ARTICLE

Exercise Therapy as a Treatment for Psychopathologic Conditions in Obese and Morbidly Obese Adolescents: A Randomized, Controlled Trial

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ABSTRACT

OBJECTIVE. We conducted a proof-of-concept, randomized, controlled trial to investigate the effects of a supervised exercise therapy intervention on psychopathologic outcomes in obese adolescents.

METHODS. The participant sample consisted of 81 adolescents (age: 11–16 years) who had been referred to a children's hospital for evaluation of obesity or who responded to a community advertisement. Participants were assigned randomly to exercise therapy, an equal-contact exercise placebo intervention, or usual care. Intervention participants attended 3 one-on-one sessions per week for 8 weeks and then completed a home program for another 6 weeks. Outcomes included self-perceptions (self-esteem), depression, affect, physical activity, aerobic fitness, and BMI.

RESULTS. A total of 18 of 81 participants were categorized as morbidly obese (BMI SD score: >3.5; adult equivalent BMI: ≥40). At baseline, 30.3% of participants had a Children's Depression Inventory score of ≥13, and 27% reported recent suicidal ideation. Repeated-measures mixed analysis of covariance (controlling for baseline scores) revealed significant changes in physical self-worth, associated measures of self-esteem, and physical activity over time, consistently favoring exercise therapy. There were no significant changes in BMI.

CONCLUSIONS. Findings confirmed psychopathologic conditions as a serious health concern in obese and morbidly obese adolescents. Our study is the first randomized, controlled trial to demonstrate that a brief supervised exercise therapy intervention has the potential to improve psychopathologic outcomes significantly and to increase physical activity in obese adolescents, relative to usual care.

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Key Words
obesity, exercise, children, psychopathologic conditions, weight, self-esteem

Abbreviations
HR—heart rate
PSW—physical self-worth
GSW—global self-worth
CDI—Children's Depression Inventory
RCT—randomized, controlled trial

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THE PREVALENCE OF overweight and obesity in children is now a serious public health issue in most developed countries.[1,2] Childhood obesity is associated with a number of long-term physiologic and psychological consequences[3,4] and is one of the most stigmatizing and least socially acceptable conditions in childhood. Overweight children have increased odds of experiencing poor psychosocial health and self-esteem.[5,6] Evidence has indicated that the likelihood of an obese young person having impaired health-related quality of life is >5 times greater than that for a healthy young person and similar to that for pediatric cancer patients.[7] Although it is accepted that being overweight in childhood and adolescence affects future quality of life[8] and increases the risk of psychopathologic conditions,[5–7] the treatment of psychopathologic conditions is not a priority for most obesity intervention programs. Studies have indicated that regular exercise can have positive effects on psychopathologic outcomes (ie, depression, anxiety, and self-esteem) in adult and nonobese child populations.[9–11] Preliminary evidence has also suggested that participation in weight loss camps that involve physical activity can affect mental health outcomes positively in obese children.[12–14] One study reported that obese adolescent girls who participated in an aerobic exercise intervention had lower depression scores than did girls allocated to other types of exercise or usual care.[15] However, all studies contained small samples and did not use randomized, controlled trial (RCT) methods.[12–15] Exercise interventions may be particularly appropriate treatments in obese populations because they have the potential to improve physical health and psychological health simultaneously. To our knowledge, no published RCT has examined the efficacy of a supervised exercise therapy intervention with specific reference to psychopathologic outcomes in obese adolescents. Furthermore, no trial has included an equal-contact exercise placebo group in an attempt to account for the attention effects that might be associated with lifestyle interventions in obese adolescents. The Sheffield Obesity Trial aimed to address the shortfalls of previous research. The primary trial hypothesis was that exercise therapy would lead to improvements in participants' physical self-esteem and reductions in psychopathologic conditions; by implication, these changes would translate into increased physical activity and reduced BMI over time.

METHODS

Participants and Methods

A detailed explanation of the Sheffield Obesity Trial intervention and outcomes can be found in a previous report.[16] Briefly, obese children 11 to 16 years of age were assigned randomly to receive exercise therapy, equal-contact exercise placebo, or usual care, after providing written informed consent. Participants were referred to the trial by pediatricians from a children's hospital in England for evaluation of obesity or responded to a community advertisement. Regardless of recruitment route, all participants were screened for eligibility by a trial pediatrician before study entry. Adolescents with a BMI that exceeded the 98th percentile for age and gender, according to 1990 United Kingdom reference data,[17] were defined as obese and were eligible. Exclusion criteria included medical conditions that would restrict the ability to be active 3 times per week for 8 weeks, unwillingness to attend supervised exercise sessions 3 times per week for 8 weeks, major cognitive or psychiatric impairments, and diagnosis of insulin-dependent diabetes mellitus or oral steroid treatment. An independent researcher performed the randomization procedures by allocating participants to groups according to a computer-generated random list. Given the lack of published studies in this field of research, sample size calculations were based on related review studies in the field of exercise and mental health. Specifically, the sample size required was calculated by using physical self-worth (PSW) as the primary outcome (predicted effect size of 0.6, providing 80% power; $P < .05$) 8 weeks from baseline; the calculation indicated that 30 participants per group were required for detection of a difference between interventions and usual care.

To facilitate recruitment and retention, a £25 sports store voucher was given to participants at the end of the intervention phase, and a contribution of £2.50 toward travel expenses to attend intervention sessions and assessments was made for each visit to the trial center. An additional £10 sports store voucher was given to participants when they completed their final follow-up assessment. It was considered reasonable to reimburse participants' travel expenses, which might otherwise have been a barrier to participation for participants from low-income families. Ethical approval was provided by the South Sheffield Local Research Ethics Committee.

Intervention and Control Groups

Exercise Therapy

The exercise therapy group participated in a range of aerobic exercise activities (eg, stepping, cycling, rowing, dance mat, and walking) and were asked to exercise intermittently at moderate intensity (40%–59% of heart rate [HR] reserve) for 30 minutes 3 times per week for 8 weeks (24 sessions). HR was recorded systematically throughout every session. Because obese individuals tend to be sedentary and to have had poor experiences with exercise, short bouts of intermittent exercise was considered most appropriate for this population. Minigames were also included in the sessions; these were designed primarily with fun in mind, but they also gave participants the opportunity to see personal development throughout the program and to introduce a small

self-referenced competitive element into the sessions. Exercise counseling for behavior change[18,19] was also an integral part of the exercise sessions. In line with the transtheoretical model, weeks 1 to 4 focused on cognitively based intervention strategies such as cognitive reappraisal and consciousness raising. During weeks 5 to 8, more behaviorally based interventions were introduced, for example, goal setting, self-monitoring, and finding social support. Participants followed a broad structured curriculum of topics over the course of the intervention.[16] The researcher also encouraged participants to discuss their thoughts and feelings about exercise, to assist with problem-solving. It was hoped that exercise counseling would provide participants assigned to the exercise therapy group with the knowledge and the psychological skills and tools necessary to sustain changes in their exercise behavior. Weight loss per se was not an intervention goal and no weight loss targets were set, although sensible eating habits were encouraged as part of the exercise therapy intervention.

Exercise Placebo

The exercise placebo group also attended 24 sessions over 8 weeks; however, instead of aerobic exercise, participants performed light body-conditioning/stretching exercises, during which HR was maintained at <40% of HR reserve, and no exercise counseling or behavioral change advice was given. Any placebo intervention must be relevant and meaningful, particularly when used with children and when blinding of the intervention is not possible. Therefore, this group also participated in other sedentary activities, such as balance and catching tasks, pool, darts, and table football. The inclusion of an exercise placebo group allows for a more-stringent test of exercise as a clinically meaningful treatment, because it equalizes social contact between the groups.

Usual Care

The usual care group participants were asked to continue with their lives as normal. They were given the opportunity to attend exercise therapy sessions at the trial center when they had completed their follow-up assessments.

Structure of Interventions

One of the authors (R.J.C.) delivered the exercise therapy and exercise placebo sessions, which took place one-on-one and lasted 1 hour. After participants completed their 8-week interventions, they were given an individualized home exercise or body conditioning program (in line with their group assignments) to follow on their own for an additional 6 weeks (14-week follow-up period). No researcher contact was provided during the home program phase. It was hoped that the follow-up phase would help participants to move toward becoming autonomous exercisers and would empower them to continue to commit to a lifestyle involving regular aerobic exercise. All participants were given a brief dietary advice information sheet, prepared by a dietician, at entry into the trial.

Outcome Measures and Assessments

Physical Self-Perceptions

The Children and Youth Physical Self-Perception Profile[20] assesses how young people feel about their physical selves and contains a series of 6-item subscales, namely, sports/athletic competence, attractive body adequacy, condition competence, strength competence, and PSW. Participants are asked to report their agreement with a series of forced-choice statements about their physical selves, on a scale of 1 to 4.

Depression

Depression was assessed with the Children's Depression Inventory (CDI).[21] The CDI is a 27-item, self-rated, symptom-orientated scale suitable for school-aged youngsters and adolescents. The following subscales are included: negative mood, interpersonal problems, ineffectiveness, anhedonia (the inability to gain pleasure from normally pleasurable experiences), and negative self-esteem. For each item, the child is asked to endorse 1 of 3 statements that best describes how he or she has felt typically over the past 2 weeks (eg, "I am sad once in a while," "I am sad many times," or "I am sad all the time"). Each response is scored as 0 (asymptomatic), 1 (somewhat symptomatic), or 2 (clinically symptomatic).

Self-Perceptions

Items measuring social acceptance, scholastic competence, and global self-worth (GSW) were taken from the Self-Perception Profile for Adolescents described by Harter.[22] The social acceptance subscale assesses the degree to which adolescents feel accepted by their peers, feel popular, have lots of friends, and feel that they are easy to like. The scholastic competence items assess adolescents' perception of their competence or ability within the school context. The GSW subscale assesses the extent to which adolescents like themselves as people and like the way they are living their lives. Score responses range from 1 to 4.

Affect

Items used by Ebbeck and Weiss[23] were included to assess positive and negative affective responses. The positive affect scale consists of 5 items (proud, satisfied, happy, excited, and relaxed), and the negative affect subscale consists of 4 items (unhappy, nervous, guilty, and angry). With a scale of 1 (very slightly) to 5 (extremely), participants are asked to indicate the degree to which each adjective described how they felt over the previous week.

Aerobic Fitness

The poorly fit category of the modified Balke protocol[24] was used to assess fitness. The protocol begins with participants walking at a pace of 3.0 miles per hour at a grade of 6% for 2 minutes. The grade is increased by 2% at the end of the 2-minute period and is increased by an additional 2% every 2 minutes thereafter, until volitional exhaustion. The speed of the treadmill remains constant at 3.0 miles per hour for the duration of the protocol. The test ends when participants feel they can no longer continue. The test is continuous, with no rest periods between stages. The distance walked (in miles) is recorded.

Physical Activity

The Physical Activity Questionnaire for Adolescents[25] was used to collect detailed information about participants' involvement in different physical activities in the previous 7 days. Specifically, participants are asked about their involvement in (1) various physical activities in their spare time, (2) physical education, (3) lunchtime physical activities, (4) extracurricular physical activities, (5) evening physical activities, and (6) weekend activities. Each activity is scored on a scale of 1 (not involved) to 5 (involved 5–7 times per week), depending on participants' degree of involvement in the various activity components.

Anthropometric Measurements

Height was measured to the nearest completed 0.1 cm by using a wall-mounted stadiometer. Weight was measured to the nearest 0.1 kg by using a balance scale. From these values, BMI values were calculated. All values were expressed as SD scores (z scores), relative to current United Kingdom standards.[17]

Assessments of Outcomes

All outcomes were assessed 8 weeks, 14 weeks, and 28 weeks after baseline assessments. Baseline assessments were completed before randomization.

Analysis

A repeated-measures mixed analysis of covariance (controlling for baseline scores) was used to compare outcomes between groups at the primary 8-week follow-up assessment, as well as 14 weeks and 28 weeks after baseline assessments. Data were analyzed on an intention-to-treat basis. The trial statistician was blinded to group codes.

RESULTS

Study Group

Participants were recruited between June 2002 and April 2005 (Fig 1). The sample consisted of 81 adolescents (mean age: 13.1 years). The recruitment rate via pediatrician referral/invitation was 48% (47 of 98 subjects). A total of 63 (77.7%) of 81 subjects were obese, and 18 (22.2%) of 81 participants were categorized as morbidly obese (BMI SD score: >3.5; adult equivalent BMI: ≥40). A total of 58% (n = 47) of the subjects were 11 to 13 years of age, and 42% (n = 34) were 14 to 16 years of age; 44.4% (n = 36) were male, 82.7% (n = 67) were of white ethnicity, 9.9% (n = 8) were of black ethnicity, and 7.4% (n = 6) were of South Asian ethnicity. The index of multiple deprivation[26] rank score was calculated for each participant on the basis of residential postal code. This measure of deprivation encompasses 7 domains, namely, income, employment, health and disability, education, skills and training, barriers to housing and services, living environment, and crime. Index of multiple deprivation rank scores indicated that 16% (n = 13) of participants were living in quartile 1 (least deprived), 14.8% (n = 12) in quartile 2, 17.3% (n = 14) in quartile 3, and 51.9% (n = 42) in quartile 4 (most deprived).

In comparison with healthy child populations,[26,27] Children and Youth Physical Self-Perception Profile (self-esteem) scores were low across all subscales at baseline. Furthermore, 25 participants (30.3%) had CDI scores of ≥13 (indicative of probable depression[21] in clinical populations), and 22 participants (27%) reported that in the previous 2 weeks they had experienced suicidal thoughts, as measured with the CDI.[21] At baseline, all groups were comparable, as were participants according to route of recruitment. Tables 1 and 2 contain means for outcomes across assessments.

Primary Outcome

Significant differences in adjusted mean PSW scores between the exercise therapy and usual care groups at 8 weeks (mean difference: 0.21; P = .02), 14 weeks (mean difference: 0.26; P = .03), and 28 weeks (mean difference: 0.23; P = .04) were recorded. Differences equate to improvements of 5.3% to 6.5% in favor of exercise therapy. There was a significant difference between the exercise placebo and usual care groups at 8 weeks (mean difference: 0.20; P = .02).

Secondary Outcomes

Analyses revealed a significant difference in adjusted mean GSW scores between exercise therapy and exercise placebo at 14 weeks (mean difference: 0.49; P = .002) and 28 weeks (mean difference: 0.42; P = .003). Differences equate to improvements of 10.5% to 12.3% in favor of exercise therapy. A significant difference between exercise placebo and usual care at 14 weeks was observed for GSW scores (mean difference: 0.36; P = .008). A significant difference in adjusted mean strength competence scores between exercise therapy and usual care at 8 weeks was noted (mean difference: 0.27; P = .03); this effect continued until 14 weeks

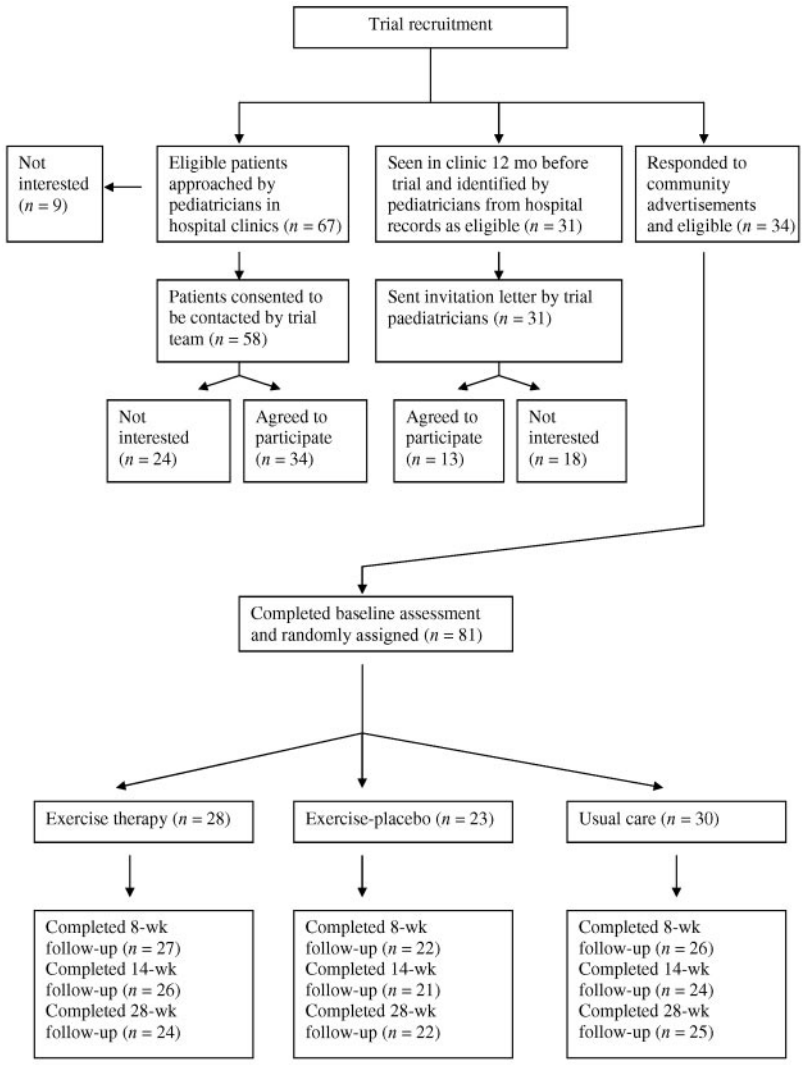

FIGURE 1
Trial flow diagram. Advert indicates advertisement.

(marginal) (mean difference: 0.31; $P = .06$; 6.8%–7.8% improvement).

Examination of the adjusted means indicated similar patterns over time for exercise therapy and usual care for attractive body adequacy scores, with both groups having reductions in scores at 14 weeks but improving beyond the initial 8-week adjusted mean scores by 28 weeks. Scores for exercise placebo also declined at 14 weeks but failed to regain the initial 8-week adjusted mean score by 28 weeks. We found evidence of a significant difference between exercise therapy and exercise placebo for this outcome at 28 weeks (mean difference: 0.22; $P = .045$; 5.5% improvement).

A marginally significant difference in adjusted mean physical activity scores between exercise therapy and usual care was observed at 8 weeks (mean difference: 5.9; $P = .06$), followed by a significant difference at later follow-up times (mean difference at 14 weeks: 8.24; $P = .02$; mean difference at 28 weeks: 9.84; $P = .002$). The exercise therapy group also reported significantly higher scores than the exercise placebo group at 28 weeks (mean difference: 9.81; $P = .0016$). Significant differences equate to improvements of 4.8% to 5.8% for exercise therapy.

Session Adherence and HR

Adherence to the interventions was high; 25 (89%) of 28 exercise therapy and 19 (83%) of 23 exercise placebo participants attended at least 80% of intervention sessions (19 of 24 sessions). HR data indicated that, on average, participants in the exercise therapy and exercise placebo groups were exercising in accordance with the trial intervention protocols (Table 3).

DISCUSSION

Using a RCT method, we found that an 8-week exercise therapy intervention had modest positive short-term and longer-term effects on outcomes, including the primary outcome measure of PSW, in obese adolescents, relative to usual care, lending support for previous non-

TABLE 1 **Baseline Scores for Study Outcomes for Each Group**

Outcome	Exercise Therapy	Exercise Placebo	Usual Care
Physical self-perception scores (score range: 1–4), mean ± SD			
PSW	1.83 ± 0.47	1.91 ± 0.52	1.97 ± 0.46
GSW	2.42 ± 0.56	2.49 ± 0.59	2.49 ± 0.49
Sports/athletic competence	2.20 ± 0.55	2.17 ± 0.71	2.03 ± 0.51
Conditioning/stamina competence	1.92 ± 0.46	2.04 ± 0.70	1.97 ± 0.57
Attractive body adequacy	1.48 ± 0.39	1.67 ± 0.35	1.59 ± 0.38
Strength competence	2.48 ± 0.77	2.52 ± 0.72	2.43 ± 0.64
Self-perception scores (score range: 1–4), mean ± SD			
Scholastic competence	2.51 ± 0.31	2.64 ± 0.32	2.59 ± 0.23
Social competence	2.46 ± 0.36	2.46 ± 0.43	2.47 ± 0.24
Depression (CDI) and affect scores (score range: 0–54 and 1–5), mean ± SD			
Depression ($n = 80$)	11.1 ± 6.04	10.1 ± 8.18	9.1 ± 6.37
Positive affect	3.39 ± 0.81	3.17 ± 0.72	2.97 ± 0.72
Negative affect	2.10 ± 0.67	2.13 ± 0.98	2.03 ± 0.92
Physiologic outcomes			
Resting HR, mean ± SD, beats per min	83.61 ± 4.45	82.26 ± 8.30	84.62 ± 10.57
Aerobic function, mean ± SD, miles ($n = 80$)	0.39 ± 0.02	0.36 ± 0.10	0.38 ± 0.12
BMI SD score, mean ± SD	3.17 ± 0.33	3.22 ± 0.61	3.32 ± 0.37
Physical activity score (score range: 0–170), mean ± SD	60.93 ± 11.5	61.22 ± 9.62	59.53 ± 8.71

$n = 81$ unless stated.

randomized research[12–15] and related reviews.[28] The associated attention effects of the exercise intervention are less clear, because participants in exercise therapy and exercise placebo reported significantly improved PSW scores, relative to usual care, which suggests that both interventions provided short-term benefit. However, only the exercise therapy group was found to demonstrate significant improvements in PSW at follow-up assessments thereafter. Findings for other outcomes reported as significant also tended to favor exercise therapy consistently over time.

How obese adolescents feel about their bodies is likely to be heavily implicated in the development and continuing presence of more-serious psychopathologic conditions.[29] With this in mind, a possible explanation for our findings is that the exercise intervention provided participants with positive cues toward a sense of achievement regarding their physical selves. This is also an important consideration in terms of the global treatment of obesity, because it seems particularly unlikely that obese adolescents will engage in sufficient amounts of regular exercise unless they have had opportunities to experience some sense of efficacy from participation. In support of this view, not only did exercise therapy participants report higher PSW and GSW scores across time, compared with exercise placebo and usual care groups, but also, as hypothesized, they reported greater amounts of physical activity at follow-up assessments, relative to the other groups. We must be mindful, however, that there were no corresponding reductions in BMI for this group. Alternatively, it could be that the modest increases in physical activity (4.8%–5.8%) were not sufficient to decrease BMI significantly. It is also possible that exercise therapy participants over-reported the amount of physical activity they were achieving during the follow-up period, although, if this had been the case, we would have expected similar over-reporting by the exercise placebo group. We cannot rule out the possibility that the increase in physical activity might have been compensated for by an increase in energy intake.

Unlike Stella et al,[15] we did not find a significant difference in depression scores over time between exercise and usual care participants by using a RCT method. However, of more concern here is the large number of participants who expressed suicidal ideation and reported CDI scores of ≤13 at baseline, confirming the findings of observational studies[6,30,31] that reported obese populations to be at high risk of psychopathologic conditions. Such findings serve to highlight the critical need to evaluate treatments that have the potential to attenuate such symptoms.

One of the challenges in the treatment and consequences of obesity is poor compliance. Therefore, treatments not only need to be effective but also need to be ones that obese adolescents are motivated enough to use. Adherence was excellent, which suggests that obese adolescents are motivated enough to engage in regular exercise when they are provided with opportunities and support to do so. Adherence to exercise interventions in obese populations is an especially important issue be-

TABLE 2 **Adjusted (for Baseline) Mean Scores for Each Group Across Follow-up Assessments**

Outcome	Mean ± SE			*F* Statistic	
	Exercise Therapy	Exercise Placebo	Usual Care	Group Effect	Group-Time Effect
Physical self-perceptions (score range: 1–4)					
PSW				3.53 ($P = .03$)	1.37 ($P = .25$)
8 wk	2.14 ± 0.07	2.14 ± 0.07	1.94 ± 0.05		
14 wk	2.02 ± 0.10	1.88 ± 0.13	1.77 ± 0.06		
28 wk	2.22 ± 0.09	2.03 ± 0.07	1.99 ± 0.06		
GSW				3.65 ($P = .03$)	3.30 ($P = .01$)
8 wk	2.61 ± 0.08	2.56 ± 0.10	2.56 ± 0.07		
14 wk	3.02 ± 0.11	2.52 ± 0.11	2.88 ± 0.07		
28 wk	2.86 ± 0.10	2.44 ± 0.09	2.66 ± 0.07		
Sports/athletic competence				2.06 ($P = .14$)	2.06 ($P = .09$)
8 wk	2.36 ± 0.10	2.36 ± 0.09	2.20 ± 0.06		
14 wk	2.23 ± 0.13	2.04 ± 0.14	1.95 ± 0.09		
28 wk	2.45 ± 0.09	2.16 ± 0.08	2.22 ± 0.08		
Conditioning competence				2.32 ($P = .11$)	0.54 ($P = .71$)
8 wk	2.20 ± 0.09	2.09 ± 0.08	2.00 ± 0.05		
14 wk	2.16 ± 0.13	1.86 ± 0.11	1.87 ± 0.08		
28 wk	2.29 ± 0.11	2.05 ± 0.10	2.08 ± 0.06		
Attractive body adequacy				0.15 ($P = .86$)	2.80 ($P = .03$)
8 wk	1.84 ± 0.08	1.87 ± 0.11	1.82 ± 0.06		
14 wk	1.46 ± 0.08	1.54 ± 0.14	1.38 ± 0.06		
28 wk	1.91 ± 0.06	1.69 ± 0.09	1.88 ± 0.08		
Strength competence				3.10 ($P = .051$)	0.12 ($P = .97$)
8 wk	2.67 ± 0.10	2.51 ± 0.10	2.39 ± 0.08		
14 wk	2.67 ± 0.12	2.51 ± 0.16	2.36 ± 0.12		
28 wk	2.45 ± 0.11	2.34 ± 0.11	2.27 ± 0.07		
Self-perceptions (score range: 1–4)					
Scholastic competence				1.06 ($P = .35$)	1.08 ($P = .95$)
8 wk	2.93 ± 0.13	2.78 ± 0.15	2.78 ± 0.12		
14 wk	3.00 ± 0.12	2.71 ± 0.16	2.90 ± 0.12		
28 wk	3.01 ± 0.12	2.66 ± 0.15	2.86 ± 0.13		
Social competence				0.78 ($P = .46$)	0.18 ($P = .45$)
8 wk	2.90 ± 0.11	2.73 ± 0.14	2.73 ± 0.12		
14 wk	2.94 ± 0.11	2.83 ± 0.13	2.80 ± 0.09		
28 wk	3.02 ± 0.13	2.81 ± 0.09	2.84 ± 0.10		
Depression (CDI) and affect scores (score range: 0–54 and 1–5)					
Depression				0.47 ($P = .63$)	0.28 ($P = .89$)
8 wk	7.68 ± 1.07	8.32 ± 1.28	8.23 ± 1.20		
14 wk	6.25 ± 1.08	7.29 ± 1.18	7.33 ± 1.45		
28 wk	4.57 ± 1.04	6.12 ± 1.15	6.64 ± 1.29		
Positive affect				2.24 ($P = .11$)	1.68 ($P = .16$)
8 wk	3.49 ± 0.13	3.39 ± 0.16	3.16 ± 0.09		
14 wk	3.16 ± 0.11	3.06 ± 0.21	3.10 ± 0.13		
28 wk	3.52 ± 0.10	3.24 ± 0.18	3.13 ± 0.11		
Negative affect				0.48 ($P = .62$)	0.86 ($P = .49$)
8 wk	1.93 ± 0.14	2.13 ± 0.19	1.72 ± 0.13		
14 wk	1.92 ± 0.13	1.83 ± 0.14	1.82 ± 0.14		
28 wk	1.84 ± 0.15	1.78 ± 0.16	1.80 ± 0.13		
Physiologic outcomes					
Resting HR, beats per min				0.72 ($P = .49$)	0.73 ($P = .58$)
8 wk	80.42 ± 0.96	82.16 ± 0.92	81.29 ± 0.96		
14 wk	80.38 ± 0.79	81.14 ± 1.05	81.62 ± 0.98		
28 wk	79.37 ± 0.76	80.24 ± 1.01	81.12 ± 1.10		
Aerobic function, miles				1.20 ($P = .31$)	0.50 ($P = .74$)
8 wk	0.39 ± 0.02	0.38 ± 0.01	0.36 ± 0.01		
14 wk	0.39 ± 0.02	0.38 ± 0.01	0.35 ± 0.02		
28 wk	0.39 ± 0.02	0.37 ± 0.01	0.36 ± 0.01		
BMI SD score				0.58 ($P = .56$)	0.71 ($P = .59$)
8 wk	3.23 ± 0.02	3.24 ± 0.02	3.23 ± 0.02		
14 wk	3.22 ± 0.03	3.24 ± 0.03	3.22 ± 0.03		
28 wk	3.16 ± 0.04	3.23 ± 0.04	3.17 ± 0.05		
Physical activity (score range: 0–170)				4.19 ($P = .02$)	1.76 ($P = .14$)
8 wk	70.24 ± 2.02	69.25 ± 2.92	64.38 ± 2.38		
14 wk	71.31 ± 2.31	68.31 ± 2.43	63.07 ± 2.52		
28 wk	72.97 ± 2.12	63.16 ± 2.17	63.12 ± 2.28		

TABLE 3 **Overall Mean HR During the Exercise Therapy and Exercise Placebo Interventions**

	HR, Mean ± SD, Beats per min	
	Exercise Therapy ($n = 28$)	Exercise Placebo ($n = 23$)
Weeks 1 and 2 (sessions 1–6)	149.7 ± 8.2	118.6 ± 8.7
Weeks 3 and 4 (sessions 7–12)	148.5 ± 7.2	117.8 ± 7.0
Weeks 5 and 6 (sessions 13–18)	149.0 ± 7.9	119.2 ± 7.1
Weeks 7 and 8 (sessions 19–24)	150.3 ± 7.9	119.8 ± 6.8

cause involvement has the potential to sensitize participants further about their weight status, thus causing additional harm. This was not the case here, because no lasting exacerbation of existing concerns regarding self-esteem or other components of psychopathologic conditions was recorded.

The findings should be interpreted in light of several strengths and limitations. The inclusion of both exercise placebo and usual care groups is a significant advancement with respect to previous research. We recorded a high rate of recruitment of eligible patients via pediatrician referral (48%). Blinding of the assessments was not possible, although we do not consider this to be a substantial limitation because the questionnaires were self-administered. The low level of attrition across follow-up assessments was encouraging (Fig 1). Although the trial was underpowered, we were able to report significant effects for our primary outcome and some secondary variables. Our sample size was also larger than, or at least equal in size to, that of most trials included in a Cochrane Library systematic review[32] of the effects of lifestyle interventions for treating obesity in children, as well as other obesity treatment trials.[33] Previous studies that examined lifestyle interventions involving obese children failed to provide detailed information about the content of the exercise sessions. We not only described in detail the nature of our interventions[16] but also collected physiologic data systematically from both the exercise therapy and exercise placebo groups, in the form of HR measurements throughout every intervention session, so that aerobic output could be quantified and considered with possible effects. Without such information, it is difficult to know what dose of exercise is likely to provide benefit. Studies evaluating behavioral and lifestyle treatments for child obesity have tended to recruit mainly white affluent children, limiting their generalizability.[32] In contrast, we were able to recruit a more racially diverse population from a range of socioeconomic status categories; we regard this as a particular strength. Although we used the 98th percentile as our inclusion criteria for obesity,[17] most participants had BMI scores above the 99.6th percentile; whether even larger effects would be seen for adolescents with lesser degrees of obesity and/or those not seeking treatment is not known. There also exists the possibility of a type 1 error attributable to multiple statistical testing, and noted differences may be spurious, but the consistent trend toward benefit for exercise therapy suggests that differences, where identified, are real. Nevertheless, we are mindful that analyses revealed a number of null results for outcomes included in this trial.

CONCLUSIONS

We found that participation in a supervised exercise therapy intervention improved measures of self-esteem and increased physical activity significantly among obese/morbidly obese adolescents over time, relative to usual care. Treatment effects were modest, however, and larger trials are needed to provide more-precise estimates of the observed effects and to clarify the mechanisms that might be responsible. This trial has highlighted the importance of assessing the efficacy of obesity treatments in relation to psychopathologic outcomes and not exclusively in terms of weight loss.

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