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Research Article

Pilot Investigation of Pediatric Weight Loss Clinic's Family Exercise Program to Improve Children's Physiological and Behaviour-Related Outcomes

Marsha B. Novick[1*], Tomeka R. Greene[2], Elizabeth C. Hulstine[2], Christopher T. Wilson[3], Ronald J. Williams[4] and Helen M. Hendy[5]

[1]*Associate Professor of Pediatrics and Family & Community Medicine, Penn State Health Milton S. Hershey Medical Center, Hershey, Pennsylvania, USA*

[2]*Clinical Exercise Physiologist, Penn State Health, Children's Heart Group, Harrisburg, Pennsylvania, USA*

[3]*Medical Student, Penn State College of Medicine, Hershey, Pennsylvania, USA*

[4]*Professor of Pediatrics and Medicine, Penn State Health Milton S. Hershey Medical Center, Hershey, Pennsylvania, USA*

[5]*Professor, Emeritus of Psychology, Penn State Schuylkill, Pennsylvania, USA*

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BMI: Body Mass Index
BMI%: Body Mass Index Percentile
USPSTF: United States Preventive Services Task Force

ABSTRACT

Introduction: Pediatric weight loss clinics recommend increased exercise, but rarely offer organized exercise programs as standard care. The present pilot study examined whether adding a family exercise program to standard clinic care improved outcomes for children with obesity.

Methods: Children were randomly assigned to standard care (n = 14) or standard care plus organized family exercise for two months (n = 12). At three study phases (pre-intervention, post-intervention, maintenance), physiological and behavioural-related measures included body mass index percentile (BMI%), blood lipids, glucose, blood pressure, timed walking distance, and parent-reported exercise barriers for children.

Results: No changes were found across the three study phases for any physiological outcomes (including BMI%), with no group differences and no phase X group interactions. However, significant improvements were found across the three study phases for behavioural-related outcomes (timed walking, reported exercise barriers), with no group differences or phase X group interactions. Participation in exercise sessions was 55.4%, but more sessions attended (by all 26 children) were associated with more walking improvements.

Conclusion: Organized family exercise added to standard clinic care of a pediatric weight loss clinic did not improve physiological outcomes but did improve behavioural-related outcomes. Future research is necessary to guide what specific factors of an organized exercise program enhance the effectiveness of physiological and behaviour-related outcomes.

Introduction

Over 30% of American children are now overweight or obese, with little change seen across the past decade [1, 2]. For children with obesity who are referred to pediatric weight loss clinics, recommendations typically include increasing fruit and vegetable intake, choosing whole grains instead of simple-carbohydrates, eating fewer high-fat and high sugar snack foods, drinking more water, and increasing exercise [3]. The 2018 Physical Activity Guidelines Advisory Committee Scientific Report recommends at least 60 minutes of moderate-to-vigorous daily physical activity for children ages 6-17 years old and concluded that higher amounts of physical activity are positively associated with a more favorable health status in children over 6 years old, including cardiorespiratory and musculoskeletal fitness, cardiometabolic health and adiposity [4]. Recent estimates suggest that this goal of 60 minutes a day of moderate-to-vigorous physical activity is reached by only 42% of elementary school-aged children [5, 6]. While physical activity is the

[*]*Correspondence to: Marsha Novick, M.D., F.A.A.F.P., Associate Professor of Pediatrics and Family & Community Medicine, Medical Director, Healthy Weight Program for Kids & Teens, Penn State Health Milton S. Hershey Medical Center, 500 University Drive, Hershey, PO Box: 850, 17033, Pennsylvania, USA; Tel: 7175318674; Fax: 7175310401; E-mail: mnovick@pennstatehealth.psu.edu*

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movement that is carried out by the muscles, exercise is structured, planned, and intended to improve physical fitness (endurance, cardiorespiratory fitness and body composition). Despite these documented benefits of exercise, few pediatric weight loss clinics offer organized exercise programs as part of their standard care for children with obesity because of limitations of cost, space and trained personnel. One meta-analysis reviewed 13 studies using randomized exercise interventions for children in a variety of settings, including during school gymnastics, at counseling-supervised programs, and while walking with parents at home or with a device that made television viewing contingent upon cycling [7]. The authors concluded that exercise significantly reduced children's body weight and fat percentage, with more months of exercise producing greater reductions in body weight, but with no dose/response associations between minutes per week of exercise and the amount of weight reduction.

Another meta-analysis by the United States Preventive Services Task Force reviewed 42 studies of randomized multi-component weight-loss interventions for children that targeted lifestyle changes including exercise and diet improvement [2]. The authors concluded that exercise interventions with 26+ hours across a period of 2-12 months produced significant reductions in children's BMI *z*-scores (another standardized score of children's BMI values in comparison to agemates). However, no significant improvements were seen in blood lipids or fasting plasma glucose levels. Less intensive exercise interventions of fewer than 25 hours produced no significant improvements in blood pressure, lipids, glucose levels or child-reported quality of life, self-esteem, or depression. None of the 42 interventions evaluated changes in parent-reported perceptions of perceived exercise barriers that may influence family participation in such exercise interventions. Currently, only one study is available in the literature that examines the effectiveness of an organized exercise program organized by a weight loss clinic for improving outcomes relevant to children with obesity [8]. This study was highly intensive with 122 contact hours over six months, with participants randomly assigned to three study groups. The authors found no improvements in BMI *z*-scores for the control group, but both their home-based and hospital-based exercise programs were significantly and similarly effective in reducing children's BMI *z*-scores.

One as-yet-unevaluated factor that could be related to children's participation in exercise programs is their "perceived barriers" to exercise as suggested by the health belief model (HBM) [9]. The theory proposes that an individual would decide to move forward with a new healthy behaviour such as exercise based on their 'perceived threats' of their present actions (such as feeling tired, being unable to participate in games with other children, embarrassment, social teasing), their 'perceived benefits' of doing exercise (such as having more energy, more activities to share with friends, more fashion options, feeling of accomplishment) and their 'perceived barriers' for doing exercise, which is often the HBM cognition most predictive for moving forward with new behaviours. When encouraging children with obesity to be more physically active, clinicians may routinely emphasize the first two HBM cognitions, but they may neglect discussing 'perceived barriers' that reduce the family's likelihood of encouraging the child to exercise. The purpose of the present pilot investigation was to add to the limited literature on the effectiveness of weight loss clinic organized exercise programs for improving relevant outcomes for children with obesity receiving standard clinic care. New features of the present study were its inclusion of a family-based exercise program and its consideration of a wide variety of physiological and behaviour-related outcomes, including the child's perceived exercise barriers (as reported by parents). Parents of obese children report that increasing exercise is more difficult than changing their other recommended weight-management behaviours such as less screen time, more sleep, and a better diet [10]. Perceived exercise barriers may include problems with transportation, unsafe play environments, children's preference for electronic media and children not finding exercise activities enjoyable [10, 11]. We hypothesized that outcome measures most likely to show improvements for all children receiving weight loss clinic care would be the behaviour-related outcomes of child walking distance and perceived exercise barriers, whereas the physiological outcomes evaluated would need more intensive contact hours to show significant changes. We also hypothesized that children assigned to receive the family exercise program in addition to standard clinic care would show greater improvements because of more total contact hours with weight management specialists. Results from our pilot investigation could guide clinics in making the decision to invest resources in developing organized exercise programs as part of their standard care, as well as guiding them in making changes to their exercise programs to increase family participation by better understanding barriers to participation.

Methods

I Participants

Study participants included children who had been referred to a pediatric weight loss clinic in south-central Pennsylvania, along with their parents. With approval from Penn State University's Institutional Review Board (ClinicalTrials.gov Protocol Record 00007398), 208 families from the clinic with children ages 6-12 years old were asked to participate in a study on health outcomes for children with obesity, with 26 (12.5%) families consenting to participate. Demographics of the cohort included 50% boys with a mean age of 9.42 years and a mean BMI% of 97.44%. Approximately two-thirds of participants were Caucasian, 20% Hispanic and 10% African American with close to a quarter of parents having four-year college degrees. (See Table 1 for participant demographics).

Table 1: Descriptive statistics of child and parent demographics for two randomly assigned study groups from a pediatric weight loss clinic.

	CONTROL GROUP (n = 14) %	EXERCISE GROUP (n = 12) %
Child gender		
Female	57.1%	41.7%
Male	42.9%	58.3%
Child age		
6-8 years	14.3%	50.0%
9-10 years	57.2%	33.3%
11-13 years	28.6%	16.7%

Child ethnicity		
White	60.0%	72.7%
ispanic	10.0%	27.3%
Black	20.0%	0.0%
Other	7.1%	0.0%
Parent education		
No high school degree	0.0%	11.1%
High school degree	18.2%	11.1%
Some college	54.6%	33.3%
Four-year college degree	9.1%	22.2%
Graduate degree	18.2%	22.2%

Of the 26 families in the present study, 14 were randomly assigned to a 'control group' that received standard clinic care across the three study phases (pre-intervention, post-intervention, maintenance). The other 12 families were randomly assigned to an 'exercise group' that received standard care plus an organized family exercise program across the same three study phases. Due to the randomization process, the control group and exercise groups were not identical in size (n = 14 in control group, n = 12 in exercise group).

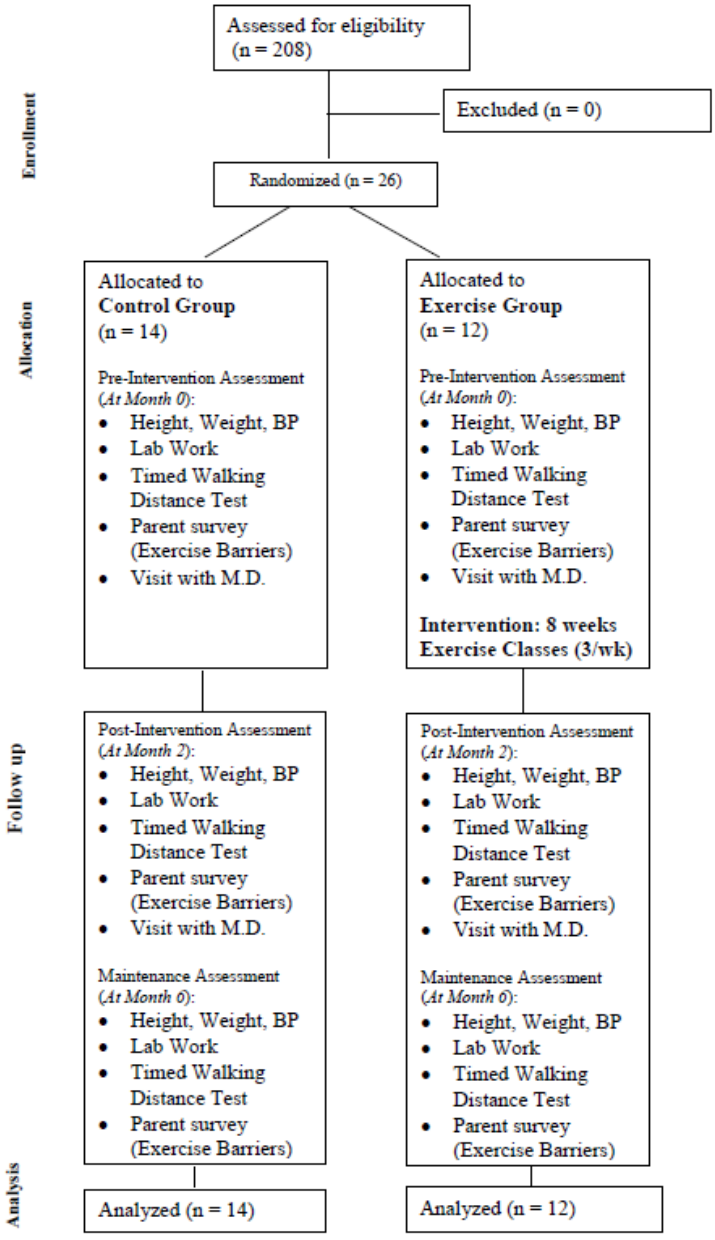


Figure 1: Participant randomization and process of intervention phases.

II Overview

After random assignment of patients to the two study groups (control, exercise), three phases of the study were conducted across six months with office visits at each stage. Pre-intervention occurred at month 0, post-intervention occurred at month 2, and maintenance occurred at month 6. Children in the exercise group were offered two months of a family exercise program three days per week from initial visit to the 2-month follow up visit. All three study phases included the following assessments: child's height, weight, blood pressure, lab work, a timed distance walking test, a parent survey about their children's perceived exercise barriers and a visit with the obesity medicine physician ("standard clinic care"). (See Figure 1 for a flow-chart of study phases).

III Procedures

i Standard Clinic Care

Across the six-month study, children in both the control group and the exercise group received standard clinic care. This standard care involved children and their parents meeting on three occasions (pre-intervention, post-intervention, maintenance) with a board-certified obesity medicine physician, who recommended increasing daily physical activity, reducing food portion sizes and reducing consumption of sugary drinks and snack foods. Each family was given specific nutrition and physical activity goals based on individual medical conditions and needed lifestyle changes.

ii Organized Family Exercise Program

For children and parents in the exercise group, an organized family exercise program was offered for the first two months of the six-month study. The exercise sessions were presented three days/week in the late afternoon at a rented church recreation room near the weight loss clinic, with each exercise session approximately 60 minutes in length. Sessions were conducted by an exercise physiologist from the weight management clinic who was experienced in making physical activity fun and game-filled for children and their parents, which past research suggests can enhance participation [12]. Examples of activities offered to the families included relay races, dodgeball and capture the flag. To encourage participation, children were also given a small token (a button) at each session, and they could then trade three tokens for small prizes such as jump ropes, water bottles and kites. Additionally, families that attended 80% or more of the 24 exercise sessions and all three of their scheduled clinic visits were offered a gift certificate of $100. Families in the control group were also offered a gift certificate of $100 if they attended all three of their scheduled clinic visits.

IV Measurement of Physiological and Behavioural Outcomes

At each of the three study phases (pre-intervention, post-intervention after two months, and maintenance after six months), eight physiological measures and two behavioural-related measures were gathered for children in both study groups (control, exercise). (See Table 2 for descriptive statistics of these outcome measures separately for each study group, and separately for each study phase). The physiological outcomes evaluated in the present study were BMI%, fasting blood lipids, glucose and blood pressure, which were chosen because these factors increase the risk for hypertension, coronary artery disease and type 2 diabetes [13]. Clinic staff measured height, weight and blood pressure. Height was measured in centimeters by using a stadiometer. Weight was measured obtained in kilograms without shoes in light clothing on the clinic's digital scale.

Table 2: Descriptive statistics for physiological and behaviour-related outcomes for children across three study phases, and for two study groups: control group (n = 14), exercise group (n = 12).

	PRE-INTERVENTION M (SD)		POST-INTERVENTION M (SD)		MAINTENANCE M (SD)
PHYSIOLOGICAL OUTCOMES:					
BMI PERCENTILE					
Control group	97.12 (5.82)		96.69 (5.99)		97.09 (4.67)
Exercise group	97.81 (1.80)		99.03 (.59)		98.02 (3.06)
CHOLESTEROL (mg/dL)					
Control group	166.25	(50.15)	164.17	(29.40)	157.82 (20.76)
Exercise group	172.36	(39.08)	181.14	(44.91)	173.63 (36.82)
TRIGLYCERIDES (mg/dL)					
Control group	123.00	(77.20)	112.00	(50.87)	95.09 (35.81)
Exercise group	88.91	(62.23)	102.00	(45.46)	137.63 (66.15)
GLUCOSE (mg/dL)					
Control group	86.18 (5.40)		88.09 (5.30)		88.82 (5.91)
Exercise group	89.50 (6.57)		89.14 (6.89)		90.63 (3.70)
SYSTOLIC BP (mmHg)					
Control group	107.43 (9.87)		112.36 (10.07)		108.15 (12.61)
Exercise group	110.33 (10.58)		112.73 (8.21)		107.33 (7.35)
DIASTOLIC BP (mmHg)					
Control group	60.43 (6.76)		60.91 (4.76)		62.31 (7.83)
Exercise group	59.00 (4.79)		60.55 (7.44)		63.33 (10.49

BEHAVIOURAL OUTCOMES:			
CHILD TIMED WALK DISTANCE (meters/6 mins)			
Control group	566.15 (44.76)	585.91 (61.01)	560.25 (42.56)
Exercise group	519.32 (41.19)	572.63 (77.73)	550.33 (66.66)
PARENT-REPORTED CHILD EXERCISE BARRIERS (3-pt rating)			
Control group	1.75 (.33)	1.41 (.51)	1.51 (.26)
Exercise group	1.57 (.21)	1.46 (.17)	1.42 (.28)

Blood pressure was measured by manual sphygmomanometer using a Welch Allyn blood pressure cuff of the appropriate cuff size at the same time as the weight measurement. Blood pressures were measured once on children after they had been sitting down for at least five minutes. Children's body mass index percentile (BMI%) in comparison to peers of the same age and gender was calculated by the clinic's electronic medical record system. Fasting total cholesterol, triglycerides and blood glucose were obtained via a blood draw by certified phlebotomists prior to all three study phases. The behaviour-related outcome of timed walking distance was measured by clinic staff, with children asked to walk as fast as they could for six minutes in the hallway of the weight loss clinic, with the distance in meters recorded. Timed walking distance was chosen as an outcome variable to evaluate children's functional fitness, and the six-minute walk test has been shown to be safe and easy to perform and provides a simple, inexpensive and validated method to measure children's functional exercise capacity [14].

Although the six-minute walk test is not routinely performed at this clinic due to lack of resources, there are other pediatric weight loss clinics that do routinely use the six-minute walk test as part of their standard care. The other behaviour-related outcome was the child's perceived exercise barriers (as reported by parents), chosen because it has not yet been evaluated as an outcome for children with obesity who are offered an exercise program and because it has been found to be one of the most difficult weight-management behaviours for obese children to change [10]. The list of possible exercise barriers used in the present study was developed based on previous research and the authors' clinical experience [10, 11]. Parents were asked to complete a brief survey to use a three-point rating (1 = never, 2 = sometimes, 3 = always) for how often their children complained about nine possible exercise barriers: cost, dislikes exercise, lack of equipment, lack of indoor places, no time, medical problems, time with technology, safety concerns and lack of transportation. The score for reported exercise barriers was calculated as the mean three-point rating across the nine concerns, with a higher score meaning more exercise barriers.

V Data Analysis

One preliminary goal for data analysis was to examine whether children randomly assigned to the two study groups (n = 14 in control group, n = 12 in exercise group) showed differences at pre-intervention in their demographics (child gender, age, BMI%, ethnicity, parent education) or in their physiological and behaviour-related measures. Using SPSS 24 software, Chi-square analyses or t-tests were conducted (as appropriate) to compare children in the two study groups. The primary goal for data analysis was to determine whether children's physiological and behaviour-related outcomes changed across the three study phases (pre-intervention, post-intervention, maintenance) and whether changes depended on study group (control, exercise). G*Power online software recommended a sample size of 20+ for statistical power of 0.80 in a mixed-factor ANOVA with two groups, three repetitions, an effect size of 0.30 and a *p* value of 0.05, indicating that our sample of 26 was adequate for the planned analysis [15].

The physiological outcomes evaluated were BMI%, fasting blood lipids, glucose and blood pressure. The behaviour-related outcomes evaluated were child timed walking distance (meters/6 minutes) and perceived child exercise barriers (as reported by parents). Using SPSS 24 software, a 3 X 2 mixed-factor analysis of variance (ANOVA) was conducted for each outcome variable, with the three study phases being the within-subjects factor and with the two study groups being the between-subjects factor. For any study phase main effects, or study phase X study group interaction effects found significant, follow-up comparisons (correlated t-tests) were planned to identify when changes occurred for the outcome measure from pre-intervention to post-intervention, from pre-intervention to maintenance. Our hypothesis was that we would find study phase X study group interaction effects for the behaviour-related outcomes, with follow-up comparisons showing improvements from pre-intervention to post-intervention occurred more for the exercise group than the control group.

Because of past research showing low compliance with exercise programs offered to children with obesity, an additional calculation was made using SPSS 24 software as a quick measure of the 'internal validity' of the exercise group's experience [12]. Therefore, for the 12 children in the exercise group, descriptive statistics (mean, SD) were calculated for the number (and percentage) of sessions attended of the 24 exercise sessions presented (3 per week X 8 weeks). Also, to determine children's top reported exercise barriers, descriptive statistics (mean, SD) were calculated for the three-point ratings given to each of nine possible exercise barriers.

Results

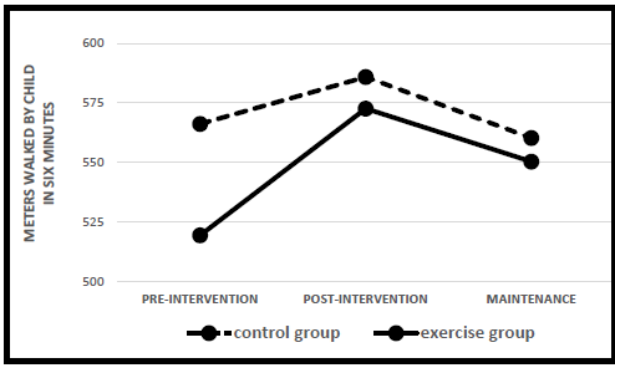
The study included 26 participating families (n = 14 in control group, n = 12 in exercise group). At pre-intervention, the two study groups did not differ significantly in demographics such as child gender (Chi-square = 1.42, p = 0.234), child age (t = 0.98, p = 0.336), child BMI% (t = 1.29, p = 0.208), child Caucasian ethnicity (Chi-square = 2.21, p = 0.145) or parent college education (Chi-square = 0.57, p = 0.452) (Table 1). Additionally, the two randomly assigned study groups did not differ significantly at pre-intervention in any physiological measures included in the present study: BMI% (t = 0.40, p = 0.694), cholesterol (t = 0.32, p = 0.749), triglycerides (t = 1.16, p = 0.260), glucose (t = 1.21, p = 0.243), systolic blood pressure (t = 0.72, p = 0.476), diastolic blood pressure (t = 0.61, p = 0.546) (Table 2). Finally, the two study groups did not differ at pre-intervention in the child's perceived exercise barriers (as reported by parents) (t = 0.76, p = 0.458). However, the control group showed slightly more meters walked during the timed walk during pre-

intervention (t = 2.65, p = 0.015; control group M = 566.15, SD = 44.76; exercise group M = 519.32, SD = 41.19).

From the 3 X 2 ANOVAs, we found no significant main effects for the study phase, main effects for study group, or phase X group interaction effects for any physiological outcomes measured: BMI%, fasting cholesterol, triglycerides, glucose, systolic blood pressure and diastolic blood pressure (Table 3). In contrast, we found significant main effects for study phase for the behaviour-related outcomes measured: timed walking distance and child's perceived exercise barriers (as reported by parents). No main effects for study group or phase X group interaction effects were significant for these behaviour-related outcomes (Table 3) (Figure 2). Follow-up comparisons for the significant study phase effects showed increases in timed walking distance from pre-intervention to post-intervention two months later, but a return to pre-intervention levels by maintenance conditions four months after that ($tcorr_{(23)}$ = 3.09, p = 0.005; $tcorr_{(21)}$ = 1.10, p = 0.284; respectively). Follow-up comparisons showed improvements in child's perceived exercise barriers (as reported by parents) from pre-intervention to post-intervention and continuing from pre-intervention to maintenance ($tcorr_{(15)}$ = 2.33, p = 0.034; $tcorr_{(18)}$ = 2.77, p = 0.013; respectively).

Table 3: Results from 3 X 2 ANOVAs comparing physiological and behaviour-related outcomes across three study phases.

PHYSIOLOGICAL OUTCOMES:						
	BMI PERCENTILE		**CHOLESTEROL**		**TRIGLYCERIDES**	
Effect	***F(df)***	***p***	***F(df)***	***p***	***F(df)***	***p***
Study phase	.87(2, 36)	.428	.41(2, 30)	.666	.33(2, 30)	.723
Study group	.61(1, 18)	.446	.69(1, 15)	.420	.02(1, 15)	.905
Phase X Group	1.11(2, 36)	.341	.39(2, 30)	.679	2.80(2, 30)	.077
	GLUCOSE		**SYSTOLIC BP**		**DIASTOLIC BP**	
Study phase	1.23(2, 26)	.308	1.81(2, 36)	.179	1.68(2, 36)	.201
Study group	.10(1, 13)	.753	.23(1, 18)	.639	.22(1, 18)	.646
Phase X Group	.08(2, 26)	.923	.81(2, 36)	.452	.55(2, 36)	.584



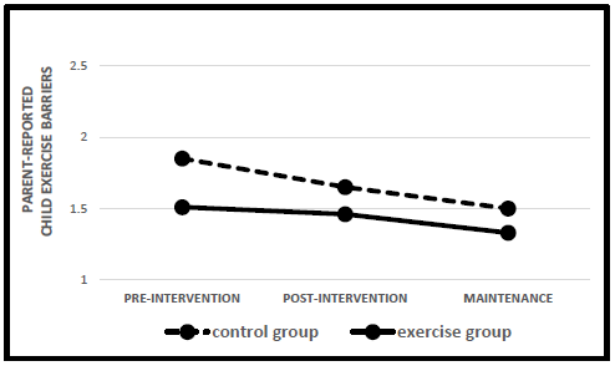


Figure 2: Significant changes in behaviour-related outcomes across three study phases and for two study groups: control Group (n = 14), exercise Group (n = 12).

All participants in the control and intervention groups attended all scheduled three clinic visits and no family dropped out of the study. The internal validity check to see if children in the exercise group attended their 24 exercise sessions found poor overall attendance, with a mean of only 13.33 (SD = 6.81) sessions attended, or 55.4% of sessions. However, the number of exercise sessions children attended (counting the # attended for children in the exercise group, counting 0 attended for children in the control group) was positively correlated with improvements in timed walking distance seen from pre-intervention to maintenance (r = 0.566, n = 22, p = 0.006). The three most highly rated child's perceived exercise barriers (as reported by parents) were time with technology (M = 2.27, SD = 0.63), no time (M = 1.86, SD = 0.56) and dislike of exercise (M = 1.86, SD = 0.64).

Conclusion

While pediatric obesity treatment guidelines recommend at least 60 minutes a day of moderate-to-vigorous physical activity, none give best-practice recommendations as to whether an activity program should be offered as part of standard care in a pediatric weight loss clinic [3, 16, 17]. As far as we are aware, the present pilot study is only the second in the literature to examine whether a clinic-organized family exercise program enhances outcomes for children with obesity. As hypothesized, results for the present investigation suggest that across three phases of pediatric weight loss clinic care (pre-intervention, post-intervention after two months, maintenance conditions after four additional months), children with obesity showed no significant changes in physiological outcomes (BMI%, fasting cholesterol, triglycerides, glucose, and blood pressure). This finding is consistent with the conclusion of a previous meta-analysis, which showed that the improvement of physiological outcomes requires more intensive contact hours [2]. One previous study showed that a more intense six-month exercise intervention was effective for reducing children's BMI z-scores [8].

However, the 122 contact hours given to each child in the previous application may not be feasible for many pediatric weight loss clinics with limited resources of time, space and personnel. Based on meta-analysis results, future studies should examine the effectiveness of

exercise interventions with 26 contact hours as a reasonable compromise [17]. Additional research is needed to guide what specific factors of an organized exercise program embedded within a weight loss program enhance the success of physiological effectiveness, including potential determinants such as improved access, location, space, types of exercise recommended, parental participation, number of months and intensity of activity. This study showed that timed walking distance improved from pre-intervention to post-intervention, but then returned to pre-intervention levels at maintenance. Unexpectedly, the improvements seen for the timed walking distance did not differ between children in the control group who were given standard clinic care and children in the family exercise group. Poor participation by families in the clinic's exercise program was a likely reason for the lack of additional benefits, with a mean of only 55.4% of the 24 exercise sessions attended [2].

Attendance of the exercise program was much lower than anticipated, with the USPSTF's meta-analysis showing 68% to 95% of participants completing all sessions in the 42 programs they examined [17]. Perhaps the requirement and expectation of 100% attendance rather than 80% attendance would have improved participation of the exercise sessions. It may also have helped to offer more available hours, such as in one past study that offered exercise classes five days each week [8]. Having greater access and flexibility to attend exercise classes may have also helped with reducing one of our findings of child's perceived exercise barriers (as reported by parents) of lack of time to exercise. In addition, because present results found that the more exercise sessions attended by the children, the greater their timed walking distance six months later, weight loss clinics should continue to recommend more exercise for children with obesity, even if best practices for exercise programs within a clinic setting have yet to be established. Along with an improvement of the behaviour-related outcome of timed walking, this randomized controlled clinical trial also showed significant improvement in the behaviour-related outcome of the child's perceived exercise barriers (as reported by parents) from pre-intervention to post-intervention, remaining steady through maintenance.

Similarly, the child's perceived exercise barriers did not differ between children in the control group who were given standard clinic care and children in the exercise group who were also participated in a clinic organized exercise program. With both control group and exercise group children showing significant reductions in their perceived exercise barriers (as reported by parents) across six months of clinic care, perhaps weight management clinics should routinely address the issue of how families might find ways to make regular exercise easier to accomplish by busy families. The top three perceived exercise barriers identified in the present study were time with technology, lack of time to exercise and the child's 'dislike of exercise.' Similarly, past research has found electronic media associated with child obesity and that children with obesity do not find exercise activities enjoyable [10, 11, 16-19]. Additional research is required to find specific strategies to target these perceived barriers within a weight loss clinic setting.

Study Strengths, Limitations and Directions for Future Research

One strength of the present pilot investigation of the effectiveness of a weight loss clinic's exercise program is that it adds to the limited literature that examines such clinic organized exercise programs, especially by including family participation. Also, the present study includes truly randomized groups (control, exercise) for comparison. An additional strength of the present study is its wide set of eight physiological and behaviour-related outcomes for the children (such as BMI%, blood lipids, glucose, blood pressure, timed walking distance). Finally, these outcomes include the rarely considered variable of the child's perceived exercise barriers (as reported by parents), which may influence family participation in exercise programs.

One limitation of the present study was its small sample size of 26 children from a pediatric weight loss clinic. Future research with larger samples would provide greater statistical power to detect changes in children's physiological and behaviour-related outcomes in response to exercise programs, as well as examination of demographic variables that may affect these outcomes (e.g., gender, age, ethnicity, income, and location). Another limitation was that our study only measured children's outcomes for relatively brief period of time, from pre-intervention to post-intervention two months later, to maintenance conditions four months after that. Although additional exercise classes would have been ideal, funding sources limited, which is a reality that most weight loss clinics encounter. However, future research should consider the benefits of family exercise programs across a longer time span, which may allow improvements in physiological outcomes to appear (such as BMI%, cholesterol, triglycerides, glucose, and blood pressure).

In addition, the present study lacked an untreated control group of children with obesity, so it remains possible that the significant improvements seen for behaviour-related outcomes (timed walking distance and child's perceived exercise barriers as reported by parents) were due to expectation effects by children and their families or to a general improvement in healthy habits. Future research should compare physiological and behaviour-related outcomes for children with obesity who are randomly assigned to four study groups: 1) an untreated 'wait list' group, 2) a group receiving standard clinic care, 3) a group receiving standard care plus home-based exercise and 4) a group receiving standard care plus school-based exercise. Such future study could provide pediatric weight loss clinics with evidence-based guidelines for their patients about benefits they can expect from exercise programs, and from where (home, school) they can most effectively get such exercise. Another limitation was that there was no objective method of reporting daily physical activity of the two groups of children. Therefore, there is no way of knowing the precise amount of physical activity and exercise the children showed across the six months of the present study. Future research should include the use of exercise-monitoring technology, such as accelerometers or fit bits, to measure more precisely daily activity and intensity of activity.

One alternative for pediatric weight loss clinics would be to refer children to community-based or school-based exercise programs. Although there is scant evidence in the literature on the impact of community-based and school-based exercise programs, there is some research to show that they can improve children's fitness, body composition, BMI z-score, and fasting glucose, often without singling out children with obesity [20-24]. Recent research has also demonstrated promising results for home-based exercise programs organized by pediatric weight loss clinics as well as use of smartphone technology to encourage exercise in adolescents [8, 26, 27]. Given the limited body of research on the collaboration of pediatric weight loss programs with community-based, school-based and home-based exercise programs,

future studies are required to determine the most successful approach to encourage exercise participation and improved physiological and behaviour-related outcomes for children with obesity who participate in a pediatric weight loss clinic.

Author Contributions

Marsha B. Novick participated in the study design, IRB submission, funding, analysis of data, critical review and drafting of all stages of the manuscript. Tomeka R. Greene and Elizabeth C. Hulstine participated in acquisition and organization of the data, Christopher T. Wilson participated in data collection/organization. Ronald J. Williams participated in the critical review and drafting of the final manuscript. Helen M. Hendy participated in the analysis of the data, critical review and drafting of all stages of the manuscript.

Conflicts of Interest

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