Physical Activity in Middle School–aged Children Participating in a School-Based Recreation Program

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Background: The increasing incidence of obesity in children may be attributed in part to increased sedentary behavior, such as watching television, which leads to less energy expended in physical activity. We have theorized that by middle school, many children lack the physical skills or self-confidence to participate in competitive physical activities. Thus, we hypothesized that if we provided a summer and after-school program featuring noncompetitive, outdoor activities such as gardening and adventure education, we would observe increased physical activity relative to habitual physical activities at home.

Methods: To test this hypothesis, 2 experiments were conducted. In the first, 4 children aged 12 years were evaluated while they participated in a summer recreation program for 2 hours and again while they watched a videotape. They wore a uniaxial accelerometer to assess physical movement, and we used a bicarbonate labeled with $^{13}$C tracer technique to assess energy expenditure. In a second experiment, we evaluated 8 children (aged 10-12 years) twice using uniaxial accelerometry only, once while they attended the after-school program for 2 hours and then during a similar period at home.

Results: The first study showed that the estimated energy expenditure (kilocalories·kilograms$^{-1}$·hours$^{-1}$) was 60% increased during the program (mean±SD) (2.6±0.5) compared with watching a videotape (1.6±0.3) ($P=0.02$). Physical movement (accelerations per minute) also was significantly increased (3959±896 vs 513±182) ($P=0.004$).

In the second experiment, movement was 95% increased during the program (4578±1004) compared with the behavior at home (2345±746) ($P=0.005$).

Conclusion: These results show that an organized, noncompetitive, leisure-time program can increase physical activity in children.

METHODS

SUBJECTS

This study was approved by the human subjects committee of Children's Hospital, Columbus, Ohio. Two experiments were conducted sequentially during the summer and fall of 1999. The subjects volunteered to participate in this study and were recruited from those attending either a summer recreation program (experiment 1) or an after-school program (experiment 2). The parents of all subjects gave informed written consent, and the children gave their written assent. The subjects were given a stipend of $25 for participating in experiment 1 (evaluating the summer program) and $15 for participating in experiment 2 (evaluating the after-school program in the fall). Attendance was taken during both programs. The children participating in the summer program were among those who became interested in the program after attending a year-long, in-school program of education in health, adventure education, and business entrepreneurship sponsored by the Borden Center for Nutrition and Wellness at the Children’s Hospital, Columbus. After the summer program was in process for approximately 1 month, the coordinator of the program (A.R.C.) approached the children attending approximately 75% or greater of the sessions and then their parents about participating in a study evaluating the effectiveness of the program. Children participating in the summer program heard about the program via mailed announcements to parents and word of mouth from other participants. Of 216 students in the sixth grade, 22% attended the after-school program at least once, but only 6% attended at least half of the possible sessions; thus, there is a potential challenge for employing such programs in other communities. The approach for recruiting subjects for the fall program was similar to that used in the summer program.

INTERVENTIONS

Both the summer program (experiment 1) and the fall program (experiment 2) were generally held outdoors on school grounds. In the event of inclement weather, activities took place inside the school (both in classrooms and the halls). Below, we describe studies to evaluate the summer program (experiment 1) and the fall, after-school program (experiment 2). Both programs involve 2 basic interventions: a gardening program and an adventure education program.

Gardening and Landscaping

For approximately 30 to 45 minutes each day, the children assisted with the cultivation, planting, maintenance, and harvesting of a garden, occurring successively during the summer. The gardening program was initiated at the beginning of the summer program, and there were some residual activities in the fall. The children participated in the planning of the garden. Cultivation of the ground was provided by the school. Local nurseries contributed plants such as basil. The children then participated in all aspects of maintaining the garden and harvesting the produce. The children also accompanied the coordinator to local farmers’ markets where the produce was sold for the benefit of the school. This latter aspect of the program gave the children a sense of participating in altruistic service and also provided some practical experience in following up education in business that some of them had in school. During the fall, the children assisted in various landscaping activities (eg, cleaning up the grounds after a thunderstorm).

Adventure Education

For approximately another 60 minutes each day the children participated in adventure games designed primarily to foster teamwork and PA by all children or skill-building exercises intended to teach children so that they could participate in various sports. The goal of adventure education is to teach people to solve problems (including succeeding in an athletic contest) by cooperating with other individuals. Because interpersonal cooperation in such games is highly necessary, all participants are required to move constantly as dictated by the particular rules of the game. Several examples illustrate the potential value of these games. Kneeling volleyball is played on the knees using a large beach ball. This requirement tends to level the playing field in order to ensure that the less athletic and more sedentary children are not left out of the endeavor. Another game we used, fleet ball, is played like dodge ball, but a soft object is passed back and forth, and those in possession of the object cannot be eliminated. The real goal of the game is to keep all kids engaged for as long as possible. In one version of the shark vs minnows tag game, the shark stands near a sprinkler through which all the other players must run to stay wet. As participants are tagged, they too become sharks. Thus, the goal is to be the last minnow, but in the meantime, all kids continue to participate and remain active.

EXPERIMENTAL DESIGN

Experiment 1

The first experiment was designed primarily to assess whether energy expenditure during participation in the summer program was increased compared with that observed when the same children were watching TV for an identical period of time. The summer program was held from 10 AM to 12 PM, Monday, Wednesday, and Friday, June through August. Parents did not actively participate in the program. All children were supervised by the program staff, which included the coordinator (A.R.C.), an adventure games specialist, and usually 1 or 2 college students. The studies of energy expenditure and physical movement were carried out by the corresponding author (C.L.K.) and one of his research technicians.

To evaluate the effectiveness of the program, we studied the 4 children, aged 12 years, who attended the summer program at least 75% of the time: 1 white boy and 3 girls (1 white and 2 African Americans). The mean (±SD) body weight, height, and body mass index (calculated as the weight in kilograms divided by the height in meters squared) were 61.4±24.8 kg, 154.8±9.1 cm, and 26.1±12.4, respectively. However, one child was particularly overweight (body mass index, 44.7); excluding her, the average body mass index was 19.9±1.6. In these 4 children, we assessed physical movement using uniaxial accelerometry and relative energy expenditure using a 13C-bicarbonate tracer technique, both during a typical 2-hour period of the summer program and during a similar 2-hour period while they watched a Disney videotape (cartoon) in a school classroom. During the study period, the outside temperature...
was very high in Columbus (in the 32°C-38°C range). Thus, frequent water breaks were required during which the children were quite sedentary.

**Experiment 2**

An after-school program modeled after the summer program was carried out from 2:30 PM to 5:30 PM, Monday through Thursday from September through December. While participating in the program, all children were completely supervised by the staff as in experiment 1. Children who attended approximately 75% of the sessions were asked to participate in a study to evaluate physical movement during the program and at home. In 7 sixth-grade students (aged 11 years) and 1 fifth-grade student (aged 10 years), we assessed physical movement using uniaxial accelerometry for a 2-hour period while the students attended the program and during a similar unsupervised 2-hour after-school period while the students were at home on a Friday, when the program was not in session. For the studies at home, the children were given the accelerometer at the conclusion of the school day. The coordinator then arranged to pick up the accelerometer after the 2-hour measurement period. He was not present when the child was at home. The children were asked to write down their activities while they were at home; we assessed how the estimated level of PA derived from the diaries correlated with the data from the activity monitors. However, the numbers were too small for this type of assessment and are not reported here. Although the overall schedule and structure of the program was similar during the evaluation of each child, the activities were not identical from day to day. The mean ±SD body weight, height, and body mass index were 46.8 ± 13.9 kg, 154.2 ± 2.7 cm, and 19.6 ± 5.1, respectively.

**MEASUREMENT TECHNIQUES**

**Accelerometry**

Uniaxial accelerometer was carried out using a uniaxial accelerometer strapped to the wrist (model 71164; Computer Science & Applications, Shalimaar, Fla). Melanson and Freedson previously showed that this accelerometer position provided the best index of energy expenditure in the field setting.

**13C-Bicarbonate Breath Test**

Physical movement measured with an accelerometer approaches zero when a subject is extremely sedentary. Thus, it is difficult to assess even relative energy expenditure among several very sedentary activities such as watching TV. The 13C-bicarbonate tracer technique, on the other hand, is applicable to the field situation because it can be used to assess continual degrees of energy expenditure, from very sedentary activities to activities involving high levels of energy expenditure. We previously described in detail the application of this technique for assessing the rate of carbon dioxide (CO2) production.

In that study, the rate of appearance of CO2 measured with the isotope technique correlated with the measurement of the net rate of CO2 excretion measured with indirect calorimetry among the following activities: TV watching, string instrument playing, and 2 levels of intensity of walking (Spearman rank correlation, 0.93; P<.05). Fractional recovery of isotope is equivalent to the ratio of the actual net rate of CO2 excretion (not measured in the present study) to the rate of CO2 production measured using the isotope technique. We have shown that incomplete recovery of administered isotope in the breath (via isotope exchange) does not greatly limit the validity of this technique for assessing changes in the relative rates of either CO2 production or energy expenditure during physical activities compared with TV watching. For example, playing a stringed instrument was associated with a 33% increase in energy expenditure measured with the isotopic technique compared with the 29% increase measured with indirect calorimetry. However, in the presentation of results in units of energy expenditure, we did assume the value of 0.565 for the fractional recovery of isotope; this was the value measured during TV watching in our previous study. In that study, the mean value ranged from 0.35 (for stringed instrument playing) to 0.64 for brisk walking. We also previously showed that the precise value for the respiratory quotient (RQ) (used to convert molar rates of CO2 production to energy expenditure) has little effect on the results. For example, we observed no significant error in using a value for RQ typically found in the resting (TV watching) period to calculate energy expenditure during physical activities. Thus, in this study we assumed an RQ of 0.85 in our calculations of energy expenditure.

Subjects were studied at least 2 hours after their last meal. A baseline breath sample was collected to establish the baseline 13C enrichment of CO2 and then the tracer dose of NaH13CO3 was administered as a single oral dose to start each study (44.7 μmol/kg body weight; 99 Atoms Percent; Cambridge Isotope Labs, Andover, Mass). Subsequent to the tracer dose, breath samples were collected at 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, and 120 minutes. Breath samples were stored in nonsiliconized, sterile Venoject tubes (Terumo Medical Corporation, Elkton, Md) until aliquots could be combined into a composite sample prior to subsequent cryogenic purification. After cryogenic purification, 13C enrichment of breath CO2 was determined using gas isotope ratio mass spectrometry (Delta E; Finnigan/MAT, Bremen, Germany). The CO2 production (micromoles per kilogram per 120 minutes) was calculated from the rate of appearance of CO2 (RaCO2) using the following equation:

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RaCO_2 = (F/IE CO_2 \times 120 \text{ min}) - F,
\]

where F is the bolus dose of labeled bicarbonate in molar units and IE CO2 is the isotopic enrichment of the pooled sample of expired CO2.

**STATISTICAL METHODS**

Results are expressed as mean±SD. Because of previous experience with isotope studies, we anticipated that we would be able to attain statistical significance with a small sample size. After completing experiment 1, we similarly felt that we could determine if the after-school program would result in a statistically significant increase in PA with 5 to 10 subjects. In mid-October, after the fall program was fully organized, we recruited students whose parents gave informed consent. At the completion of data collection at the end of the fall program (and after cessation of pilot funding for this program), we then analyzed the difference between the subjects’ PA at the program and at home. For both experiments, comparisons between activities were analyzed using the paired t test.

**RESULTS**

**EXPERIMENT 1**

**SUMMER PROGRAM**

Physical movement (accelerations per minute) was increased during the recreation program (3959±896) compared with that while watching the videotape on TV (513±182) (P=.004). Also, during participation
in the program the rate of CO₂ production (micromoles·kilograms⁻¹·minutes⁻¹) was 60% increased (535±98) compared with CO₂ while watching TV (333±68) (P = .02).

As discussed in the “Methods” section, by assuming values for isotope recovery and RQ, one can derive a value of energy expenditure using the isotope method. Based on this assumption, energy expenditure (kilotcalories·kilograms⁻¹·hours⁻¹) was 2.6±0.5 during the program and 1.6±0.3 while watching TV (P = .02).

EXPERIMENT 2
(FALL AFTER-SCHOOL PROGRAM)

There was a 95% increase in physical movement (accelerations per minute) during the after-school program (4578±1004) compared with when the children were home (2345±746) (P = .005).

COMMENT

Participation in the recreation program increased energy expenditure approximately 60% compared with watching TV, and, during the fall, physical movement was increased 95% compared with that observed at home. In addition, by comparing the mean movement measured by accelerometry during the fall and summer programs, we noted a further 16% increase in PA in the fall program compared with that observed during the summer months. As anticipated, the effect size of the program was large compared with either TV watching or activity at home, which enabled us to detect statistical significance with a small sample size. One could question whether there was any bias in the selection of subjects, but for each experiment, we basically studied all children who regularly participated in the program. We acknowledge that children who attend the program regularly may respond differently compared with children who only attend occasionally, but it is our belief that, based on casual observation, the level of PA observed during the program did not vary that much. Moreover, it is plausible that regular participation in the program would narrow, not widen, the difference between the level of PA observed during the program and that observed at home. In fact, future studies of programs like this might evaluate whether regular participation would enhance, over time, PA at home. Transportation to the program during the summer and home from the program during both the summer and fall was one of the most obvious barriers to participation. Nevertheless, to achieve greater participation, schools and communities might strive to show that such a program would enhance PA, at least during the program, and that it represents a “healthy” alternative to more sedentary activity at home. In this regard, we did not detect via simple activity diaries any evidence that activity at home primarily consisted of school homework.

In the “Methods,” we indicated why the measurements of the rate of CO₂ production and energy expenditure might not be accurate in an absolute sense (assumed values for isotope recovery and RQ). We could assume that TV watching has the energy cost of other sedentary activities, that is, only 1 kcal·kilograms⁻¹·hours⁻¹, rather than 1.6 kcal·kilograms⁻¹·hours⁻¹ as measured in this study. Based on the assumed validity of the bicarbonate tracer technique for assessing relative changes in energy expenditure and the Atwater value for the caloric density of fat (9.3 kcal/g), the 60% increase in energy expenditure seen with the activity program would still result in a difference of adipose tissue gain of 2.2 kg/y if this kind of activity were substituted for TV watching for 2 h/d every day, even in our subject with the lowest body mass (45 kg) (0.6 kcal/kg/h · 730 h/y · 45 kg · [1 g adipose tissue/9.3 kcal]). Furthermore, considering this same subject as an example, this small difference in body weight at this subject’s height (1.46 m), even in the absence of normal statural growth, would result in a change in body mass index of 1.0, a somewhat greater effect than that observed in a recently published trial aimed at reducing TV watching (change in body mass, 0.45 kg/m²).

CONCLUSIONS

We observed that participation in a recreation program involving gardening and group games increased PA relative to either watching TV or habitual activity at home in children not participating in competitive sports. The novel aspect of this study is that we used quantitative methods to show that nonathletic, noncompetitive activities can have a significant impact on PA. In other words, almost any activity that draws children away from very sedentary activities such as watching TV will enhance PA. This program might be compared with other organized activities in which children participate, such as 4-H or Scouting. We believe that these observations, even if self-evident in terms of showing a benefit relative to TV, provide an initial quantitative basis for future research and programmatic endeavors to involve school-aged children in after-school activities; our results illustrate the potential benefit to parents and communities of providing safe venues where children can engage in PAs that are not dependent on athletic skills. In this regard, schools

Previous studies have suggested that children who spend more time in very sedentary activities such as watching TV are apt to be more overweight. One recent study has shown that reducing the time spent watching TV reduces the body mass index. However, other than educational programs designed to reduce TV watching per se, previous studies have not demonstrated school- or community-based interventions for increasing PA that would help the many youth who do not participate in competitive sports, perhaps because of both psychological or physical factors. In this article, we first describe a summer and after-school activity program that other communities might replicate in many different forms. Of particular interest to us is that the program does not require that participants have physical skills but only a reasonable desire to socialize with other children and adults. This study shows that such a program can have a statistically, and potentially nutritionally, significant impact on PA.

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or communities could replicate this program in many different guises, depending on the interests of students, teachers and school administrators, parents, or members of the community. Also, although we did not attempt to address because of the small number of subjects studied, there could be other benefits of similarly structured programs, such as improved self-esteem, acceptance of mentorship (in learning to tend a garden), teamwork, and overall socialization.

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