A 12-week Interdisciplinary Intervention Program for Children who are Obese

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ABSTRACT
Childhood obesity is a growing problem, for which multidisciplinary interventions are needed. **Purpose:** This interdisciplinary intervention program was designed to improve the health of children who were obese. **Methods:** Twenty-five children, mean age 8.1 (1.5) years; body mass index (BMI)> 98th percentile, and their parents completed the 12-week (3 days/wk) intervention consisting of aerobic and resistance exercise appropriate to age and developmental levels. Baseline and posttest measures of blood values, fitness, and cardiovascular risk factors were performed. Data were analyzed using paired t-tests with significance accepted at $P \leq .05$. **Results:** Significant differences between means (SD) for pre- and post-measurements were, respectively: BMI 30.31 (4.56), 27.80 (4.54), body-fat percent 43.7 (11.5), 40.7 (10.9), waist circumference 82.1 (7.1), 80.4(6.1) cm, calf circumference 34.2 (3.1), 35.2 (3.1) cm; step-test heart rate 137 (20), 126 (12) bpm, push-ups 1.0 (1.8), 5.6 (3.8), sit-ups 23.6 (12.7), 33.2 (13.8), sit-and-reach 35.1 (7.4), 41.2 (5.8) cm; systolic BP 102 (10), 108 (9) mmHg, glucose 4.9(0.3), 4.8 (0.4) mmol/L, total cholesterol 4.6 (1.0), 4.2 (0.8) mmol/L, ALT 41 (9), 35 (8) U/L, bilirubin 6.3 (2.4), 5.6 (2.1) µmol/L, and BUN 4.9 (1.1), 4.3 (0.9) mmol/L. **Conclusions:** This interdisciplinary intervention program positively affected the fitness and health status of children who were obese by involving the children and parents.

Key Words: childhood obesity, cardiovascular risk factors, health, fitness

INTRODUCTION AND PURPOSE

The increased prevalence of childhood obesity has been known for over 3 decades.[1] Despite this awareness, the obesity rate in children has increased 2- to 3-fold during this same time period.[2,3] The current child obesity rate in the United States appears to be leveling off but obesity prevalence still remains high and above national goals.[3,4] Based upon the National Health and Nutrition Examination Survey (NHANES) data, the current national prevalence of child obesity is estimated as follows: ages 2-5, 12.4%; ages 6-11, 17%; and ages 12-19, 17.6%.[2,3,5] The current national goal for the obesity rate in children is 5%.[6]

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Within certain demographic groups (ethnicity, culture, economic status, and educational level of parents), prevalence of child obesity may be greater than national averages.[7-9] More importantly, all children who are obese have an increased risk of cardiovascular disease when compared to their normal weight peers.[10-12]The number of cardiovascular risk factors increases as the level of obesity increases in children. Also, the risk of being obese as an adult is greater if a child's weight status tracks into adolescence. Because of the increased prevalence of cardiovascular disease risk factors observed both in children who are overweight and in children who are obese, there is a need for interventions that effectively reduce the degree of obesity and the prevalence of cardiovascular disease risk factors in children. Statewide policies geared toward decreasing childhood obesity may slow the rate of the rise of obesity in children but have not substantially decreased overall obesity.[13,14] There are many school-based and community-based interventions that have been reported. School-based programs may have positive benefits on activity levels, blood lipids, aerobic capacity, and television watching time, but they do not appear to have a positive influence on leisure time activity, blood pressure, heart rate, and body mass index (BMI)[15] unless specifically programmed for overweight or obese children.[16] Community-based programs may have a beneficial effect on the body weight status and physical fitness of children[17,18] if the environment and social networks are such that leisure time activity is facilitated.[17,19] In school-based and community-based interventions, improvements in specific groups of children may be masked by the overall response of the population.[15,17] Effective components of childhood obesity intervention programs include diet and nutrition education/activities, physical activity, reducing sedentary behavior, behavioral change methods, inclusion of the family, creating an environment for socially safe interaction, and ease of access and frequent use of a facility for physical activity.[12,20-23] Family-based clinical trials that have incorporated most of these components have consistently demonstrated an improvement in the weight status of children who were overweight or obese.[12,24-26] The purpose of this study was to translate these known effective components into common practice and measure the outcomes of an intervention designed to improve the physical fitness of children who were obese while reducing their weight status and health-related risk factors. The intervention was adapted to meet local needs and available resources.

METHODS

Subjects

Fifty-one children (15 male, 36 female), age 8.4 (1.7) years [mean (SD), age range 6 – 12 years] were admitted into the intervention program. Twenty-five children (5 male, 20 female) completed the intervention program and the pre- and postintervention measurements, except for 2 children (both female) who did not complete the postintervention blood draw. The children, through their parents, were referred to the program either by a physician or school nurse or by parental-self-referral subsequent to media advertising and public relations efforts. The children were included in the intervention program if they had a BMI that was in the obese category for their age and sex (see Anthropometric Measures section below).The age range chosen was based on previous work[27,28] and Arkansas child BMI data[14] that indicated an increase in childhood obesity generally occurred when children were in the third or fourth grade. Therefore, an elementary-school-aged population of children was targeted for this intervention program. The parent applied to the program for the child and then both the child and parent(s) were interviewed regarding their motivation and willingness to participate through the completion of the program. The overall intervention program and testing procedures were approved by the Northeast Arkansas (NEA) Clinic Foundation Board of Directors and the testing protocols and data collection were approved by the Arkansas State University Institutional Review Board to ensure that the rights of the subjects were protected. Informed consent was obtained from parents with assent from the children through willing participation.

Intervention Program

An interdisciplinary team with representatives from physical therapy, medicine, nutrition, exercise and fitness, and administration was established to discuss the initial design and development of this project. Multiple planning meetings occurred before the implementation of the intervention program for the first cohort of children and families. Most of the individuals involved in the planning meetings actively participated in the delivery and assessment of the intervention. This interdisciplinary team met during and after completion of the first pilot intervention and implemented modifications to the program based on intervention assessment and feedback from all involved. The same interaction and assessment processes were used during the second pilot intervention, which led to further program adaptations. Modifications to the program included overall duration (to coordinate with local school semesters and breaks), group scheduling (to determine the best time for parents to bring children), number of children in a cohort (to schedule appropriate staffing and available assistance for monitoring children), implementation of laboratory blood assessment for all participating children both pre- and postintervention, continued development of community activities and partnerships, and defining outcome measurements for the intervention program. The physical therapist on this team had a vital role in developing this program from design through implementation and follow-up. The PT in this project was responsible for the initial conceptualization and project design, seeking a funding source, developing collaborations with individuals from other disciplines, consulting on equipment purchases and exercise programming, training of staff for outcome measurements, analysis of the outcome data, and leading the writing of the final report. Because of the financial support and human resources available, the physical therapist assumed research outcomes director and project consulting roles for the current intervention. There was approximately one year between the initial meetings, the first two pilot interventions, and the beginning of the intervention program for the cohort of children represented in this report.

The intervention program was delivered at the Center for Healthy Children (CHC) that was housed within the NEA Clinic Wellness Center in Jonesboro, Arkansas. The CHC facility was remodeled to include an educational/meeting room, a child exercise room, a restroom/changing room, and a staff office. The CHC exercise room was equipped with child-sized pneumatic resistance machines, elliptical machines, game-bikes, and a climbing wall. The NEA Clinic Wellness Center is a full-service fitness center with an indoor walking track, pool, and traditional fitness facility exercise equipment for adults. The intervention program for the children and parents was 14 weeks long and coincided with the elementary school semesters in the local area. The first week of the program was dedicated to preintervention measurements, as well as program overviews and introductory sessions for both children and parents. Also within the first week, the parents were required to take their child to the family physician for a physical and blood panel, or the parents could use a physician from the NEA Clinic for free. During the next 12 weeks, the intervention program was delivered. The final week was dedicated to postintervention measurements and other program culmination activities. The intervention program consisted of two required exercise sessions per week and one fun activity session, usually on Fridays. The children were divided into two exercise groups that met on Monday and Wednesday or on Tuesday and Thursday. These groups were further divided according to parent preference into a group that met after school and a group that met after work. The intent was to keep group size to about 12 children for an approximate 12:2 ratio of children to staff for each group.

When each exercise group of children met, they participated in a one-hour session of exercise and activities that was led by a certified (American Council on Exercise) personal trainer, who also had a Master's degree in exercise science. Additional exercise monitors included university graduate students from the physical therapy and exercise science programs, who assisted the children and the personal trainer during exercise activities. Exercise sessions consisted of a brief callisthenic-type warm up, followed by resistance exercises using the pneumatic machines (PACE Fitness, Rancho Santa Margarita, CA) and floor exercises (push-ups, curl-ups, lunges).The exercise session continued with aerobic activity (jogging, brisk walking, jumping rope) and ended with stretching exercises. Children were encouraged to exercise at a level of at least 6-7 (out of 10, with 10 being their maximum effort) for both the resistance and aerobic portion of the exercise session. The children were also instructed to "slow-down" or "lighten the load" if their breathing became too rapid or the resistance felt too heavy. The certified trainer and exercise monitors assisted the children with proper form, adjusting resistance, and maintaining the pace with aerobic activities. The intent was to have the children performing moderate to vigorous activity for 60 minutes[22] with a balance between resistance and aerobic exercise. Fun activities, also an hour in duration, were planned for the end of each week (Fun Fridays) and included swimming, roller skating, hiking, karate, cycling, rock climbing, and active games (eg, Dance Dance Revolution™, PlayStation2™ game bikes). Two nutritional education activities were given to the children that required them to make a poster with healthy food choices and to sample a number of healthy food choices.

During the child exercise session, the parents were encouraged to exercise using the adult facilities and were offered free use of the walking track or a reduced-rate membership to the NEA Clinic Wellness Center for the duration of the program. Parents were also encouraged to participate in the fun activities when possible. Parents were required to attend nutrition education classes in the CHC facility. These classes were presented by a licensed dietician and included the following topics: basic nutrition overview, label reading, managing calories, understanding hunger, quick healthy meals, best choices for eating out, best choices for school lunch, review, and resources. The intervention program and visits to the NEA clinic physicians for the children were provided free of charge to the participating families.

Outcome Measures

Blood Pressure: Blood pressure was measured using aneroid sphygmomanometers with cuff sizes appropriate for each child's arm girth. All children sat quietly for at least 5 minutes before blood pressure readings were recorded by the investigators. The procedure used for measurement of blood pressure was that described by the American College of Sports Medicine (ACSM).[29] Systolic and diastolic blood pressure measurements were recorded and converted to age and height appropriate percentiles.[30-32] The age and height adjusted blood pressure percentile categories were then assigned numerical ranks as follows: 1, Normotensive - below the 90th percentile; 2, Prehypertension ≥ 90th and < 95th percentile; 3, Stage 1 hypertension - ≥95th to the 99th percentile + 5 mm Hg; or 4, Stage 2 hypertension > 99th percentile + 5 mm Hg.[30] The pre- and postintervention blood pressure category values were then analyzed using a Wilcoxon signed rank test.

Laboratory Blood Values: At the pre- and postintervention physician visit, blood was drawn for a panel of variables after an overnight fast. Samples were analyzed by a certified clinical laboratory. Variables reported in conventional units by the laboratory were converted to SI units as reported in the results section below. The variables analyzed by the laboratory were: serum glucose, creatinine, total protein, albumin, blood urea nitrogen (BUN), sodium, potassium, chloride, carbon dioxide, calcium, alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase, total bilirubin, cholesterol, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL), and very low-density lipoprotein (VLDL). Parents were strongly encouraged to have their children participate in this part of the health screening but it was not required for participation in the intervention program.

Anthropometric Body Measures: Height was measured to the nearest one-half inch with a tape measure affixed to a wall. Children stood erect, stocking footed, in front of the tape and height was determined using a carpenter's square from the wall to the top of the head. Weight was measured to the nearest one-half pound using a Detecto Eye-Level Physicians Scale (Cardinal/Detecto, Webb City, MO). Height was converted to meters and weight was converted to kilograms. Body mass index (kg/m^2) was calculated from these measurements and each child's BMI was also converted to the appropriate age- and sex-related percentile rank (BMI-P) and the appropriate age- and sex-related Z-score (BMI-Z). The recommended terms and definitions related to childhood obesity have been recently modified[7] but the use of older terminology[33] still exists in recent articles. New recommendations are as follows: overweight should be defined as a child's age- and sex-specific BMI that is equal to or greater than the 85th percentile and below the 95th percentile; obesity should be defined as a child's age- and sex-specific BMI that is equal to or greater than the 95thpercentile.[7] The most recent recommended terms and definitions were used for this study. Circumferential measurements of the arm, chest, waist, hip, thigh, and calf were performed according to the procedures described by the ACSM.[29] Skin-fold measurements from the triceps and medial calf were used to estimate body percent fat according Slaughter et al.[34] These sites were chosen because they were easily accessible and minimally invasive for the children. The same investigator performed the pre- and postmeasurements on the children using a Baseline skinfold caliper Model 12-1110 (Fabrication Enterprise, Inc., White Plains, NY).

Physical Performance: The sit-and-reach test was used to assess flexibility, push-ups and curl-ups were used to assess muscular function, and a modified step test was used to assess cardiopulmonary function. The sit-and-reach test was performed using a commercially available metal sit-and-reach box. The children sat on the floor in the long-sitting position with knees straight and with the soles of their feet (socks on) against the box and performed the test according to ACSM guidelines.[29] Push-ups and curl-ups were performed according to the procedures outlined in the Fitnessgram Reference Guide.[35] The step test used was a modified 3-minute YMCA step test using a commercially available aerobic exercise step that was adjusted to a height of 8 inches.[36] The step cadence was 24 steps per minute and was obtained by using a metronome set to 96 beats per minute (bpm) with the children stepping in time with the metronome and using an up-up-down-down stepping pattern alternating legs. Immediately after the 3 minutes of stepping, the children sat down on the step and heart rate (bpm) was taken within 20 seconds using a BCI Digit 3420 Finger Pulse Oximeter (Smiths Medical, Dublin, OH).

Data Analysis

All data are reported as group mean ± (SD) and analyzed using SPSS 19 (IBM, Armonk, NY). Preintervention data for the subjects who did not complete the intervention program or did not participate in the postintervention tests and measurements (DNF group) were compared to the preintervention data for the group who completed the intervention program (INT group) using independent t tests and 1-way ANOVA. Forty-one of the 51 original children participated in the initial blood draw. Twenty-three of the final 25 children completing the program participated in the final blood draw. Pre- and postintervention data for the INT group were analyzed using dependent t tests and 1-way ANOVA, unless noted otherwise.

RESULTS

Subjects

The characteristics of the children in the DNF group are as follows: n = 26; age, 8.7 (1.9) years; height, 1.372 (.114) m; weight, 58.51 (18.82) kg; and BMI, 31.1 (6.7) kg/m^2. Only 21 subjects were used in the anthropometric and physical performance analysis of the DNF group because 5 subjects from this group did not participate in the pretest measurements and did not complete the intervention program. There was no significant difference between the preintervention anthropometric or physical performance data of the DNF group and the INT group. There were significant differences between the DNF group and the INT group for serum glucose (P = .004) and triglycerides (P = .050), with a nonsignificant trend for VLDL (P=.052). The DNF group had higher values for these three variables and the means for these variables were as follows: serum glucose, 5.28 (0.25) mmol/L; triglycerides, 1.62 (0.62) mmol/L; and VLDL, 0.74 (0.29) mmol/L.

The characteristics of the children in the INT group are as follows: n = 25; age, 8.2 (1.5) years; height, 1.328 (.081) m; weight, 53.80 (10.70) kg; and BMI, 30.31 (4.56) kg/m^2. Twenty-five completed the pre- and postintervention anthropometric and physical performance tests and measurements. Only 23 completed the pre- and postmeasurements for the blood related variables. The pre- and postintervention data for the INT group is presented below.

Blood Pressure

Before the intervention program, systolic blood pressure (SBP) was 103 (11) mmHg and diastolic blood pressure (DBP) was 65 (11) mmHg for the INT group. After the intervention program, mean SBP was 108 (9) mmHg and DBP was 69 (9) mmHg (Table 1). There was a significant difference between pre- and postmeasurements for SBP (P = .003) but not for DBP (P = .165). When blood pressure measurements were converted to age and height appropriate percentiles, there was no significant difference between the pre- and postintervention measurements.

Laboratory Blood Values

Pre- and postintervention data for the panel of laboratory blood values are presented in Table 1 for the INT group. Significant (P < .05) changes in pre- vs. postintervention values are as follows: BUN, chloride, carbon dioxide, calcium, ALT, bilirubin, and cholesterol. There was a nonsignificant trend (P = .057) for a change in pre- vs. postintervention values for serum glucose.

Anthropometric Body Measures

Pre- and postintervention measurements for the anthropometric data for the INT group are presented in Table 2. Significant (P < .05) changes in pre- vs. postintervention values are as follows: height, BMI, BMI-Z, waist circumference, thigh circumference, calf skin-fold, and percent fat. There was a nonsignificant trend (P = .073) for a decrease in BMI-P.

Physical Performance

Pre- and postintervention physical performance data for the INT group are presented in Table 3. Significant (P ≤ .05) changes in pre- vs. postintervention values are as follows: sit-and-reach, push-ups, curl-ups, and step-test heart rate.

DISCUSSION

Overall, this intervention program was successful at increasing physical fitness, improving anthropometric measurements related to body composition, and improving certain biological markers related to cardiovascular disease in children. For 12 weeks, the intervention program involved children who were obese and their parents in exercise and structured activity for two days per week, an alternative fun activity one day per week, and nutritional education.

Subject Retention

Even with an apparent desire to participate and an interview process believed by the investigators to identify those families with the motivation to complete the program, there was nearly a 51% drop-out rate over the course of the intervention program. Telephone follow-ups with parents of children who did not finish the program revealed that dropping out was related to the parents' ability to bring the children to the clinic (time, convenience, distance, cost of travel). Anecdotally, families living more than 15 miles from the CHC experienced a near 100% drop-out rate. Another reason that was noted was that some children began playing organized sports and chose to no longer attend the program. Some parents credited the program for helping their children to participate in organized sports. Despite dropping out of the program, beginning to participate in organized sports was considered a positive benefit for those children. Others have looked at drop-out rates in studies involving children. Robertson et al[26] noted an overall 33%

Table 1. Blood Pressure and Laboratory Blood Values

Variables	Preintervention		Postintervention		P
	Mean	SD	Mean	SD	(2-tailed)
Systolic Blood Pressure (mm Hg)	103	11	108	9	0.003*
Diastolic Blood Pressure (mm Hg)	65	11	68	9	0.165
Glucose mmol/L (mg/dL)	4.9 (89.8)	0.3 (5.4)	4.8 (86.8)	0.4 (6.6)	0.057
BUN mmol/L (mg/dL)	4.9 (13.7)	1.1 (3.1)	4.3 (12)	0.9 (2.6)	0.017*
Creatinine µmol/L (mg/dL)	50.7 (0.574)	8.8 (0.1)	50.3 (0.569)	8.0 (0.09)	0.77
Sodium (mmol/L)	141.0	1.5	140.7	1.7	0.35
Potassium (mmol/L)	4.57	0.26	4.47	0.2	0.135
Chloride (mmol/L)	103.6	1.8	104.9	1.8	0.007*
Carbon Dioxide (mmol/L)	23.6	1.0	25.6	1.5	<0.001*
Calcium mmol/L (mg/dL)	2.6 (10.3)	.05 (0.2)	2.5 (10.0)	.05 (0.2)	0.001*
Total Protein g/L (g/dL)	73 (7.3)	4 (0.4)	72 (7.2)	4 (0.4)	0.187
Albumin g/L (g/dL)	47 (4.7)	2 (0.2)	46 (4.6)	2 (0.2)	0.553
ALT (U/L)	41.7	9.8	35.0	8.5	0.001*
AST (U/L)	30.6	8.2	28.4	7.3	0.165
Alkaline Phosphatase (U/L)	283.5	76.6	287.8	69.1	0.679
Bilirubin µmol/L (mg/dL)	6.3 (0.37)	2.4 (0.14)	5.6 (0.33)	2.1 (0.12)	0.047*
Cholesterol mmol/L (mg/dL)	4.6 (176.8)	1.0 (37.9)	4.2 (162.5)	0.8 (30.0)	0.033*
Triglyceride mmol/L (mg/dL)	1.2 (107.3)	0.7 (66.1)	1.1 (97.4)	0.7 (59.6)	0.213
HDL mmol/L (mg/dL)	1.2 (47.8)	0.4 (17.3)	1.2 (47.1)	0.4 (17)	0.669
LDL mmol/L (mg/dL)	2.7 (104.3)	0.7 (25.5)	2.5 (95.8)	0.7 (27.1)	0.160
VLDL mmol/L (mg/dL)	0.6 (21.5)	0.3 (13.3)	0.5 (19.5)	0.3 (11.9)	0.209
Chol:HDL	4.1	1.6	3.8	1.4	0.134
Legend: * = (p ≤ 0.05)					

Table 2. Anthropometric and Body Status Measurements

Variables	Preintervention		Postintervention		p-value
	Mean	Std. Deviation	Mean	Std. Deviation	(2-tailed)
Height (meter)	1.328	0.081	1.394	0.081	<0.001*
Weight (kg)	53.80	10.70	54.07	9.89	0.494
BMI (kg/m^2)	30.31	4.56	27.80	4.54	<0.001*
BMI-P (%ile)	99.51	0.41	98.54	2.81	0.112
BMI-Z	2.65	0.27	2.39	0.39	0.026*
Arm-Circum (cm)	29.2	3.1	29.1	2.8	0.564
Chest-Circum (cm)	87.5	8.1	86.8	7.6	0.297
Waist-Circum (cm)	82.1	7.1	80.4	6.1	0.040*
Hip-Circum (cm)	92.7	7.9	92.5	7.1	0.769
Thigh-Circum (cm)	51.3	5.3	52.5	4.3	0.054
Calf-Circum (cm)	34.2	3.1	35.2	3.1	0.002*
Total-Circum (cm)	377.1	30.5	376.5	28.2	0.772
Triceps – SF (mm)	29.6	5.4	28.4	5.4	0.120
Calf – SF (mm)	32.1	6.3	29.9	5.3	0.007*
Body Fat (%)	43.6	7.7	41.5	7.1	0.012*
Legend: * = (P ≤ .05).Circum = circumference, SF = skinfold					

Table 3. Pre- and Postintervention Physical Performance Measurements

Variables	Preintervention		Postintervention		p-value
	Mean	Std. Dev	Mean	Std. Dev	(2-tailed)
Step Test HR (bpm)	137	20	127	12	0.047*
Push ups (n)	1.0	1.8	5.4	3.9	<0.001*
Sit ups (n)	22.3	13.3	33.1	13.6	0.002*
Sit-and-Reach (cm)	35.1	7.4	41.2	5.8	<0.001*
Legend: * = (p ≤ 0.05)					

drop-out rate, but families who self-referred after publicity in the local media had only a 15% drop-out rate whereas families referred by health professionals or who enrolled upon recommendations of friends/family had drop-out rates of 60% and 100%, respectively. In another study, Gutin et al[37] used a bus to transport children to their facility afterschool and offered a $100 incentive to the children for finishing all of the study requirements; they had a 7% drop-out rate over a 10-week period but did not mention family involvement. Additional methods, beyond those used in this study, to increase retention of participants and their parents will need to be investigated and implemented in future intervention programs.

Blood Pressure

When the SBP and DBP values were categorized according to each child's age- and height-appropriate percentile, there were no significant differences in pre- and postintervention blood pressure measurements. Similar findings have been reported after interventions of longer duration.[25] Suggestions for interventions to lower blood pressure in children who are overweight or obese could include increasing the weekly frequency of supervised exercise sessions, increasing the overall duration of the intervention, and working toward a greater amount of weight loss in the participants.[38,39]

The blood pressure responses of the INT group were quite variable. Twelve children had no change in their SBP or DBP category during the study. Of the remaining children, there was a fairly even split between those who had a decrease (toward normal) and those who had an increase (toward hypertension) in the SBP or DBP categories. Eleven children remained in the normotensive category throughout the study. The rest of the children were classified as being Stage 1 hypertensive at some point during the investigation. There is no apparent explanation for the blood pressure response observed during this study. The variable responses and the individual changes observed underscore the importance of regular blood pressure monitoring in overweight and obese children regardless of their initial blood pressure status. Also, health care professionals should be aware of the age appropriate percentiles for blood pressure in children, be able to discuss the percentiles in relationship to the categories for hypertension in children, and refer the children for medical care when appropriate.[30,40]

Laboratory Blood Values

The higher values for serum glucose and triglycerides and the trend toward higher values of VLDLs for the DNF group compared to the INT group are important to note for two reasons. First, these were the only differences found between the two groups and do not appear to have any effect on whether the children remained in the intervention program. Secondly, because of the increased glucose and triglyceride values, it is possible that the DNF group children had increased physiological risk factors compared to the INT group and could benefit by completing this type of intervention programming.

For the serum glucose values, none of the children had elevated fasting levels indicative of abnormal glucose control. There was a nonsignificant trend for fasting glucose levels to be decreased after the intervention. Others have found that fasting glucose levels exhibit little or no change after exercise interventions in children[25] or adolescents,[16,18,38,41] but in these same populations insulin resistance or insulin homeostasis is significantly improved.[16,18,25,38,41] Shaibi et al[42] contend that improved insulin sensitivity can occur when fasting measurements of blood glucose and insulin are not significantly improved. The reductions in BUN, ALT, total bilirubin, and total cholesterol in this study present a picture of possible improved liver and kidney function and decreased risks related to non-alcoholic fatty liver disease and metabolic syndrome.[43,44] In adolescents who are obese, van der Heijden et al[41] reported that decreases in hepatic fat content were directly related to decreases in ALT levels in those who participated in a 12-week exercise training intervention. Therefore, it is possible that the children in this study improved their health status by decreasing certain health-related risk factors.

Anthropometric Body Measures

Overall, there were a number of variables that were indicative of positive changes in body composition at the completion of the intervention. Weight was maintained while height increased that resulted in decreases in BMI and BMI-Z. This result is important because the tracking of obesity into adolescence is related to an increased risk of obesity and cardiovascular disease risk factors in adulthood.[11,45] As in the current study, Robertson et al[26] reported similar BMI changes in children (7-13 years of age) who were obese and participated in a 12-week intervention involving only one 2.5 hour exercise session each week. Savoye et al[25] looked at the anthropometric changes of children (8-16 years of age) who were obese and participated in a 6-month program with two weekly exercise sessions. The authors noted that weight remained constant but BMI was reduced. Although indirect measurements were used in the current study to assess body composition, the overall anthropometric changes as evidenced by the decreased waist circumference, the trend for an increase in thigh circumference, the increased circumference and decreased skin fold thickness of the calf, and the decrease in the estimation of body fat percent points to reductions of abdominal fat and increases in lean mass of the legs. Others have reported decreased waist circumferences in children and adolescents who are obese after 12- and 10-week intervention programs[16,26] and decreased subcutaneous abdominal adipose tissue in children after 4 months of exercise intervention.[46] Reductions in visceral fat and increases in lean body mass are associated with decreased hepatic fat and improved insulin sensitivity.[18,41,47] The positive changes in body status measurements for the INT group in this study suggests that if these children and their families continue the effort they put forth during this intervention that their future cardiovascular disease risks and other health-related risk factors would be reduced.

Physical Performance

The physical performance of these children also improved during this intervention program. General flexibility was also improved as measured by the sit-and-reach test. Muscular strength and muscular endurance was improved as noted by the significant increases in both the push-up and the curl-up performances of the children at the postintervention measurements. In adolescents who are obese, increases in muscular fitness have been related to improved insulin regulation.[18,47] Cardiovascular improvement was noted by the decrease in the heart rate response to the step-test in the postintervention measurements. Similar cardiovascular improvements have been observed in other intervention studies involving children who are obese. In adolescents who are obese, improvements in aerobic capacity occurred for those in a 12-week program compared to normal weight controls[41] and for those in a 10-week randomized controlled trial afterschool program.[16] The question of how much exercise or activity is enough for health-related improvement in children who are obese can be somewhat addressed by the findings of this study. Keeping in mind that the children who participated in this study were involved with two one-hour sessions of guided exercise per week with the addition of one fun alternative activity day for 12 weeks, it would seem that this amount of activity elicits measurable and significant gains in cardiovascular and muscular fitness--both of which were related to significant improvements in anthropometric and biological health-related measures.

Limitations

Because this intervention program was designed to be a real-world intervention, there are a few limitations that should be considered before generalizing these results. A control group was not used for this intervention so the effect of maturation cannot be addressed. Physical activity levels prior to the intervention or in addition to the intervention were not determined so the influence of the children's activity levels outside of the intervention is unknown. Although established methods and protocols for the collection of anthropometric and physical data were used and all investigators were well trained and experienced with the methods, intrarater reliability was not established for these investigators with this population of subjects. All children who completed the pre- and postintervention measurements were included in the analyses but precise adherence records were not kept. Observationally, nearly all of the children attended at least 2 exercise sessions per week and most attended 3 sessions per week; therefore, the results reflect the effects of the intervention on the children regardless of compliance with the exercise sessions.

CONCLUSION

This report is presented as evidence that a 12-week childhood obesity intervention program based in a community fitness center and designed for the participation of children who are obese and their parents, along with interdisciplinary collaboration and community partners, can be effective at improving the overall health-related status of these children. The results of this study are encouraging and suggest that successful methods from studies using control group comparisons and randomized controlled trials to reduce obesity in children can be translated to a practical setting. Although not directly measured, the parental involvement and the inclusion of only children who were similar in body and physical characteristics very likely lead to a healthier environment for these children.[12,21] Because of the positive changes observed in the children who participated in this intervention, programs that include a combination of structured exercise in a welcoming environment, alternative fun activities, and parent/family involvement can effectively address the issues related to the increasing rate of childhood obesity and the associated cardiovascular risk factors.

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