School-Based Fitness Changes Are Lost During the Summer Vacation

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Objective: To determine the changes in percentage of body fat, cardiovascular fitness, and insulin levels during the 3-month summer break in overweight children enrolled in a school-based fitness program.

Study Design: Overweight middle-school children were randomized to a lifestyle-focused physical education class (treatment) or standard physical education class (control) for 1 school year (9 months; previously reported). This analysis reports changes during the 3-month summer break in children who participated in the fitness intervention group and who remained at this school the following year and repeated a fitness class. At the beginning and end of the school year, children underwent evaluation of (1) fasting levels of insulin and glucose, (2) body composition by means of dual x-ray absorptiometry, and (3) maximum oxygen consumption as determined by treadmill use.

Setting: Rural middle school and an academic children's hospital.

Participants: Overweight middle-school children.

Intervention: School-based fitness curriculum, followed by summer break, and an additional year of school-based fitness intervention.

Main Outcome Measures: Cardiovascular fitness test results (maximum oxygen consumption), body composition, and fasting insulin levels.

Results: Improvements seen during the 9-month school-year intervention in cardiovascular fitness, fasting insulin levels, and body composition were lost during the 3-month summer break. During this summer break, mean ± SD fitness level decreased (maximum oxygen consumption, −3.2 ± 1.9 mL/kg per minute; $P = .007$), fasting insulin level increased (+44 ± 69 pmol/L [+6.1 ± 9.7 mIU/mL]; $P = .056$), and percentage of body fat increased (+1.3% ± 1.3%; $P = .02$) to levels that were similar to those seen before the school intervention.

Conclusion: In obese middle-school children, school-based fitness interventions are an important vehicle for health promotion, but without sustained intervention, these benefits may be lost during the extended summer break.

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CHILDHOOD OBESITY IS NOW considered one of the most important nutritional issues in the United States, increasing the risk of insulin resistance (IR) and other complications, including diabetes mellitus. An increasingly pervasive environment of reduced physical activity coupled with easy access to calories is leading to an epidemic of morbidities, including poor cardiovascular fitness (CVF), obesity, IR, type 2 diabetes mellitus (T2DM), blood lipid abnormalities, and hypertension in youth.[1,2] Studies in adults have shown IR to be an independent predictor for the development of hypertension, coronary heart disease, stroke, cancer, and T2DM, for which greater insulin sensitivity is a protective factor.[3] These data serve as a strong stimulus to devise effective public health strategies to improve insulin sensitivity in children and adolescents. The degree to which such a strategy should emphasize improving fitness or reducing fat in children remains unresolved. We previously reported significant improvements in fitness in overweight middle-school children randomized to fitness-oriented physical education classes.[4] In this study, we investigate the changes in fasting insulin levels, CVF (measured by maximum oxygen consumption [$\dot{V}O_{2max}$]), and percentage of body fat (measured using dual x-ray absorptiometry [DXA]) in a cohort of overweight middle-school children during the 3-month summer break.

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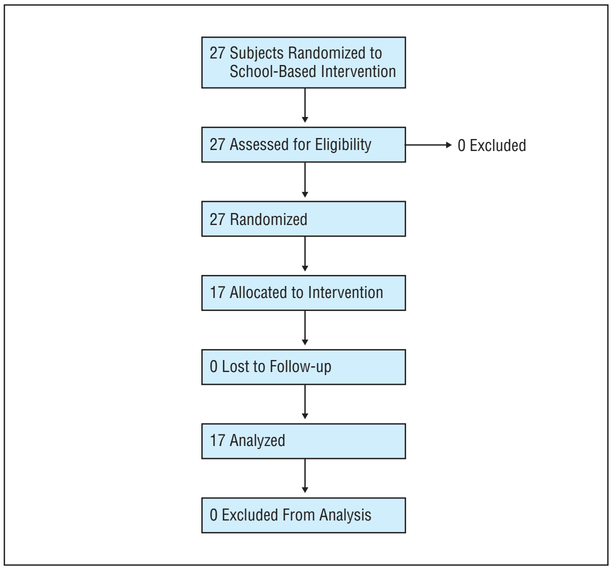

Figure 1. Flowchart showing randomization scheme of 27 children who were previously randomized to a school-based intervention and assessed,[4] of whom 17 were allocated to an additional year of intervention and analyzed at the start of the subsequent school year.

METHODS

SUBJECTS

Of a total of 53 children, 27 were previously enrolled in a lifestyle-focused, fitness-oriented physical education class for 9 months (the entire school year). Only children who were randomized to the fitness-oriented class 2 years in a row were included in this analysis (n = 17) (**Figure 1**). During a 12-month period (September 2005 through September 2006), 17 children who had a body mass index above the 95th percentile for age participated in this study; all the children were from the same school. Each underwent "baseline testing" at the University of Wisconsin Exercise Science Laboratory before the start of the school year in a single visit after an overnight fast, and were supervised by the same investigators (A.L.C., R.R.C., and S.P.). The procedures were approved by the Human Subjects Committee, and informed written consent was obtained before initiating the testing protocol. Testing included a physical examination, blood work for fasting glucose and insulin levels, baseline body composition values, and CVF assessment before beginning the program. Height was measured on a wall-mounted stadiometer to the nearest 0.5 cm. Weight was measured on a calibrated beam balance platform scale to the nearest 0.1 kg. Each subject had 4 visits during the 12-month study period: at the start and end of the school year, and again at the start and end of the subsequent school year.

MEASUREMENTS

Percentage of body fat and lean body mass were measured by means of DXA. Whole body scans were performed using a whole body bone densitometer (Norland XR-36; Norland Corporation, Fort Atkinson, Wis), and tissue masses were analyzed using a commercially available software program (software version 3.7.4/2.1.0; Norland Corporation). The XR-36 radiographic tube operates at 100 kV and uses dynamic samarium filtration (K-edge [Norland Corporation] at 46.8 keV) to produce energy peaks at a maximum of 40 and 80 keV. Dual sodium lodide detectors measure the attenuated x-ray using a pixel size of 6.5 × 13.0 mm and a scan speed of 260 mm/s. Subjects removed metal objects or clothing containing metal components and wore only workout shorts and a T-shirt for the scan procedure, which was described previously.[4] Each scan session was preceded by a calibration routine using multiple quality control phantoms that simulate soft tissue and bone. Based on 18 scans of 6 subjects using the XR-36 whole body procedures, the total body coefficients of variation were as follows: soft tissue mass, 0.2%; total body mass, 0.2%; lean body mass, 1.0%; fat mass, 2.5%; percentage of fat, 2.4%; and total bone mineral content, 0.9%.

Children underwent a measurement of $\dot{V}O_{2max}$ with open circuit spirometry using a progressive treadmill walking protocol to volitional fatigue using a metabolic cart (model CPX-D; Medical Graphics, St. Paul, Minn). To ensure that subjects reached their $\dot{V}O_2$max with this protocol, they had to meet at least 2 of the following 3 criteria: (1) maximal heart rate of more than 200/min; (2) respiratory exchange ratio ($\dot{V}CO_2/\dot{V}O_2$) more than 1.0; and (3) a plateau in oxygen consumption. The subject's oxygen consumption at a heart rate of 170 was recorded ($\dot{V}O_{2\,(170)}$) if he or she was unable to meet the criteria for a $\dot{V}O_{2max}$ test.

A 10-mL fasting blood sample for insulin and glucose was obtained from an antecubital vein. Samples were prepared using low-speed centrifugation at 4000g for 10 minutes. Fasting insulin concentration was determined using a chemiluminescent assay (Esoterix, Callabasas Hills, Calif) and glucose concentration was determined by an enzymatic method (Beckman Diagnostics, Fullerton, Calif).

The fitness-oriented physical education classes were held 5 times in a 2-week period for a 45-minute class period. Classes were designed to make fitness and good nutrition fun and achievable and maximize the amount of movement during the class. We previously reported improved CVF and reduced fasting insulin levels in children enrolled for 9 months in the lifestyle-focused physical education class compared with those in the standard physical education class.[4] Seventeen subjects completed school-based evaluations in 24 months. Evaluations occurred at the start and end of the school year. Measurements from the end of year 1 to the start of year 2 (3-month summer break) were compared. No instructions for summer activity were given.

STATISTICAL METHODS

Body composition, CVF, and insulin sensitivity variables were summarized using standard descriptive statistics in terms of means and standard deviations. A nonparametric Wilcoxon signed rank test was used to compare changes in CVF ($\dot{V}O_{2max}$) and percentage of body fat.

RESULTS

Patient characteristics are presented in the **Table**. At study enrollment, mean ± SD age of the study participants was 12.0 ± 0.5 years, and 55% of the subjects were girls. The mean ± SD body mass index (calculated as weight in kilograms divided by height in meters squared) was 30.8 ± 5.9, and mean ± SD percentage of body fat was 36.6% ± 5.5%. Mean ± SD measurement of $\dot{V}O_{2max}$ at study initiation was 31.2 ± 5.2 mL/kg per minute for the combined group. Mean ± SD fasting insulin level was 174 ± 115 pmol/L (24.3 ± 16.1 μIU/mL; normal values, 29-136 pmol/L [4-19 μIU/mL]).

Comparison of test results obtained in September with those obtained in June of the previous year revealed a significant increase in mean body fat of 1.3% (relative change,

Table. Baseline Demographics

Characteristic	Total*
Age, y	12 ± 0.5
BMI	30.8 ± 5.9
$\dot{V}O_{2max}$, mL/kg per minute	31.2 ± 5.2
% of Body fat	36.6 ± 5.5
Fasting insulin, μIU/mL	24.3 ± 16.1
Fasting glucose, mg/dL	86.0 ± 6.6

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); $\dot{V}O_{2max}$, maximum oxygen consumption.

SI conversion factors: To convert fasting insulin to picomoles per liter, multiply by 6.945; to convert fasting glucose to millimoles per liter, multiply by 0.0555.

*Data are given as mean ± SD for 17 children.

3.7%; $P = .02$) (**Figure 2**), as well as a significant decrease in $\dot{V}O_{2max}$ of 3.2 mL/kg per minute (relative change, 9.5%; $P = .007$) during the summer break (**Figure 3**). Mean ± SD fasting insulin levels increased 44 ± 69 pmol/L (6.1 ± 9.7 mIU/mL; $P = .056$) during the summer break.

COMMENT

The development of IR is an independent predictor of the development of stroke, cancer, coronary artery disease, hypertension, and T2DM during adulthood.[5-8] Reduced physical activity and obesity are known to increase a child's risk for insulin resistance.[9-11] Childhood is a critical period for nurturing lifetime behavior,[11] and an attractive starting point for collaborative effort is the school setting, where active and passive decisions regarding physical activity, food choices, and attendance can be reasonably controlled and programmatically altered. Still, the importance and feasibility of changing fitness levels in children as well as the application of policies and programs required to achieve this goal have limited acceptance.

To our knowledge, this study shows for the first time in children that changes seen in a school-based intervention are reversed during a 3-month summer break. This observation illustrates the need to evaluate interventions for a sustained period. It is important to design interventions that will effectively improve childhood fitness and diminish obesity. Developing and evaluating interventions to influence students' opportunities for healthful choices has been a focus of school-based health promotion research, including nutrition programs and physical education.[12] However, when interventions occur in a school-based setting, and are confined to the school year, an inherent question is one of sustainability. The Child and Adolescent Trial for Cardiovascular Health was the largest school-based health education study designed to decrease cardiovascular risk factors in children. Goals were met by improving the school cafeteria, physical education programs, health curricula, and establishing a nonsmoking school district environment.[13] Improved physical fitness is clearly effective in improving insulin sensitivity in adults,[14] but most adults do not achieve the surgeon

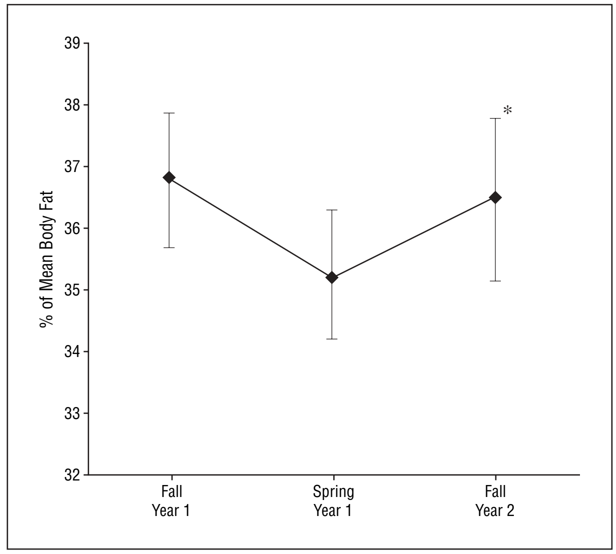

Figure 2. Changes seen in the percentage of mean body fat during the school year and summer. Asterisk indicates $P < .02$ between fall year 2 and spring year 1.

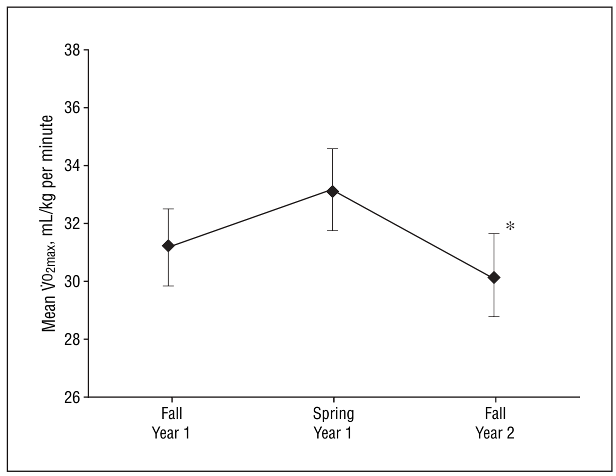

Figure 3. Changes seen in cardiovascular fitness (mean maximum oxygen consumption [$\dot{V}O_{2max}$]) during the school year and summer. Asterisk indicates $P = .007$ between fall year 2 and spring year 1.

general's recommended 30 minutes of moderate physical activity on most days of the week.[15] While other school-based interventions have been "successful," traditionally school-based programs such as ours are conducted during the school year. The issue of sustainability has been more difficult to analyze with more sophisticated measurements of physical fitness.

Strengths of this study include the direct measurement of cardiovascular fitness ($\dot{V}O_{2max}$), body fat, and fasting insulin levels, rather than questionnaires or self-reports. While this may be too labor intensive and expensive to do on a large population, these new data provide direct evidence of changes seen during prolonged breaks from the school year. These findings were surprising, because most children report high levels of physical activity during the summer when school is not in session. This notion was not supported by these data. It is also important to note particular characteristics of the study group and limitations of this report. First, all the children in our study had a body mass index that was higher than the 95th percentile, so our data may not be applicable to all children. Second, the sample size of the study (17 subjects) was fairly small, and although there was no control group for this study, we believe that our observation of the loss of school-based benefits is an important one. More investigation will be needed to determine if these losses during the summer are seen routinely.

CONCLUSIONS

School-based fitness programs have been effective during the school year at improving fitness, decreasing body fat, and improving insulin sensitivity. Still, there is skepticism about the importance and feasibility of changing fitness levels in children and the application of policies and programs required to achieve this goal. We and others have shown that school-based programs can significantly improve CVF and reduce fasting insulin levels in overweight children.[4,16-18] However, children were not specifically instructed to exercise during the summer; in fact, no instructions were given about summer activity. Even during this relatively short period (3 months) of unsupervised activity, there was a significant loss of the fitness benefits previously described, resulting in a return of fitness levels to those at baseline. These data show that in children, efforts to improve insulin sensitivity and reduce risk of T2DM and other morbidities of IR should include exercise intervention in a sustained manner to improve CVF throughout the year, not just during the school year.

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