

Research Article

School Based Physical Activity Intervention to Reduce Obesity and Increase Physical Fitness in Obese Elementary Children

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Citation: Kelly LA, et al. School Based Physical Activity Intervention to Reduce Obesity and Increase Physical Fitness in Obese Elementary Children. J Pediatric Adv Res. 2024;3(1):1-8.

<http://dx.doi.org/10.46889/JPAR.2024.3104>

Received Date: 29-02-2024

Accepted Date: 14-03-2024

Published Date: 22-03-2024



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Abstract

Background: The prevalence of obesity is extremely high and increasing in elementary school children in the US, but recent systematic reviews have concluded that there are no simple, generalizable and successful obesity prevention strategies available.

Objective: To assess whether an 8-week-school-based physical activity intervention would reduce BMI percentiles and improve physical fitness in both normal weight and obese children.

Material and Methods: One hundred and one children were consented to the study (mean age 8.12 ± 0.10 years). BMI and BMI percentiles for age and gender were determined using EpiInfo. Participants were classified as Obese (OB) (n=48) if they had a BMI percentile of $\geq 95\%$ for their age and gender. Normal weight (NW) was (n=53) classified as having a BMI percentile lower than 75% for age and gender. Intervention consisted of an 8-week enhanced physical activity program in school (100 minutes/week). Physical fitness was assessed using the FITNESSGRAM test battery. Repeated measures GLM was used to assess within and between subjects' effects from pre- to post-testing.

Results: GLM showed significant results within subject and between subject for BMI percentile, trunk lifts, push-ups, sit ups, sit and reach and the 1-mile run (p's < 0.01). However, our results also showed that there was a significant reduction in BMI percentile (0.001), weight (p=0.05) and waist/hip ratio (p=0.01) for the obese group.

Conclusion: Our study demonstrated that an 8-week physical activity intervention was successful in improving physical fitness in NW and OB children. The 8-week program also was successful in reducing BMI percentile in the OB group. Future studies should consider increasing both the duration of the program and the sample size.

Keywords: FITNESSGRAM®; BMI Percentiles; Pediatrics; Obesity; Physical Activity

Introduction

Pediatric obesity endures as a significant public health burden, given its increasing prevalence and destructive health consequences [1]. Modern children have a higher Body Mass Index (BMI) than the previous generation [2]. This is of deep concern particularly as overweight status has been shown to track from childhood to adulthood. In the United States, the prevalence of obesity in the pediatric population is defined as having a BMI percentile relative to age and gender of $\geq 95^{\text{th}}$. Unfortunately, since the 1970's the BMI percentile of children in the United States has risen at an alarming rate. From 1971-1974 only 4% of children aged 6-11 years were classified as having a BMI percentile $\geq 95^{\text{th}}$. However, in 2003-2004 this prevalence had risen to 18% [3,4]. According to Hales, et al., obesity rates have been rising steadily from 1999-2016 [5]. The latest data from the National Health and Nutrition Examination Survey (NHANES) has stated that from 2015-2016 the percentage of children in the United States who were defined as obese was a staggering 18.2% [5].

Obesity is characterized by the excessive accumulation of adipose tissue and is considered a multifactorial disease. Disease ordinarily seen in obese adults is now common in obese pediatric patients [6,7]. Studies consistently show associations between obesity psychological and physical health. Subsequently, comorbidities such as obesity-related cancers, cardiovascular disease hypertension, diabetes, metabolic syndrome, sleep apnea, poor body image, poor self-esteem, anxiety and clinical depression are normally associated with obese adults are common in our obese pediatric population [6,7]. Consequently, this results in a lower life expectancy in the developed world [6-10].

Treatment of pediatric obesity is imperative given the short and long-term consequences. The treatment is analogous to that of adults, reduce calorie intake and increasing energy expenditure (i.e., resting metabolic rate, Physical Activity (PA) and thermogenesis [11]. As PA accounts for 25% of energy expenditure interventions to reduce obesity in the pediatric population studies should target the PA component of energy expenditure. Children spend a significant amount of time at home and at school. However, the home setting may not be conducive to increasing PA in children [12,13]. It has been suggested that the home setting is not an ideal place to focus PA interventions [12,13]. Research suggests the home setting is a place where a significant amount of sedentary behavior occurs, such as watching television and playing computer games [12,13].

Alternative to the home, schools potentially serve as effective settings for public health initiatives, as they have access to large populations of children from diverse ethnic and socio-economic backgrounds. School settings as appealing as adherence can be improved. The World Health Organization (WHO) specifically identified school settings as an ideal location for increasing PA in children [14,15]. The evidence also suggests that children exposed to school-based physical activity interventions are approximately three times more likely to engage in moderate to vigorous physical activity during the school day than those not exposed.

Despite the low number of schools offering physical education several school-based studies continue to affirm improvements in physical fitness and reductions in obesity [17]. Eather, et al., saw improvements health related components such as physical activity and BMI after conducting a 6-month elementary school-based intervention aimed at improving [16]. Carlson et al. saw significant improvements in physical activity levels of elementary school children after they conducted a year long. This study was interesting as the study design of the intervention was 10-minute blocks of teacher led structured physical activity [17]. Upon completion of a twenty-month cluster designed randomized controlled school-based study aimed at reducing BMI, Gryeland, et al., found significant reductions in the BMI and BMI Z scores of girls but not boys [18]. In a relatively large study, yearlong study, significant improvements were seen in physical activity and fitness. The study also resulted in significant decreases in BMI and BMI Z scores [19]. It is recommended that children should engage in 60 minutes of physical activity at a moderate intensity most days of the week. Sadly, most children get little to no regular physical activity either at home or in school [20]. In the state of California, it is mandated that elementary school children must engage in 100 minutes of physical activity per week. Regrettably, current research suggests that only 3.8 percent of elementary schools provide daily physical education [21]. Therefore, our study aimed to assess whether an 8-week-school-based physical activity intervention would reduce BMI percentiles and improve physical fitness in normal weight and obese children.

Material and Methods

Study Design

Participant characteristics, along with a description of the intervention and the general procedures used in this study have been previously reported [22]. However, findings from this study regarding the effects of an 8-week fitness intervention on the reduction of BMI and the increase in physical fitness have not been pushed. Participants were recruited from local elementary schools. These schools were chosen as they not meet the California State recommendation of 100 minutes per week of physical activity. Children's ages range from 5-11 years and were from grades kindergarten, 2nd and 5th. Participants were consented to the study if they met the following study criteria, from the relevant grades, not participating in organized sport outside of school, not diagnosed any syndrome or disease that would influence physical activity or body composition that would prohibit them from participating in the physical activity intervention, not taking any medication that would affect weight status, for obese participants have a body mass index greater than the 95th percentile for our normal weight participants have a BMI percentile of lower than the 75th. Normal weight participants did not receive the intervention and as such acted as our control group. The design of the study is presented in Fig. 1.

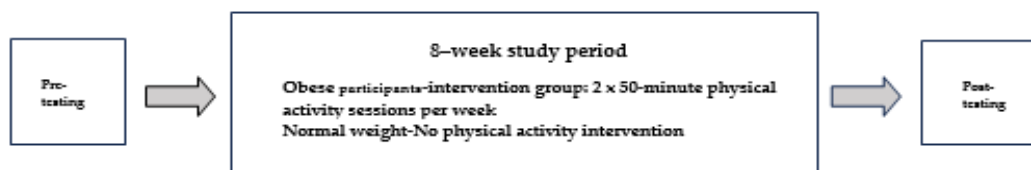


Figure 1: Study design.

Participants

The study included 101, children age range 5-11 year-old children. The study included thirty-three females and twenty male Normal Weight (NW) and obese twenty-seven girls and twenty-one male participants. Based on their BMI percentile fifty-three participants were defined as normal weight, eight children were 5 years, seven were 6 years, ten were 7 years, nine were 8 years, nine were 9 years, ten were 10 years and 0 were 11 years. Forty-eight children were characterized as obese (OB), seven children were 5 years, seven were 6 years, eight were 7 years, ten were 8 years, seven were 9 years, nine were 10 years and 0 were 11 years. All children completed the weight status measurements and physical fitness tests before and after the intervention. None of the children participated in Physical Education class as their schools did not have a program. Parental written informed consent was obtained from all parents and children's assent was obtained before testing. This study was approved by the institutional Review Board and was conducted in accordance with the guidelines in the Helsinki Declaration.

Anthropometric Measurements

Using a beam medical scale and wall-mounted stadiometer (SECA Hamburg, Germany), we measured weight and height to the nearest 0.1 kg and 0.1 cm, respectively. Our primary outcome measure was Body mass index (BMI), expressed as BMI percentiles for age and gender were determined using EpiInfo Version 7.2 (CDC, Atlanta, GA). Anthropometric tape measures were used to measure waist and hip circumferences (to the nearest 0.5 cm). All anthropometric data were collected according to the Canadian Standardized Test of Fitness (CSTF) Operations Manual. (Ottawa: Government of Canada, Fitness and Amateur Sport, 1986) [23]. All measurements of weight status were assessed by the same trained observer who was blinded to the group allocation. Participants were classified as Obese (OB) if they had a BMI percentile of $\geq 95\%$ for age and gender. Normal Weight (NW) was classified as having a BMI percentile lower than 95% for age and gender.

Assessment of Physical Fitness

The FITNESSGRAM® program was used to measure cardiorespiratory fitness and muscular strength. FITNESSGRAM® is an assessment and promotion tool developed by the Cooper Institute. It has been the recommended assessment tool and promotion tool for the Society of Health and Physical Educators (SHAPE) and the required assessment for the state of California and many other states and districts. FITNESSGRAM® has gained widespread support and adoption, largely due to its sound scientific basis [24,25]. The participants were asked to perform various fitness tests, including pushing themselves up 90 degrees, curling up for abdominal strength, sitting and reaching for flexibility and running a mile for cardiovascular fitness assessment.

Post Testing Procedures

At the conclusion of the 8-week intervention period, participants completed all testing identical to those conducted during the baseline visit.

Intervention - Obese Children (OB)

The OB children received 2 x 50-minute sessions per week from the Gameday program with a rotating plan of 8 activities designed to increase, physical fitness, concepts of fitness and improve motor skills such as kicking, dribbling with feet, dribbling with hands, jumping, landing and running. The intervention was delivered over an 8-week period. The PE teachers from school delivered intervention. Prior to baseline testing PE teachers received 3 full days of training from the Gameday company (Simi Valley, California, USA [26].

Control-Normal Weight Children (NW)

The NW children acted as our control group. The NW group did not receive PE classes or the intervention between pre- and post-data collection. The rationale for including the NW participants as controls in this study is to assess "background changes" due to growth and/or other natural factors.

Statistical Analysis

All data were checked for normality prior to statistical analysis using descriptive statistics, histograms with normal distribution curves and employing Anderson-Darling (AD) normality tests. To identify a possible randomization imbalance, across-group comparisons of baseline characteristics were conducted using ANOVA. Wilcoxon signed rank-tests were used to test for significance differences between pre- and post-test data. A repeated measure GLM was used to compare the magnitude of change among outcome measures between the OB and the NW groups across time. This was an intent-to-treat analysis. Power calculation estimated that a mean difference in Body Mass Index percentiles of around 3 units between the Obese and Normal Weight would be detectable with 67% power at a significance 0.05 among a sample size of 50 children per group. All analyses were conducted using SPSS version 29 for Mac (SPSS, Inc, Chicago, IL) with α set at 0.05.

Results

Anthropometrics of Participants Characteristics

Participant characteristics are presented in Table 1. The mean age of the participants was 8.12 ± 0.10 years.

Primary Outcome-Weight Status

At baseline, the BMI percentile for the NW group was $63.46 \pm 29.29\%$ group and for the OB group percentile was $98.42 \pm 1.44\%$. At follow-up, there were significant increases in weight ($p=0.01$), waist ($p<0.01$) and waist/hip ratio ($p=0.03$) in the NW group. Whereas in the OB group, there were significant decreases in weight ($p=0.05$), BMI percentile ($p=0.001$) and waist/hip ratios. Characteristics for weight status between groups are shown in Table 1. There were significant within-subject differences in BMI throughout the 8-week intervention. There were also significant between subject differences in BMI percentile ($p = <0.01$).

Physical Fitness

Fitness characteristics are shown in Table 2. Wilcoxon Signed Rank test showed from baseline to follow-up, the only component of fitness that was significantly improved, in the NW group was sit-ups ($p=0.04$). The NW group improved their time in the mile run but this was not significant ($p=0.33$). In the OB group pull-ups, push-ups and sit-ups improved but not significantly. In the OB group Wilcoxon Signed Rank test showed a reduction in the sit and reach and the mile run time, but these were not significant ($p=0.40$; 0.88 respectively). There was a significant decrease in the number of trunks lifts the OB group could perform ($p = 0.01$). Results from the General Linear Model (GLM) showed nonsignificant within-subject improvements in the trunk lift and sit-ups throughout the 8-week intervention ($p = 0.939$; $p=0.245$ respectively). However, there were significant within-participants differences for both trunk lifts and sit-ups ($p = <0.001$; <0.001 ; respectively). For trunk lifts the NW group outperformed the OB group, whereas, for sit-ups, the OB did more. There was a trend in between-subject differences in pull-ups ($p = 0.084$), with the NW group performing more pull-ups than the OB group. We found significant within-participants differences for push-ups ($p < 0.001$) and significant between subject differences for push-ups ($p < 0.001$), again the NW group performed more push-ups than the OB group. For sit and reach, there were significant within-subject improvements for the OB group ($p = 0.01$) and significant between-subject differences were also observed ($p < 0.001$). Finally, for the 1-mile run there were significant improvements for the NW group ($p=0.029$), with significant between-subject differences ($p = <0.01$), with the NW group running the mile faster than the OB group.

Outcomes	Normal Weight (NW) (N = 53)			Obese (OB) (N= 48)		
	Baseline	Follow-up	p-value	Baseline	Follow-up	p-value
Age (years)	8.00 ± 2.11	8.28 ± 2.17		8.18 ± 2.09	8.32 ± 2.09	
Height (m)	1.31 ± 0.14	1.32 ± 0.23	0.21	1.28 ± 0.28	1.36 ± 0.16	0.38
Weight (kg)	31.91 ± 11.84	35.52 ± 12.18	0.01*	47.62 ± 21.14	37.49 ± 13.39	0.05*
BMI Percentile (%) [#]	63.46 ± 29.29	65.11 ± 29.07	0.31	98.42 ± 1.44	76.80 ± 32.68	0.001*
Waist circumference (cm)	59.62 ± 9.63	63.68 ± 10.68	$<0.001^*$	71.88 ± 18.17	67.42 ± 12.04	0.15
Hip Circumferences (cm)	70.61 ± 9.91	73.52 ± 9.66	0.17	79.03 ± 18.98	78.12 ± 11.49	0.72
Waist/Hip Ratio	0.84 ± 0.06	0.86 ± 0.06	0.03*	0.91 ± 0.08	0.86 ± 0.05	0.01*
Data are mean (SD) unless otherwise stated. P-values represent, * indicates a significance difference, #indicates intervention groups are significantly different from one another ($p < 0.05$).						

Table 1: Anthropometric characteristics for evaluable participants by weight status (n=101).

Outcomes	Normal Weight (NW) (N = 53)			Obese (OB) (N= 48)		
	Baseline	Follow-up	<i>p</i> -value	Baseline	Follow-up	<i>p</i> -value
Trunk [#]	32.26 ± 7.15	27.63 ± 10.32	0.60	31.04 ± 7.15	20.52 ± 10.56	0.01*
Pull-up	1.65 ± 4.03	1.74 ± 2.44	0.34	0.41 ± 0.89	0.85 ± 1.85	0.44
Push-up [#]	14.71 ± 9.43	14.36 ± 12.60	0.73	7.52 ± 6.05	7.65 ± 7.14	0.41
Sit-up [#]	14.36 ± 13.97	19.02 ± 20.85	0.04*	11.68 ± 18.74	14.88 ± 18.30	0.40
Sit and Reach [#]	22.65 ± 7.58	22.28 ± 6.40	0.62	29.86 ± 10.28	26.31 ± 6.54	0.19
1 Mile Run (minutes) [#]	6.2 2 ± 3.57	7.62 ± 5.05	0.33	7.86 ± 4.88	7.61 ± 4.18	0.88
Data are mean (SD) unless otherwise stated. P values represent, * indicates a significance difference, #indicates intervention groups are significantly different from one another (p < 0.05).						

Table 2: Fitness outcomes for evaluable participants by weight status (n=101).

Discussion

Interventions to change lifestyle habits through a change in the school environment are found to be more successful when compared with changing the individual or the families. Schools serve as effective settings for public health initiatives, as they have access to large populations of ethnically diverse children from a varied socio-economic background. It has also been noted that schools provide opportunities for children and teens to engage in regular physical activity. Policies that make physical activity in schools compulsory contribute significantly to the increased health of youth. It is recommended that children should engage in 60 minutes of physical activity at a moderate intensity most days of the week. Alas, most children get little to no regular physical activity at home or in school. Regrettably, the children in our study did not have any physical education classes at their schools. The study aimed to examine whether an 8-week-school-based physical activity intervention would reduce BMI percentiles and improve physical fitness in normal weight and obese children.

Overall, our findings showed improved physical fitness and decreased BMI percentiles in 5-11-year-old children. Weight, BMI percentile, Waist/hip ratio and significantly decreased in our OB group. In the OB group we also saw some improvements in physical fitness, but they were not significant. Interestingly, during the 8-weeks, the NW group had significant weight and hip circumference increases. The NW group decreased performance in most of the components of fitness, except for sit-ups where we saw significant increases in the number performed at post testing. Given the difficulty of decreasing BMI percentiles in children's intervention studies, our results have shown that without any structured physical activity classes that focus on physical fitness, children's BMI percentile will continue to increase and their physical fitness will decrease too. These results are important considering previous research that has shown tracking of obesity and physical activity from childhood to adulthood [20].

Our findings are consistent with some previous research. Contreras-Jordán et al. in a sample of slightly older obese Australian children (n=38 children) found similar results to our study. After a highly intensive 6-month intervention, children in the intervention group had significant increases in activity decreases in components of body composition [27]. Similarly, a one-year Swiss school based Randomized Control Trial (RCT) study found significant increases in physical fitness as measured by a 20-meter shuttle run and a decrease in body fat percentages derived from skin-fold measurements compared to the control group [28]. A 6-month RCT conducted in France in a similar age group to the children in this study saw a significant increase in physical fitness as measured by the 20-meter shuttle run. While the physical activity intervention for obese participants was 120 minutes of supervised physical exercise twice a week and an additional 2 hours of physical activity per week, no significant difference in BMI calculated using French reference data was observed [29]. These findings would suggest that their intervention while intense enough to improve fitness was not intensive enough to reduce the participants BMI. Another school-based intervention found significant improvements in physical fitness and weight status after a 10-week (40 minute, 5 times per week) intervention in China. Despite their intervention being conducted at a higher intensity than ours (Maximal fat oxidation) [30] and only included obese boys, their results support our findings that higher intensity exercises are needed to see improvements in body composition.

In contrast, several studies have found contradictory results to ours. A two-year study conducted on 339 Nebraskan children found increases in classroom physical activity increased by 6% in the intervention group, while outside physical activity

decreased by 16%. Their study did not find significant differences in body composition despite this being an intervention that included a nutritional education and a modified school lunch program [31]. Reilly and colleagues also found some contradictory results to our intervention. Their preschool based 6 months single blinded RCT trial intervention focused on increased physical activity and decreasing BMI calculated using Scottish standards in younger children aged 3-5 years. They found significant improvements in physical activity as measured by accelerometers but did not see any significant decreases in BMI. This study did not measure the physical fitness of their participants which was a study limitation [32]. A longitudinal study on compulsory school based physical activity in Australian schools did not show improvements in physical fitness or BMI. The study did conclude that the intensity of physical activity being offered in the study was not sufficient to see any improvements [33]. A meta-analysis by Harris and colleagues who included 18 studies of elementary aged children in their analysis concluded that school-based interventions did not improve BMI but did improve other health benefits such as physical activity [34]. Although, a recent systematic review and meta-analysis on 28 studies in obese children aged 5-18 years found physical activity interventions had a positive effect on body composition and fitness [35].

Our study had several limitations worth noting. Firstly, the parents, children, school administration were not blinded to group allocation. This could not be avoided as none of the schools in our study had any physical activity class in their curriculum. Secondly, the research assistants were not blinded to the study allocation either as the children divulged this information almost immediately as the assistants began baseline testing. Thirdly, the participants for this study were from a relatively small city, results may differ for participants living in a much more urban environment. Finally, while the intervention was designed to engage children in moderate to vigorous levels of physical activity, it would have been beneficial to formally assess the program using accelerometers. However, our obese participants significantly decreased weight and increased physical fitness (though not significantly).

Conclusion

In conclusion, our study demonstrated that an 8-week physical activity intervention was successful in improving physical fitness in Normal Weight and Obese children. This 8-week moderate to vigorous intensity program was successful in reducing BMI percentile in the Obese group. Future studies focusing on increasing physical fitness should focus on increasing the intensity of the intervention.

Conflict of Interest

The authors have no conflict of interest to declare.

Ethical Statement

The Institutional Review Board of California Lutheran University approved this study and all procedures were performed in accordance with standards outlined in the Helsinki Declaration.

Financial Disclosers

The authors have no financial relationships relevant to this article to disclose.

Author Contributions

L.A.K. had full access to all the data in the study and take responsibility the integrity of the data and the accuracy of the data analyses. Study concept and design: L.A.K. Acquisition of data: L.A.K. Analysis and interpretation of data: L.A.K. Drafting of the manuscript: all authors. Critical revision of the manuscript for important intellectual content: all authors. Statistical analysis: L.A.K. Administrative, technical, or material support: all authors. Study supervision: L.A.K. All authors have read and agreed to the published version of the manuscript.

Data Availability Statement

Data available upon written request to the corresponding author.

Acknowledgment

We are particularly grateful to the children, families and the following schools: Peach Hill, Walnut Canyon and Arroyo West for

their enthusiastic participation and help in recruitment for the study.

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