participation in physical activity	16.4 (7.8)	16.0 (6.2)	15.9 (6.8)	14.4 (5.4)	14.9 (7.4)	14.2 (5.9)	15.5 (6.3)	19.1 (7.5)	15.7 (7.0)	18.7 (7.7)	15.3 (7.9)	16.4 (6.5)	14.2 (4.6)	13.5 (4.9)	15.6 (7.4)	SFM vs control[b,c,f] SFM vs BSM[c,d,e]

Abbreviations: BSM, behavioral skills maintenance; CDSS, Child Dietary Self-efficacy Scale; CEDE, Child Eating Disorder Examination; CTS, Coping with Teasing Scale; SESCPA, Self-efficacy Scale for Children's Physical Activity; SFM, social facilitation maintenance; SSEH/ES, Social Support for Eating Habits/Exercise Survey.

[a] The treatment comparisons indicate relative effects among treatment conditions on each of the secondary outcomes, and the superscripts (b-e) designate at which time comparisons the interaction is significant. Interactions with $P \leq .10$ are reported. All interactions presented are significant ($P \leq .05$) unless otherwise noted.

[b] Randomization vs 1-year follow-up comparison.

[c] Randomization vs postweight maintenance comparison.

[d] Randomization vs 2-year follow-up comparison.

[e] Baseline vs 2-year follow-up comparison.

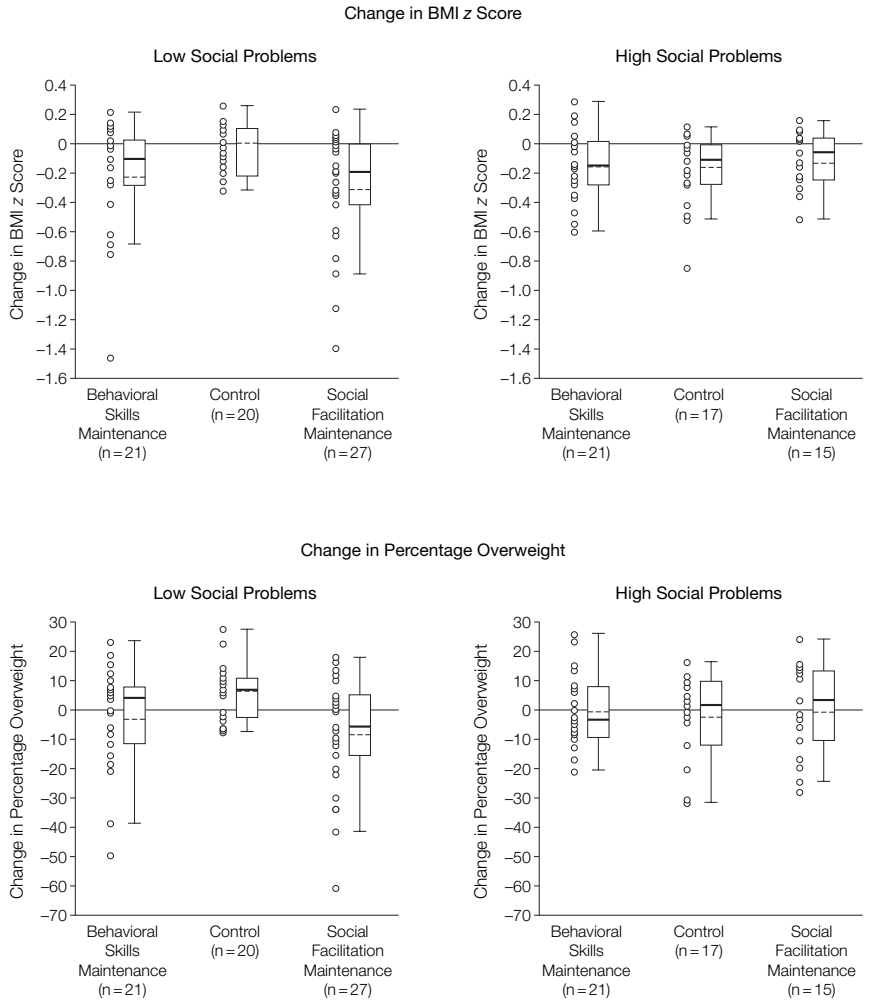
[f] Baseline vs 2-year follow-up and randomization vs 2-year follow-up comparisons for this outcome are significant at a trend level ($P < .06$).

cially adept children in the SFM group may have been better able to implement such strategies, whereas children with more social problems may have lacked the basic social skills needed to enlist such support. Future directions to enhance the long-term efficacy of SFM for such children might include teaching basic social skills before applying them to more specific weight maintenance behaviors or increasing follow-up duration and number of sessions to allow further social skills consolidation.

Children in the SFM group had positive psychosocial effects consistent with treatment content, including the best improvements compared with other conditions in coping with teasing and enlisting friends to support healthful eating and physical activity. This is important given that peer support appears positively related to youth physical activity,[43,44] and such coping and support also likely enhance the quality of life for overweight children.[45] Relative to the control condition, both active maintenance treatments demonstrated greater long-term improvements in dietary self-efficacy and overcoming barriers to physical activity. All conditions retained the reduced weight/shape concerns that occurred during weight loss suggesting, like other studies,[46] that treatments using moderate and flexible approaches to reducing caloric intake do not increase eating-disorder–related cognitions.

There were study limitations. We did not measure the impact of weight loss maintenance on health-related outcomes. Although similar weight changes have been associated with significant physical health improvements (eg, blood pressure, lipid profiles, and insulin resistance)[47,48] in children and adolescents in the short-term, future research is needed to examine the relative weight changes necessary for long-term physical health benefits among preadolescent children. Future studies of pediatric weight maintenance treatments should also continue to evaluate the long-term effects of treatment on psychosocial functioning.[49] Additionally, although we adjusted for age, weight, and height by using BMI-derived outcome variables, we did not adjust for Tanner stage. There is little empirical evidence that pubertal stage affects pediatric weight control treatment efficacy, but Tanner staging may be beneficial in future studies to understand long-term treatment outcomes in the context of hormonal, body fat distribution, and other changes that accompany puberty.[50] Although more ethnically diverse than most prior trials, our study participants were treatment seeking volunteers, and severely overweight children were excluded, perhaps limiting generaliz-

Figure 3. Child Social Problems as a Treatment Specific Moderator of Long-term Child Weight Outcomes (Baseline to 2-year Follow-up)



Horizontal lines within boxes indicate group medians (solid line) and means (dotted line). The bottom and top limits of the boxes represent the 25th and 75th percentiles, respectively. The top and bottom whiskers represent the highest and lowest observed scores found within a distance equal to twice the interquartile range above or below the median. The figure includes those individuals with 2-year follow-up data, excluding 2 outliers. Low (≤62) and high (>62) social problems were defined by a median split (median=62) of baseline Child Behavior Checklist Social Problems score. For low social problems, $P=.05$ for behavioral skills maintenance vs control and $P=.005$ for social facilitation maintenance vs control for change in BMI z score, and $P=.008$ for social facilitation maintenance vs control for change in percentage overweight. The mean and median for change in BMI z score for controls with low social problems overlay one another.

ability. Finally, we did not include a placebo control intervention. Future studies comparing active maintenance interventions to a credible psychoeducation control group are warranted to determine whether it was maintenance content, or the greater frequency and duration of treatment contact, which contributed to initial maintenance efficacy.

The alarming prevalence of child overweight necessitates the development of more effective long-term intervention strategies. Our study demonstrated that extended treatment contact with either a continued BSM focus or a novel SFM focus improves weight loss maintenance in a childhood overweight population in comparison with a weight loss program alone at least in the short-term, with some evidence for sustained long-term efficacy among more socially adept children receiving an SFM treatment.

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