Preventive Medicine Reports 8 (2017) 72–78

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

The cost-effectiveness of physical activity interventions: A systematic review of reviews

Karim Abu-Omar[a,*], Alfred Rütten[a], Ionuţ Burlacu[a], Valentin Schätzlein[a], Sven Messing[a], Marc Suhrcke[b]

[a] Institute of Sport Science and Sport, Friedrich-Alexander University Erlangen-Nürnberg, Germany
[b] Centre for Health Economics, University of York, United Kingdom

ARTICLE INFO

Keywords:
Physical activity
Physical activity intervention
Costs
Cost-effectiveness
Health-economic
Review of reviews
Systematic review
Review

ABSTRACT

Background: Despite growing recognition of the need to promote physical activity, the existing evidence base on the cost-effectiveness of relevant interventions appears scant and scattered. This systematic review of reviews set out to take stock of the evidence on the cost-effectiveness of physical activity interventions.
Methods: Ten literature databases were systematically searched for available reviews on the cost-effectiveness of physical activity interventions, complemented by a hand search. Out of the 515 articles identified, 18 reviews met the inclusion criteria. A quality appraisal of the 18 reviews was undertaken.
Results: Of the 18 reviews, 4 contained information on the target group of children and adolescents, 12 on adults, 3 on older adults, and 6 on the general population. Across the reviews some intervention strategies were identified as being particularly cost-effective, including certain school-based interventions (children and adolescents), interventions using pedometers (adults), fall prevention programs (older people), mass media campaigns and environmental approaches (general population). However, for some of these approaches (e.g. mass media campaigns), the underlying evidence of being able to change physical activity behavior remains inconsistent.
Conclusion: Available evidence for the cost-effectiveness of physical activity interventions is scattered, but points towards the cost-effectiveness of certain interventions. Until this moment, cost-effectiveness has more often been studied for individual-level interventions. This is potentially due to some methodological challenges in assessing the cost-effectiveness of population-based interventions.

1. Introduction

Arguments for efforts to promote physical activity on the population level are increasingly based on calculations of the costs of inactivity. For example, a recent study estimated the costs for health care systems attributable to physical inactivity to be 54 billion (INT$) worldwide in 2013 (Ding et al., 2016). In another study, it has been stated that a 20% reduction of inactivity rates on the population level would already yield important cost savings (ISCA/CEBR, 2015). Such figures might have contributed to international calls for increasing physical activity promotion efforts (European Union, 2008; World Health Organization, 2004; World Health Organization, 2013).

In order to make informed public health decisions on how to promote physical activity, information on the overall effectiveness of different intervention types to increase physical activity, and considerations of cost-effectiveness of different interventions types are highly relevant. While an impressive number of reviews have been conducted on the topic of effectiveness of physical activity promotion (a recent scoping review yielded more than 350 reviews; Rütten et al., 2016), the interest in assessing the cost-effectiveness of physical activity interventions appears to have grown only recently, as evidenced by a series of relevant systematic reviews that have been published in the last 5 years (Campbell et al., 2015; GC et al., 2015; Laine et al., 2014; Foster et al., 2013; Balzer et al., 2012; Lehnert et al., 2012). Mainly, existing reviews on the cost-effectiveness of physical activity interventions have focused on particular target groups (e.g. older people; Balzer et al., 2012), specific intervention types (e.g. face-to-face interventions; Gordon et al., 2007), or specific settings where interventions were conducted (e.g. worksite; van Van Dongen et al., 2011). Only some reviews have presented findings across different target groups, intervention types, and settings (e.g. Laine et al., 2014; Wu et al., 2011).

By systematically identifying, assessing and synthesizing results of

* Corresponding author.
E-mail addresses: karim.abu-omar@fau.de (K. Abu-Omar), alfred.ruetten@fau.de (A. Rütten), ionut.burlacu@fau.de (I. Burlacu), valentin.schaetzlein@fau.de (V. Schätzlein), sven.messing@fau.de (S. Messing), marc.suhrcke@york.ac.uk (M. Suhrcke).

http://dx.doi.org/10.1016/j.pmedr.2017.08.006
Received 26 April 2017; Received in revised form 11 July 2017; Accepted 15 August 2017
Available online 15 August 2017

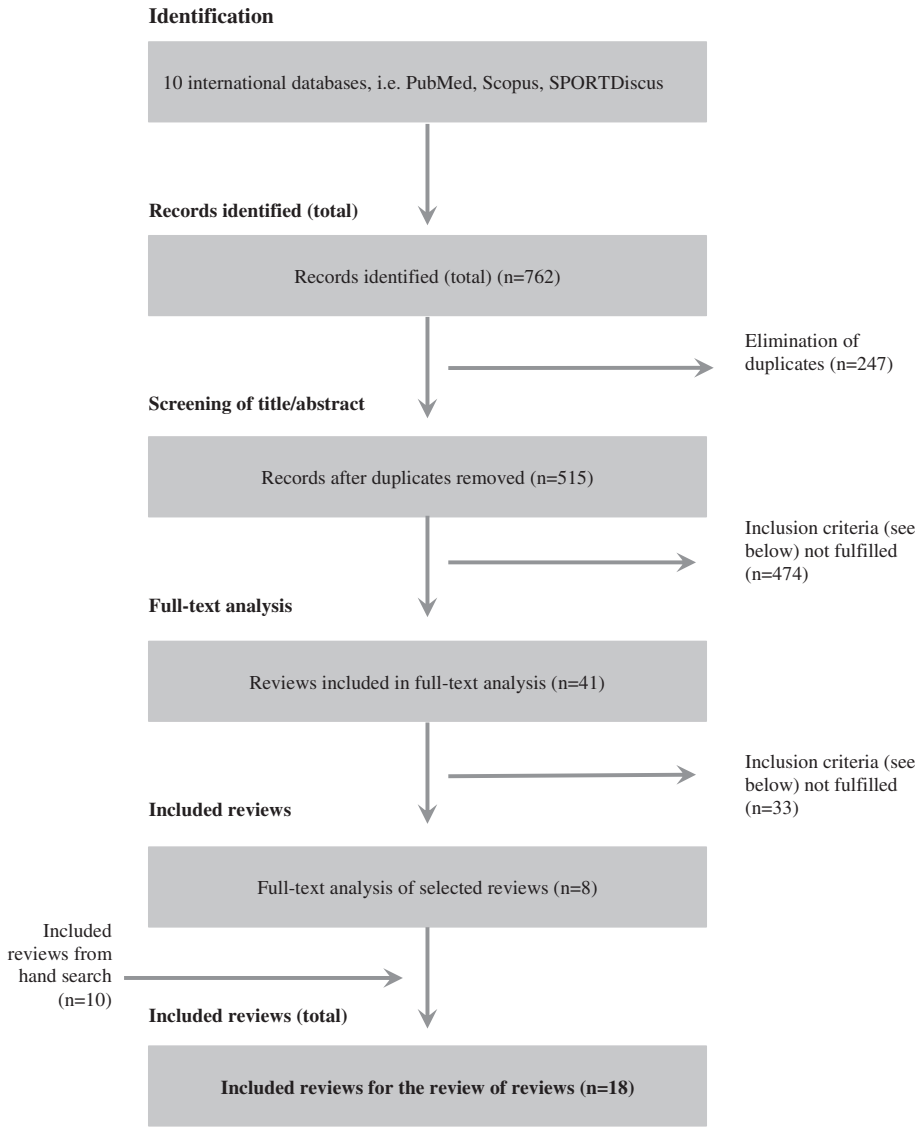

Fig. 1. Flowchart of the literature search for the review of reviews.

all relevant studies, bias can be minimized in well conducted systematic reviews. More recently, overviews of systematic reviews have been used to summarize research evidence relevant to a wide range of health interventions (Hartling et al., 2014; Thomson et al., 2010). In the present paper we took stock of the state of the evidence on the cost-effectiveness of physical activity interventions by critically reviewing and synthesizing published systematic reviews on the topic.

To the best of our knowledge, the present systematic review of reviews on the cost-effectiveness of physical activity interventions is the first such endeavor. We utilized rigorous methodology, systematically screened the international literature, and appraised and summarized the evidence. The intention of this endeavor was to provide a more comprehensive overview regarding the available evidence for the cost-effectiveness of physical activity promotion efforts. Such knowledge might be valuable to inform decisions regarding efforts to promote physical activity on the population level.

2. Methods

This systematic review of reviews was based on a literature search in each of the following 10 databases: PubMed, Scopus, EBSCOHost, PsychInfo, SPORTDiscus, EBSCON-ECON LIT, Pro-Quest, ERIC, IBSS and NHSEED. A title and abstract search was conducted and restricted to reviews published between January 2000 and October 2015. Search terms linked with 'AND' were "physical activity", "cost", "intervention", "systematic review", and "health outcome". For each search term, related terms were added as alternatives using 'OR' (e.g. for "physical activity": physical fitness, active lifestyle, moving, move*, sport*, exercis*, biking, bike*, bicycl*, cycling, cycle, walk*, active transport*, active travel, active commut*, human powered transport). Additionally, a hand search was conducted, which included a systematic search of websites (e.g. WHO, NICE UK) that featured articles or reports that are not necessarily indexed in peer-reviewed journals. Additionally, the authors gathered reviews of which they were aware and that were not located by the systematic literature search.

Two reviewers firstly screened the titles and abstracts from all search results and later the full text. Reviews were included if they met the following criteria:

- Language of the article was English or German.
- The article was a review that either modeled or summarized health economic evaluations of physical activity interventions.
- The article included a description of how the literature was identified, and stated inclusion and exclusion criteria.

- Interventions included in the article aimed at increasing physical activity or improving health (via increasing physical activity).
- Interventions targeted healthy individuals.

All included reviews were summarized independently by two reviewers following an extraction table. Disagreements were resolved by discussion, and by a third reviewer analyzing the review. In analyzing the results of the different reviews, we used the term "cost saving" to indicate that the costs of an intervention were actually outweighed by the benefits (e.g. saved medical costs) it achieved. In comparison, "cost-effectiveness" implied that the costs of an intervention were not outweighed by the benefits, but rather that the intervention provided "good value for money" compared to alternative intervention options (Drummond et al., 2015; Kelly et al., 2005).

Quality appraisals were performed by following the Quality Assessment Tool for Quantitative Studies of the National Collaborating Centre for Methods and Tools (National Collaborating Centre for Methods and Tools, 2008). The tool appraises the methodological quality of reviews by different criteria (e.g. focused research question, appropriate inclusion criteria, comprehensive search strategy, description of level of evidence, assessment of methodological quality of primary studies, appropriateness of combining results across studies). The more criteria are fulfilled, the higher the quality of the review is rated.

Results were categorized by target group (children and adolescents, adults, older people and the general population), taking a life-course perspective. Within these different target groups, results were categorized by settings (e.g. for children and adolescents: family and home setting, child care facilities, schools). This categorization was developed and utilized in the German Recommendations for Physical Activity and Physical Activity Promotion (Rütten and Pfeifer, 2016).

3. Results

3.1. Literature search

In the first step of the literature search, 515 references (excluding 247 duplicates) were identified. After reviewing titles and abstracts, 41 documents were selected for further analysis by reading the full text. Of those, 8 met the inclusion criteria and were selected. Additionally, 10 reviews were identified via hand search. In total, the analysis included 18 reviews (Fig. 1).

For the most part, the methodological quality of the reviews was high. Fourteen out of the 18 reviews were assigned a high methodological quality (Table 1). Most reviews focused on more than one target group. Four reviews were concerned with children and adolescents. The target group of adults was covered in 12 reviews, and the target group of older people in 3 reviews. Six reviews covered the general population (Table 2).

3.2. Reviews on the cost-effectiveness of physical activity interventions in children and adolescents

Three of the four reviews on this target group (Laine et al., 2014; Lehnert et al., 2012; Wu et al., 2011) dealt with physical activity interventions in schools. Laine et al. (2014), and Wu et al. (2011) both cautiously considered school interventions to be cost-effective. However, both reviews included a diverse set of school-based interventions (from health education to environmental modifications) that varied substantially regarding the size of cost-effectiveness. Lehnert et al. (2012) primarily included school-based interventions that promoted active commuting in the review. In this review, such interventions were unlikely to be cost-effective.

Lewis et al. (2010) investigated physical activity interventions in the family and home, school, and community settings. The review found some interventions to be cost-effective (e.g. dance classes and walking school bus programs), whereas others were found to be cost-effective only for a particular group of children (e.g. curriculum-based interventions for healthy diet and physical activity in girls only), or not cost-effective at all (e.g. free swimming classes).

3.3. Reviews on the cost-effectiveness of physical activity interventions in adults

Twelve reviews focused on interventions in adults. Of those, three investigated interventions in the workplace setting (Van Dongen et al., 2011; Lewis et al., 2010; Müller-Riemenschneider et al., 2009). Results across the three reviews remained inconclusive, with Müller-Riemenschneider et al. (2009) reporting no cost-effectiveness, Van Dongen et al. (2011) reporting no cost-effectiveness when investigations utilized RCT trial designs, and cost-effectiveness when other study designs were utilized, and Lewis et al. (2010) reporting worksite interventions as being cost-effective or even cost-saving.

Two reviews analyzed the cost-effectiveness of pedometer interventions (GC et al., 2015; Lewis et al., 2010). Such interventions had the highest cost-effectiveness compared to other interventions in the review of GC et al. (2015). Lewis et al. (2010) identified pedometer based interventions as being cost-effective or cost-saving in two out of three included studies.

Eight reviews investigated the cost-effectiveness of interventions for physical activity promotion in the health care setting (Campbell et al., 2015; GC et al., 2015; Pavey et al., 2011; Wu et al., 2011; Garrett et al., 2011; Lewis et al., 2010; Müller-Riemenschneider et al., 2009; Williams et al., 2007). The review of Garrett et al. (2011) blended interventions that take place in the health-care or community setting.

Of the reviews, 3 saw good cost-effectiveness for such interventions (GC et al., 2015; Lewis et al., 2010; Müller-Riemenschneider et al., 2009). Two reviews saw either no cost-effectiveness (Williams et al., 2007) or only in a very limited way (Campbell et al., 2015). The reviews of Garrett et al. (2011), Pavey et al. (2011) and Wu et al. (2011) pointed towards some more specific results. In all 3, rather brief advice and/or unsupervised exercise programs reached good cost-effectiveness. On the other hand, more extensive advice and supervised exercise programs seemed to achieve lower cost-effectiveness.

Gordon et al. (2007) investigated face-to-face interventions. These were mainly structured exercise programs or physical activity counseling in different setting. The authors concluded that the interventions among this target group were, in general, cost-effective.

Foster et al. (2013) reported a lack of studies to deduce cost-effectiveness regarding computer-based and other new technology-driven interventions.

Wolfenstetter and Wenig (2010) investigated various interventions in the worksite, health care and community setting. As intervention types, this review includes among others exercise referral schemes, physical activity counseling and exercise programmes. Most studies included were deemed as being cost-effective.

3.4. Reviews on the cost-effectiveness of physical activity interventions in older adults

The reviews of Balzer et al. (2012), Davis et al. (2009) and Windle et al. (2010) concentrated on physical activity interventions targeting older people.

Windle et al. (2010) investigated studies that attempted to promote mental health and well-being through physical activity. Only one of these studies included an economic evaluation, rating the intervention as being cost-effective.

Davis et al. (2009) and Balzer et al. (2012) focused on studies of fall prevention. Davis et al. (2009) showed that tailored interventions that include strength and balance training and multi-component interventions are cost-effective or cost-saving. Balzer et al. (2012) included quite similar studies in their review. Also in this review, such physical activity interventions for fall prevention were deemed to be cost-effective.

Table 1
Reviews on cost-effectiveness of interventions for physical activity promotion included in the review of reviews.

Author, year	Focus of the review	Number of studies	Quality rating	Health-economic benefit
Laine et al., 2014	Cost-effectiveness of population-level physical activity interventions	14	High (8/10)	Cost-effective
Cavill et al., 2008	Cost-effectiveness of interventions which promote active transport with regard to general health benefits	16	Moderate (6/10)	Cost-saving
Wolfenstetter and Wenig, 2010	Cost-effectiveness of a wide range of measures for physical activity promotion	18	High (10/10)	Cost-effective/cost-saving
GC et al., 2015	Cost-effectiveness of brief interviews for physical activity promotion	13	High (10/10)	Cost-effective
Campbell et al., 2015	Cost-effectiveness of exercise referral schemes	8	High (9/10)	Not cost-effective
Pavey et al., 2011	Cost-effectiveness of exercise referral schemes	7	High (8/10)	Cost-effective
Williams et al., 2007	Excercise referral schemes, covers also cost-effectiveness	17 (CE: 1)	Moderate (5/10)	Not cost-effective
Foster et al., 2013	Remote and web 2.0 interventions for promoting physical activity, covers also cost-effectiveness	11 (CE: 3)	High (10/10)	Cost-effective
Gordon et al., 2007	Cost-effectiveness of face-to-face behavioural interventions, also with regard to physical activity promotion	64 (PA: 13)	High (9/10)	Cost-effective/cost-saving
Windle et al., 2010	Cost-effectiveness of physical activity promotion for the promotion of mental well-being	13 (CE: 1)	High (10/10)	Cost-effective
Davis et al., 2009	Cost-effectiveness of physical activity promotion for falls prevention	9	High (10/10)	Cost-effective/cost-saving
Balzer et al., 2012	Cost-effectiveness in falls preventions, also covers physical activity programmes	13 (PA: 4)	Low (4/10)	Cost-effective
Wu et al., 2011	Cost-effectiveness of interventions for physical activity promotion	91	High (9/10)	Cost-effective/not cost-effective
Lewis et al., 2010	Cost-effectiveness of interventions for physical activity promotion	53	Moderate (6/10)	Cost-effective/cost-saving
Müller-Riemenschneider et al., 2009	Cost-effectiveness of interventions for physical activity promotion	8	High (8/10)	Cost-effective
Garrett et al., 2011	Cost-effectiveness of interventions for physical activity promotion in primary care and the community	13	High (10/10)	Cost-effective
Lehnert et al., 2012	Cost-effectiveness of interventions for the prevention of obesity, covers also physical activity promotion	3	High (8/10)	Cost-effective/not cost-effective
Van Dongen et al., 2011	Return on Investment of worksite health promotion programmes (especially nutrition and/or physical activity)	18 (PA: 2)	High (10/10)	Cost-saving/not cost-saving

Table 2
Reviews on cost-effectiveness of physical activity interventions by target group and intervention setting or type.

Children and adolescents	Adults	Older adults	General population
Family and home setting	**Workplace setting**	**Physical activity counseling & exercise in home or community**	**Mass-media campaigns**
Lewis et al., 2010	Lewis et al., 2010 Müller-Riemenschneider et al., 2009 Van Dongen et al., 2011	Windle et al., 2010	Lewis et al., 2010 Lehnert et al., 2012
Schools	**Physical activity counseling and exercise programs in health care**	**Programmes for fall prevention**	**Point-of-decision prompts**
Laine et al., 2014 Lehnert et al., 2012 Wu et al., 2011	GC et al., 2015 Campbell et al., 2015 Pavey et al., 2011 Williams et al., 2007 Wu et al., 2011 Lewis et al., 2010 Müller-Riemenschneider et al., 2009 Garrett et al., 2011	Davis et al., 2009 Balzer et al., 2012	Wu et al., 2011
Community	**Interventions taking place in different settings**		**Community-based multi-component approaches**
Lewis et al., 2010	Pedometers: GC et al., 2015 Lewis et al., 2010 Face-to-face: interventions: Gordon et al., 2007 Computers & new technologies: Foster et al., 2013 Various (e.g. exercise referral schemes, physical activity counseling, exercise programmes): Wolfenstetter and Wenig, 2010		Wu et al., 2011 Lehnert et al., 2012 **Environmental approaches** Laine et al., 2014 Cavill et al., 2008 Wu et al., 2011 Lewis et al., 2010 Müller-Riemenschneider et al., 2009

Table 3
Summary of results: on cost-effectiveness of physical activity interventions by target group and intervention setting or type.

Children and adolescents	Adults	Older adults	General population
Family and home setting	**Workplace setting**	**Physical activity counseling and exercise programs in the home and community settings**	**Mass-media campaigns**
Inconclusive evidence for cost-effectiveness from 1 review. Some interventions were cost-effective, others not.	Inconclusive evidence for cost-effectiveness from 3 reviews. Potentially, study design influences cost-effectiveness results.	Very limited number of studies available (one) to investigate cost-effectiveness.	Evidence for cost-effectiveness from 2 reviews. Limited evidence of the positive effects of mass media campaigns on physical activity behavior.
Schools	**Physical activity counseling and exercise programs in health care**	**Programmes for fall prevention**	**Point-of-decision prompts**
Evidence for cost-effectiveness from 2 reviews. One review found no cost-effectiveness for interventions that promote active transport.	Inconclusive evidence for cost-effectiveness from 8 reviews. Potentially, results support cost-effectiveness if interventions are inexpensive (brief advice, unsupervised walking groups) for healthy populations.	Evidence for cost-effectiveness from 2 reviews.	Evidence for cost-effectiveness from 1 review.
Community	**Interventions taking place in different settings**		**Community-based multi-component approaches**
Inconclusive evidence for cost-effectiveness from 1 review. Some interventions were cost-effective, others not.	Pedometers: Evidence for cost-effectiveness from 2 reviews.		Inconclusive evidence for cost-effectiveness from 2 reviews.
	Face-to-face: Evidence for cost-effectiveness from 1 review.		**Environmental approaches**
	Computers and new technologies: No evidence for cost-effectiveness from 1 review.		Evidence for cost-effectiveness from 5 reviews. Diverse cost-effectiveness estimates across reviews and studies.
	Various (e.g. exercise referral schemes, physical activity counseling, exercise programmes): Evidence for cost-effectiveness from 1 review.		

3.5. Reviews on the cost-effectiveness of physical activity interventions in the general population

The reviews of Lehnert et al. (2012) and Lewis et al. (2010) investigated the cost-effectiveness of mass-media campaigns for the promotion of physical activity. Both identified such mass media campaigns as being highly cost-effective.

Wu et al. (2011) rated point-of-decision prompts as being highly cost-effective.

Community-based multi-component approaches were covered in the reviews of Lehnert et al. (2012) and Wu et al. (2011). Both reviews reported inconclusive evidence, stating that cost-effectiveness measures outcomes differed greatly between single studies. Nevertheless, in both reviews some community campaigns were cost-effective.

Environmental modifications are an important physical activity promotion strategy. The review of Cavill et al. (2008) synthesized exclusively interventions designed to improve the infrastructures for human-powered transportation. While the review could only build on a methodologically limited and diverse set of primary studies, the authors saw evidence for the cost-effectiveness of such approaches. Laine et al. (2014) also reported highly diverse results, with the most cost-effective and the least cost-effective interventions being simultaneously the development of rail-trails. Large differences in estimates of cost-effectiveness across single studies were also reported by Wu et al. (2011). Lewis et al. (2010) saw strong evidence for environmental modifications to be cost-effective. Also, in the review of Müller-Riemenschneider et al. (2009), the development of trails was seen as being cost-effective. Table 3 summarizes the findings across age groups and settings.

4. Discussion

4.1. Main findings

This systematic review of reviews conducted a comprehensive summary and analysis of the existing literature on the cost-effectiveness of physical activity interventions. While our review pointed to favorable cost-effectiveness of many physical activity interventions, it also identified a number of methodological limitations from previous studies, and highlighted challenges for future research that will outline in this section.

As a key result, there was some evidence that physical activity interventions are cost-effective. However, there remain considerable gaps in the literature regarding cost-effectiveness of different types of interventions. Nevertheless, evidence for cost-effectiveness, could be found for most school-based interventions except for the promotion of active transport (for children and adolescents), for pedometer interventions and brief intervention in the health care setting (in adults), for interventions on fall prevention (in older people), and for environmental approaches and mass media campaigns (general population). The evidence mostly comes from a limited number of reviews.

Placing these findings within a public health perspective is important: For children and adolescents, there is an urgent need to more specifically investigate which type of school-based physical activity interventions are cost-effective. One review concluded that multi-component interventions that do not require the hiring of additional staff seem to be particularly cost-effective (Wu et al., 2011). Another

review concluded that interventions promoting active transport in children are not cost-effective (Lehnert et al., 2012).

Regarding adults, exercise referral schemes were investigated in several reviews. Results remain inconclusive. There might be some indication that such schemes are more cost-effective when targeting individuals carrying risk factors, compared to healthy individuals. Not surprisingly, the cost-effectiveness results of any such schemes will crucially depend on how costly such schemes are in the first place (e.g. hiring professional instructors for exercise groups compared to lay people). Such findings point in the direction of the need to carefully plan exercise referral schemes (e.g. in terms of target group and intervention costs) prior to potential scale-up.

Some cautious remarks are called for regarding mass media campaigns in the general population: The WHO (2011) considers mass media campaigns as a "best buy" for the prevention of chronic diseases. This was supported by two reviews included in our analysis that saw good cost-effectiveness of this intervention type (Lehnert et al., 2012; Lewis et al., 2010). However, there has been considerable debate about the effectiveness of such interventions in initiating behavior change (Brown et al., 2012; Vos et al., 2010), thus questioning the results of these cost-effectiveness analyses. Also, it has been shown that mass media campaigns might rather increase health inequalities (Lorenc et al., 2012). Regarding point-of-decision-prompts, review results also indicated a high potential for cost-effectiveness. However, it has to be taken into account that such interventions only seem to result in very minor physical activity increases for individuals (Wu et al., 2011).

4.2. Methodological limitations and challenges

This review has identified a number of methodological limitations of previous studies and challenges for future research (Wolfenstetter and Wenig, 2010).

Across reviews and included single studies, it is apparent that individual level interventions are investigated for cost-effectiveness more often. Compared to e.g. population level interventions, these studies are more likely to be based on widely accepted study designs, in particular randomized-controlled trials. At the same time, it seems apparent from the reviewed studies that population-level interventions have higher potential for cost-effectiveness. As such, it might be warranted to conduct more research investigating these types of interventions. However, study designs often perceived as having a high methodological quality are generally much more difficult to apply, and may even be inappropriate to population-level interventions. For example, policy and environmental approaches to physical activity promotion are highly "contextual", i.e. depending on certain collective decisions within a specific environment (e.g. a municipality that wants to establish bicycle-friendly infrastructures). Studies on such approaches often have to be designed as an evaluation of a "natural experiment", with the attendant challenge of identifying a truly causal impact of the intervention (Brownson et al., 2006). As a consequence, our review found a general lack of studies on population-level physical activity interventions. Moreover, many of the articles on environmental approaches included in the reviews, e.g. on promoting active transport, are simulation studies, and as such not based on "real world" interventions (Macmillan et al., 2014; Cavill et al., 2008; Rutter, 2006).

We identified several contradicting conclusions between reviews. Those might be caused by the heterogeneity of methodological approaches used in the different reviews: First, across reviews, quite different interventions have been included in any given category. For example, regarding the school setting, Wu et al. (2011) and Laine et al. (2014) mainly included studies on multi-component and environmental approaches to promote physical activity, and both draw positive conclusions on cost-effectiveness. Contrastingly, Lehnert et al. (2012) mainly included studies on active transport to school with more negative results. Second, the reviews tend to report on different outcomes: For example physical activity at school (Laine et al., 2014), total physical activity (Campbell et al., 2015; Müller-Riemenschneider et al., 2009) or overweight/obesity rates (Lehnert et al., 2012). Third, different definitions of benefits are used. For example, "Quality Adjusted Life Years" (GC et al., 2015), reduction of absenteeism (Pavey et al., 2011), reduced medical costs (Williams et al., 2007), or productivity gained (Van Dongen et al., 2011). Fourth, differences existed across reviews regarding how to conduct the health economic analysis: while most reviews conducted a cost-effectiveness analysis, cost-benefit analysis was frequently used when investigating the effects of physical activity interventions in the worksite setting (Van Dongen et al., 2011) or active transport (Cavill et al., 2008).

In spite of the many differences between reviews, one rather methodological issue seemed to permeate analyses of cost-effectiveness: The existing curvilinear relationship between physical activity level and health benefits. It is a well established fact in physical activity research that the more active an individual is prior to the physical activity intervention, the smaller the health gains of this individual will be if he/she engages in additional physical activity (Warburton and Bredin, 2016). That is to say that, for instance, a sedentary individual who takes up exercise twice a week will likely have bigger health gains when compared to an individual that increased her/his exercise behavior from twice to four times a week. To our knowledge, very few cost-effectiveness studies consider such a curvilinear relationship between physical activity and health benefits. This might influence results regarding the cost-effectiveness of different interventions.

4.3. The public health relevance of cost-effectiveness reviews of physical activity interventions

The most important finding of our review of reviews might be that existing knowledge on cost-effectiveness of physical activity interventions is currently scattered and of somewhat limited practical public health value. Taking a national or global perspective (which would need to include developing and developed nations), few interventions for physical activity have consistently shown to be cost-effective across reviews. For these interventions, the reviews contained very little information regarding their impact on health inequalities, scale-up costs, and distribution of costs and benefits between the public and other sectors.

In order to overcome such limitations, we would suggest the following way forward:

(1) Increasing efforts to conduct natural experiments to investigate the effectiveness of policy and environmental approaches to physical activity promotion. Based on the promising result of such interventions to promote physical activity and their potential to combat health inequalities (Lorenc et al., 2012), more efforts should be dedicated to strengthening the evidence-base for the cost-effectiveness of these intervention strategies.
(2) Relaxing inclusion criteria for reviews on the cost-effectiveness of physical activity promotion studies to allow for the inclusion of natural experiments. Limiting such reviews to rigorous study designs such as randomized-controlled studies might be counter-productive, since this leaves out more promising interventions that cannot easily be studied by these designs.
(3) Agreeing on a common classification of interventions and outcome measures in order to increase the comparability of results across studies and reviews. The value of conducting reviews could be

vastly increased if their results could be more directly compared, and if they were built upon agreed categorizations of intervention types and outcome measures.

(4) Developing a research agenda that more clearly seeks to provide specific answers to which intervention strategies should be internationally scaled-up for physical activity promotion. Such an agenda should be concerned, beyond health equity, with identifying important target groups for physical activity promotion efforts, intervention strategies that require little upfront costs and are thus suitable for e.g. developing nations, and intervention strategies that can be used within certain contexts.

Conflict of interest

The authors declare there is no conflict of interest.

Funding

This research has been partially funded by the Sport Department of the City of Berlin.

References

Balzer, K., Bremer, M., Schramm, S., et al., 2012. Falls prevention for the elderly. GMS Health Techno Assess 8. http://dx.doi.org/10.3205/hta000099.

Brown, D.R., Soares, J., Epping, J.M., et al., 2012. Stand-alone mass media campaigns to increase physical activity: a community guide updated review. Am. J. Prev. Med. 43 (5), 551–561.

Brownson, R.C., Haire-Joshu, D., Luke, D.A., 2006. Shaping the context of health: a review of environmental and policy approaches in the prevention of chronic diseases. Annu. Rev. Public Health 27, 341–370.

Campbell, F., Holmes, M., Everson-Hock, E., et al., 2015. A systematic review and economic evaluation of exercise referral schemes in primary care: a short report. Health Technol. Assess. 19 (60). http://dx.doi.org/10.3310/hta19600.

Cavill, N., Kahlmeier, S., Rutter, H., et al., 2008. Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review. Transp. Policy 15 (5), 291–304.

Davis, J.C., Robertson, M.C., Ashe, M.C., et al., 2009. Does a home based strength and balance programme in people aged ≥ 80 years provide the best value for money to prevent falls? A systematic review of economic analyses of falls prevention interventions. Br. J. Sports Med. 44 (8), 80–89.

Ding, D., Lawson, K.D., Kolbe-Alexander, T.L., et al., 2016. The economic burden of physical inactivity: a global analysis of major non-communicable diseases. Lancet 388, 1311–1324.

Drummond, M.F., Sculpher, M.J., Claxton, K., et al., 2015. Methods for the Economic Evaluation of Health Care Programmes, 4th ed. Oxford University Press, Oxford.

European Union, 2008. EU Physical Activity Guidelines. Recommended Policy Actions in Support of Health-Enhancing Physical Activity, Brussels.

Foster, C., Richards, J., Thorogood, M., et al., 2013. Remote and web 2.0 interventions for promoting physical activity. Cochrane Database Syst. Rev. 2. http://dx.doi.org/10.1002/14651858.CD010395.

Garrett, S., Elley, C.R., Rose, S.B., et al., 2011. Are physical activity interventions in primary care and the community cost-effective? A systematic review of the evidence. Br. J. Gen. Pract. 61 (584), e125–e133.

GC, V., Wilson, E.C., Suhrcke, M., et al., 2015. Are brief interventions to increase physical activity cost-effective? A systematic review. Br. J. Sports Med. http://dx.doi.org/10.1136/bjsports-2015-094655.

Gordon, L., Graves, N., Hawkes, A., et al., 2007. A review of the cost-effectiveness of face-to-face behavioural interventions for smoking, physical activity, diet and alcohol. Chronic Illn 3 (2), 101–129.

Hartling, L., Vandermeer, B., Fernandes, R.M., 2014. Systematic reviews, overviews of reviews and comparative effectiveness reviews: a discussion of approaches to knowledge synthesis. Evid Based Child Health 9, 486–494.

ISCA/Cebr, June 2015. The economic cost of physical inactivity in Europe. In: An ISCA/Cebr Report, (http://inactivity-time-bomb.nowwemove.com/download-report/The%20Economic%20Costs%20of%20Physical%20Inactivity%20in%20Europe%20(June%202015).pdf. Accessed 06. April 2017).

Kelly, M.P., McDaid, D., Ludbrook, A., et al., 2005. Economic appraisal of public health interventions. In: Briefing Paper. NHS Health Development Agency (http://www.cawt.com/Site/11/Documents/Publications/Population%20Health/Economics%20of%20Health%20Improvement/Economic_appraisal_of_public_health_interventions.pdf. Accessed 06 Apr 2017).

Laine, J., Kuvaja-Köllner, V., Pietilä, E., et al., 2014. Cost-effectiveness of population-level physical activity interventions: a systematic review. Am. J. Health Promot. 29 (2), 71–80.

Lehnert, T., Sonntag, D., Konnopka, A., et al., 2012. The long-term cost-effectiveness of obesity prevention interventions: systematic literature review. Obes. Rev. 13 (6), 537–553.

Lewis, C., Ubido, J., Holford, R., et al., 2010. Prevention programmes cost-effectiveness review. In: Liverpool Public Health Observatory Report, (https://www.liverpool.ac.uk/media/livacuk/instituteofpsychology/researchgroups/lpho/83_28th_Feb_Physical_activity_and_cost_FINAL.pdf. Accessed 06 Apr 2017).

Lorenc, T., Petticrew, M., Welch, V., et al., 2012. What types of interventions generate inequalities? Evidence from systematic reviews. J. Epidemiol. Community Health 67, 190–193.

Macmillan, A., Connor, J., Witten, K., et al., 2014. The societal costs and benefits of commuter bicycling: simulating the effects of specific policies using system dynamics modeling. Environ. Health Perspect. 122, 335–344.

Müller-Riemenschneider, F., Reinhold, T., Willich, S.N., 2009. Cost-effectiveness of interventions promoting physical activity. Br. J. Sports Med. 43 (1), 70–76.

National Collaborating Centre for Methods and Tools, 2008. Quality Assessment Tool for Quantitative Studies. MCMaster University, Hamilton, ON ((Updated 13 April 2010), http://www.nccmt.ca/registry/view/eng/14.html. Accessed 06 Apr 2017).

Pavey, T.G., Anokye, N., Taylor, A.H., et al., 2011. The clinical effectiveness and cost-effectiveness of exercise referral schemes: a systematic review and economic evaluation. Health Technol. Assess. 15(44). http://dx.doi.org/10.3310/hta15440.

Rütten, A., Pfeifer, K., 2016. National Recommendations for Physical Activity and Physical Activity Promotion. FAU University Press, Erlangen.

Rütten, A., Schow, D., Breda, J., et al., 2016. Three types of scientific evidence to inform physical activity policy: results from a comparative scoping review. Int J Public Health.

Rutter, H., 2006. Mortality benefits of cycling in London. In: Transport for London, (http://content.tfl.gov.uk/benefits-of-cycling-report.pdf, Accessed 06 Apr 2017).

Thomson, D., Russell, K., Becker, L., et al., 2010. The evolution of a new publication type: steps and challenges of producing overviews of reviews. Res Synth Methods 1, 198–211.

Van Dongen, J.M., Proper, K.I., Van Wier, M.F., et al., 2011. Systematic review on the financial return of worksite health promotion programmes aimed at improving nutrition and/or increasing physical activity. Obes. Rev. 12 (12), 1031–1049.

Vos, T., Carter, R., Barendregt, J., et al., 2010. Assessing cost-effectiveness in prevention: ACE–prevention. In: Final Report. University of Queensland (https://public-health.uq.edu.au/files/571/ACE-Prevention_final_report.pdf. Accessed 06 Apr 2017).

Warburton, D., Bredin, S., 2016. Reflections on physical activity and health: what should we recommend? Can. J. Cardiol. 32, 495–504.

Williams, N.H., Hendry, M., France, B., et al., 2007. Effectiveness of exercise-referral schemes to promote physical activity in adults: systematic review. Br. J. Gen. Pract. 57 (545), 979–986.

Windle, G., Hughes, D., Linck, P., et al., 2010. Is exercise effective in promoting mental well-being in older age? A systematic review. Aging Ment. Health 14 (6), 652–669.

Wolfenstetter, S.B., Wenig, C.M., 2010. Economic evaluation and transferability of physical activity programmes in primary prevention: a systematic review. Int. J. Environ. Res. Public Health 7 (4), 1622–1648.

World Health Organization, 2004. Global Strategy on Diet, Physical Activity and Health. WHO Press, Geneva.

World Health Organization, 2011. Global Status Report on Noncommunicable Diseases 2010. WHO Press, Geneva.

World Health Organization, 2013. Global Action Plan for the Prevention and Control of Noncommunicable Diseases 2013–2020. WHO Press, Geneva.

Wu, S., Cohen, D., Shi, Y., et al., 2011. Economic analysis of physical activity interventions. Am. J. Prev. Med. 40 (2), 149–158.