Literature Review: Financial Analysis; Physical Activity

Cost-Effectiveness of Population-Level Physical Activity Interventions: A Systematic Review

Johanna Laine, MSc; Virpi Kuvaja-Köllner, MSc; Eija Pietilä; Mikko Koivuneva, MSc; Hannu Valtonen, PhD; Eila Kankaanpää, PhD

Abstract

Objective. *This systematic review synthesizes the evidence on the cost-effectiveness of population-level interventions to promote physical activity.*

Data Source. *A systematic literature search was conducted between May and August 2013 in four databases: PubMed, Scopus, Web of Science, and SPORTDiscus.*

Study Inclusion and Exclusion Criteria. *Only primary and preventive interventions aimed at promoting and maintaining physical activity in wide population groups were included. An economic evaluation of both effectiveness and cost was required. Secondary interventions and interventions targeting selected population groups or focusing on single individuals were excluded.*

Data Extraction. *Interventions were searched for in six different categories: (1) environment, (2) built environment, (3) sports clubs and enhanced access, (4) schools, (5) mass media and community-based, and (6) workplace.*

Data Synthesis. *The systematic search yielded 2058 articles, of which 10 articles met the selection criteria. The costs of interventions were converted to costs per person per day in 2012 U.S. dollars. The physical activity results were calculated as metabolic equivalent of task hours (MET-hours, or MET-h) gained per person per day. Cost-effectiveness ratios were presented as dollars per MET-hours gained. The intervention scale and the budget impact of interventions were taken into account.*

Results. *The most efficient interventions to increase physical activity were community rail-trails ($.006/MET-h), pedometers ($.014/MET-h), and school health education programs ($.056/MET-h).*

Conclusion. *Improving opportunities for walking and biking seems to increase physical activity cost-effectively. However, it is necessary to be careful in generalizing the results because of the small number of studies. This review provides important information for decision makers. (Am J Health Promot 2014;29[2]:71–80.)*

Key Words: Motor Activity, Exercise, Economics, Program Evaluation, Population. Manuscript format: literature review; Research purpose: intervention testing/ program evaluation; Study design: content analysis; Outcome measure: other financial/economic; Setting: workplace, school, local community, state/national; Health focus: fitness/ physical activity; Strategy: skill building/ behavior change, incentives, policy; Target population: youth, adults, seniors.

Johanna Laine, MSc; Virpi Kuvaja-Köllner, MSc; Mikko Koivuneva, MSc; Hannu Valtonen, PhD; and Eila Kankaanpää, PhD, are with the Department of Health and Social Management, University of Eastern Finland, Kuopio, Finland. Eija Pietilä, is a student at University of Eastern Finland, Kuopio, Finland.

Send reprint requests to Virpi Kuvaja-Köllner, MSc, Health Economics, University of Eastern Finland, Department of Health and Social Management, PO Box 1627, FI-70211 Kuopio, Finland; virpi-liisa.kuvaja-kollner@uef.fi.

This manuscript was submitted December 10, 2013; revisions were requested March 5 and May 29, 2014; the manuscript was accepted for publication June 14, 2014.

0890-1171/14/$5.00 + 0
DOI: 10.4278/ajhp.131210-LIT-622

OBJECTIVE

Insufficient physical activity (PA) is associated with an increased risk of various chronic diseases[1] and increases in health care expenditure.[2,3] There are cost-effectiveness and cost-benefit studies demonstrating the ability of PA interventions to offer "good value for money," but most of these studies have focused on interventions at the individual or patient group level (disease prevention, secondary prevention).[4–7] Studies of the cost-effectiveness of PA interventions at the population level are lacking. However, if an intervention can change the amount of PA in a population, it also may change health care costs.

The present review summarizes and compares the results of economic evaluation studies promoting PA at a population level. The research question is as follows: What types of community interventions are cost-effective PA interventions? The results may assist decision makers in various fields—health policy, PA policy, schools, workplaces, and also traffic and community planning—to allocate resources in a way that will efficiently increase PA.

In systematic reviews, the literature search is often conducted on a narrowly defined topic.[8] In the present review, all types of population-orientated interventions were to be investigated. To achieve a balance between the specificity required for the search strategy and the wideness of the topic, therefore, six different intervention categories for promoting PA were used in the search strategy. These were (1) the environment, (2) the built environment and transportation (active

Table 1
Search Strategy and Search Terms Used

	Search Strategy
	Search Terms
1	"physical activity"
2	Exercise
3	cost*
4	"economic evaluation"
5	"cost-effectiveness"
6	"cost effectiveness"
7	"cost-benefit"
8	"cost benefit"
9	"cost-utility"
10	"cost utility"
11	"economic analysis"
12	"economic evaluation"
13	"benefit-cost"
14	"benefit cost"
15	"health promotion"
16	"health policy"
17	Intervention
18	park OR "built environment"
19	pedestrian* OR transport* OR travel* OR bike*
20	"sporting organisation" OR "sporting organization" OR "sports club" OR incentive OR bonus OR voucher
21	*school* OR student* OR universit* OR college*
22	"mass media" OR "media campaign" OR media OR communit*
23	work* OR employe*
	Search for Different Categories Promoting Physical Activity
1	(#1 OR #2) AND (#3 OR #4) AND #18
2	(#1 OR #2) AND (#3 OR #4) AND (#15 OR #16 OR #17) AND #19
3	(#1 OR #2) AND (#3 OR #4) AND (#15 OR #16 OR #17) AND #20
4	(#1 OR #2) AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14) AND (#15 OR #16 OR #17) AND #21
5	(#1 OR #2) AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14) AND (#15 OR #16 OR #17) AND #22
6	(#1 OR #2) AND (#5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13 OR #14) AND (#15 OR #16 OR #17) AND #23

* PA indicates physical activity.

traveling), (3) sports clubs and improved (enhanced) access to places for PA, (4) school-based interventions, (5) mass media and community interventions, and (6) workplace interventions. The purpose of the study was to synthesize the evidence on the cost-effectiveness of population-level interventions to promote physical activity.

METHODS

Data Sources

A systematic literature search was conducted between May 2013 and June 2013 in three databases: PubMed, Scopus, and Web of Science. A separate search of SPORTDiscus (EBSCOhost Academic Search Premier, EBSCO Information Services, Ipswich, Massachusetts) was conducted in August 2013. To identify all relevant publications published in or prior to June 2013, a structured search was conducted using the methods of the Cochrane Collaboration.[8,9] The "first layer" of the search strategy consisted of economic evaluation and PA terms, and the "second layer" combined terms from the six different intervention categories for promoting PA (see Table 1).

Inclusion and Exclusion Criteria

The titles and abstracts of the publications identified were screened for relevance by four different researchers (two at a time, as recommended by Moher et al.[10]). Additionally, a manual search was conducted after scrutiny of the references of the identified articles. There were no restrictions as to study design. Any differences in interpretation of the relevance of the articles were resolved through discussion.

The articles included in this review fulfilled the following criteria: (1) The interventions included aimed at promoting and maintaining PA in wide population groups (for example, population-level or community-level interventions supporting active living and reducing a sedentary lifestyle), and (2) the economic evaluation took account of both effectiveness and cost. An outcome measure assessing the change in the amount of PA (for example, metabolic equivalent of task [MET] minutes per week) or the number of physically active individuals (for example, the number of users) was required. There were no restrictions as to the duration of interventions or follow-up periods. Only primary and preventive interventions (for example, prevention of obesity) for a nonselected population were considered, with no restrictions regarding the age of the target population. Secondary interventions (person already has an increased risk or preclinical disease, but no symptoms) such as primary health care interventions, treatment of diagnosed diseases, rehabilitation, or interventions targeting some specifically selected population groups, were excluded. Interventions focusing on single individuals were also excluded.

Data Extraction and Data Synthesis

The full-text articles of the included studies were assessed independently by two researchers with respect to relevance and methodological quality.[11–13] The quality of each study was classified by the presence or absence of the following criteria: (1) the study population was clearly described; (2) the year of the calculation of costs was clearly stated; (3) the chosen time horizon was appropriate for the inclusion of relevant consequences (PA); (4) the chosen time horizon was appropriate for the inclusion of relevant costs; (5) PA outcomes were measured appropriately (time, frequency, and amount); (6) PA outcome

Table 2
Quality Scores of the Articles Included in the Present Review*

No.	Quality Checklist	Abildso et al.[22]	Cohen et al.[23]	Dallat et al.[24]	De Smedt et al.[33]	Frew et al.[34]	Guo and Gandavarapu[25]	Moodie et al.[21]	Stokes et al.[26]	Wang et al.[27]	Sum
1	Was study population clearly described? (Country, target population, number of participants)	1	1	1	1	1	1	1	1	1	9
2	Was the year of the calculation of costs clearly described?	1	0	0	1	0	1	1	0	1	5
3	Was the chosen time horizon appropriate to include relevant consequences (physical activity)?	0	0	1	1	0	0	1	1	0	4
4	Was the chosen time horizon appropriate to include relevant costs?	1	0	1	1	1	1	1	0	1	7
5	Were PA outcomes measured appropriately? (Time, frequency, amount, all these)	1	0	1	1	0	1	0	0	0	4
6	Were PA outcomes measured objectively?	0	1	0	1	0	0	0	0	0	2
7	Was the used effectiveness data source suitable for evaluating the PA effects on target population?	1	1	1	1	1	0	1	1	1	8
8	Was there a control/comparison group or comparison to no intervention situation, or before/after measurement?	0	1	0	1	1	0	1	0	0	4
9	Were all intervention costs valued appropriately?	1	1	1	1	0	1	1	0	1	7
10	Were all future costs identified appropriately?	1	1	1	1	0	0	1	0	1	6
11	Were all future PA outcomes identified appropriately?	0	0	0	0	0	0	0	0	0	0
12	Were all future intervention costs discounted?	0	0	1	1	1	1	1	0	0	5
13	Were all important PA variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	1	0	0	0	1	0	1	0	0	3
14	Were all important cost variables, whose values are uncertain, appropriately subjected to sensitivity analysis?	1	0	0	0	0	0	1	0	1	3
15	Does the study discuss the generalizability of the results to other settings and population groups?	1	0	1	0	0	0	0	0	1	3
	Total quality score; maximum 15	10	6	9	11	6	6	11	3	8	

* PA indicates physical activity.

was measured objectively; (7) the source used for effectiveness data was suitable for the evaluation of PA effects on the target population; (8) there was a control or comparison group (or comparison to a no-intervention situation); (9) all intervention costs were valued appropriately; (10) all future costs were identified appropriately; (11) all future PA outcomes were identified appropriately; (12) all future intervention costs were discounted; (13) all important PA variables with uncertain values were appropriately subjected to sensitivity analysis; (14) all important cost variables with uncertain values were appropriately subjected to sensitivity analysis; and (15) the study discussed the generalizability of the results to other settings and population groups. The quality criteria checklists[11,12] normally used to assess the relevance and methodological quality of studies did not quite satisfy the needs of this review. To enable better comparison of the quality of the studies, four additional items (items 2 and 6–8) were added to the list by authors of this study (see Table 2). These dichotomous quality scores (1 or 0) combined into a total quality score (range 0–15) were then used as an aid to evaluate the strength of the study evidence. The quality score had no influence on the inclusion of the articles. The search results were com-

Table 3
Translation Formula for Physical Activity Outcome[14]

Original Outcome Indicator	Translation Formula*
Steps per day on walking	MET-h = (steps/10,000) × 4.25 × (1/3) × 3 MET
30-min blocks in physical activity per day	MET-h = [(30-min block)/4] × MET assigned
Minutes per day on physical activity	MET-h = [(min/d) × MET assigned]/60
People meeting guideline (%)	MET-h = (% people) × (1.5 MET-h for adults or 3.0 MET-h for children)
MET-minutes per week	MET-h = (MET-min/wk)/60/7
Active days (at least 3 MET-h) per week	MET-h = (active days) × (3.0 MET-h)/7

* MET indicates metabolic equivalent of task.

bined and are discussed as a single entity.

The studies included in this review had varying practices in defining both PA outcomes and intervention costs, and their results cannot be directly compared. For this reason, the measure of effectiveness was standardized, if possible, using the procedure presented by Wu et al.[14] In this, the reported time spent in activities was translated into metabolic equivalent intensity levels (MET-hours gained per person per day; see Table 3) using a PA coding scheme.[15] The MET intensity level, defined as the ratio of work metabolic rate to a standard resting metabolic rate of 1.0 (4.184 kJ)$*kg^{-1}*h^{-1}$, presents intensity levels of physical activities (rate of energy expenditure, measured or estimated from body size) in METs. One MET equates to a resting metabolic rate attained during quiet sitting for 1 hour.[15] Moderate PA (MPA) equates to 3.0 METs, moderate to vigorous PA (MVPA) to 4.5 METs, and vigorous PA (VPA) to 6.0 METs. A typical amount of energy spent in 20 minutes of moderate activity produces 1 MET.[14] This enabled comparison of the results.

The cost information and costing methodologies in the studies included in the review also varied greatly, e.g., in relation to the currency used, the reference year, and the time frame for the costs. All costs were first transformed to 2012 values using national consumer price index/inflation calculators[16–19] and finally to U.S. dollars using a currency converter.[20]

Only direct costs reflecting the resources used to produce the intervention were taken into account. The costs were further calculated as cost per person per day, according to the length of the intervention and the frequency of participation (days during intervention). The number of physically active days ranged from 120 d/y (equal to 3 d/wk for 40 wk/y)[21] to 329 d/y (equal to 7 d/wk for 47 wk/y).[22–27] The cost-effectiveness of interventions was calculated as cost-effectiveness ratios (CE ratios), i.e., cost per person per day divided by MET-hours gained per person per day. Average CE ratio (ACER), here CE ratio, evaluates an intervention against baseline option, i.e., no program or current practice. In health care, doing nothing is very seldom a relevant option, but in the case of PA promotion, it may be.

The scale of interventions (indicating a varying budget impact) was also evaluated. For this, the studies were divided into three scale categories. Interventions with costs over $1 million had "large budget impact," interventions with costs from $100,000 to $1 million had "medium budget impact," and interventions with costs less than $100,000 had "small budget impact."

RESULTS

Studies Included in the Review

The search of PubMed, Scopus, Web of Science, and SPORTDiscus identified 2058 articles. Forty full-text articles were assessed in detail. Of those, only 16 articles met the selection criteria and were included. The most common reasons for exclusion were that the interventions were aimed at the treatment or rehabilitation of a specific patient group or that the description of intervention, costs, or an indicator for the effectiveness of an intervention was missing. Six more articles were excluded because the effectiveness of the study was based on a very small number of participants[28] or because the cost of the intervention[4,29] or CE ratios[30–32] could not be calculated.

The final number of articles included was 10, producing 14 studies. Many of the studies finally included were modeling studies evaluating health impact or health care costs averted. Nevertheless, the modeling studies also reported the amount of PA and thus could be included. The study selection process is presented in the flow chart in Figure 1.

The majority (nine) of the included articles were modeling studies[21–27,33,34]; the tenth was a systematic review.[14] Based on the findings of Wu et al.,[14] five more studies were also included in this analysis. All five[35–39] were randomized controlled trials (RCTs) and belonged to the school-based category of PA intervention. Taken together, the 10 articles brought 14 studies into this review.

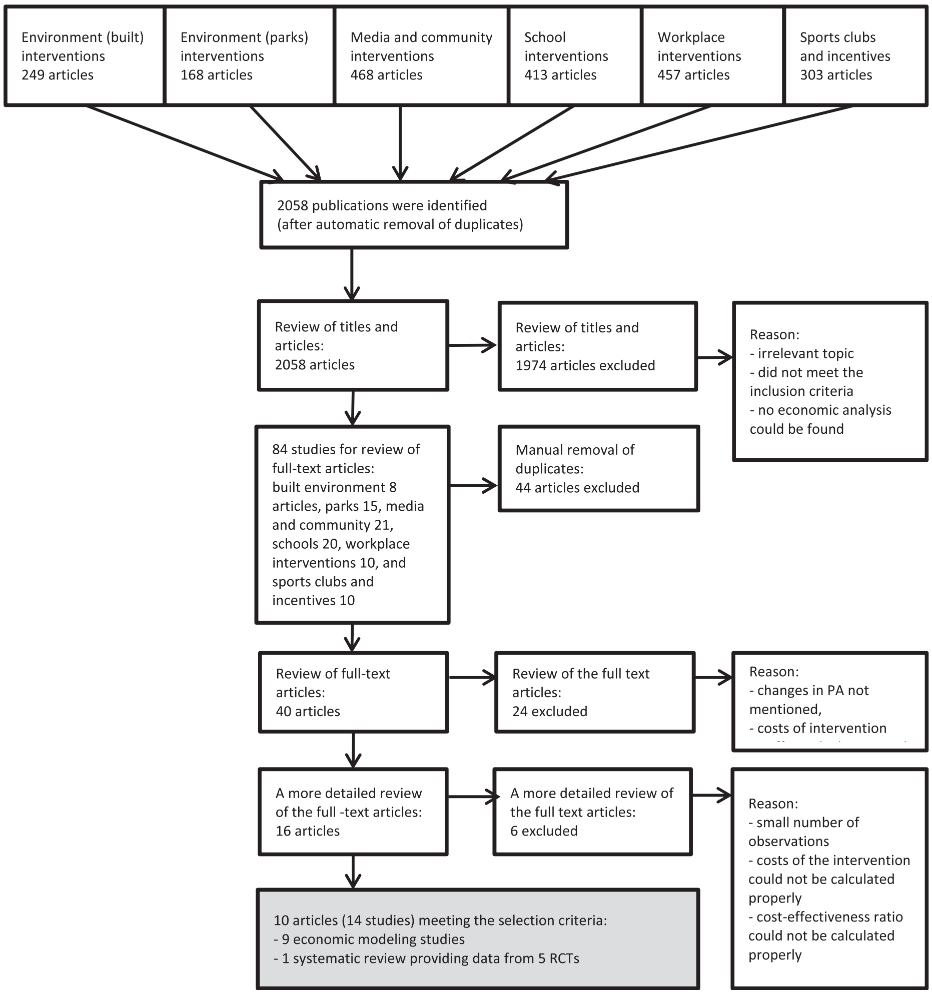
Most (six) of the included studies were conducted in the United States, two in the United Kingdom (one of them in Northern Ireland), four in Belgium, and one each in Australia and Greece. Six of the interventions concerned the built environment, one was community based, one improved access to places for PA, and six were school interventions (see Table 4).

Six interventions each had a total cost of over $1 million[21,24–27,34]; the most expensive interventions cost over $500 million. Three interventions belonged to the medium budget impact category[22,37,38] and four to the small budget impact category.[23,35,36,39]

For one intervention, the total cost of the intervention was not available[33] (see Table 4, columns 3 and 4).

The built environment interventions mainly involved offering citizens opportunities for safe and active transport, such as the use of light-rail trails,[26] rail trails,[22] or bicycle and pedestrian trails built beside

Figure 1
Flowchart of Study Selection*



*PA indicates physical activity; and RCT, randomized controlled trial.

roads.[24,25,27] One study concerned easy-to-use outdoor exercise equipment in parks.[23]

One community-based campaign promoted walking and was based on enhanced use of pedometers.[33,40] One study[34] used monetary incentives: Citizens could access certain local council-run leisure centers (fitness gyms, swimming pools, and group fitness classes) free of charge at certain times of the day.

School-related interventions aimed to increase the PA levels of school children during recess[35–39] and to increase walking, cycling, or the use of public transportation to and from school.[21]

Cost-Effectiveness Results

In this review, the CE ratio was calculated by dividing the intervention costs per person per day (U.S.$ 2012) with the MET-hours gained per person per day. A lower CE ratio means that an increase in PA level (1 MET-hour) can be achieved with lower costs, and a higher ratio means that the same increase is associated with higher costs. For the majority of the studies included, it was possible to carry out calculations of costs per MET-hours gained (see Figure 2).

There was a huge variation in the efficiency (CE ratio) of the interventions. The most inefficient intervention cost almost 400 times more (about $2.33) per MET-hour gained than the most efficient intervention ($.006).

Building a community rail trail was the most cost-effective method of increasing PA at the population level, with a CE ratio of $.006/MET-h. This intervention was effective at 1.06 MET-hours per person per day and its costs were low. The main reason for the success of this intervention might be the low construction costs because the rail trail was only partly asphalted.[22] The only community-level intervention, encouraging the use of pedometers,[33] provided the second best CE results ($.014/MET-h) in this review. The low costs of the intervention explain the favorable CE ratio, even though the actual number of MET-hours gained per person per day (.38) was quite moderate.

Generally, most of the environmental interventions (four of six) produced low CE ratios. The fitness zones succeeded in encouraging people to be more active in parks and achieved a CE ratio of $.087/MET-h.[23] The effectiveness of four new bicycle/pedestrian trails[27] in increasing PA was the best (1.843 MET-hours gained per person per day) in this review, and this intervention did well in comparison with $.2431/MET-h. The modeling study that assumed that 2% of the population would become active if better opportunities for active transport were provided produced a CE ratio of $.324/MET-h.[24]

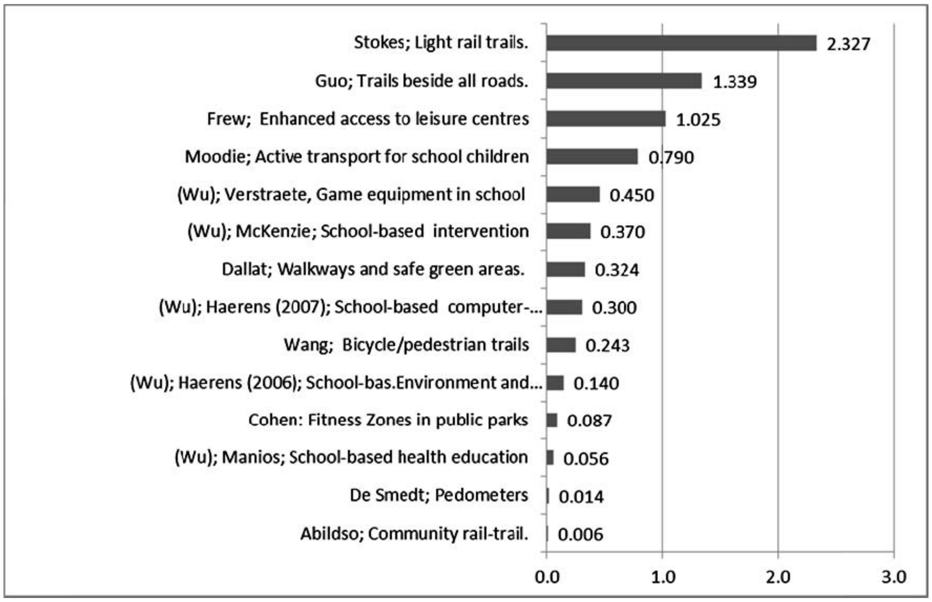
Schools play an important role in increasing health-related PA. The CE ratios of all six school interventions ranged from $.06 to $.79 per MET-hour gained per person per day. The most cost-effective (CE ratio .056)[14] was a health and nutrition program among school children in Greece.[37] This intervention succeeded in increasing MVPA during PA education classes with pleasant, noncompetitive, and cooperative activities, and also increased children's PA out of school. The impact was lasting and was still found several years after the intervention. The intervention in Belgium[35] combined environmental changes (offering sports equipment such as balls and ropes) with computer-tailored feedback plus parental involvement. Positive effects on school-related PA were found, and the intervention

Table 4
Articles Included in the Review, Classified into Four Categories of Intervention*

Study	Intervention	Cost of Intervention/ Population Reached (U.S.$ 2012)	Budget Impact Effect	MET-h Gained/ Person/d	Cost per MET-h Gained/ Person ($)
Environment (parks), built environment (trails for pedestrians, biking)					
Abildso et al.[22]	Community rail-trail use (active transport)	$852,071/29,660 inhabitants	M	1.06	0.006
Cohen et al.[23]	Easy-to-use outdoor gyms, also known as fitness zones, for aerobic exercise and strength training in public parks	$48,158 per park/40,964 inhabitants	S	0.0045	0.087
Dallat et al.[24]	Connswater Community Greenway project, park and trail for 19.4 km	$12,583,600/87,500 of the total population (110,600) living within a 1 mile radius from the park and trail	L	0.045	0.324
Guo and Gandavarapu[25]	Trails beside all roads in Dane County, 1220 km	$575,363,330/438,881 inhabitants	L	0.0992	1.339
Stokes et al.[26]	Light-rail trails 9.6 mile, 15-station system	$501,979,713/15,609 riders	L	1.40	2.327
Wang et al.[27]	Four new bicycle/pedestrian trails (total 16.3 miles)	$7,861,811/3986 trail users	L	1.843	0.243
Mass media interventions and community-level interventions					
De Smedt et al.[33]	Effectiveness of community-based "10,000 Steps Ghent" project promoting walking and enhancing the use of pedometers	Total cost was not mentioned, annual cost/ person $1.28/population 245,000 (16.4% using pedometers = 40,180)	Could not be evaluated	0.38	0.014
School interventions					
Wu et al.[14]; Haerens et al.[35]	Intervention combining environmental changes with computer-tailored feedback (plus parental involvement)	$1260/2232, age 13	S	0.29	0.140
Wu[14]; Haerens[36]	The computer-tailored intervention to increase PA, provided on CDs, was completed during classes	$598/281 participants, age 13	S	0.23	0.304
Wu et al.[14]; Manios and Kafatos[37]	Health education, parental involvement	$608,492/4171 children	M	1.25	0.056
Wu et al.[14]; McKenzie et al.[38]	Physical and health education, school health services	$455,672/13,308 adolescents	M	1.37	0.370
Wu et al.[14]; Verstraete et al.[39]	Provide game equipment during morning recess and lunch break	$2096/122 children, age 11	S	0.62	0.450
Moodie et al.[21]	TravelSmart schools curriculum program, obesity prevention program to promote PA: walking, cycling or using public transportation to/from school	$17,879,400/267,738 children, ages 10 and 11	L	0.71	0.790
Sports clubs and incentives to increase PA					
Frew et al.[34]	Community-based Be Active program: free access to local council-run leisure centers at certain times of the day	$8,136,420/94,498 estimated users (80% of the 118,123 members)	L	0.23	1.025

* U.S.$ 2012 indicates U.S. dollars as valued in 2012; MET, metabolic equivalent of task; PA, physical activity; S, small; M, medium; L, large; and CD, compact disc.

Figure 2
Cost-effectiveness Ratios of the Studies Included in the Present Review



achieved a CE ratio of $0.14/MET-h.[14] The other computer-tailored school-based intervention in the Belgian context,[36] which aimed to encourage a physically active lifestyle among sedentary adolescents, was provided on CDs and completed during lessons. The CE ratio was $.30/MET[14] for the average 3.5 min/d increase in PA observed. In a multisite trial by McKenzie et al.,[38] direct observation was used to study physical education (PE) in American schools. The authors found that the school environment can contribute an increase in the amount of MVPA: 1.37 MET-hours were gained per person per day at a cost of $.370 per person.[14] Providing sports equipment during recess periods[39] also significantly increased the time spent in PA and produced a CE ratio of $.450/MET-h gained.[14] Here, it is noteworthy that the costs of interventions were assessed by Wu et al.[14] and not by the original researchers.

The five school-based interventions offering game and other sports equipment or carrying out environmental changes in the school area during school, reviewed by Wu et al.,[14] were all more cost-effective than the TravelSmart schools curriculum program of Moodie et al.[21] Encouraging active transport to and from school, originally designed for obesity prevention among school children, was less cost-effective and produced a CE ratio of $.79/MET-h.

The only study that investigated monetary incentives[34] and offered access to certain local council-run leisure centers free of charge at certain times of the day showed that this intervention was far more expensive/less cost-effective than those mentioned above. The 15% increase in the number of participants reaching the PA level "recommended activity and above" was accomplished at the cost of a CE ratio of $1.025/MET-h.

The most expensive, large environmental interventions were the least cost-effective in this comparison. The one with a light-rail trail system[26] produced the second best MET-hours (1.4) in this review, but it was estimated that it would reach only 15,609 people, which is why its CE ratio was the weakest ($2.33/MET-h) in this review. On the other hand, the intervention with trails beside all roads[25] was estimated to reach over 400,000 people, but its effectiveness in MET-hours gained was only .1, which equates to 1.7 minutes per day. The best CE ratio from the large budget impact intervention category was calculated for four new bicycle/pedestrian trails. With the cost of almost $8 million, this produced the best MET-hours value (1.84) and took sixth place in this comparison.

The quality scores assigned ranged from 3 points[26] to 11 points[21,33] out of 15 (see Table 2, total quality score). Generally, higher quality studies also had better CE ratios.[22,33] Overall, the costs of interventions were better defined and valued than PA outcomes. Although the effectiveness data were in most cases suitable for the evaluation of the effects of PA on the target population, the quality of PA measurements and also the quality of evaluation of possible future PA outcomes was lower. The time horizon was appropriate for the inclusion of relevant consequences (PA) in fewer than half of the studies, and in only four of the studies was there a comparison group or another form of comparison. In three of the studies, PA outcomes were measured objectively. Only three studies had subjected all important PA and cost variables with uncertain values to sensitivity analysis. In addition, surprisingly few (only three) of the studies discussed the generalizability of the results to other settings or population groups.

CONCLUSIONS

The main finding of this review was the fact that the number of relevant studies related to the cost-effectiveness of population-level PA studies is limited. Also, the review found that modeling studies outcomes are usually health related and concentrate on the intervention costs and potential changes in health care costs. In this review we used only the information about effectiveness of interventions to increase PA and costs of interventions and not the results of the model. Only 14 studies on the cost-effectiveness of population-level PA interventions allowed proper comparative cost-effectiveness analysis between different types of interventions, and this was one of the biggest limitations for the interpretation of the results of this study. The number of studies is low, especially when taking into account the fact that the need to increase PA in the population is urgent and the (public) budget for health care and other services is tighter than ever.

The quality of the included studies varied a lot. The quality checklists generally used in cost-effectiveness studies as such are not suitable for population-based PA interventions.

The quality of PA measurements and the assessment of sustainability of future PA outcomes were particularly low. Only three of the included studies had subjected all important uncertain PA and cost variables. Generally, the costs of interventions were better defined and valued. However, the detailed or transparent information about fixed and variable costs of interventions was not always reported. Information about construction and maintenance costs was available in the majority of the studies. They both are important in ex-ante decision making, which this review aims to aid. Ex-post, the construction costs could be regarded as sunk cost and should no longer be included in the costs.

Because of low numbers of studies and uncertainty in the long-term effectiveness of interventions, the comparison between different categories must be performed with caution. Directional conclusions can be drawn according to the list of the order of cost-effectiveness, but based on the limited number of studies, conclusions regarding the difference in relative cost-effectiveness should not be made. The capability of short-term studies to predict long-term benefits of population-level PA interventions might be limited. Despite a growing interest regarding public health and PA promotion, appropriate cost-effectiveness studies are rare. Similar results were found in the cost-effectiveness of PA interventions study conducted by Müller-Riemenschneider et al.[41] Although their study also included individually targeted PA interventions, they accepted only 11 out of 6543 publications.[41]

The search strategy used in this review did not help in finding studies conducted in sparsely populated and rural areas. For example, walking on nature trails in forests is common in many countries, but its impact on the general levels of PA has not been studied in depth.[42] It is also possible that the search strategy used did not succeed in finding all possible interventions.

According to our findings, the most cost-effective strategy for increasing PA among large populations is changing the built environment (structural environment). This means, for example, the creation of better opportunities for PA by offering the use of pedestrian or bicycle trails en route to public transport stations or providing public parks in densely populated areas. These built environment interventions often require substantial investments, but have long, useful life spans. The most cost-effective interventions in this review were all from the small and medium budget-impact categories,[22,23,35–37] although there were also three large impact interventions with a CE ratio of less than \$1/MET-h gained.[21,24,27] The cost-effectiveness of interventions cannot, thus, be based purely on either costs or effects; both must be considered in unison.

School-based interventions seemed to potentially have a capacity for the cost-effective production of PA among school children, whereas work-related interventions and subsidized use of places for PA (e.g., leisure/sports centers) were less successful.

The impact of pedometer programs was good for increasing PA, but questions were raised about the sustainability of their impacts. An effective duration of 5 years was assumed for the use of pedometers (provided that the program will be implemented each year). A meta-analysis[43] found that the impact may diminish when, for example, people lose interest in or get used to the campaigns.

The effects of interventions can be converted into more comparable forms using MET-hours gained per person per day, but this requires accurate and appropriate measurements of PA levels.

Using a benchmark value, such as, for example, the one employed by Wu et al.,[14] could help decision makers to judge the cost-effectiveness results. Wu et al.[14] used \$.50 to \$1.00/MET-h gained for adults and \$.17 to \$.35 for youth as a threshold value. Interventions that had a CE ratio below these values were deemed worth implementing. The threshold value was based on the estimated additional annual health care cost of sedentary behavior (\$184–\$384 per capita, 2008) and current minimum recommended annual levels of PA (390 MET-hours gained per person for adults and 1095 for youth).[14] Applying the same rule in our analysis, the majority of the interventions (8/14) were considered cost-effective. However, it should not be forgotten that the potential changes in health care costs depend on the health care systems of the country in question.

Interventions, especially those that might reduce the use of private cars and increase PA, have some additional beneficial effects, such as less traffic congestion and reduced air pollution. These additional benefits were not considered in the present review. Had they been recognized, the efficiency of the interventions would potentially have been increased, as the intervention costs would have been equal, but with additional benefits.

To our knowledge, this review is one of the first studies to focus on the economic evaluation of population-level interventions to increase PA. The lack of economic evidence has already been recognized.[22,44] Some individual studies have focused on economic evaluations of changes in built environments,[25,27,45] and there is at least one study comparing the cost per participant of becoming physically more active,[41] but none of the studies have tried to compare different kinds of interventions similarly, as does the present review.

The quality checklists generally used in these kinds of studies were not suitable for this population-level research; therefore the present authors modified the used criteria. The results of our quality analysis showed that costs were better valued than changes in PA levels, and there is clearly a need for future studies promoting PA to take into account both costs and effects. Although the costs of PA interventions are mostly assessed and valued appropriately, there is a lack of quality (accuracy) in evaluations of the amounts (duration, intensity, and frequency) of PA. Further development of the quality criteria is important. Objective measurements of PA are rare, but including them would definitely increase the validity of the results. Without proper cost data and estimates of effectiveness, it is impossible to produce a reliable estimate of the cost-effectiveness of any intervention. Transdisciplinary cooperation might also be beneficial, especially in the case of built-environment PA interventions.

The strength of this review was its focus on interventions at the population level. The efficiency of interventions was assessed as a CE ratio. The cost of the intervention per day per person was divided by the MET-hours gained per person per day, thus increasing the comparability between interventions. Additionally, this review took account of the intervention scale and the budget impact, which provides important information for decision makers. The results of this review support the idea that an increase in PA can in some cases be a beneficial by-product, e.g., when the primary aim is to decrease air pollution and the use of private cars.

In general, the assessment of population-level interventions was challenging. Assessing the costs and the permanence of effects was very difficult. Using MET-hours gained as an indicator of effectiveness was possible for all of the studies. However, in the case of five school-based interventions, the costs had been calculated by Wu et al.,[14] and not all economic information was available to the authors of this review. For this reason, there may be differences in the way costs and CE ratios were assessed, and the calculations may not be fully comparable.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

There are some economic evaluation studies demonstrating physical activity (PA) interventions' ability to offer "good value for money," but most of these studies have focused on interventions at the individual or patient group level. The evidence of the cost-effectiveness of PA interventions at the population level is lacking.

What does this article add?

This review managed to compare the cost-effectiveness of very different kinds of PA interventions. Based on the present review, interventions that primarily aimed at decreasing the use of private cars and air pollution would have some additional benefits, such as increased levels of PA. This is important information for decision makers.

Implications for health promotion practice or research

Based on this review, the cost-effectiveness of PA interventions can and should be studied by calculating costs per MET-hours instead of modeling disease costs. It is also important to take into account the intervention scale and the budget impact of an intervention when the cost-effectiveness is assessed. The benefits of PA are well-known. Now it is important to find efficient ways to increase PA among populations.

Acknowledgments

This study was funded by the Finnish Ministry of Education and Culture and supported by the University of Eastern Finland. The authors would also like to thank information specialist Maarit Putous from the University of Eastern Finland for her assistance in search strategy.

References

1. US Dept of Health and Human Services. *Physical Activity and Health. A Report of the Surgeon General 1996.* Atlanta, Ga: Centers for Disease Control and Prevention; 1996.
2. Colditz GA. Economic costs of obesity and inactivity. *Med Sci Sports Exerc.* 1999;31: S663–S667.
3. Pratt M, Norris J, Lobelo F, et al. The cost of physical inactivity: moving into the 21st century. *Br J Sports Med.* 2014;48:171–173.
4. Roux L, Pratt M, Tengs TO, et al. Cost effectiveness of community-based physical activity interventions. *Am J Prev Med.* 2008; 35:578–588.
5. Sevick MA, Bradham DD, Muender M, et al. Cost-effectiveness of aerobic and resistance exercise in seniors with knee osteoarthritis. *Med Sci Sports Exerc.* 2000;32: 1534–1540.
6. Sevick MA, Dunn AL, Morrow MS, et al. Cost-effectiveness of lifestyle and structured exercise interventions in sedentary adults: Results of project ACTIVE. *Am J Prev Med.* 2000;19:1–8.
7. Wolfenstetter SB, Wenig CM. Economic evaluation and transferability of physical activity programmes in primary prevention: a systematic review. *Int J Environ Res Public Health.* 2010;7:1622–1648.
8. Centre for Reviews and Dissemination. *CRD's Guidance for Undertaking Reviews in Health Care.* Layerthorpe, York: York Publishing Services Ltd; 2009.
9. Armstrong R, Waters E, Jackson N, et al. *Guidelines for Systematic Reviews of Health Promotion and Public Health Interventions.* Version 2. Melbourne, Australia: Melbourne University; 2007.
10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Int J Surg.* 2010;8:336–341.
11. Drummond MF, Jefferson TO. Guidelines for authors and peer reviewers of economic submissions to the BMJ. The BMJ economic evaluation working party. *BMJ.* 1996;313:275–283.
12. Evers S, Goossens M, de Vet H, et al. Criteria list for assessment of methodological quality of economic evaluations: consensus on health economic criteria. *Int J Technol Assess Health Care.* 2005;21:240–245.
13. Langer A. A framework for assessing health economic evaluation (HEE) quality appraisal instruments. *BMC Health Serv Res.* 2012;12:253.
14. Wu S, Cohen D, Shi Y, et al. Economic analysis of physical activity interventions. *Am J Prev Med.* 2011;40:149–158.
15. Ainsworth BE, Haskell WL, Whitt MC, et al. Compendium of physical activities: an update of activity codes and MET intensities. *Med Sci Sports Exerc.* 2000; 32(suppl 9):S498–S504.
16. US Dept of Labor. Bureau of Labor Statistics. CPI inflation calculator. Available at: http://www.bls.gov/data/inflation_calculator.htm. Accessed October 15, 2013.
17. Australian Bureau of Statistics. Available at: www.abs.gov.au. Accessed October 15, 2013.
18. Bank of England. CPI calculator. Available at: http://www.bankofengland.co.uk/education/Pages/inflation/calculator/index1.aspx. Accessed October 15, 2013.
19. Statistics Belgium. Consumer price index. Available at: http://statbel.fgov.be/en/statistics/figures/economy/consumer_price_index/. Accessed October 15, 2013.
20. Currency converter, OANDA. Available at: http://www.oanda.com/currency/converter/. Accessed October 15, 2013.
21. Moodie M, Haby MM, Swinburn B, Carter R. Assessing cost-effectiveness in obesity: active transport program for primary school children—TravelSMART schools curriculum program. *J Phys Act Health.* 2011;8:503–515.
22. Abildso CG, Zizzi SJ, Selin S, Gordon PM. Assessing the cost effectiveness of a community rail-trail in achieving physical activity gains. *J Park Recreat Admi.* 2012;30: 102–113.
23. Cohen DA, Marsh T, Williamson S, et al. Impact and cost-effectiveness of family fitness zones: a natural experiment in urban public parks. *Health Place.* 2012;18: 39–45.
24. Dallat MA, Soerjomataram I, Hunter RF, et al. Urban greenways have the potential to increase physical activity levels cost-effectively. *Eur J Public Health.* 2014;24: 190–195.
25. Guo JY, Gandavarapu S. An economic evaluation of health-promotive built

environment changes. *Prev Med*. 2010; 50(suppl 1):S44–S49.

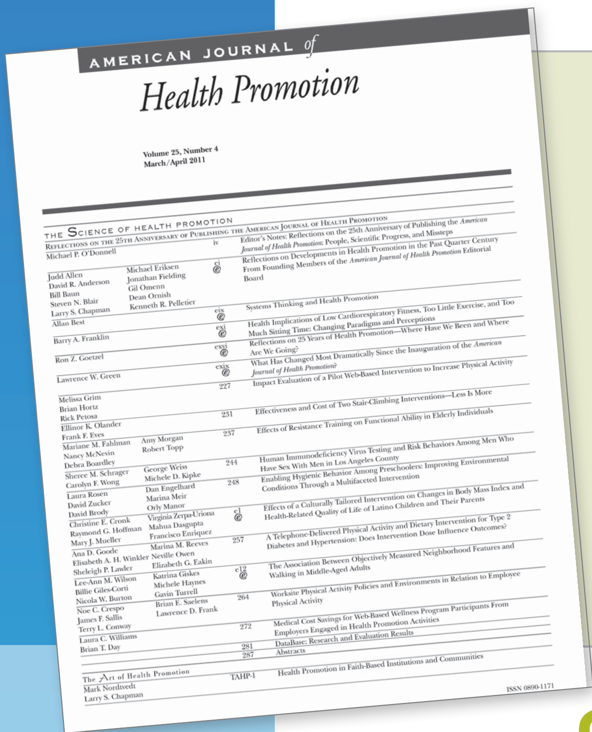
26. Stokes RJ, MacDonald J, Ridgeway G. Estimating the effects of light rail transit on health care costs. *Health and Place*. 2008;14:45–58.
27. Wang G, Macera CA, Scudder-Soucie B, et al. Cost effectiveness of a bicycle/pedestrian trail development in health promotion. *Prev Med*. 2004;38:237–242.
28. Pringle A, Cooke C, Gilson N, et al. Cost-effectiveness of interventions to improve moderate physical activity: a study in nine UK sites. *Health Educ J*. 2010;69:211–224.
29. Cobiac LJ, Vos T, Barendregt JJ. Cost-effectiveness of interventions to promote physical activity: a modelling study. *PLoS Med*. 2009;6:e1000110.
30. McEachan RR, Lawton RJ, Jackson C, et al. Testing a workplace physical activity intervention: a cluster randomized controlled trial. *Int J Behav Nutr Phys Act*. 2011;8:29.
31. Olander EK, Eves FF. Effectiveness and cost of two stair-climbing interventions-less is more. *Am J Health Promot*. 2011;25:231–236.
32. Peterson M, Chandlee M, Abraham A. Cost-effectiveness analysis of a statewide media campaign to promote adolescent physical activity. *Health Promot Pract*. 2008; 9:426–433.
33. De Smedt D, De Cocker K, Annemans L, et al. A cost-effectiveness study of the community-based intervention "10 000 Steps Ghent." *Public Health Nutr*. 2012;15: 442–451.
34. Frew EJ, Bhatti M, Win K, et al. Cost-effectiveness of a community-based physical activity programme for adults (be active) in the UK: an economic analysis within a natural experiment. *Br J Sports Med*. 2014;48:207–212.
35. Haerens L, Deforche B, Maes L, et al. Evaluation of a 2-year physical activity and healthy eating intervention in middle school children. *Health Educ Res*. 2006;21: 911–921.
36. Haerens L, Deforche B, Vandelanotte C, et al. Acceptability, feasibility and effectiveness of a computer-tailored physical activity intervention in adolescents. *Patient Educ Couns*. 2007;66: 303–310.
37. Manios Y, Kafatos A, Preventive Medicine and Nutrition Clinic University of Crete Research Team. Health and nutrition education in primary schools in Crete: 10 years follow-up of serum lipids, physical activity and macronutrient intake. *Br J Nutr*. 2006;95:568–575.
38. McKenzie TL, Nader PR, Strikmiller PK, et al. School physical education: effect of the child and adolescent trial for cardiovascular health. *Prev Med*. 1996;25: 423–431.
39. Verstraete SJ, Cardon GM, De Clercq DL, De Bourdeaudhuij IM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *Eur J Public Health*. 2006;16:415–419.
40. De Cocker KA, De Bourdeaudhuij IM, Brown WJ, Cardon GM. Effects of "10,000 steps Ghent." A whole-community intervention. *Am J Prev Med*. 2007;33:455–463.
41. Muller-Riemenschneider F, Reinhold T, Willich SN. Cost-effectiveness of interventions promoting physical activity. *Br J Sports Med*. 2009;43:70–76.
42. Brownson RC, Housemann RA, Brown DR, et al. Promoting physical activity in rural communities: walking trail access, use, and effects. *Am J Prev Med*. 2000;18: 235–241.
43. Bravata DM, Smith-Spangler C, Sundaram V, et al. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*. 2007;298:2296–2304.
44. Kahn EB, Ramsey LT, Brownson RC, et al. The effectiveness of interventions to increase physical activity: a systematic review. *Am J Prev Med*. 2002;22(suppl 1): 73–107.
45. Wang G, Macera CA, Scudder-Soucie B, et al. Cost analysis of the built environment: the case of bike and pedestrian trials in Lincoln, Neb. *Am J Public Health*. 2004;94: 549–553.

www.HealthPromotionConference.com

AMERICAN JOURNAL *of*

Health Promotion

The Wisdom of Practice and the Rigor of Research


AMERICAN JOURNAL of
Health Promotion
Volume 25, Number 4
March/April 2011

"The American Journal of Health Promotion provides a forum for that rare commodity — practical and intellectual exchange between researchers and practitioners."

Kenneth E. Warner, PhD
Dean and Avedis Donabedian Distinguished University Professor of Public Health
School of Public Health, University of Michigan

"The contents of the American Journal of Health Promotion are timely, relevant, and most important, written and reviewed by the most respected researchers in our field."

David R. Anderson, PhD, LP
Senior Vice President & Chief Health Officer, StayWell Health Management

onlineFirst

Available exclusively to ONLINE SUBSCRIBERS

Be the first to know.

The American Journal of Health Promotion is now publishing all articles online, ahead of print. Articles are available as a PDF document for download as soon as they have completed the review process. This means you can access the very latest papers in the field of health promotion – in some cases up to a year before they appear in print.

Subscribe Today.

Subscribe Online at www.HealthPromotionJournal.com
Call 800-783-9913 (US only) or 731-645-4496

ANNUAL SUBSCRIPTION RATES: (Effective 1-1-14 through 12-31-14)

	INDIVIDUAL	INSTITUTION			
	Print + Online	Tier 1 Print + Online Online Only	Tier 2 Print + Online Online Only	Tier 3 Print + Online Online Only	Print Only*
U.S.	$139	$359	$459	$559	$184
Canada and Mexico	$148	$368	$468	$568	$193
Other Countries	$157	$377	$477	$577	$202

*Print-only subscriptions are based on location. For multi-site institutions, each site must have its own subscription.

Tier 1 — Most Employers and Corporations except Health Organizations, Libraries and Schools

Tier 2 — Health Organizations including Hospitals, Clinics, Health Promotion Providers, Insurance Companies and Voluntary Health Agencies

Tier 3 — Libraries, Colleges and Universities