Systematic review of interventions for promoting active school transport

Abbreviations: ALBD, Active Living By Design; AST, Active school transport; BMI, body mass index; CVD, cardiovascular disease; EPHPP, Effective Public Health Practice Project; MeSH, medical subject headings; MVPA, moderate-to-vigorous physical activity; NA, not applicable; SRTS, Safe Routes to School; PA, physical activity; WHO, World Health Organization.

Introduction

Physical activity (PA) is associated with lower cardiovascular disease morbidity and mortality in adults (Haskell et al., 2007) and prevents several cardiovascular risk factors in both healthy and unhealthy children (Andersen et al., 2011; Janssen and LeBlanc, 2010). The World Health Organization (WHO) updated their pediatric PA recommendations (WHO, 2010), which suggested that previous guidelines underestimated the physical activity necessary to reduce cardiovascular disease risk in youth. The WHO guidelines now recommend children aged 5–17 years accumulate at least 60 min of moderate-to-vigorous physical activity (MVPA) daily, and that vigorous physical activity should be incorporated at least three times per week (WHO, 2010). However, population data indicate that the majority of children and adolescents fail to meet this threshold, requiring structural solutions over evidence generation (Moore et al., 2014).

Active forms of transport, such as walking and cycling, have been recognized as potential avenues to increase the daily physical activity providing an alternative to more traditional physical activity domains such as sport and exercise (Heath et al., 2012; Reynolds et al., 2014; Sahlqvist et al., 2012). Active school transport has been proposed as a way to increase physical activity in children and youth at the population level (Tudor-Locke et al., 2001), with the added benefit of reducing emissions of greenhouse gases and other pollutants (Chapman, 2007; Woodcock et al., 2009). It is an inexpensive source of physical activity that can be integrated into individuals' routines as most children and adolescents have to travel to and from school twice per day. In addition, it has been argued that if sufficient intensity is achieved, active transport could lead to an increase in cardiovascular fitness (Shephard, 2008). In spite of these benefits, longitudinal studies performed in the last decades in Canada (Buliung et al., 2009), the United States (McDonald, 2007), Australia (van der Ploeg et al., 2008), and European countries (Chillon et al., 2013) have shown a decline in the rates of active transport mainly due to for barriers such as distance from home to school or family decisions. Moreover, in 2011 a systematic review of 14 intervention studies to promote this behaviour indicated limited success (Chillon et al., 2011). This review concluded that more research with higher quality study designs and measures should be conducted to further evaluate interventions and to determine the most successful strategies for increasing active transport to school. Thenceforth, a systematic review can help determine if the field has progressed in the *design* and *development* of interventions, including new perspectives and application contexts. A systematic review can also help identify successful strategies to provide effective public health policies. Therefore, the main aim in the current study was to update the previous review published in 2011 (Chillon et al., 2011), following the same methodology and addressing the quality and effectiveness of new studies detected in the more recent scientific literature from 2010 to 2016.

Methods

Search strategy

The search strategy was conducted following PRISMA guidelines (Moher et al., 2010) and the same procedure as the previous mentioned review study (Chillon et al., 2011). In short, the literature search was conducted including five electronic databases: MEDLINE (PubMed), Web of Science (SCI and SSCI), SPORT Discus, the Cochrane library, and the National Transportation Library. Three categories of search terms were identified: school-age children, active transportation, and interventions. Specific terms used in the search were obtained from active transportation to school review study, from the medical subject headings (MeSH) within PubMed and from the librarian's and researchers' expertise. The specific terms were adapted for each database in a similar way as the previous review **(additional File 1)**. All English language publications from February 2010 to December 2016 were included.

Selection and review process

Once the list of potentially relevant studies was compiled, titles and abstracts were reviewed to determine if the articles met the following four inclusion criteria: 1) focused on children and adolescents (5-18 y); 2) described an intervention focused on increasing active travel to school; and 3) included at least one outcome of active transportation to/from school or physical activity. Any disagreements in the inclusion process were resolved through discussion among authors. Data were therefore extracted from the articles, including descriptive information, indicators of study quality, intervention strategies employed, and effectiveness. All data were abstracted and checked by two other reviewers on the same date.

Quality assessment

The quality assessment was conducted using a standardized evaluation framework, the Effective Public Health Practice Project (Hamilton, 2015). EPHPP assesses six methodological dimensions: selection bias, study design, confounders, blinding, data collection methods, and withdrawals and dropouts, all of which comprise a global rating. Each dimension is rated on a three-point scale: strong, moderate, or weak based on standard criteria. Overall quality ratings were derived from the component ratings as follows: "strong" when there were no weak component ratings, "moderate" when there was one weak component rating, and "weak" when there were at least two weak component ratings. Intervention integrity and appropriate analysis were included as two additional methodological dimensions; however, they were not involved in the calculation of the global rating in the EPHPP tool, according to an earlier review (Oja et al., 2011). The quality assessment was assesed independently by three reviewers (EV, YB, and PC) for all studies. The reviewers then discussed any ratings where there was a disagreement to reach a consensus. This procedure was previously employed by de Bourdeaudhuij and colleagues (De Bourdeaudhuij et al., 2011). The EPHPP was created primarily for individual level observational and clinical studies based on populations; consequently, rating criteria for some items were modified by authors to improve the suitability of the tool for the interventions included in this review (detailed in **additional file 2)**.

Intervention strategy framework

The intervention design for each study was examined using a standardized intervention framework: the Active Living By Design (ALBD) Community Action Model. This framework outlines five strategies (the 5 P's): Preparation, Promotions, Programs, Policies, and Physical (Bors et al., 2009). This model uses an ecologic framework with multi-level strategies to increase physical activity and has been successfully applied in studies of active transportation to school (Chillon et al., 2011).

Effectiveness assessment

The effectiveness assessment was conducted by calculating the effect size using Cohen's d. Effect size was calculated between experimental and control groups, or between baseline and follow-up for the experimental group. The majority of the studies included active commuting to school for the main outcome; however, some studies included active commuting as measured by physical activity (e.g., physical activity levels or steps during the route to or from school). The calculations used standardized mean or proportion differences (Nakagawa and Cuthill, 2007), t statistics, or P values (Abramowitz and Stegun, 1964; Hunter and Schmidt, 1991; Meta-Analysis: Methods of Accumulating Results Across Research Domains) for this study (**additional file 3)**. The Cohen's d was divided into five levels: trivial (Cohen's d ≤ 0.2), small (>0.2), moderate (>0.5), large (>0.8), and very large (>1.3) (Cohen, 1988).

Results

Study selection

The electronic search strategy is described in **Figure 1. Supplementary table 1** shows a list of the excluded studies. Finally, 23 intervention studies related to active transportation to school were included in this review.

Study population

Characteristics of the different interventions about active transportation to school are presented in **Table 1**. The 23 studies took place on three continents (North America, Europe, and Oceania). Eleven studies were conducted in the United States (Buckley et al., 2013; Bungum et al., 2014; Gutierrez et al., 2014; Hoelscher et al., 2016; Kong et al., 2010; McDonald et al., 2014; McDonald et al., 2013; Mendoza et al., 2011; Sayers et al., 2012; Sirard et al., 2015; Stewart et al., 2014), eight studies were conducted in European countries (Belgium, Denmark, Spain, and the United Kingdom) (Christiansen et al., 2014; Coombes and Jones, 2016; Ducheyne et al., 2014; Goodman et al., 2016; McMinn et al., 2012; Ostergaard et al., 2015; Vanwolleghem et al., 2014; Villa-Gonzalez et al., 2016), two studies in Canada (Buliung et al., 2011; Mammen et al., 2014), and one study in Australia (Crawford and Garrard, 2013). Further, one study was carried out jointly in the United Kingdom and Canada (Hunter et al., 2015). Fourteen studies focused on children (from age 5 to 12 y), and were set in elementary schools (Buckley et al., 2013; Bungum et al., 2014; Coombes and Jones, 2016; Crawford and Garrard, 2013; Ducheyne et al., 2014; Goodman et al., 2016; Hoelscher et al., 2016; Kong et al., 2010; McMinn et al., 2012; Mendoza et al., 2011; Ostergaard et al., 2015; Sayers et al., 2012; Vanwolleghem et al., 2014; Villa-Gonzalez et al., 2016), whereas nine studies included adolescents from secondary schools (from age 13 to 18 y) (Buliung et al., 2011; Christiansen et al., 2014; Gutierrez et al., 2014; Hunter et al., 2015; Mammen et al., 2014; McDonald et al., 2014; McDonald et al., 2013; Sirard et al., 2015; Stewart et al., 2014).

The number of participants varied across the intervention studies, ranging from 25 participants (Kong et al., 2010) to seven studies that reported between 1000 to 3400 participants (Buliung et al., 2011; Bungum et al., 2014; Christiansen et al., 2014; Goodman et al., 2016; Hunter et al., 2015; McDonald et al., 2013; Ostergaard et al., 2015). Moreover, one study was carried out in approximately 65,000 students and 16,000 parents (McDonald et al., 2014) and another study in 25,000 students (Sirard et al., 2015). Two studies only reported the number of schools who participated in the study (n=79 (Hoelscher et al., 2016) and n=1019 (Stewart et al., 2014)) rather than the number of participants.

Quality assessment

The quality assessment of the interventions was conducted using the EPHPP tool **(Table 2)**. Only two studies received a global rating of moderate (Christiansen et al., 2014; Mendoza et al., 2011) and the remainder was evaluated as weak in the global rating. Regarding selection bias**,** only one study included a representative sample (e.g., 25,500 students from all public elementary schools in Minneapolis, Minnesota) classified as strong (Sirard et al., 2015). Three studies were received moderate classification for selecion bias (Christiansen et al., 2014; Ducheyne et al., 2014; Hoelscher et al., 2016), whereas the rest of the studies were classified as weak. Regarding study design, three studies were rated as strong because randomized controlled trial designs were used (Christiansen et al., 2014; Ducheyne et al., 2014; Mendoza et al., 2011). However, most study designs were moderately rated using quasi-experimental designs (two group pre + post (Bungum et al., 2014; Coombes and Jones, 2016; Crawford and Garrard, 2013; Goodman et al., 2016; Gutierrez et al., 2014; Hoelscher et al., 2016; McDonald et al., 2014; McDonald et al., 2013; McMinn et al., 2012; Villa-Gonzalez et al., 2016) or one group pre + post (Buckley et al., 2013; Buliung et al., 2011; Hunter et al., 2015; Kong et al., 2010; Mammen et al., 2014; Ostergaard et al., 2015; Sayers et al., 2012; Sirard et al., 2015; Stewart et al., 2014; Vanwolleghem et al., 2014). Concerning the control of confounders, three studies were rated as strong (McDonald et al., 2013; Mendoza et al., 2012; Sayers et al., 2012), five as moderate (Christiansen et al., 2014; Crawford and Garrard, 2013; Goodman et al., 2016; McDonald et al., 2014; McMinn et al., 2012), and nine as weak (Buckley et al., 2013;

Bungum et al., 2014; Coombes and Jones, 2016; Ducheyne et al., 2014; Gutierrez et al., 2014; Hoelscher et al., 2016; Ostergaard et al., 2015; Stewart et al., 2014; Villa-Gonzalez et al., 2016). Since six intervention studies did not have a control group, the evaluation of control of confounders was not applicable (Buliung et al., 2011; Hunter et al., 2015; Kong et al., 2010; Mammen et al., 2014; Sirard et al., 2015; Vanwolleghem et al., 2014). Blinding or masking in most of the studies was assessed as moderate, since most studies used self-administered questionnaires, making it difficult to assess if both assessors and participants were masked.

Regarding the primary outcome assessment method, eleven studies were rated as strong, since they reported evidence of validity and reliability for the measurement instruments (Christiansen et al., 2014; Coombes and Jones, 2016; Crawford and Garrard, 2013; Ducheyne et al., 2014; Gutierrez et al., 2014; Hoelscher et al., 2016; Mammen et al., 2014; McMinn et al., 2012; Mendoza et al., 2011; Sayers et al., 2012; Vanwolleghem et al., 2014). In three of these, objective measurement was used (e.g., accelerometer (McMinn et al., 2012; Sayers et al., 2012) and pedometer (Vanwolleghem et al., 2014)). Only one study was evaluated as moderate (McDonald et al., 2014), and the rest of the studies were rated as weak. Self-report measurements were completed by students in eleven studies (Buckley et al., 2013; Christiansen et al., 2014; Coombes and Jones, 2016; Hunter et al., 2015; Kong et al., 2010; Mammen et al., 2014; McMinn et al., 2012; Mendoza et al., 2011; Ostergaard et al., 2015; Stewart et al., 2014; Villa-Gonzalez et al., 2016), by parents in three studies (Ducheyne et al., 2014; Goodman et al., 2016; Gutierrez et al., 2014), and by both students and parents in seven studies (Buliung et al., 2011; Crawford and Garrard, 2013; Hoelscher et al., 2016; McDonald et al., 2014; McDonald et al., 2013; Sayers et al., 2012; Vanwolleghem et al., 2014). In some studies (n=5), the researchers reported the main outcome (e.g., volunteers, team of observers, or researchers) (Buckley et al., 2013; Bungum et al., 2014; Crawford and Garrard, 2013; Gutierrez et al., 2014; Sirard et al., 2015). Mode and frequency of transportation to school were usually asked, but the form of the questions and the way of asking them differed from each study.

Regarding the withdrawals and dropout criteria, five interventions reported 80% or more participants who completed the study obtaining a strong rating (Coombes and Jones, 2016; Ducheyne et al., 2014; Kong et al., 2010; McDonald et al., 2014; Mendoza et al., 2011), and three studies reported between 60-79% of participants who completed the study and obtained a moderate rating (Christiansen et al., 2014; Hoelscher et al., 2016; Vanwolleghem et al., 2014). In describing intervention integrity, six studies reported the percentage of participants receiving the allocated intervention, corresponding to less than 60% in one study (Mammen et al., 2014) to 80-100% in six studies (Christiansen et al., 2014; Ducheyne et al., 2014; Goodman et al., 2016; Hunter et al., 2015; Kong et al., 2010; Mendoza et al., 2011). Two studies measured the consistency of the intervention (Mendoza et al., 2011; Vanwolleghem et al., 2014), whereas none of the studies reported contamination that might influence the results. The unit of intervention allocation in most of the studies was the organization/institution (e.g., school), except for three studies where it was the individual (Ducheyne et al., 2014; Kong et al., 2010) or the community (Sirard et al., 2015). The unit of analysis was individual in all but two studies, where it was school (Mammen et al., 2014; McDonald et al., 2013). Finally, most of the studies used appropriate statistical methods for the study design.

Intervention description

Four studies included all five strategies from the Community Action Model (Crawford and Garrard, 2013; McDonald et al., 2014; McDonald et al., 2013; Ostergaard et al., 2015). Five studies included four strategies such as preparation, promotion, programs, and policies (Buliung et al., 2011; Gutierrez et al., 2014; Hoelscher et al., 2016; Mammen et al., 2014; Sirard et al., 2015) or preparation, programs, policies, and projects (Christiansen et al., 2014). Seven of the studies incorporated three strategies such as preparation, promotion, and programs (Buckley et al., 2013; Bungum et al., 2014; Coombes and Jones, 2016; Hunter et al., 2015; Kong et al., 2010; Vanwolleghem et al., 2014). Seven studies included two of the strategies as preparation and programs (Ducheyne et al., 2014; Goodman et al., 2016; McMinn et al., 2012; Mendoza et al., 2011; Sayers et al., 2012; Stewart et al., 2014; Villa-Gonzalez et al., 2016). Interventions about active transportation to school involved three main elements: schools, parents, and communities. School involvement was the common element in all interventions. Almost all interventions also reported the involvement of parents and the community (n=20), except three who incorporated only school and parents (Ducheyne et al., 2014) or only schools (Goodman et al., 2016; McMinn et al., 2012). Regarding the economic investment a wide range of studies received government funding for implementing the program, such as *Safe Routes To School* (Buckley et al., 2013; Bungum et al., 2014; McDonald et al., 2014; McDonald et al., 2013; Stewart et al., 2014), *Walking School Bus* (Kong et al., 2010; Mendoza et al., 2011; Sayers et al., 2012), or a *School Travel Program* (Buliung et al., 2011; Hoelscher et al., 2016; Mammen et al., 2014).

Effectiveness

Fourteen studies reported an increase in the percentage of active transportation to school following the interventions; however, the degree of change varied widely (2% to 101%). Two studies reported improvements on active commuting to school using others outcomes, such us step counts (Vanwolleghem et al., 2014) or physical activity (Kong et al., 2010). Five studies did not report significant improvements in active transportation to school (Ducheyne et al., 2014; Goodman et al., 2016; Gutierrez et al., 2014; McMinn et al., 2012; Ostergaard et al., 2015). Moreover, two studies reported a decline in the percentage of active transportation to school after the intervention program (Hoelscher et al., 2016; Hunter et al., 2015). Based on the Cohen's d effect size (**additional File 3**), nine studies had trivial effect sizes (Buliung et al., 2011; Christiansen et al., 2014; Goodman et al., 2016; Gutierrez et al., 2014; Hunter et al., 2015; Mammen et al., 2014; Ostergaard et al., 2015; Stewart et al., 2014; Villa-Gonzalez et al., 2016), four had small effect sizes (Bungum et al., 2014; Coombes and Jones, 2016; McMinn et al., 2012; Sayers et al., 2012), one had large effects (Vanwolleghem et al., 2014), and one had very large effects (Mendoza et al., 2011). Cohen's d was not calculated for five studies (Buckley et al., 2013; Crawford and Garrard, 2013; Kong et al., 2010; McDonald et al., 2014; McDonald et al., 2013) due to insufficient data.

Discussion

The main aim of this study was to update a previous systematic review (Chillon et al., 2011) on interventions focused on active travel to school, following the same methodology and addressing the quality and effectiveness of new studies detected in the more recent scientific literature. In this review, 23 interventions that promoted active transportation to school among children and adolescents were identified. Most studies (21/23) received a weak global rating in the quality of the study components. The most common strategies used, based on Community Action Model framework, were preparation, promotions, and programs. Furthermore, the effect size varied with only two interventions with a large or very large effect size. Fourteen studies indicated an increase in active transportation to and from school after the intervention program, albeit it highly differed across the studies (2% to 101%).

In recent years, the proliferation of studies focused on active commuting to/from school is evident. In the previous review conducted from 2006 to 2011 (Chillon et al., 2011), the number of scientific articles focused on interventions to promote active commuting to school identified was 14, and the number of articles on ¨*active transport to school*¨ in the same date was 501. However, in the subsequent five years (i.e., from 2011 to 2016), the number of articles have considerably increased. In the current review, the number of scientific articles focused on interventions to promote active commuting to/from school identified was 23, and the number of articles on *"active transport to school"* within the same date was 944. Consequently, the current systematic review provides improvements and recommendations for setting successful strategies in the public health policies analyzing the published intervention studies.

Quality assessment

In the current review study, most studies (21/23) were rated as weak in the quality of the study components. The main reasons were low scores (i.e., weak rating) in selection bias, study design, control of confounders, and data collection components. Regarding selection bias, nineteen studies (83%) were rated with low scores. Similar results were found in the previous review study with 78% of the studies rated as weak in this component. In the present study only one study (Sirard et al., 2015) was rated as strong since it included a representative sample. Future studies should consider enrolling participants representative of the target population. This can be solved, for example, by performing a random selection from a comprehensive list of students within the school, or schools within a geographic area, althought this strategy may not always be practical.

Only three randomized controlled trial design studies (i.e., strong rating) were detected in the current review study. Similarly, this was another concern reported by the previous review (13% vs. 21%) (Chillon et al., 2011) as well perhaps this is due to the specificity of the topic and the wide range of variables to consider such as personal, environmental, family, and community factors (Panter et al., 2008). Moreover, some studies in the current review could not be categorized as randomized controlled trial following the Quality Assessment Tool, since investigators did not describe the allocation process and only used the words 'random' or 'randomly', so the study was categorized as a controlled clinical trial (Hoelscher et al., 2016; Ostergaard et al., 2015). Hence, future studies randomized trials should describe their method to generate a random allocation sequence.

Considering control of confounders, fifteen studies (65%) were rated as weak in the current review. The lack of confounding assesment is of concern particularly for nonrandomized studies. Similar data were found in the previous review with 71% of the studies rated as weak in this component. Fourteen studies (61%) considered distance from home to school as key confounder in their analysis in the current review. However, there is still scarce information about including distance from home to school as an inclusion criterion, albeit more than two or three miles from school is often considered a distance not typically walked for school (McKee et al., 2007) and theoretically this population should be excluded for walking interventions. Furthermore, previous studies reported that although cross-sectional studies have consistently shown that distance is the strongest predictor of active transportation to school among children (Huertas-Delgado et al., 2017; Pont et al., 2009; Rodriguez-Lopez et al., 2017), few of the intervention studies accounted for distance in their study design or analyses.

Regarding data collection, in the current review twelve intervention studies (52%) were rated as moderate or strong, providing details with respect to the validity and reliability of the questions used to assess mode of transportation. Lower scores were detected in the previous review study (Chillon et al., 2011), where only ten studies (28%) were rated as moderate or strong, since measures used to assess active transportation to school were usually weak and often lacked evidence of validity or reliability. Thus, there has been an improvement of using psychometrically sound measures. Future studies should make use of valid and reliable tools for assessing active transportation to school, using at least a standard question designed to elicit reliable, comparable information on commuting to school (Chillón et al., 2017; Herrador-Colmenero et al., 2014).

Intervention description

In the current review, the most common Community Action Model strategies used across studies were preparation, promotion, and programs. Only four studies (17%) included all five strategies from the Community Action Model (Crawford and Garrard, 2013; McDonald et al., 2014; McDonald et al., 2013; Ostergaard et al., 2015). In addition, The Safe Routes to School curriculum recommends that 5 strategies (Encouragement, Education, Enforcement, Environment, and Evaluation) be used in active transport to school interventions (Boarnet et al., 2005). The previous review highlighted the importance of parent, school, and community involvement, as well as interaction between these groups such as regular meetings. In the current review, this intervention issue improved and most (n=20) of the studies (87%) included school, parents, and community involvement, while the previous review (Chillon et al., 2011) these were included in only eight of the studies (57%).

Related to the dose and content of the intervention programs, although most intervention studies across reviews showed some improvement in use of active transportation to/from school, it is possible that intervention programs would have produced a more lasting effect if the dose had been larger. A previous study concluded that not only are the number of strategies important, but also the quality of those strategies (Fesperman et al., 2008). The previous review indicated that interventions focused on active transportation to school may be more effective than those with a broader focus (Chillon et al., 2011). Consequently, in the current review one study (Christiansen et al., 2014) attempted to evaluate the effect of a multicomponent school-based physical activity intervention on adolescent active school transport; however, there were no differences between the intervention and comparison schools. The reasons for not finding an intervention effect on active transportation to school could be ascribed to a combination of design, implementation feasibility, and the venue of the intervention, since their intervention had a broad focus on non-curricular physical activity and did not systematically involve parents.

Effectiveness

Concerning the effectiveness of the analyzed intervention studies, the current review reported poor effectiveness in most of studies (*Cohen's d:* from -1.45 to 2.37). Our review found only two (9%) studies (Mendoza et al., 2011; Vanwolleghem et al., 2014) with a large or very large effect sizes, whereas the previous review (Chillon et al., 2011) found three interventions with large or very large effect sizes (21%, *Cohen's d:* from 0.07 to 2.9). The highest reported effect size in this review was 2.9 (Mendoza et al., 2011). In this study, although there was not a very large sample (i.e., 70 in experimental group and 79 in control group), the percentage of change in the experimental group was large between pre and post intervention, while the control group decreased the percentage of active commuting after the intervention. The largest increase in percentage of active travel to/from school in the current review was 101%, but effect sizes could not be calculated (Buckley et al., 2013). In the present study, calculations were not possible in five studies (22%) due to missing data. Studies should report critical data elements (such as the standard deviation or sample size).

Limitations and strengths

This review study included some limitations. First, we found some gaps when assessing the quality of the interventions using the EPHPP tool, because this tool was designed primarily for individually focused studies. For example, the blinding component could be considered non-applicable because it is virtually impossible to blind participants receiving an active transportation to school intervention (Larouche et al., 2014). Our study group again adapted the tool in effort to make it most useful for this review. Second, caution should be taken when comparing the effect size from different studies since different formulas are used. As strength, this is the first update of interventions designed to promote active transportation to school among young people. Moreover, a rigorous review process for selecting the studies and extracting the data, including both the effectiveness and quality assessments were performed.

Conclusions

Most of the intervention studies on walking and bicycling to/from school indicated poor quality of the study components as well as low effect size. The implementation of interventions focused on active transport to and from school could be a useful strategy to promote this behavior. However, the development of quality and effective intervention programs focused on active commuting to/from school requires improvements. The current systematic review study can aid researchers and practitioners who wish to create future strategies to promote this behavior and understand the effects of intervention programs on children using active transportation to school. Future intervention studies should be more rigorous assessing the effectiveness of the intervention programs, including using representative samples with greater statistical power, randomized controlled trial designs, assessment of important potencial confounders, and using valid and reliable instruments, all to increase confidence and generalizability of the results. Thus, the use of a standardized evaluation framework, such as the Effective Public Health Practice Project, could be a useful tool during the study-planning phase in order to ensure quality interventions to promote this behaviour.

Conflict of interest statement

All authors have completed the Preventive Medicine conflict of interest policy form and declare that there are no conflicts of interest

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Additional file 3. A summary of the calculation of effect size using Cohen´s d

The effect size using Cohen's d values was calculated for each study when enough data were provided. Manual calculations (for studies with no control group) and a meta-calculator were used (http://www.lyonsmorris.com/ma1/index.cfm) based on calculations from Cohen (J Cohen, 1988) and Abramowitz and Stegun (M Abramowitz and IA Stegun, 1964).

The effect size was calculated between experimental and control groups for changes between baseline and follow-up, when data were provided. Changes could be in only one variable, i.e., active commuting to school. However, there were different forms of AST data in the different studies, such as mean and proportion of travels (n=21), AST measured through PA (Sayers et al., 2012) and total steps (Vanwolleghem et al., 2014). If differences between pretest and posttest were not provided, the effect size was calculated between experimental and control groups for the posttest only. If there was no control group in the study, the effect size was calculated between baseline and follow-up for the experimental group. For three studies, we calculated effect size two times for different groups: a large (experimental group 1) and small effect (experimental group 2) (Ducheyne et al., 2014), a small (experimental group 1) and a large effect (experimental group 2) (Hoelscher et al., 2016), and two trivial effect sizes for both measures (i.e., morning and afternoon) (Sirard et al., 2015).

There are different ways of calculating the effect size using Cohen's d values provided.

1) Method 1: If the mean or proportion, standard deviations, and sample sizes were provided, the calculation used the standard formula (mean/proportion differences divided by the pooled standard deviation) (J Cohen, 1988). Effect sizes for 5 studies were calculated using means (Ducheyne et al., 2014; Gutierrez et al., 2014; McMinn et al., 2012; Mendoza et al., 2011; Villa-Gonzalez et al., 2016). After manual calculation, SDp was revised at *www.psychometrica.de*. When studies met these criteria but they did not have control group, the standard formula (proportion differences divided the standard deviation) was applied. Effect sizes for 3 studies were calculated in this way (Hunter and Schmidt, 1991; Sirard et al., 2015; Vanwolleghem et al., 2014).

2) Method 2: If only proportions and sample sizes were provided, but standard deviations were not, then the effect size was calculated using proportions at baseline ($\sqrt{pq}$; q=1-p) and the standard formula (proportion differences divided the standard deviation) was applied. Effect size for 3 studies were calculated in this way (Buliung et al., 2011; Mammen et al., 2014; Stewart et al., 2014).

3) Method 3: If P values and sample sizes were provided, an intermediate calculation using Cohen (J Cohen, 1988) and Abramowithz and Stegun (M Abramowitz and IA Stegun, 1964) formulas were used. Effect sizes for 6 studies were calculated in 2 ways using means (Ostergaard et al., 2015) and proportions (Bungum et al., 2014;

Christiansen et al., 2014; Coombes and Jones, 2016; Goodman et al., 2016; Sayers et al., 2012). In the case of Bugum et al. (Bungum et al., 2014), p-value was used from Chi Square test (with one df to Effect Size) through Meta-calculator.

	Calculation of Cohen´s d		
First author	**Procedure**	**Numerical data**	**Formula**
(Buckley et al., 2013)	***Data provided*** Mean or proportion: ✓ SD: ✗ Sample size: ✓ ***Method used:*** NA Control group: No (fall) and Yes (spring) ***Conceptual data*** Fall event: Calculation not applicable because mean or proportion of AST (pretest) was not provided. There was only the proportion change between posttest and pretest. Spring event: Calculation not applicable because p-value for the differences between experimental and control schools were not provided. There was only provided the separately increase of each group.		
(Bungum et al., 2014)	***Data provided*** Mean or proportion: ✓ SD: ✗ Sample size: ✓ ***Method used:*** 3 Control group: Yes ***Conceptual data*** Differences between experimental and control group for the proportion of students who actively commuted to school in the posttest. Pretest and 2-posttest (one week after event) were similar in both experimental and control groups.	P <0.001 N for experimental schools: 638. N for control schools: 698. N Total: 1336	$\varphi=\sqrt{X^2/n}$ (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm) (Chi Square with one df to Effect Size)

(Buliung et al., 2011)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✗ / ✓ ***Method used**:* 2 Control group: No ***Conceptual data*** Differences in the experimental group for the change in the proportion of AST (children reports) between pretest and posttest.	Xpo – Xpr (change in the proportion between pre and posttest)= 2%; Pretest= 44%	d= Xpo – Xpr/SD SD= $\sqrt{pq}$; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)
(Christiansen et al., 2014)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✗ / ✓ ***Method used**:* 3 Control group: Yes ***Conceptual data*** Differences in the experimental group and control group for the proportion (percentage) of AST between pre and posttest.	P= 0.30 N for experimental group: 498; N for control group: 516. N total: 1014	P 1-tailed= P / 2. Look up the associated Z in a normal probability table. (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm)
(Coombes and Jones, 2016)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✗ / ✓ ***Method used**:* 3 Control group: Yes	P= 0.056 N total: 109	P 1-tailed= P / 2. Look up the associated Z in a normal probability table. (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm)

	Conceptual data Differences between the experimental and control group for the proportion of AST between pre and posttest.		
(Crawford and Garrard, 2013)	***Data provided*** Mean or proportion: ✓ · SD: ✗ · Sample size: ✓ ***Method used***: NA Control group: Yes ***Conceptual data*** Calculation not applicable because N total (phase 1), p-value of the comparison between schools and pre-post (phase 2) were not provided. There was only qualitative data in Phase 3.		
(Ducheyne et al., 2014)	***Data provided*** Mean or proportion: ✓ · SD: ✓ · Sample size: ✓ ***Method used***: 1 Control group: Yes ***Conceptual data*** Differences in the experimental group (1 and 2) and control group for the mean (minutes/week) of AST between pre and posttest.	Xe (SD) for experimental group in pretest: 19.6 (27.1); and Xe in posttest: 26.7; Xc (SD) for control group in pretest: 15.5 (29.7) and Xc in postest: 10.2; N for experimental group-1: 25; N for control group: 35. Xe (SD) for experimental group in pretest: 19.6 (27.1); and	d= Xe – Xc / SDp SDp= (Ne * SDe) + (Nc * SDc) / N total Xe: mean in experimental group; Xc: mean in control group; SDp: standard deviation pooled; Ne: sample in experimental group; SDe: standard deviation in experimental group; Nc: sample in control group; SDc: standard deviation in control group; N: sample size) SDp *revised at* www.psychometrica.de

		Xe in posttest: 26.7; Xc (SD) for control group in pretest: 15.5 (29.7) and Xc in posttest: 10.2; N for experimental group-2: 34; N for control group: 35.	
(Goodman et al., 2016)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✗ / ✓ ***Method used***: 3 Control group: Yes ***Conceptual data*** Differences between experimental and control group for the proportion (percentage) of students who cycling to school in the posttest.	P ≥ 0.4. N total: 3336	P 1-tailed= P / 2. Look up the associated Z in a normal probability table. (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm
(Gutierrez et al., 2014)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✓ / ✓ ***Method used***: 1 Control group: Yes ***Conceptual data*** Differences between experimental and control group for mean of students who actively commuted to school in pre and posttest.	Xe (SD) for experimental group in pretest: 41.6 (29.8); and Xe in posttest: 43.1; Xc (SD) for control group in pretest: 34.8 (33.4) and Xc in posttest: 35.1; N for experimental group: 34. N for control group: 24 N total= 58	d= Xe – Xc / SDp SDp= (Ne * SDe) + (Nc * SDc) / N total (Xe: mean in experimental group; Xc: mean in control group; SDp: standard deviation pooled; Ne: sample in experimental group; SDe: standard deviation in experimental group; Nc: sample in control group; SDc: standard deviation in control group; N: sample size) SDp *revised at www.psychometrica.de*
(Hoelscher et	***Data provided***	P= 0.078	P 1-tailed= P / 2. Look up the associated Z in

al., 2016)	Mean or proportion / SD / Sample size ✓ / ✗ / ✓ ***Method used****:* 3 Control group: Yes ***Conceptual data*** Differences in the experimental (1 and 2) and control schools for the proportion (total daily) of AST between pre and posttest.	23 schools in experimental group-1; 34 in control group schools. N total: 57 P= 0.036 21 in experimental group-2 34 in control group schools. N total: 55	a normal probability table. (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm
(Hunter et al., 2015)	***Data provided*** Mean or proportion / SD / Sample size ✓ / ✓ / ✓ ***Method used****:* 1 Control group: No ***Conceptual data*** Differences in the experimental group for the change in the proportion (average for all schools) in AST between pretest and posttest.	Xpo – Xpr (change in the proportion): -17%; p (proportion) in pretest: 29% (average for all schools)	d= Xpo – Xpr / SD SD= √pq; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)
(Kong et al., 2010)	***Data provided*** Mean or proportion / SD / Sample size ✗ / ✗ / ✓ ***Method used****:* NA Control group: No ***Conceptual data*** Calculation not applicable because mean or proportion of active walking to school (pre and posttest) were not		

	provided.		
(Mammen et al., 2014)	***Data provided*** Mean or proportion: ✓ SD: ✗ Sample size: ✓ ***Method used:*** 2 Control group: No ***Conceptual data*** Differences in the experimental schools for the change in the proportion (percentage at the national level) of children who walking to school between pretest and posttest.	Xpo – Xpr (change in the proportion): 4%; p (proportion) in pretest: 27%	d= Xpo – Xpr / SD SD= $\sqrt{pq}$; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)
al. (McDonald et al., 2014)	***Data provided*** Mean or proportion: ✓ SD: ✗ Sample size: ✓ ***Method used:*** NA Control group: Yes ***Conceptual data*** Calculation not applicable because differences (p-value) of AST (pre-post) between experimental and control schools were not provided.		
(McDonald et al., 2013)	***Data provided*** Mean or proportion: ✓ SD: ✗ Sample size: ✓ ***Method used***: NA Control group: Yes		

	Conceptual data Calculation not applicable because differences (p-value) of AST (pre-post) between experimental and control schools were not provided.		
(McMinn et al., 2012)	***Data provided*** Mean or proportion ✓ / SD ✓ / Sample size ✓ ***Method used:*** 1 Control group: Yes ***Conceptual data*** Differences in the experimental and control group for the mean (steps/total daily) of AST to school between pre and posttest.	Xe (SD) for experimental group in pretest: 2395 (936); and Xe in posttest: 2124; Xc (SD) for control group in pretest: 2186 (1091) and Xc in posttest: 1861. N for experimental group: 79. N for control group: 87	d= Xe – Xc / SDp SDp= (Ne * SDe) + (Nc * SDc) / N total (Xe: mean in experimental group; Xc: mean in control group; SDp: standard deviation pooled; Ne: sample in experimental group; SDe: standard deviation in experimental group; Nc: sample in control group; SDc: standard deviation in control group; N: sample size) SDp *revised at* www.psychometrica.de
(Mendoza et al., 2011)	***Data provided*** Mean or proportion ✓ / SD ✓ / Sample size ✓ ***Method used:*** 1 Control group: Yes ***Conceptual data*** Differences in the experimental group and control group for the change in the mean of AST between pre and posttest.	Xe (SD) for experimental group in pretest: 23.8 (9.2); and Xe in posttest: 54; Xc (SD) for control group in pretest: 40.2 (8.9) and Xc in posttest: 32.6; Ne for experimental group: 70; Nc for control group: 79	d= Xe – Xc / SDp SDp= (Ne * SDe) + (Nc * SDc) / N total (Xe: percentage of change in experimental group; Xc: percentage of change in control group; SDp: standard deviation pooled; Ne: sample in experimental group; SDe: standard deviation in experimental group; Nc: sample in control group; SDc: standard deviation in control group) SDp *revised at* www.psychometrica.de
(Ostergaard et al., 2015)	***Data provided*** Mean or proportion / SD / Sample size	P=0.463 (change in an unfavorable direction in	P 1-tailed= P / 2. Look up the associated Z in a normal probability table.

	✓ ✗ ✓ ***Method used***: 3 Control group: Yes ***Conceptual data*** Differences between experimental and control group for the mean (cycling trips last week) of students who actively commuted to school between pre and posttest.	the intervention group compared to the control group). N total= 2401 students (25 schools).	(Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm)
(Sayers et al., 2012)	***Data provided*** Mean or proportion / SD / Sample size ✓ ✗ ✓ ***Method used***: 3 Control group: Yes ***Conceptual data*** Differences between experimental and control group for the proportion (total %MVPA during weekdays) of students between pre and posttest.	P= 0.33 N total= 77 students	P 1-tailed= P / 2. Look up the associated Z in a normal probability table. (Meta-calculator: http://www.lyonsmorris.com/ma1/index.cfm)
(Sirard et al., 2015)	***Data provided*** Mean or proportion / SD / Sample size ✓ ✓ ✓ ***Method used***: 1 Control group: No ***Conceptual data*** Differences in the experimental schools for the change in the proportion (morning and afternoon percentage) of students who	Morning data: Xpo – Xpr (change in the proportion): 0.7%; p (proportion) in pretest: 9.1% Afternoon data: Xpo – Xpr (change in the proportion): 0.7%; p	d= Xpo – Xpr / SD SD= $\sqrt{pq}$; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)

	actively commuting to school between pretest and posttest.	(proportion) in pretest: 9.1%	
(Stewart et al., 2014)	***Data provided*** Mean or proportion: ✓; SD: ✗; Sample size: ✓ ***Method used**:* 2 Control group: No ***Conceptual data*** Differences in the experimental schools (projects) for the change in the proportion of AST (all AST modes) to school between pre and posttest.	Xpo – Xpr (change in the proportion): 4.7%; p (proportion) in pretest: 12.9%	d= Xpo – Xpr / SD SD= √pq; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)
(Vanwolleghem et al., 2014)	***Data provided*** Mean or proportion: ✓; SD: ✓; Sample size: ✓ ***Method used**:* 1 Control group: No ***Conceptual data*** Differences in the experimental schools for the change in the mean (step counts per day before and after school hours) to school between pre and posttest.	Xpo – Xpr (change in the proportion): 732 (step); p (proportion) in pretest: 1711 (step)	d= Xpo – Xpr / SD SD= √pq; q=1-p (Xpo: percentage in posttest; Xpr: percentage in pretest; SD: standard deviation; p: proportion of successes in pretest; q: proportion of failures in pretest)
(Villa-Gonzalez et al., 2016)	***Data provided*** Mean or proportion: ✓; SD: ✓; Sample size: ✓ ***Method used**:* 1 Control group: Yes ***Conceptual data*** Differences in the	Xe (SD) for experimental group in pretest: 4.4 (0.3); and Xe in posttest: 4.7; Xc (SD) for control group in pretest: 4.5 (0.4) and Xc in posttest: 5.2.	d= Xe – Xc / SDp SDp= (Ne * SDe) + (Nc * SDc) / N total (Xe: mean change in experimental group; Xc: mean change in control group; SDp: standard deviation pooled; Ne: sample in experimental group; SDe: standard deviation in experimental group; Nc: sample in control group; SDc: standard deviation in control group)

	experimental group and control group for the change in the mean of AST (travel/week) to school between pre and posttest.	N for experimental group: 117; N for control group: 89	SDp *revised at www.psychometrica.de*