Journal of Physical Education and Sports Management Vol. 2(3), pp. 32-36, July 2011
Available online http://www.acadjourn.org/jpesm
ISSN 1996-0794 ©2011 Academic Journals

Full Length Research Paper

An after-school exercise program improves fitness, and body composition in elementary school children.

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Accepted 13 June, 2011

Reduced cardiovascular fitness (CVF) is a risk factor for obesity and cardiovascular disease. It has previously been shown that a school-based fitness curriculum can improve CVF, and other health indicators in middle school aged children. Whether an afterschool program improves CVF and other health markers in elementary-school children is unresolved. To determine whether an on-site afterschool-based fitness program improves body composition, cardiovascular fitness level in elementary school children, 80 elementary school children were evaluated in a "fitness-oriented" afterschool program managed by the local YMCA. Children underwent evaluation of CVF by maximal VO_2 treadmill testing and body composition by dual x-ray absorptiometry (DXA), at baseline (prior to the school-year) and again at end of the school year. At baseline, children had a mean age of 8.8 years, body mass index (BMI) of 18.7± 3, with a maximal VO_2 of 40.03 ± 7.6 ml/kg/min, and percent body fat of 28.7 ± 7%. After a 9-month intervention, children maximal VO_2 increased to 44.8 ± 7.5 ml/kg/min (p=0.04) and percent body fat decreased to 25.8 ± 6.2% (p=0.033). On-site afterschool programming focusing on fitness improved body composition and cardiovascular fitness, in elementary school children. Combined with prior studies, these data demonstrate that afterschool-based fitness curricula can benefit both obese and non-obese children. Partnerships with schools to promote fitness even outside of school time should be a part of a school approach to improving children's health.

Key words: Schools, obesity, poor fitness, children.

INTRODUCTION

Poor physical fitness as well as obesity is risk factors for type 2 diabetes mellitus (T2DM), and cardiovascular disease (Katzmarzyk et al., 2001; Must and Strauss, 1999; Freedman et al., 1987).

In adults, poor CVF is a risk factor for illness, independent of obesity (Blair et al., 2001). Given the multiple factors contributing to the current epidemic of childhood obesity, an effective strategy for the prevention and treatment of childhood obesity must be pervasive and collaborative in its scope. One attractive venue for such a collaborative effort is the school setting, even outside of formal school hours. While obesity increases the risk of illness and other cardiovascular diseases (Dietz, 1998), it has been demonstrated in adults that fitness level is a stronger predictor of mortality than obesity (Lee et al., 1999). It is thought that the beneficial effect of fitness training reflects the combined effects of increased lean mass and reduced fat mass in adults (Sinha et al., 2002; Kelley and Goodpaster, 1999) and children (Travers et al., 1998; Eliakim et al., 2001). We have shown that, in obese children, both CVF, as measured by maximal VO_2, and

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body fat were highly significant independent predictors of insulin sensitivity and health (Allen et al., 2007). Thus efforts to improve health in children should include a focus on increasing physical activity, in addition to encouraging healthy eating for health promotion (Dietz, 1998). We have previously reported that a school-based intervention for obese children was effective at improving CVF, and decreasing percent body fat and fasting insulin (Carrel et al., 2005). However, whether these beneficial changes would also occur in non-obese children is unclear. Most adults do not achieve the Surgeon General's recommendations for moderate physical activity (United States Department of Health and Human Services, 2000).

Thus, childhood has been identified as a critical period for nurturing lifetime physical activity behavior, and school physical education as a vehicle to promote active lifestyles (United States Department of Health and Human Services, 2000). We hypothesized that beneficial changes could also occur in non-obese children from a school-based program. Encouraging additional exercise in children can be promoted or obstructed in varying environments (Knowler et al., 1995; Epstein et al., 1994). The most successful programs are those that incorporate activity into the child's lifestyle, as a part of the family and school environment (Gutin et al., 2002; Tuomilehto et al., 2001; Sallis et al., 1997) Gutin et al. (2002) have successfully designed school-based programs that promote physical activity and monitor changes in fitness, as well as metabolic parameters including lipid profiles (Gutin et al., 2002). Jamner (2004) demonstrated that a school-based intervention in adolescent females can increase physical activity and prevent a decline in CVF (Jamner 2004). Some school-based nutrition and exercise interventions such as "Planet Health" have been successful at reducing BMI and triceps skinfold thickness among female students (Gortmaker et al., 1999; Robinson, 1999). while others (for example, the "Pathways" project) have fallen short of their goals in Native American schools (Caballero et al., 2003). Our study differs from previous interventions by focusing upon fitness and body composition, rather than weight or BMI, in both "non-obese" and obese children. By incorporating the intervention into the school environment, we believe we have a greater chance for success at incorporating health changes.

MATERIALS AND METHODS

Ninety-five children participating in an afterschool program were invited for participation in this study. Ninety children agreed to be evaluated for "baseline testing" at the University of Wisconsin Exercise Science Laboratory (ESL). Eighty children completed both baseline and post-intervention testing; only subjects who completed both testing sessions were included for analysis. The same investigators completed all testing, during a single visit. The University Human Subjects Committee approved the procedures, and informed written consent was obtained from parent and child prior to initiating the testing protocol. Inclusion criteria include all children who were attending the after-school program. Exclusion criteria were if children were unable to perform exercise testing.

Afterschool fitness curriculum

The frequency of the fitness-oriented program was 2 times every week, as part of a 2 hours after-school session. The recommended target for time spent in moderate to vigorous physical activity was greater than 30 min, and most programs were 40 min. All activities took place at the school, after the normal school day. The curriculum was modified to encourage student participation. Competitive games were de-emphasized and replaced with lifestyle-focused activities (walking, games, station-based activities and snowshoeing). All students participated in "structured or teacher-led" activity, and the goal of the activity was predominately cardiovascular fitness. The games and activities were specifically designed to minimize down time. A consistent warm-up plan brought students into movement participation led by YMCA fitness instructors. The activities encouraged physical fitness and fun, and full group participation.

Testing include baseline body composition, and cardiovascular fitness assessment prior to beginning the program. Height was measured on a wall-mounted tar to the nearest 0.1 cm. Weight was measured on a calibrated beam balance platform scale to the nearest 0.1 kg, Seca (Chino, CA). Percent body fat and fat free mass (FFM) were measured by DXA. Whole body scans were performed using the Norland XR-36 whole body bone densitometer (Norland Corporation, Ft. Atkinson, Wisconsin USA) and tissue masses were analyzed using software version 3.7.4/2.1.0. Subjects wore only workout shorts and a t-shirt for the scan procedure, methods described previously (Clark et al., 2004). Each scan session was preceded by a calibration routine using multiple quality control phantoms that simulate soft tissue and bone.

Children underwent measurement of maximal oxygen consumption (VO_2max) performed by open circuit spirometry using a progressive treadmill walking protocol to volitional fatigue using a Medical Graphics CPX-D (St. Paul, MN) (Grant et al., 1995). Requirements to assure subjects reached their maximal oxygen consumption by this protocol include at least two of the following three criteria: 1) maximal heart rate>200 beats per minute; 2) respiratory exchange ratio (VCO_2/VO_2) >1.0; and 3) a plateau in oxygen consumption. All subjects reached their maximal oxygen consumption according to the above criteria.

Study design

Once baseline testing was completed, children were enrolled into an afterschool fitness oriented program for 9 months (the entire school year). This (after-school fitness) program was designed to focus on lifelong fitness, and make fitness fun and achievable and maximize the amount of movement during the afterschool time. At the end of the school year, post-treatment assessment of all study outcomes was obtained. The study was designed so that each participant served as his/her own control.

Statistical analyses

Categorical variables were summarized using frequencies and percentages. All continuous variables were summarized and reported in terms of means ± standard deviations (SD). Changes from baseline were evaluated using a paired t-test or the non-parametric

Table 1. Baseline demographics (n=80).

Variable	Mean ± SD
Age (years)	8.8 ±0.8
BMI	18.7±3.4
VO_{2max} (ml/kg/min)	40.03 ± 7.6
Percentage body fat	28.7±6.6

Table 2. Change from baseline evaluation.

Variable	Mean ± SD	P value
BMI	-0.03 ± 0.33	0.52
Muscle mass (grams)	1558 ± 483	<0.001
Percent body fat	-3.0 ± 1.3%	0.03
VO_{2max} (ml/kg/min)	4.77 ± 2.34	0.04

Wilcoxon Signed Rank test, if data were not normally distributed. All p-values were two-sided, and p<0.05 was used to indicate statistical significance. Statistical analyses were performed using SAS software version 8.2 (SAS Institute, Cary, NC, USA).

RESULTS

Ninety-five children from the program were randomly recruited to perform baseline and end of the school years evaluations. Ninety children performed baseline testing. However, due to student dropout, only 80 subjects completed both pre- and post-measures. For the purposes of program analyses, only subjects who completed both pre- and post-procedures were included. YMCA staff reported that many families reported "dropping" from the program due to economic difficulties in the area, rather than a reflection on the YMCA programming. Students were considered to have met the curriculum criteria if they attended at least 75% of classes.

Anthropometrics and body composition

At baseline, the mean age of the study participants was 8.8±0.5 years (range 7 to10), and 53% of the subjects were female. The mean BMI was 18.7± 3. Seven percent of the subjects were obese at baseline. In this fitness oriented class there was a decrease in BMI z-score (-0.14 ± 0.33, p= 0.022), and an increase in muscle mass (2281.9 ± 1882.7 grams, *p <0.0001*, after completion of the 9-month intervention. The results are summarized in Table 1 and Table 2.

Cardiovascular fitness (CVF)

After 9 months of the fitness intervention, the group showed significant improvements in CVF [VO_2 max] when compared to baseline measurements (+4.8±4.3 ml/kg/min, p=0.04). No difference was seen with respect to genders.

DISCUSSION

This study evaluated the effect of an on-site afterschool based fitness program for elementary school children. These results demonstrate that body composition, and cardiovascular fitness (VO_2), were favorably changed in elementary-aged children who participated in an after-school program with a YMCA fitness curriculum. It is generally acknowledged that change in health behavior is facilitated when interventions focus on both the individual and the environment, and for children one of the most important environments is the school (Owens and Gutin, 1999) and (Swinburn et al., 1999). While the amount of time spent in after-school activity is below recommendations for children, it is important to consider that activity outside of this project may have been additive to these outcomes. Even this small change in the amount of physical activity (5 sessions every 2 weeks) showed beneficial health effects. Similar benefits have been shown following lifestyle improvements in adults. These data are important as a recent meta-analysis and review showed that there was limited evidence that after-school programs can improve physical activity levels and other health-related aspects, and called for additional studies (Beets et al., 2010, 2009). Despite the evidence of the association between CVF and Insulin resistance (IR) in children (Allen et al., 2007), questions remain whether targeting "healthy" levels of CVF can be identified and how such standards for fitness should influence public health policy (Ruiz et al. 2007).

It is important to note that the most significant changes noted in our program, specifically changes in CVF (as measured by maximal O_2 consumption during treadmill testing to voluntary exhaustion), have not routinely been measured in most previous programs. Further, given the expected and desired normal growth of middle-school children, we specifically did not use weight as a primary endpoint of this intervention. We acknowledge that there are many ways of evaluating health and fitness, including maximal VO_2 testing, body composition, BMI z-scores (percentiles corrected for age and gender) and insulin sensitivity. In this and prior studies, we have demonstrated improved BMI z-score and insulin sensitivity in spite of an increase in total body fat. Thus, there is growing evidence that physical activity and fitness, as well as fatness, are each individually important in affectting health in children. While it has been shown that aerobic exercise is useful as a treatment strategy for obesity (Katzmarzyk et al., 2003), it is important to consider what changes in fitness levels would normally be expected for children.

This is especially true in our study, which has no formal control group, and each subject acts as his/her own control. In a longitudinal study of fitness in 8 to 10 year olds, data suggests that fitness levels tend to remain constant without formal intervention, but that children with obese parents tend to have less physical activity and lower fitness levels (Treuth et al., 2004; Baranowski et al., 1992). In children and adolescents, percent body fat and visceral adipose tissue are also positively correlated with IR (Kang et al., 2002), an independent predictor of stroke, cancer, coronary artery disease, hypertension and T2DM in adulthood (Sinha et al., 2002; Yip et al., 1998). Our group has previously shown that CVF is a stronger predictor of fasting insulin levels than fatness in overweight middle school children (Allen et al., 2007). As childhood obesity is predictive of adult obesity (Dietz, 1998). it is important to develop and evaluate interventions that begin during childhood. This study aimed to determine if after-school activity programs could demonstrate measurable benefits in children's health.

These data demonstrate that it is feasible to achieve changes in physical activity sufficient to favorably affect fitness level and percent body fat in children. These findings can provide encouragement to both public health researchers and school personnel that increases in physical activity have tangible benefits, and should encourage the development of fitness-emphasis after-school and physical education programs. Optimally, an effective public health approach would also promote increased physical activity outside of school and throughout the summer months (Carrel et al. 2007), as physical activity recommendations cannot be met through physical education classes alone. Limitations of this study include the lack of a formal control group, and the relatively small sample size. Without a control group, we acknowledge that there may be confounding factors playing a role in these data that are unrecognized. This project focused on increasing physical activity and no dietary intervention or outcomes were measured.

Conclusions

School based fitness programs can significantly improve cardiovascular fitness levels, and body composition in young children. These findings suggest that modifications of school physical education curricula and after-school programs toward a fitness emphasis may be an effective vehicle for increasing physical activity and improving cardiovascular health for all children.

ACKNOWLEDGEMENTS

We thank the YMCA of Dane County staff and the administration and students of YMCA after-school programs. Funding for this evaluation came from the Carol M. White, Department of Education Physical Education Programming (PEP) Grant, Q215F070128.

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