
Promoting Physical Activity Participation among Children and Adolescents

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With global increases in the prevalence of overweight and obesity among children and adolescents, there has never been a more urgent need for effective physical activity programs. The aim of this narrative review is to summarize the evidence of the effectiveness of interventions that report physical activity outcomes in children aged 4–12 years and adolescents aged 13–19 years. A systematic search of electronic databases identified 76 interventions. Most interventions were delivered via the school setting (57 interventions), nine through the family setting, six via primary care, and four in community- or Internet-based settings. Children's physical activity interventions that were most effective in the school setting included some focus on physical education, activity breaks, and family strategies. Interventions delivered in the family setting were not highly effective, but many were pilot studies. The use of motivationally tailored strategies and program delivery in the primary care setting showed promise among adolescents. Many studies had methodological and reporting flaws (e.g., no baseline data, poor study design, physical activity measures of unknown reliability and validity, and poor reporting of sample size, response rates, attrition/retention, compliance, year of intervention, and duration of intervention). Publications reporting the results of evaluations of intervention studies should follow the Consolidated Standards of Reporting Trials guidelines or, for nonrandomized studies, should follow the Transparent Reporting of Evaluations with Nonrandomized Designs guidelines. Further evidence of the effectiveness of interventions promoting young people's physical activity in family and community settings is needed.

adolescent; child; exercise; health education; health promotion; motor activity; program evaluation; schools

Abbreviations: CATCH, Child and Adolescent Trial for Cardiovascular Health; PACE+, Patient-centered Assessment and Counseling for Exercise + Nutrition; PATH, Physical Activity and Teenage Health; PLAY, Promoting Lifetime Activity in Youth.

INTRODUCTION

Physical activity is important for young people's health (1). Children and adolescents who participate in higher levels of physical activity are less likely to display risk factors for cardiovascular disease (2, 3) and more likely to have positive outcomes in weight regulation (4–6). With unprecedented global increases in the prevalence of childhood overweight and obesity (7), there is an urgent need for effective physical activity programs to reduce the incidence of overweight and obesity. Recent systematic reviews of the

effectiveness of young people's physical activity interventions have focused only on school settings (8), noncurricular approaches (9), studies published over a short time period (1997–2003) (10), the effectiveness of physical activity interventions in pediatric obesity treatment and prevention (11–14) or cardiovascular disease outcomes (15), or physical activity strategies across the lifespan with limited application to children (16), or they were published some time ago (17).

Given the central role of physical activity in the prevention of overweight and obesity (18, 19), a comprehensive critical review of the evidence is needed. A meta-analysis

may be preferable in order to provide a quantitative summary, but variability across research designs and methods of physical activity assessment precludes such an approach. Because so few studies have followed the Consolidated Standards of Reporting Trials (20) or Transparent Reporting of Evaluations with Nonrandomized Designs (21) guidelines in reporting evaluation results (e.g., sample size, response rates, attrition/retention, compliance), it is not possible to determine the effectiveness of studies based on reporting compliance.

As there are several important differences in physical activity between children and adolescents (e.g., younger children's physical activity tends to consist of intermittent and spontaneous bursts, they rarely engage in sustained activity bouts (22), and they typically have less autonomy than adolescents), this review will focus on the two age groups separately. The aim of this paper is to provide a narrative review of the evidence of the effectiveness of interventions that report physical activity outcomes among children aged 4–12 years and among adolescents aged 13–19 years. The review will inform the development of effective intervention strategies and policies.

MATERIALS AND METHODS

The following databases were searched for English-language, original research articles published in peer-review journals between January 1985 and the end of June 2006: Medline and Premedline; Sportsdiscus; PsychInfo; PsycARTICLES; Cochrane; CINAHL; ScienceDirect; Web of Knowledge; Social SciSearch; and all Ovid databases.

Inclusion criteria were as follows: 1) children aged 4–12 years or adolescents aged 13–19 years; 2) report of physical activity outcomes (studies that reported only fitness outcomes were excluded); 3) sample size of more than 16; and 4) a randomized controlled trial, group randomized trial, or quasi-experimental study design. The inclusion of studies using postintervention, assessment-only designs or no control condition was decided upon on a case-by-case basis. Overweight or obesity treatment studies or studies of clinical populations were also excluded. Each paper was independently screened by two people to determine if it met the inclusion criteria. Any discrepancies were resolved through discussion with a third reviewer.

Based on the behavioral setting concept favored by population health approaches to promoting physical activity (23), the intervention studies were grouped under four intervention settings: school, family, primary care, and community. Within the school setting, studies were further grouped according to intervention strategies. These included curriculum only; curriculum and physical education; curriculum, physical education, and environment; physical education only; physical education and environment; environment only; activity breaks; school and family; and school, family, and community. A meta-analysis of this literature was not performed because of the absence of comparable exposure and outcome measures. However, we have synthesized the evidence across those studies by broadly grouping the interventions wherever possible by strategy within setting. For

strategies that have only been trialed in a small number of studies, this was not feasible.

RESULTS

Search results

Ninety published studies, representing 42 separate interventions involving children and 25 interventions involving adolescents, were identified. A further nine interventions crossed the specified age range for this review (from 8 to 21 years) (24–32). Most were delivered predominantly through the school setting (57 interventions), nine through the family setting, six via primary care, three in community-based settings, and one via the Internet. Most interventions (56 in total) were delivered in the United States, with the remainder delivered in Canada, the United Kingdom, Ireland, Greece, Belgium, Finland, France, Spain, and Australia. Locations are reported in the text only if the intervention was delivered outside the United States. Eleven studies reported inclusion of young people from rural populations (29, 33–42), 21 studies included children from low-mid socioeconomic status areas and/or families (25, 33, 36, 39, 42–57), and 26 studies specifically targeted ethnic minority groups (27, 28, 32, 36, 37, 39, 43, 47–49, 51–54, 57–68). Details of the interventions and the study designs used to evaluate them are summarized in Web tables 1–4. (These four supplementary tables are posted on the *Journal's* website (<http://aje.oxfordjournals.org/>)).

School settings

Curriculum only. Five of the interventions targeting children used curriculum strategies only (50, 55, 69–71); one of these was effective (55). Marcus et al. (55) assessed the effectiveness of the multiple risk factor Know Your Body program among low-socioeconomic status children 9–11 years of age. There were four groups (curriculum and health screening, health screen only, curriculum only, and control). The two curriculum groups received two 45-minute/week modules over 18 weeks (repeated in consecutive school years). One of the nine modules focused on fitness and exercise. Children in the curriculum and health screening group scored higher on the physical activity measure than children in the control group. It is noteworthy that a replication of this program, using a similar self-report measure, was not effective (70).

Of the other three ineffective curriculum-based programs, one was successful in reducing television viewing (its sole focus) and preventing unhealthy weight gain among third and fourth grade children (69). The second program (Planet Health) aimed to reduce energy intake and television viewing and to increase physical activity among sixth and seventh grade children, through the delivery of 16 lessons/year over 2 years, but it succeeded only in increasing fruit and vegetable servings among girls and reducing television viewing among boys and girls (69). More recently, Palmer et al. (50) targeted cardiovascular function, physical activity, nutrition, and tobacco use through a Web-based curriculum program (twice a week for 50 minutes/week) but had no

impact on the children's physical activity. In summary, all of the ineffective interventions addressed risk behaviors additional to physical activity and used self-report measures of physical activity. The only intervention to report positive outcomes (55) also had these limitations, but this program was not effective when delivered by different investigators to a different sample of children (70).

Seven school-based, curriculum-only interventions targeting adolescents used strategies ranging from didactic teaching to multimedia and Internet-based intervention (48, 57, 69, 72–76). Only one intervention resulted in significantly increased physical activity participation (73, 74). The Stanford Adolescent Heart Health Program was a multiple risk factor intervention delivered over 20 classroom sessions by university staff to grade 10 students. Of those who were inactive at baseline, 30 percent of the treatment group and 20 percent of the control group were active 4 months later. Although these findings appear promising, the intervention was delivered by university staff (which is unsustainable), and the evaluation used a poor quality measure of physical activity, excluded some students from the analyses, and had a short period between the baseline and subsequent data collection.

Of the ineffective interventions, Slice of Life was delivered by peer leaders and university staff over 10 classroom sessions to grade 9 students (72); Goldfine and Nahas (76) exposed the experimental groups to information sessions 1 or 2 days/week over 12 weeks; and Planet Health (as described above) was not effective in promoting physical activity (69). Everhart et al. (75) provided physical activity and nutrition information through a multimedia program with which students interacted four times during a year. Frenn and Malin (48) also delivered a five- to six-session video/Internet intervention over 1 month to grade 7/8 students. The time spent in moderate- to vigorous-intensity physical activity decreased significantly less in the intervention than in the control group over the 1-month evaluation period. However, when the above study was extended to an eight-session video/Internet intervention, moderate- to vigorous-intensity physical activity did not increase significantly in the intervention group compared with the control group (57).

Limitations of most curriculum-only, school-based studies include inadequate sample size, control and intervention classes being located in the same schools (with contamination not being assessed), and poor measures of physical activity. Therefore, with only two of 11 curriculum-only studies among children or adolescents being effective, the weight of evidence suggests that curriculum strategies are not effective for promoting physical activity when used in isolation.

Curriculum and physical education. Among children, two studies combined curriculum and physical education strategies, and both reported some positive effect on children's physical activity (35, 77). The first study termed "Cardiovascular Health in Children" was delivered to 1,274 children in urban and rural areas (35), and over an 8-week period, children received two classes/week on health topics incorporating theoretical principles and three physical education classes/week (each including 30 minutes of physical

activity). On the basis of a categorical self-report measure of aerobic exercise (55, 70), there were no intervention effects on children's physical activity at the individual level, but there was a small positive effect ($p < 0.05$) at the school level (35).

The second study, Go For Health, targeted third and fourth grade children and incorporated a new physical education program over two semesters (6–8 weeks each), a 6-week physical activity curriculum program, and a 4-week nutrition program (77). According to observation of physical activity during physical education lessons compared with physical education lessons in the control schools (~5 percent of class time being active), physical activity increased from less than 10 percent of class time at baseline to 40 percent at posttest in the intervention schools. The children obtained an average of 16 minutes of physical activity per physical education period (80 minutes/week). There was also a time \times group effect at the individual level for self-reported physical activity; however, it was difficult to determine the extent of these effects based on the data presented, as children from both intervention and control schools increased their physical activity over time, and the mean differences between intervention and control schools decreased over time (78).

Eight studies used curriculum and physical education strategies among adolescents (37, 38, 63–65, 79–81), with only two resulting in increased physical activity (79, 80). Project Active Teens involved 1 day/week of concepts and 1 day/week of gym lessons over 1 year among students in grades 9–12 (79, 80). In the first wave of students, only the prevalence of participation in moderate- to vigorous-intensity physical activity increased significantly over 2 years, and only among boys. The prevalence of participation in vigorous-intensity activity did not increase for either wave. The Lifestyle Education for Activity Program assisted teachers to develop curriculum to improve the self-efficacy, self-regulatory skills, and motor skills among grade 9 girls (82, 83). The prevalence of participating in two or more 30-minute blocks of moderate- to vigorous-intensity physical activity/day did not change significantly over the 12-month evaluation period. However, the prevalence of participating in any 30-minute block of vigorous-intensity physical activity/day increased by 3.5 percent, a change which was statistically significant only after declines in prevalence in the control group were taken into account.

Ineffective studies included a teacher-designed, 10-week, health-related fitness course that involved lectures and introductions to different kinds of activity to adolescents aged 13–14 years (38). The Physical Activity and Teenage Health (PATH) Program incorporated delivery of classroom education sessions and 25-minute walk/run sessions on alternate days over 10 weeks to multiethnic grade 10 students (64). PATH was also modified to a daily program of circuit training plus 5-minute information sessions over 11 weeks (63); there was no change in physical activity. Bayne-Smith et al. (65) also evaluated the PATH Program among girls and found no change in physical activity. The New Moves Program offered physical activity sessions 4 days/week interspersed with knowledge/skill development sessions over a 16-week semester for grade 9/10 girls (66, 84). Only

small and nonsignificant changes in moderate- to vigorous-intensity physical activity occurred over 4 months.

In summary, the ineffective interventions promoting physical activity among adolescents had similar limitations to the curriculum-only interventions, including intervention and control groups within the same schools, the study conducted in just one school, control group solicited by teachers, and poor measures of physical activity participation. Among children, compared with curriculum-only interventions, including a focus on increasing physical activity during physical education lessons may be more effective for increasing children's physical activity during physical education (77) and generally (35). Among adolescents, the evidence suggests that adding physical education curriculum change to classroom curriculum change does not bring about substantial increases in physical activity.

Physical education only/physical education and environment. Two studies focused only on new physical education strategies (33, 85), and two also changed the school environment (25, 34). Three of the studies targeted children (33, 34, 85), and one study targeted youth aged 11–14 years (25). Donnelly et al. (33) delivered a 2-year intervention with third to fifth grade children that included aerobic activities for 30–40 minutes, three times/week, nutrition education, and modification of school lunches. Observed physical activity during physical education was significantly higher (6 percent) in the intervention group over the 2 years compared with the control group (33); however, there was no intervention effect for physical activity outside school hours, with greater increases among the control than the intervention group.

A more recent study in the United Kingdom (85) used a range of strategies to increase the physical activity of children aged 11–12 years during physical education (gym class). Over a 5-week period, intervention students spent a higher proportion of lesson time (19 percent) in physical activity (assessed by observation) compared with controls (14 percent), and the energy expenditure rate was 8 percent greater. Whether the increased physical activity during gym class increased overall physical activity participation is unknown (85).

The Australian Move It, Groove It study targeting children 7–10 years of age included physical education professional development for teachers, school project teams, a buddy program, a project website, and funding for equipment. It was effective in increasing the observed time spent in vigorous-intensity physical activity during physical education lessons among intervention schools (3 percent) compared with controls (34); however, neither physical activity outside school hours nor overall physical activity was assessed. The 2-year Middle School Physical Activity and Nutrition intervention targeted sixth to eighth grade children's nutrition, as well as changes to the school environment and increasing the time spent in moderate- to vigorous-intensity physical activity during physical education lessons, before and after school and during breaks (25, 86). Boys attending intervention schools engaged in more physical activity during physical education (4 minutes/lesson) and outside these lessons (3 minutes/day) compared with boys attending control schools. The results were not significant

for girls. Although the results were statistically significant among boys, the increases in physical activity were very small.

In summary, interventions that focus on physical education lessons among children or adolescents can have a small effect on activity during lessons. The impact on physical activity outside school or overall was equivocal.

Environment only. Three studies tested strategies to change the school physical environment for primary school-aged children (56, 87, 88). A study from the United Kingdom examined the effects of painting a school playground with fluorescent markings designed by children (e.g., pirate ship, clock face, hopscotch, snakes, and ladders) on the children's (ages 5–7 years) physical activity during breaks (assessed with heart rate telemetry). The time spent in moderate- to vigorous-intensity physical activity increased by 18 minutes/day and 10 minutes/day in the intervention and control schools, respectively (87). In a replication of this intervention among British children aged 4–7 and 8–11 years, it was found by use of heart rate telemetry that moderate- to vigorous-intensity physical activity increased from 37 percent of recess time at baseline to 50 percent at postintervention among children in the intervention group compared with a decrease from 40 percent of recess at baseline to 33 percent at postintervention among children in the control group (56).

A Belgian study tested the effectiveness of providing games equipment and activity cards (with examples of games and activities for the equipment) to fifth and sixth grade students and encouraged prompt use of equipment by the teacher (88). There were significant increases in girls' moderate-intensity physical activity during recess (12 percent decline and 10 percent increase in control and intervention groups, respectively) and total sample differences during the lunch break between the intervention group (12 percent increase in moderate, 1 percent increase in vigorous activity) and the control group (5 percent decrease in moderate, 6 percent decrease in vigorous activity).

These three studies produced small increases in physical activity. However, none assessed overall physical activity participation or whether increases in physical activity were maintained beyond the intervention period.

Curriculum, physical education, and environment. Only two studies have implemented whole-of-school strategies including changes to curriculum, physical education, and the physical, social, and organizational school environments; one targeted children (89) and one targeted adolescents (67). The first study intervention termed "Active Programme Promoting Lifestyle in Schools" used curriculum-based, physical education and environmental intervention strategies to reduce risk factors for obesity in children (89). The intervention included teacher training, modified school meals, and development of school action plans (targeting curriculum, physical activity, school canteens, and playground activities). The group-randomized controlled trial showed no effect of the intervention on children's self-reported frequency of activity and sport over the past week (89).

An intervention study by Cass and Price (67) targeted girls in grades 7–10 from a Middle Eastern cultural background and modified many curriculum and physical, social,

and organizational environmental aspects of the girls' school, as well as focusing on school-home-community links. Assessments were conducted in grades 7 and 10, and the changes were compared with an historical control group. Compared with the control, the intervention group demonstrated a significantly higher prevalence of participation in moderate- but not vigorous-intensity physical activity. As only two studies have been published using a whole-of-school intervention on young people's physical activity, it is not possible to draw any conclusions about the effectiveness of such strategies.

Activity breaks. Two studies have investigated the effectiveness of activity breaks on children's physical activity (45, 90). The intervention termed "Promoting Lifetime Activity in Youth" (PLAY) included the introduction of 15-minute play breaks during class time among children (45, 90). In the first evaluation, intervention class teachers taught games and activities during the breaks for 4 weeks, and children self-monitored their physical activity for the next 8 weeks (45). The comparison classes also had activity breaks but without prompting to be active, and the children recorded their television viewing rather than physical activity. After 12 weeks, boys and girls in the intervention group had significantly higher self-reported physical activity (10 percent and 7 percent increases, respectively) than did those in the control group (no change).

The second evaluation assessed the effectiveness of PLAY in schools that did or did not have a physical education program (90). Of the four groups (PLAY and physical education schools, PLAY-only schools, physical education-only schools, and no treatment control schools), children in the PLAY-only and PLAY and physical education schools recorded significantly higher steps/day at postintervention than did children in the control schools, and girls in the PLAY and physical education and physical education-only schools recorded significantly higher steps/day than did girls in the control schools. Although this latter study did not collect baseline physical activity data (90), it is notable that both studies found that the PLAY intervention had a significant effect on children's overall physical activity, by using either self-report (45) or objective measures (90).

Special classes/pedometers. One study examined the effectiveness of delivering special classes to promote adolescents' physical activity. Phillip et al. (91) delivered information about health and fitness over six sessions and conducted field trips to roller- and ice-skating rinks, aerobics classes, and hiking during summer programs to students in grades 9–12. There were no differences in physical activity between the control and intervention groups. However, the measures of physical activity were of poor quality and the sample size was small.

Two interventions assessed the effectiveness of pedometers in promoting adolescents' physical activity (41, 92). Zizzi et al. (41) sought volunteers from four high schools to participate in a walking intervention study. Half were allocated randomly to either a pedometer-only group or a pedometer plus goal-setting group. The goal-setting group was asked to set goals for the number of steps walked each day but was not given feedback on goal attainment; this group also received a health-related handout each week to

assist with the goal-setting process. The intervention was found to have no impact over the 3-week assessment period. Schofield et al. (92) administered three intervention strategies to low-active, grade 11–12 Australian girls: log book plus pedometer, log book only, or control. Six weekly 30-minute sessions were delivered involving discussions of the previous week's progress and problems, a brief education session on healthy eating, and planning for the ensuing week. The number of pedometer-measured steps increased significantly in both intervention groups (8,000- to 10,000-step increase over a 4-day count) compared with the control group, but self-reported physical activity did not. Although these results appear promising, the intervention was intensive and was assessed only over a short period (12 weeks). Further research using pedometers is needed before conclusions regarding their effectiveness in promoting children's and adolescents' physical activity can be made.

Tailored advice and/or brief counseling. Four studies among adolescents offered tailored advice and/or brief counseling in the school setting (40, 46, 68, 93). A computerized risk assessment and individualized behavior plan (30 minutes of exposure), evaluated over 3 months (93), was termed "Patient-centered Assessment and Counseling for Exercise + Nutrition" (PACE+). There was no significant impact on physical activity among girls. Among boys, activity increased by 2–9 minutes/week, significantly greater than that for the control group whose physical activity declined on average by approximately 30 minutes/week. Girls on the Move randomly allocated inactive girls from grades 6–8 to a control or intervention group (46). Intervention group girls responded to a series of computer-based questionnaires at baseline, 3 weeks, and 9 weeks and, on each occasion, received tailored advice on behavior change and a 10-minute counseling session with the school nurse. They also received three telephone counseling sessions, and their parents were mailed two tip sheets. There was no change in physical activity in the intervention group compared with the control group.

A brief motivational intervention by Werch et al. (40) focused on reducing alcohol consumption and promoting sport among grade 8 students. Adolescents were randomly assigned to one of three conditions: tailored prevention messages from school nurses focusing specifically on sport promotion; tailored prevention messages from school nurses focusing on sport promotion and avoiding alcohol use; and prevention messages targeting sport and alcohol plus print materials (mailing five postcards home to the students' parents). Although physical activity increased significantly in all groups at the 3-month follow-up assessment, the absence of a true control group, potential seasonal effects (the study commenced in fall and finished in spring), potential contamination across groups, and the short period of follow-up time limited confidence in the efficacy of this intervention. As a follow-up to the previous intervention, Project SPORT (a one-on-one fitness consultation with print materials) attempted to better integrate physical activity promotion with drug and alcohol prevention messages targeting students in grades 9 and 11 (68). Students were randomly assigned to receive either a brief personal health screen, fitness consultation, and a take-home fitness prescription followed by

a mailed flyer or a minimal comparison condition that received a “wellness” pamphlet administered in school and a mailed general brochure about health and fitness. The physical activity measures were administered at baseline, 3 months, and 12 months. Participation in moderate- but not vigorous-intensity physical activity increased significantly in the intervention group at 3 months but did not persist at the 12-month assessment.

While two of the four studies had modest effects (68, 93), it is not possible to determine if effects were diminished because of concurrent targeting of multiple behaviors. Other limitations include the possibility of contamination due to randomization of classes within schools (46, 68), although one study did measure and adjust for this (93). The use of computer-tailored feedback and behavioral programs among adolescents appears to be an acceptable and potentially sustainable approach within schools; however, the use of school nurses (provided schools have such a resource) who would need to be trained or the use of fitness consultants who would come at an extra expense to the school may not be feasible for many schools.

After-school programs. Two studies examined the effectiveness of after-school programs among adolescents (39, 47). Wilson et al. (47) recruited African-American students 11–15 years of age who had enrolled in an after-school sports program and randomized the adolescents to one of three intervention conditions to promote fruit and vegetable intake and physical activity: an education program with behavioral skills training and reinforcement and feedback; the same program with motivational interviewing; and only the educational program promoting fruits and vegetables and physical activity. There was no change in physical activity in any group over the 12-week intervention.

In a further study, Wilson et al. (39) also recruited grade 6 girls from two economically disadvantaged schools (intervention and matched control groups). The intervention involved three 2-hour after-school sessions/week over 4 weeks and comprised 60 minutes of student-selected activities and 30 minutes of behavioral skill training delivered by graduate students. Accelerometer-assessed, moderate-to vigorous-intensity physical activity increased significantly more in the intervention group (by 22.4 minutes/day) compared with the control group, which declined by almost the same amount over 4 weeks. It is not known if the positive impact was sustained beyond the brief intervention period.

School and family. Nine interventions used a combination of school curriculum and family-based strategies to promote children’s physical activity (42, 43, 53, 54, 94–98), seven reporting some element of success and two reporting no effects (43, 94). By far the most successful long-term intervention was conducted in Greece by Manios et al. (99) and Manios and Kafatos (100). Between 1992 and 1998, 831 children received an intervention based on the Know Your Body program (13–17 hours/year), two physical education lessons (each 45 minutes/week), classroom sessions delivered by physical education teachers (4–6 hours/year), 3–5 homework activities completed with parents per year, and two parental meetings at the school each year. Based on proxy-report at baseline and self-report at post-intervention, children in the intervention group had a signif-

icantly greater increase in physical activity outside school over the 6-year period compared with the control group (281 vs. 174 minutes/week) (99). These effects were maintained at the 4-year follow-up (38 vs. –13 minutes/week) (100).

The Child and Adolescent Trial for Cardiovascular Health (CATCH) study was a 3-year intervention delivered to more than 4,000 children aged 8 years who were attending 96 schools (97). Half of the intervention schools delivered the CATCH program (increased physical activity during physical education classes, health promotion curriculum, and food service changes), and the other half delivered the CATCH program and a family-based component of 19 physical activity packs/curriculum over the 3 years. Although children attending intervention schools participated in more intense physical activity during physical education compared with controls (observed) and at postintervention participated in more daily vigorous-intensity activity compared with controls (59 vs. 47 minutes/day), there were no additional effects among children in the CATCH plus family-based intervention compared with the CATCH-only intervention children. The overall intervention effects were maintained, although slightly attenuated, at 3-year follow-up (44). When the generalizability of the CATCH intervention was tested among Hispanic children attending low-income schools (El Paso CATCH), where teachers were encouraged to adapt the materials for their school, children in the intervention schools engaged in a greater amount of vigorous-intensity activity during physical education lessons compared with children in control schools (53). However, overall physical activity was not assessed. In summary, although it appears that the CATCH intervention is effective for promoting physical activity during physical education, it is unclear whether it is also effective in promoting children’s overall physical activity (the original CATCH study did not include baseline measures of overall physical activity). Although El Paso CATCH did not test the family component separately, this element did not appear to have additional effects on physical activity in the earlier study (97).

One other school- and family-based intervention that has been shown to be effective is the Sports, Play, and Active Recreation for Kids study (96). This 2-year intervention focused on increasing children’s physical activity in physical education lessons in grades 4 and 5; included a curriculum-based program, homework, and monthly newsletters to parents to stimulate parent-child interaction; and compared specialist-led with teacher-led effectiveness of the program (96). Although the effects on physical activity participation during physical education were greater in the specialist-led classes compared with the teacher-led classes, which in turn were greater than in the control groups, there were no significant differences among groups for overall physical activity (measured by accelerometry at postintervention only) or for self-reported physical activity outside school hours.

The Pathways intervention targeted Native American children’s physical activity and nutrition while they were in grades 3–5 (54). It included a curriculum program, physical education lessons, exercise breaks during class, changes to the school food service, and family involvement in creating supportive environments at home and family events at

schools. This 3-year intervention produced no differences between control and intervention children based on 24-hour accelerometry data (from postintervention only), and although self-reported physical activity (24-hour recall) declined in both groups, the average decline was lower in the intervention group (23 percent) compared with the control group (31 percent).

The Be Smart intervention assessed the effectiveness of nutrition and physical activity programs, alone and together, compared with a general health group over one school year among British children aged 5–7 years (98). Although the authors report modest effects on self-reported physical activity during morning recess and lunchtime among some groups and no effects on walking to school or physical activity outside school, no statistical tests appear to have been performed. Another pilot study among sixth grade Greek children that used similar intervention strategies over 1 year was effective in increasing children's self-reported organized physical activity and the proportion of children meeting physical activity recommendations (45 percent absolute increase among intervention children, 29 percent increase among controls) (95).

Of the two studies that were not effective, the study by Fitzgibbon et al. (43) aimed to prevent progression to overweight among young children (3–5 years) from African-American families. However, the proxy-reported physical activity frequency and intensity measure that was used may not have been able to detect intervention effects in such young children, and the extent to which families engaged in the program was not reported. The other school- and family-based intervention study that reported no significant effects on physical activity involved an 8-week program that used a combination of multimedia, CD-ROM, classroom-based activities, as well as homework assignments involving family members for promoting activity among fourth grade children (94). The extent of family involvement was not reported, and the investigators speculated that further tailoring of the materials to meet the needs of boys and girls and children from different ethnic backgrounds may be necessary. Further, the intervention may have been too brief.

In summary, most interventions that incorporated school- and family-based components have been shown to be successful in promoting increases in at least some elements of children's physical activity. No studies were found that included school and family components in promoting adolescents' physical activity.

School and family/community. Six interventions delivered in schools also involved the community in some way (31, 51, 62, 101–104), with three of these also incorporating family-based strategies (31, 51, 62). The Eat Well, Keep Moving study was a 2-year study targeting African-American children from grades 4 and 5 which incorporated curriculum, family-based strategies, and links between parent liaisons at schools and community organizations (51). The intervention was not effective in increasing children's vigorous physical activity in the previous month.

The Kahnawake Schools Diabetes Prevention Project targeted Native American children in grades 1–6 and incorporated curriculum, mass media, community events, and construction of sidewalks and bicycle paths (62). There

were no differences in self-reported physical activity at postintervention nor after 6 years. The third study involved 21 schools in the United Kingdom that received 16 hours of expert assistance from a school travel coordinator to develop and implement travel plans (101). There were no effects on children's active transport compared with that of control schools, on the basis of proxy-reported active transport on the day of the survey.

Three intervention studies incorporated school and community strategies in promoting physical activity from childhood to adolescence (31, 102–104). Action Heart was a community-wide initiative aimed at reducing the prevalence of risk factors for cardiovascular disease across the population in the United Kingdom (31). The school-based component targeted youth 11 and 14 years of age and included peer-led health education, policy development, an Action Heart club and charter, publicity, and curricular activities. The community component included family exercise initiatives and policy implementation. There was an overall intervention effect of 4 percent of children participating in physical activity ("exercise") three or more times/week among children attending intervention versus control schools. It was perceived by the investigators that the intervention effect was due more to physical activity increases in children 11 years of age than to any real intervention effects.

A multicomponent, prospective, comparative study that used a community-wide intervention conducted over 4 years in eastern France, known as the "Intervention Centered on Adolescents' Physical Activity and Sedentary Behavior," involved students who were 11 years of age at the commencement of the intervention (104). Investigators developed a multilevel program that included individual, social, and environmental strategies to promote children's physical activity. Six months into the intervention it was found that the proportion of participants not doing physical activity outside schools (in sports clubs or through study activities) was reduced from 36 percent to 17 percent compared with controls and was more marked among girls than boys. The outcomes of the remaining 3.5 years are yet to be published.

The Class of 89 Study was a 5-year health behavior program nested within the Minnesota Heart Health Program (102, 103). Grade 6 students were recruited from two communities in Minnesota with one cohort receiving an educational intervention. In seventh and eighth grades, students received booster session greeting cards (one targeting smoking, one targeting physical activity), and eighth grade students were also involved in a competitive peer-led program that encouraged them to exercise outside school hours for 4 weeks. Grade 10 students were exposed to Slice of Life (a 10-lesson, peer-led curriculum promoting healthy eating and regular exercise) (102). Students were also indirectly exposed to broader community-based initiatives, such as risk factor screening, direct education, mass media campaigns, and environmental change. Among boys, there were no differences between the intervention and reference communities. However, compared with girls in the reference community, those in the intervention community reported significantly more time in exercise at each of the annual assessments (range of mean difference: from -0.4 to -0.8 hours/week) except for grade 11.

In summary, one school-based intervention that incorporated a community element was successful in promoting physical activity among girls (102, 103), one reported promising initial effects (104), and one reported weak inconclusive effects (31). The other three interventions were not successful (51, 62, 101).

Family-based interventions

Of nine family-based physical activity interventions, eight targeted children (49, 52, 59–61, 105–107) and one targeted adolescent girls (30, 108). There were many pilot interventions, mostly part of the US Girls' Health Enrichment Multisite Studies. Two of the nine interventions ran between 1 and 3 years (106, 107), with the remainder being short-term interventions (on average, 12 weeks). Two of the short-term interventions were successful (30, 105), and three showed positive trends (49, 52, 61). One study of 300 Canadian children aged 6–12 years (105) assessed the efficacy of promoting print materials through the mass media and sending them to families. The study was not controlled, and the proxy-report measure of active play was crude and of unknown validity and reliability. The uptake of the intervention was higher among mid-high socioeconomic status families, and only 27 percent of families remained in the study at follow-up. The proportion of families reporting active play once a day or more had significantly increased from 28 percent at pretest to 55 percent at posttest (105). However, with such high attrition and in the absence of a control group, the results may be unreliable.

The Daughters and Mothers Exercising Together program compared the effectiveness of a center-based versus home-based mother-daughter intervention with 34 mother-daughter (aged 11–17 years) pairs and triads recruited from the community (30, 108). The program consisted of 24 sessions delivered over 12 weeks, with the center-based participants attending three sessions/week delivered by an instructor and the home-based group required to complete three physical activity sessions/week in or near home. Both groups significantly increased participation in vigorous-intensity activity. There was no control condition, however, so it is not possible to determine how much of these effects can be attributed to the intervention.

Of the two longer-term, family-based interventions, only the 3-year Finnish intervention targeting children 4 years of age was shown to be effective (106). Strategies included annual meetings with parents, delivery of print materials biannually, an annual physical activity demonstration session with children, and a one-off radio program for parents. By use of a physical activity diary that assessed sleep and indoor play and outdoor play, it was found that intervention children spent more time in very active outdoor play than did controls (3.11 vs. 1.99 hours/weekend).

Although there was variation in the strategies used, all family interventions were based on theory, apart from one study that did not specify which theory was used (59). In one study, the participant compliance rates were low (25 percent), suggesting poor uptake of the program (59), and a low study retention rate was a concern for another study (105). However, retention rates for participants in the fam-

ily-based interventions were reasonably high overall. Many of the family-based intervention studies targeted young people from ethnic minority or low socioeconomic status groups. Further studies assessing generalizability of the intervention and testing effective strategies for engaging families and increasing children's and adolescents' physical activity are required.

Primary care interventions

Six primary care studies have been published: one Irish study (24), one Spanish study (26), one British study (109), and three US studies (27, 28, 58). Two studies targeted children (58) or children and adolescents (24), and the remainder targeted adolescents. The Irish Galway Health Project (24), which was uncontrolled, targeted those aged 8–11 and 12–15 years who presented at 12 different primary care practices. The 10-minute intervention involved a one-off interview with either a general practitioner or nurse and take-home educational materials. After 12 months, self-report frequency of participation in 15- to 20-minute exercise bouts/week was not significantly different from baseline (24). However, the psychometric properties of the self-report instrument are not known, and the study lacked a true control group and suffered almost 50 percent loss to follow-up.

In Spain, Ortega-Sanchez et al. (26) conducted a study in which physicians provided three 10-minute counseling sessions over a 12-month period to 448 adolescents (12–21 years). Substantial and statistically significant increases in physical activity at both 6-month and 12-month follow-up assessments were reported (a 36-minutes/week and a 48-minutes/week increase in the intervention group compared with a –28-minutes/week and a –36-minutes/week decline in the control group at 6 and 12 months, respectively). Nevertheless, the study had two significant limitations: the validity of the physical activity measure was not reported; and those who administered the measures (the physicians) were not blinded to the intervention. In the United Kingdom, Walker et al. (109) recruited adolescents aged 14–16 years from general practice registers for a 20-minute intervention delivered by practice nurses. No details were provided regarding the measurement of physical activity, and no significant changes were reported at 3 and 12 months postintervention.

A primary care pilot study (58) was conducted with children 7–12 years of age from low-income, African-American families in the United States attending one primary care clinic. Both groups received a 5- to 10-minute family counseling session with the primary care provider and a brochure addressing the risks of excess media use. The intervention group also received an additional 15- to 20-minute discussion regarding children's television budgets, a brochure that incorporated monitoring of media use, establishing and maintaining a media budget, and an electronic television time manager. Although posttest data were collected after 4 weeks, it is unclear how long the intervention families kept the television time manager. On the basis of a questionnaire that was self-administered at baseline and administered by telephone for some at posttest, there was a

significant increase in organized sport participation in the intervention compared with the comparison group (2.5 vs. -3.6 hours/week). An increase in outdoor play (1 hour/week) compared with the comparison group (-4.7 hours/week) approached significance.

PACE+ involved recruiting those aged 11–18 years prior to a physician visit (28). Participants completed a computerized assessment of their activity and food habits, chose a behavior to target, and received a tailored self-change plan endorsed by the physician. After 4 months, there were a significant increase in vigorous-intensity physical activity (17 percent) over time and a nonsignificant increase in moderate-intensity physical activity (10 percent) among those who targeted that behavior. In a second evaluation of PACE+, those aged 11–15 years were recruited by contacting those due for a well-child visit and through outreach programs (27). The intervention strategies were similar to those of the earlier study (28) with the exceptions that the participants were given a manual that provided instruction on behavior management strategies and a plan was also provided to parents. Eleven telephone-counseling calls were made over the next 12 months, and supplementary worksheets and tip sheets were mailed to the participants. The number of active days (participation in ≥ 30 minutes of vigorous-intensity physical activity, ≥ 60 minutes of moderate-intensity physical activity, or a combination of both) increased significantly by 0.3 days/week among intervention group boys. However, there was no change in the self-reported number of minutes of activity or in accelerometer-measured activity among boys or girls.

Of the six studies that evaluated the impact of primary care-based interventions, two resulted in no change in physical activity (24, 109), with the remainder reporting some impact on child and/or adolescent physical activity. In spite of methodological limitations (e.g., no control group), primary care-based interventions show some promise. However, more research in this setting utilizing study designs capable of determining efficacy and effectiveness, with adequate sample size, measures, and analyses, is required.

Community-based interventions

All three community-based studies were conducted in the United States, and each targeted children (29, 36, 110). Huhman et al. (29) assessed the effects of a 12-month mass media campaign (television and print advertising, in-school promotions, radio and Internet communications) among those aged 9–13 years. Child-parent diads who were unaware of the campaign were used as “controls.” No overall effects on children’s free-time physical activity, organized sport sessions at the population level, or previous days of physical activity were identified, although there were some effects in subgroups (e.g., girls aged 9–10 years, parents with less than a high school education, those living in high-density urban areas, and those who were low active at baseline).

In the second community-based study, a cross-sectional retrospective evaluation was used to assess the impact of changes to areas surrounding schools including the following: traffic control; improvements to pedestrian crossings;

and sidewalk improvements (new and improved sidewalks, bicycle paths) (110). The study was conducted with a sample of third and fourth grade children; those who did not pass the improvements on the way to school were treated as the comparison group. Posttest data were collected 1–18 months after the completion of construction (average of 12 months). Based on parent proxy reports, a higher proportion of parents with children who passed by the improvements reported that their child walked or cycled more compared with those who did not pass by the improvements (15 percent vs. 4 percent) (110).

Active Winners was an 18-month intervention primarily targeting African-American children 11 years of age. This intervention incorporated four key strategies: intensive summer and after-school physical activity programs; newsletters for families; formation of committees to improve school environment; and newspaper articles and physical activity at local events (36). No significant differences were found between the intervention and control groups. Attendance at many of the sessions (especially the day camps) was very low (5 percent of children attended just half the sessions); however, further analyses by attendance groups (low, moderate, high program attendance) also revealed no effect.

In summary, the community-based interventions were limited by study design issues (e.g., retrospective design, no true control condition) and low response (110) and participation (36) rates. Drawing conclusions on the effectiveness of changing environments is limited by variations in the number and intensity of improvements in each site, even within the same types of changes (110), highlighting the challenges of evaluating such interventions. The mass media campaign may have been effective in particular subgroups, importantly among the low active (29).

Internet-based interventions

Marks et al. (32) randomly allocated girls in grades 6–8 who had home Internet access to either a website or print intervention group. The website intervention included interactive games, quizzes, planning charts, and behavior management strategies, and the print intervention group received a printed workbook similar to the website in content, appearance, and organization. Physical activity increased significantly over the 2-week evaluation period in the print intervention group only. The absence of a control group and the very short time period between assessments are limitations of this study.

Summary of outcomes

In table 1, a summary of the outcomes of the interventions delivered to primary school-aged children using objective measures of physical activity reports positive findings (12 of 18 studies) compared with studies that used survey measures (12 of 34 studies). Further, six studies that used both survey and objective measures demonstrated positive or at least weak effects from the objective measures but no effect based on the survey (25, 33, 49, 52, 61, 96).

Table 2 shows a summary of physical activity outcomes for interventions targeting adolescents. Although fewer

TABLE 1. Summary of intervention outcomes by strategy and physical activity measures (children)

Intervention setting and strategy	Overall		Physical activity measure			
	Findings*	References	Survey		Objective/observational	
			Findings	References	Findings	References
School						
Curriculum only	0	50, 69–71	0	50, 69–71		
	+	55	+	55		
Curriculum and physical education	+	35, 77	+	35, 77	+	35
Curriculum, physical education, and environment	0	89	0	89		
Physical education only	+	33, 85	0	33	+	33, 85
Physical education and environment	+	34			+	34
Environment only	+	56, 87, 88			+	56, 87, 88
Activity breaks	+	45, 90	+	45	+	90
School and family	+	25, 53, 54, 95–99	+	54, 95, 98, 99	+	25, 53, 96, 97
	0	25, 43, 54, 94, 96, 98	0	25, 43, 96, 98	0	54, 94
School, family, and community	0	51, 62, 101	0	51, 62, 101		
Family						
Education	+	105	+	105		
Education and physical activity sessions	0	59, 107	0	49, 59, 61, 107	~	49, 61
	+	106	+	106		
	~	49, 61				
Education, physical activity sessions, and family nights	~	52	0	52	~	52
Day camp and Internet delivery	0	60	0	60	0	60
Primary care	+	58	+	58		
Community	~	29	~	29		
	+	29	+	110		
	0	36	0	36		

* 0, no association; ~, positive trend, not statistically significant; +, positive outcome, statistically significant.

TABLE 2. Summary of intervention outcomes by strategy and physical activity measures (adolescents)

Intervention setting and strategy	Overall		Physical activity measure			
	Findings*	References	Survey		Objective/observational	
			Findings	References	Findings	References
School						
Curriculum only	+	74	+	74	0	75
	0	48, 69, 72, 75	0	48, 69, 72, 75		
	~	57, 76	~	57, 76		
Curriculum and physical education	+	37, 79	+	37, 79		
	0	38, 63–65	0	38, 63–65		
	~	66, 84	~	66, 84		
Physical education and environment	+	25			+	25
Curriculum, physical education, and environment	+	67	+	67		
Special classes/pedometers	+	40, 92	+	40	+	92
	0	41, 91	0	41, 91, 92		
Tailored advice/brief counseling	+	68, 93	+	68	+	93
	0	46	0	46		
After-school programs	+	39			+	39
	0	47			0	47
School/family and community	+	103, 104	+	103, 104		
	~	31	~	31		
Family	+	30	+	30		
Primary care	+	26–28	+	26–28	0	27
	0	24, 109	0	24, 109		
Internet based	+	32	+	32		

* 0, no association; ~, positive trend, not statistically significant; +, positive outcome, statistically significant.

studies among adolescents used objective measures compared with studies of children, approximately half of those that used an objective measure (four of seven studies) reported a positive intervention outcome for adolescents' physical activity, whereas fewer than half (13 of 32 studies) that used a survey measure reported positive intervention outcomes. When combined with the children's outcomes, 38 percent of studies that used survey measures of physical activity (25 of 66) reported a positive intervention effect, whereas 64 percent of studies that used an objective measure of physical activity (16 of 25) reported a positive intervention effect.

DISCUSSION

This narrative review of the effectiveness of 76 physical activity interventions for young people suggests that, while there is a growing body of evidence of strategies in school settings, evidence about intervention strategies within other settings is very preliminary. Although it is difficult to compare studies and many had major limitations, on balance, interventions delivered in the school setting that included some focus on physical education, that involved activity breaks, or that included family strategies appeared to be the most effective among children. Among adolescents, in-

terventions in primary care settings and tailored advice/brief counseling appeared to be most effective. Although interventions delivered in the family setting showed weak positive trends, many were pilot studies that were not adequately powered to detect group differences, and we found only one intervention delivered in the family setting that targeted adolescents' physical activity.

Among children, studies that focused on increasing physical activity during physical education lessons, as well as incorporating curriculum and/or environmental changes, were more effective than curriculum-only interventions. However, a major limitation of many of these studies was that overall physical activity levels were not assessed. Previous research suggests that children may compensate for higher levels of physical activity during school by reducing their physical activity outside school (111). Consistent with previous review findings (9), interventions that utilized activity breaks and those that made simple environmental changes in the school setting also showed promise. Although not always reported, such strategies are likely to be sustainable, little training is required, and they are likely to promote less structured types of physical activity (e.g., active play) that can be performed any time with little equipment. As with the adult literature (112), tailored advice/brief counseling intervention strategies based on theoretical models of behavior change showed promise among adolescents. However,

evidence of the efficacy of after-school programs and special classes/pedometers in that age group was equivocal.

Consistent with findings from an earlier review of physical activity interventions among young people (10), involving family appears to enhance the effectiveness of interventions delivered in the school setting. Of the 16 school-based studies that reported a family component, 11 reported some level of effect. Although including family and community elements in school-based physical activity interventions showed positive outcomes among adolescents, none of the studies that incorporated a community focus with a school-based physical activity intervention were effective among children. Likewise, of the nine interventions that were delivered in the family setting, three reported positive outcomes, and the results of three approached significance. Although the evidence was not overwhelming, most families showed high levels of compliance and retention (possibly a reflection of the types of families likely to volunteer for such studies). Interestingly, intervention dose did not appear to be a critical factor for some interventions delivered in the family setting. The Finnish family intervention, for example, involved minimal contact over a 3-year period yet reported positive effects on children's active play (106), suggesting that small repeated intervention doses via parents may be enough to effect children's behavior change. Including parents in children's physical activity interventions (delivered through schools or the family) may be important given that parents are the likely gatekeepers of children's physical activity outside school hours, and there are many family-related correlates of children's physical activity (e.g., role modeling, social support) (113). Among adolescents, further family-based intervention studies are needed to generate evidence to either support or refute its relevance for that age group.

Of the six interventions delivered in the primary care setting, four reported positive effects on young people's physical activity (three targeted adolescents). Reviews of physical activity interventions delivered in the primary care setting targeting adults (114, 115) have concluded that short-term changes in physical activity can be achieved in a brief intervention; however, evidence of long-term effects is weak, and other strategies and support from other sectors (e.g., community, family) may be required to sustain change. Further strategies (in addition to brief counseling) and family support appear to be important for promoting physical activity among young people (27, 28, 58) and, unlike studies with adults, may also have longer-term effects (26, 27).

The only intervention to examine the impact of Internet-versus print-based delivery modes on adolescents' physical activity reported positive outcomes in the print group only (32). Other interventions that incorporated an Internet/Web-based strategy targeting children's (50, 60) or adolescents' (57) physical activity reported no effects; although none of these compared Web-based delivery with other modes of intervention delivery, studies with adults have also found print-based delivery to be more favorable than Web-based delivery (116). Considering that the Internet is a popular and frequently used medium among young people, more research into the efficacy and effectiveness of Internet- or Web-based approaches for promoting young people's physical activity is needed.

There are a number of common methodological flaws in many of the 76 studies reviewed. These include the following: no baseline data; poor study design (e.g., no control group, no baseline data); atheoretical, physical activity measures of unknown reliability and validity; and poor reporting of study details (e.g., sample size, response rates, attrition/retention, compliance, year of intervention, duration of intervention). A higher proportion of studies that used objective measures of physical activity reported positive intervention effects compared with those that used survey measures. This clearly illustrates the importance of using an objective measure of physical activity to determine program effectiveness and, if self-report measures are to be used, they need to be valid, reliable, and sensitive to behavioral change. Other important limitations include a lack of follow-up data on interventions and a lack of reporting of mediators of short-term and long-term behavior change.

As noted in the Introduction, publications reporting the results of evaluations of intervention studies should follow the Consolidated Standards of Reporting Trials guidelines (20) or, for nonrandomized studies, should follow the Transparent Reporting of Evaluations with Nonrandomized Designs guidelines (21). Given that so few studies followed these guidelines and, apart from school-based initiatives, much of the evidence of the efficacy of physical activity interventions among young people is still emerging, we considered it important to be inclusive and to also include less rigorous designs in the interests of communicating the range of strategies that have been included in trials but that could be replicated with a stronger design. Interventions that were evaluated with a less rigorous design provide preliminary but important information regarding potentially promising intervention strategies for promoting physical activity among young people.

It is recommended that future interventions include a longer follow-up period (1–2 years) to determine maintenance effects. In addition, there is a need to develop and test theoretical approaches through mediator analyses. In order to develop a better understanding of the successful elements of each intervention, reporting the short- and long-term mediators of change in physical activity behavior is critical for understanding the mechanisms of change and increasing the likelihood of efficacious interventions in the future. More studies are required in a variety of subgroups and across different countries to increase generalizability of study findings. Although there is some evidence of intervention effectiveness in both the school and family settings, the use of motivationally tailored strategies, and program delivery in the primary care setting, further evidence of efficacy and sustainability of interventions promoting young people's physical activity in the family and community settings is needed.

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