Estimated Energy Expenditures for School-Based Policies and Active Living

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Background: Despite overwhelming evidence of the health benefits of physical activity, most American youth are not meeting the 60 minutes per day recommendation for moderate- to vigorous-intensity physical activity (MVPA). Policy changes have the potential to bring about substantial increases in physical activity in youth, within school and community settings.

Purpose: The purpose of this study was to quantify the increase in energy expenditure for school-based policies and built environment changes.

Methods: Scientific literature reviews were consulted, and more than 300 published studies (1995–2011) in English were identified based on titles and abstracts. After an initial screening, 85 articles were included. Study quality was assessed, and the impact of various strategies for increasing physical activity in youth was estimated from objective measurements/direct observation.

Results: Within school settings, the average minutes of MVPA gained per school day for studies in each intervention category were as follows: mandatory physical education (23 minutes); classroom activity breaks (19 minutes); afterschool activity programs (10 minutes); standardized physical education curricula (6 minutes more than traditional physical education); modified playgrounds (6 minutes); and modified recess (5 minutes more than traditional recess). Within community settings, significant MVPA was associated with active commuting (16 minutes) and park renovations (12 minutes), but proximity to parks had a small effect (1 minute). No conclusions could be drawn regarding joint-use agreements, because of a lack of studies quantifying their impact on energy expenditure.

Conclusions: Of the various policies and built environment changes examined, the largest effects were seen with mandatory physical education, classroom activity breaks, and active commuting to school. Policymakers can use this information along with estimates of the cost, feasibility, and population reach, to identify the best options for increasing physical activity in youth.
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Background

Physical activity has many health benefits in children, including increased physical fitness, reduced body fatness, improved cardiovascular and metabolic disease risk profiles, enhanced bone health, and reductions in symptoms of anxiety and depression.[1] Despite overwhelming evidence of the health benefits of physical activity, and national efforts to educate and implore individuals to become more active over the past few decades, most U.S. children and adolescents are not sufficiently active. For instance, based on accelerometer data from the National Health and Nutrition Examination Survey (NHANES), only 42% of U.S. children aged 6–11 years meet the national physical activity guideline of at least 60 minutes of moderate- to vigorous-intensity physical activity (MVPA) per day, and fewer than 8% of U.S. adolescents achieve this goal.[2] In addition, pedometer studies indicate that boys and girls in the U.S. and Canada are less active than those in other countries.[3]

There is great potential to increase physical activity through policy changes affecting schoolchildren (K–12) and altering the built environment. Several types of interventions have been demonstrated to increase physical activity levels of energy expenditure in youth. For exam-

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ple, providing regularly scheduled physical education classes, adopting standardized high-quality physical education curricula designed to keep youth moving, providing daily recess with ample game equipment, integrating classroom physical activity breaks into the normal school day, modifying school playgrounds to promote active play, and afterschool programs have all been shown to increase physical activity in youth.[4]

In addition, it is possible to increase the amount of physical activity that children acquire within their neighborhoods, as they go about their daily activities. The CDC *Community Guide* recommends the following approaches: (1) community-scale urban design and land use policies; (2) creation of, or enhanced access to, places for physical activity combined with information outreach; (3) street-scale urban design/land use policies; and (4) point-of-decision prompts to increase use of stairs.[5]

Individual or small-group approaches have been shown to increase physical activity levels in children and adolescents. However, in order to increase the reach of physical activity interventions, researchers and practitioners are turning to *policy* as a means to increase population-level physical activity.[6] Policy refers to laws, regulations, and rules that can change physical, economic, and social environments.[6,7]

The CDC has recently released recommendations for school-based policies, called *School Health Guidelines to Promote Healthy Eating and Physical Activity*.[8] Some school policies, such as mandatory physical education, would require a legislative mandate. However, other policies contain an element of choice, and would "nudge" children to make good decisions by making the healthy choice the easy choice.

As Eyler[6] has noted, there are several benefits to using a policy approach to attack a public health problem. Policy interventions can benefit everyone exposed to the environment, rather than focusing on changing the behavior of one person at a time. In addition to a broader scope, a policy intervention may have a substantial impact on a population for a considerable length of time.

For policymakers, it is not easy to determine which approaches would have the greatest impact on a desired behavior. Thus, the purpose of this project is to quantitatively estimate the increase in energy expenditure for school-based policies and built environment changes, in community and school settings. With this information, it is hoped that policymakers and school administrators will have more detailed information so that they can make better informed decisions to promote physical activity among children and adolescents.

Methods

Comprehensive recent literature reviews were consulted to identify effective strategies for increasing children's physical activity levels. Investigators sought to identify built environment changes or policy interventions that have been shown to increase levels of physical activity in youth. For example, an Active Living Research evidence synthesis (*School Policies on Physical Education and Physical Activity*)[4] was consulted, which discussed the impact of the following practices:

- Regularly scheduled physical education classes
- Quality in-service training for physical education and classroom teachers
- Daily recess with ample game equipment
- Classroom activity breaks
- Modified school environments including playgrounds and open spaces
- Afterschool programs
- Joint-use agreements between schools and communities

The *Community Guide*,[5] which includes environmental and policy approaches to increasing physical activity, also was consulted. Several approaches/strategies are recommended, including community-scale urban design and land use policies, creation of or enhanced access to places for physical activity, street-scale urban design, and point-of-decision prompts. In addition, comprehensive recent reviews on physical education,[9] parks,[10] active commuting,[11] school siting,[12] afterschool programs,[13] and other approaches to increasing physical activity in youth also were consulted. Additional literature searches were conducted using PubMed and SPORTDiscus to locate recent studies on these topics.

More than 300 original investigations published between 1995 and 2011 were identified based on the titles and abstracts. After an initial screening of the articles, 85 underwent additional review. In the final analysis, 65 articles met the inclusion criteria described below and could be translated into energy expenditure. Seven of the interventions in the report on *School Policies on Physical Education and Physical Activity*[4] and two other approaches (municipal parks and walking/biking to school) were examined.

Quality Ranking Score

The rigor or quality of each study was ranked using a 9-point scale, as reported by Wu et al.[14] The presence or absence of dichotomous criteria was determined, including (1) a control group; (2) random recruitment of participants and response rate >60%; (3) similar baseline characteristics between control and comparison groups; (4) attrition rate <30%; (5) assessment period more than 1 day; (6) follow-up being at least 6 months after the intervention; (7) objective measure of physical activity; (8) a reliable and valid measurement tool; and (9) that the participant's baseline activity was below the national physical activity guidelines. Studies that achieved an eligibility criterion of three or higher were included in the analyses to determine energy expenditure. This ensured that the study design was sufficiently rigorous, but not so rigorous as to exclude all cross-sectional studies. As the quality ranking scores increase, only RCT studies can qualify, and the panel determined that there was merit in including cross-sectional studies.

Table 1. Formulas for translating physical activity outcomes

Reported measure	MET-hour gained per day translation formula[a]
kcal/kg/minute	(kcal/kg/minute)× (average weight)×(6/7)
kcal/minute	(kcal/kg/minute)×(6/7)
kcal/week	(kcal/week)/70/7
Steps/day on walking	(Steps/10,000)×4.25× (1/3)×(3 MET)
30-minute blocks in physical activity per day	[(30-minute block/4]× MET assigned
Minutes/day on physical activity	[(minutes/day)× MET assigned]/60
% people meeting guideline	(% people)×(1.5 MET-hour for adults or 3.0 MET-hour for children)
MET minutes/week	(MET minutes/week)/60/7
Active days (at least 3 MET-hour) per week	(active days)× (3.0 MET-hour)/7

Note: Definitions/default values: If the study outcome is time spent in moderate- to vigorous-intensity physical activity (MVPA), the assigned MET level is the average of moderate physical activity (MPA) and vigorous physical activity (VPA)=(3+6)/2=4.5 (all people). MPA=3.0 MET, VPA=6.0 MET; walking speed: 20 minutes/mile. 10,000 steps=4.25 miles. To get a reasonable baseline, subtract 5000 steps. School recess time: morning=15 minutes, lunch=30 minutes. Reprinted with permission from: Wu S, Cohen D, Shi Y, et al. Economic analysis of physical activity interventions. Am J Prev Med 2011;40(2):149–58.[14]

[a]Gives the equivalent of 1 MET-hour.

Estimates of Energy Expenditure

Objective methods used to assess physical activity in these studies included accelerometers, pedometers, heart rate monitors, and direct observation (e.g., System of Observing Fitness Instruction Time, and System for Observing Play and Leisure Activity in Youth). Studies relying solely on self-report instruments to assess physical activity were not included because children can have difficulty remembering aspects of physical activities that they have performed in the past (e.g., intensity, duration, frequency, and mode). Energy expenditure was estimated using the primary physical activity outcome variable in each article (minutes of MVPA, pedometer steps, or % of classroom time spent in physical activity).

These outcome variables were converted to a common unit (MET-hour gained per day, using the usual definition of MET).[14,15] MET-hour is a common scientific variable that expresses the volume of physical activity and is computed by multiplying the energy expenditure of an activity (in METs) by the duration over which the activity is performed (in hours).[15] For example, a 3-MET activity performed for 20 minutes is equivalent to 60 MET-minute or 1.0 MET-hour. The impact of various strategies designed to increase physical activity in youth was determined, and the strategies were rank-ordered in a way that could be useful to policymakers and advocates. Thus, the MET-hour gained were converted to minutes of MVPA, using an energy expenditure value of 4.5 METs for MVPA (Table 1).

Results

The study characteristics, quality ranking score, and the amount of physical activity gained as a result of each school policy or built environment change, were summarized into tables (Appendix A, available online at www.ajpmonline.org). To visualize the results of numerous studies, a "box and whiskers" plot was constructed to illustrate the range and distribution of the effects for each approach (Figure 1). Because the studies with large sample sizes were believed to have greater evidence of ability to be translated into policy interventions with a broad scope, a weighted mean was computed for each study in accordance with the sample size. This allowed rank-ordering of the various approaches according to their effect sizes on physical activity energy expenditure.

Figure 2 illustrates the minutes of physical activity associated with each of the school policies and built environment changes. After converting the physical activity outcome variables to MET-hour gained, the weighted means for each category were then converted to minutes of MVPA, assuming a 4.5-MET equivalent for MVPA. If multiple policies were implemented, the combined effect would assist youth in meeting or exceeding the national physical activity guidelines (60 minutes per day). Many of these policies can be implemented within the normal school day, whereas others (e.g., afterschool programs) are ancillary to schools.

Discussion

In the present study, the impacts of policy interventions and built environment changes on daily caloric expenditures in school-aged children were estimated. The data were converted to a common metric for physical activity energy expenditure (MET-hour gained per day), to allow the impacts of various interventions to be compared. Taken together, the analysis suggests that policies mandating daily physical education may have the greatest impact on physical activity of U.S. youth.

The studies reviewed indicate that traditional physical education classes increase physical activity; there were no modifications to the curriculum or activities within the classes. Physical education helps children to develop motor skills (e.g., throwing, catching, kicking) and other important skills (e.g., teamwork, self-confidence, and understanding of concepts that foster healthy living).[16,17] Despite the fact that 78.3% of schools in the U.S. require students to take physical education, in 2006 only 3.8% of elementary schools, 14.5% of middle schools, and 6.6% of high schools offered daily physical education.[9] With 55 million elementary, middle, and high school students in the U.S.,[18] a policy that mandated daily physical

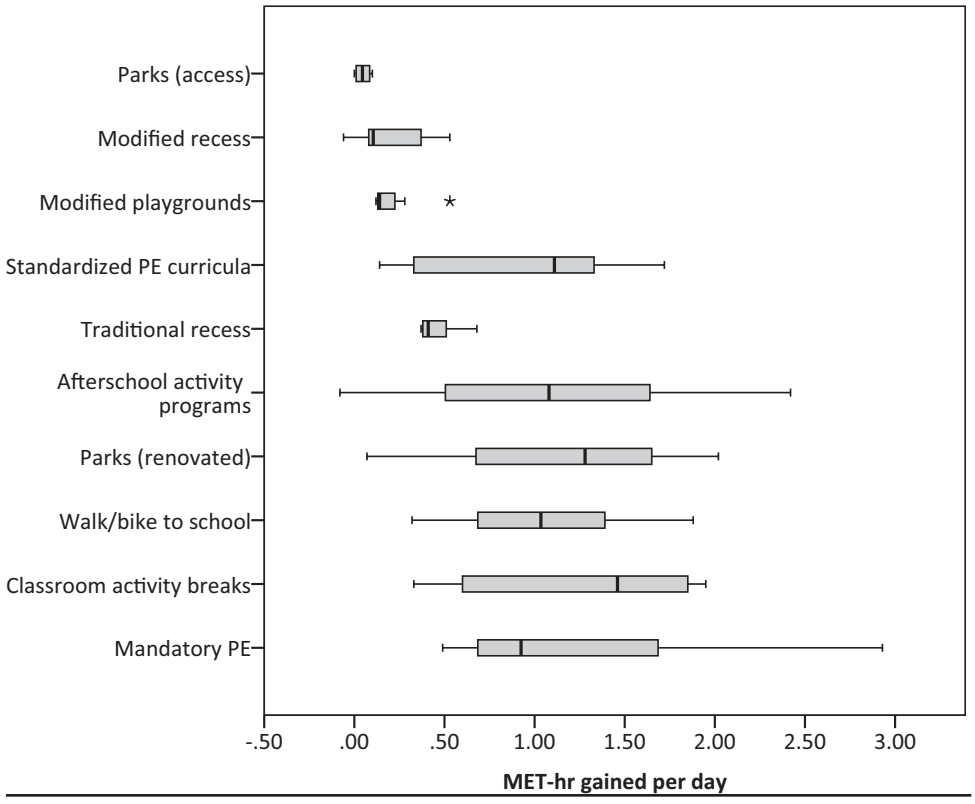

Figure 1. MET-hour gained per day in response to various physical activity interventions

Note: The vertical lines within each box depict the medians; the boxes represent the interquartile ranges (25th–75th percentile); and the ends of the horizontal lines represent the minimums and maximums.

*Study outcome was an outlier.

PE, physical education

education for all U.S. schoolchildren would have an enormous reach. However, even if a policy to mandate physical education were implemented, there would need to be no exemptions, monitoring for compliance, and enforcement for the mandate to be effective.

When trained teachers deliver physical education classes using standardized curricula (e.g., Sports, Play, and Active Recreation for Kids [SPARK]), it results in an additional increase in children's physical activity (6 minutes per day of MVPA beyond traditional physical education). The main focus of standardized curricula is to increase the proportion of active time during physical education by reducing time spent on administrative tasks and modifying traditional physical education activities. At least 50% of physical education time should be spent in MVPA.[19] Training teachers (either classroom teachers or physical education specialists) to deliver standardized curricula provides them with lesson plans specially designed to promote activity, thus increasing their involvement and enthusiasm for the subject matter.

Classroom physical activity breaks appear to have the second-greatest impact on increasing physical activity of elementary and middle school students. These breaks, usually 10 minutes in duration, once or twice per school day, often add a physically active component to the academic material being taught. The primary target population for this type of program is elementary schoolchildren (Physical Activity Across the Curriculum, TAKE 10! and Energizers). Surprisingly, these brief interludes supervised by classroom teachers were 80% as effective at increasing elementary schoolchildren's energy expenditure as traditional physical education classes.

Traditional recess periods of 15 minutes also can result in accumulation of MVPA (about 7 minutes per day, data not shown), for elementary and middle school children. Modifying the recess period by providing playground equipment (e.g., slides, swing sets, monkey bars); colored markings on the playground surface (e.g., hopscotch, 4-square, beanbag toss, number grid); and play equipment (e.g., balls, hula hoops, Frisbees, fabric tunnels) further increases MVPA obtained during recess, increasing it by 5 minutes per day. Recess periods can be structured or can allow children to develop their own games and activities in a safe, supervised situation. Currently, there are 34.7 million U.S. elementary and middle school students,[18] so a federal policy mandating recess would have enormous reach. However, recess policies would most likely affect only elementary school students, because most middle and high school students do not have recess.

Afterschool programs also are effective at increasing physical activity in youth. They provide supervised care of children for several hours between the end of the school day and the time parents are able to pick up their children. However, the magnitude of their impact was highly dependent on the type of afterschool program; thus, this category had the greatest variability of all those examined. It ranged from almost zero to levels that were similar to standardized physical education. In the U.S., 8.4 million K–12 children currently attend afterschool programs, and 18.5 million others would attend if suit-

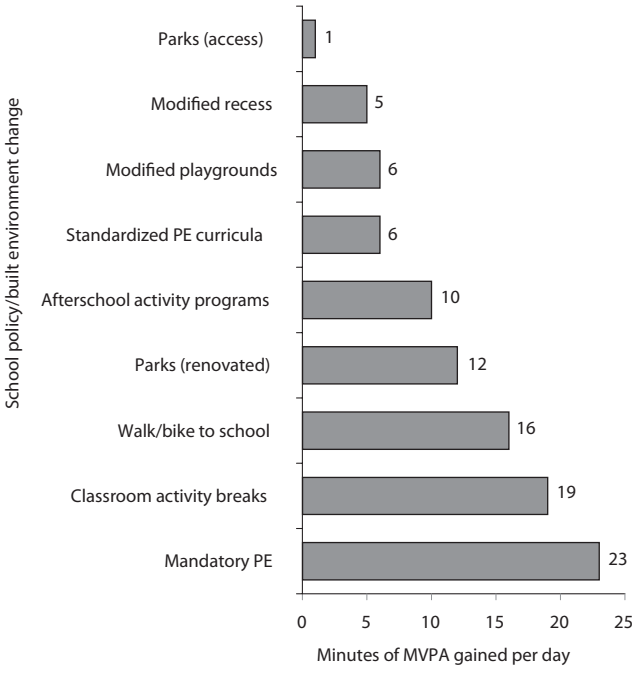

Figure 2. Minutes of physical activity resulting from school-based policies and built environment changes

Note: For purposes of comparison, physical activity outcome variables were converted to MET-hour gained, and the means for each category (weighted according to the total number of participants) were then converted to minutes of MVPA, using a 4.5-MET equivalent to reflect MVPA.

MVPA, moderate- to vigorous-intensity physical activity; PE, physical education

able programs were available.[20] Thus, the potential reach of policies that incorporate physical activity into these programs would be substantial.

Walking/biking to school also has the potential to meaningfully increase children's physical activity. The results of cross-sectional studies comparing children who actively commute to those who are driven to and from school show that walking or biking to school results in substantial increases in children's daily physical activity. Other studies evaluated the effectiveness of promoting active transportation through awareness, family involvement, and contests, and reported roughly twofold increases in walking and biking to school.[21]

An additional study introduced changes to the built environment (i.e., sidewalks, street crossings, and traffic signals) and reported promising results.[22] However, those studies did not use an objective assessment of physical activity. Currently only 12.9% of U.S. schoolchildren in Grades K–8 walk or bike to school, and the vast majority are driven or bused to school.[23] This represents a dramatic decline from the 47.7% of children who walked or biked to and from school in 1969. While the impact of walking or biking to school is sizeable for an individual child, the feasibility of implementing this on a widespread basis is limited by several factors, including size of school zoning area and the availability of safe walking and biking routes.

The effect of parks and recreational areas on children's physical activity is somewhat less well known. Modifying parks by providing equipment that children and adolescents enjoy using (e.g., skateboarding areas and ice-skating rinks) yields modest increases in youth physical activity levels. In other studies, access, or proximity, to parks is often measured using various distances or buffers around youth's residences, as determined by using GIS.[24–27]

Having a park located within 1 mile of a child's home has a significant, but relatively weak, association with the likelihood that the child will use the park. It could be that organized sport programs within parks (soccer leagues, baseball leagues, tennis programs) are needed to encourage youth participation. It also is possible that mere proximity to a park does not sufficiently reflect accessibility, and children may be unlikely to use a park if they cannot travel to it safely without an accompanying parent. Other factors such as the crime rate in areas surrounding the park,[25] park staffing,[27] and the presence of crosswalks and sidewalks on roads surrounding the park[24,25] are important considerations.

Strengths and Limitations

The current study has both strengths and limitations. One strength is that it reviews a wide range of approaches to increase physical activity in youth. In addition, the physical activity outcome variables reported by these studies were converted to a common metric in order to allow the results of different types of interventions to be compared. The major limitation is that the studies varied in design quality, physical activity assessment instruments, and study population. In addition, the literature review was not comprehensive, although an attempt was made to identify a representative sample of studies in each category.

Conclusion

The present study provides evidence that several school policies and built environment changes can increase the amount of time children spend being physically active during a normal school day. If multiple policies were implemented, it could help children achieve, or even exceed, the national recommendation for physical activity in youth (i.e., 60 minutes or more of MVPA per day). Policymakers should take the results of the current study under consideration to help make well-informed decisions that will enhance physical activity in youth. Such considerations will need to include the impact of various approaches on children's energy expenditure as well as cost, feasibility, and population reach.

Determining which among many physical activity interventions to support may depend on issues of feasibility for any one community, given that what is feasible in one community may be impractical in another. School administrators and teachers can play an important role in helping their students to be physically active. Federal and state legislators, as well as city officials (including urban and transportation planners), also have important roles to play in ensuring that schools and the environments surrounding them promote active lifestyles in young people.

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Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.amepre.2012.10.017.