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Review Article

Interventions promoting active transport to school in children: A systematic review and meta-analysis

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ABSTRACT

The systematic review investigated the effectiveness of active travel (AT) interventions on physical activity and fitness in primary school children. The review assessed intervention effectiveness, design, complexity, and study quality.

Searches were conducted in five databases on 30/08/2018. Studies with an AT intervention compared to an inactive control, in 4 to 11 year olds, measuring AT or fitness outcomes were included. Two-stage screening identified relevant studies. Relevant data were extracted using Cochrane Extraction Form, Quality Assessment Tool for Quantitative Studies, Active Living by Design model, and intervention Complexity Assessment Tool for Systematic Reviews. Meta-analysis and Cohen's D effect size assessed effectiveness.

Seventeen eligible studies were included. Effectiveness assessment found a statistically significant standardised mean difference (SMD) in AT outcomes in favour of the intervention (continuous AT - SMD 0.78 (CI 0.11–1.46); frequency AT - SMD 1.87 (CI 0.88–2.86)). Cohen's D calculation concurred with this finding. Fifteen studies had SMD favouring the intervention – two studies had SMD favouring the control. Sixteen studies received a weak quality rating - one study rated moderate.

Active travel shows promise in increasing physical activity in primary school children. The review found walking school buses and educational strategies most effective for increasing relevant outcomes, although overall study quality was weak. Effect size did not associate with the complexity of an intervention, therefore supporting efforts to promote active travel through interventions may be easier to scale. Further intervention studies of greater methodological quality are necessary to confirm these findings due to the limited evidence available.

1. Introduction

Regular participation in physical activity (PA) reduces overall cardio-metabolic risk, with inactive children at a significantly greater risk of hypertension, obesity and cancer than their physically active peers (Vaisto et al., 2019; Abadie and Brown, 2010). Associated psychological benefits include improved cognition, self-esteem and emotional well-being, with reduced risk of depression and anxiety (Rasmussen and Laumann, 2013; Cheung et al., 2008; Parfitt et al., 2009; Tomson et al., 2003; Parfitt and Eston, 2005; NHS, 2016). Furthermore, there are improvements to academic behaviour and performance from PA interventions in schools (Sullivan et al., 2017). In 2017,

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National Health Service reported an increase in the proportion of children meeting the PA guidelines between 2012 and 2015 (boys: 21% to 23%; girls: 16% to 20%) (NHS Digital: National Statistics, 2017). Although this rise is promising, the proportion of children meeting the guidelines is still low. Overall, only 22% of children aged 5 to 15 years met the national guidelines for PA (NHS Digital: National Statistics, 2017; Scholes, 2015). Similarly low physical activity participation rates are evident globally (Ekelund et al., 2011).

Active travel is widely recommended for promoting PA, with research suggesting it is one of the simplest and most acceptable forms of PA that is easily incorporated into everyday lives (Sustrans, 2011; Public Health England, 2015; NICE, 2012; Department of Health, Physical Activity, Health Improvement and Protection, 2011; Saunders et al., 2013). In 2016, researchers stated that comprehensive national and international initiatives to re-normalise active transport to school are necessary to address the decline in children's PA levels (Pate et al., 2016). International research shows a decrease in the number of children using an active form of transport to school (Institute of Medicine, 2013; Fyhri et al., 2011; Garrard, 2009). The global decline in the use of active travel modes to school by children is of concern. Active travel not only benefits child health through PA, it reduces injury rates, minimises environment damage and improves body composition (Garrard, 2009). Additional benefits include reduced traffic congestion, economic savings and minimised noise pollution (Garrard, 2009). Active travel is a practical and sustainable way to increase PA, with the benefits beyond health gains (Healthy Ireland, 2016). The Institute of Medicine reports that active transport provides an excellent opportunity to be active, with family and community involvement increasing sustainability (Institute of Medicine, 2013).

In 2010, a systematic review investigated the effectiveness of school-based active transportation interventions in increasing active commuting to school in 6–18 year olds (Chillon et al., 2011). The search identified 14 studies from various countries including United States, Australia and United Kingdom. Although the eligibility criteria included ages up to 18 years, all included studies (except one) focused on children between 5 and 12 years old. The review concluded that there was a small positive effect on active transport to school, noting heterogeneity in 'size, scope and focus' of the included interventions (Chillon et al., 2011). In 2018, Villa-Gonzalez and colleagues produced an update of this review, with 23 included studies (Villa-Gonzalez et al., 2018). Most included studies reported a small effect size on active travel to school, with 21 studies rated poor quality (Villa-Gonzalez et al., 2018).

Active travel research has grown substantially in past years, however there lacks a recent, comprehensive review of the effectiveness of interventions to promote active travel. Furthermore, previous research and review findings present conflicting conclusions. An updated systematic review to evaluate the effect of active travel interventions in primary school aged children is necessary to fill a gap in knowledge, and provide a comprehensive summary of effectiveness. Furthermore, the lack of intervention description in previous research highlights the need for descriptive analysis, including complexity analysis, in the current review. Therefore the aim of this study was to systematically review the effectiveness of active travel interventions in primary school children.

2. Method

This systematic review adhered to the PRISMA reporting guidelines for systematic reviews (PRISMA, 2009).

2.1. Search procedure

A literature search was conducted in MEDLINE, Web of Science, PsychINFO, EMBASE and TRIS for published studies up to 30th August 2018, without date restrictions. No restriction on language was placed at this stage to allow authors to attempt to identify English language translations of articles. The search was inclusive of all publication types, with search terms identified from previous review studies and relevant MeSH headings (Chillon et al., 2011; Villa-Gonzalez et al., 2018; Ogilvie et al., 2014; Pont et al., 2009). Search strategies and terms were adapted as necessary for each database (Supplement A).

2.2. Eligibility criteria

2.2.1. Participants

Only studies in which all participants, or the majority (>50%) of participants, were 4–11 years old attending primary school or equivalent were included.

2.2.2. Intervention

Eligible studies involved school-based active travel interventions among primary school children. Active travel interventions were defined as targeting the journey to and from school using a physically active form of transport (e.g. walking, cycling). Studies including additional PA co-interventions (e.g. sport participation or active school lessons) were excluded to ensure the findings were directly related to active transport only. Non-PA co-interventions (e.g. nutrition, mental health) were deemed acceptable.

2.2.3. Comparator

Only studies with a control group, where no PA intervention was provided, were eligible for inclusion.

2.2.4. Outcome

Studies with at least one outcome related to active transportation or physical fitness, measured either objectively or subjectively at baseline and on at least one occasion post intervention, were eligible for inclusion. Outcomes included, but were not exclusive to, daily steps, frequency of active travel and PA levels.

2.2.5. Study design

Eligible studies were controlled quantitative designs. Included study designs were randomised control trials (RCT), cluster RCT and controlled quantitative quasi-experimental studies. Within the context of this review, quasi-experimental studies are controlled before and after evaluations of planned but non-randomised interventions, often used when randomisation is not possible because the delivery of the intervention is outside of the control of researchers (Shadish et al., 2002; Craig et al., 2012). Non-controlled, cohort, and case studies were excluded, as were studies written in a non-English language. Authors manually searched for published English language translations of non-English language papers.

2.3. Selection and review process

Potentially relevant studies were compiled and duplicates removed using a reference manager (RefWorks, ProQuest, Michigan, USA) (ProQuest, n.d.). Titles and abstracts were screened for inclusion independently by three investigators (RJ, MT, NB). Relevant reviews were included at this stage for reference screening. The full-text of potentially relevant studies were subsequently assessed for inclusion independently by investigators (RJ, MT, NB). Any discrepancies were discussed by investigators for an agreed decision. A third investigator (MT) assisted to resolve any discrepancies where required.

2.4. Data extraction

2.4.1. Characteristics of included studies

Data extraction was completed independently by two investigators (RJ and MT) using a modified Cochrane Public Health Group Data Extraction Form (JPT and Green, 2011). Extraction forms were piloted

with two studies to ensure it was fit for purpose.

2.4.2. Quality assessment of individual studies

The methodological quality of included studies was assessed using the Quality Assessment Tool for Quantitative Studies (QATQS) (Effective Public Health Practice Project, 1998). This tool has been recommended by the Cochrane Collaboration for use in systematic reviews (JPT and Green, 2011). An overall rating of methodological quality (strong/moderate/weak) was assessed by extracting information across six domains: selection bias; study design; confounders; blinding; data collection methods; withdrawals and dropouts. All six components contributed to the calculation of the study's global rating. A study's global rating is dependent on the number of component rated weak study (weak – 2 or more; moderate – 1; strong – none). Intervention integrity and analysis assessment were also included in the tool but did not contribute to the global rating. The component 'blinding' was modified to exclude participant blinding from influencing the study quality due to the inability to blind participants in active travel interventions. The characteristics of the QATQS have been evaluated and shown validity, test-retest reliability and inter-rater reliability (JPT and Green, 2011). Information from quality assessment was used for descriptive analysis of study quality and risk of bias. Two authors (RJ and MT) independently appraised study quality of all included studies, with discrepancies resolved through discussion.

2.5. Assessment of intervention strategy usage

The design of each intervention was described using the Active Living by Design Community Action Model (Bors et al., 2009). This model has been successfully applied in active transport to school studies previously (Brennan et al., 2012; Fesperman et al., 2008). The included studies were assessed for explicit referral of the model strategies (5P's): preparation, promotions, programs, policies and physical projects.

2.5.1. Assessment of intervention complexity

The complexity of the studies included was assessed using the intervention Cochrane Collaboration's intervention Complexity Assessment Tool for Systematic Reviews (iCAT_SR) (Lewin et al., 2016). The tool assessed various dimensions of the studies and categorised the level of complexity as 'complex', 'moderately complex' or 'simple'. The dimensions assessed included: the number of active components, level of skill required for intervention delivery and the level of component interaction. The global score for each included study was calculated by the sum of the individual component rating scores (simple = 1, moderately complex = 2, complex = 3). The tool was piloted on two studies by both investigators to ensure consistency in the way it was applied. Two authors (RJ and MT) independently appraised intervention complexity of all included studies, with discrepancies resolved through discussion.

The relationship between complexity and effectiveness was assessed through scatter plot and correlation using IBM SPSS Statistics 23 software. In a scatter plot, each study's global score for complexity was plotted against effect size (Cohen's D). If a study had multiple outcomes, the mean of the calculated effect sizes was used. From the scatter plot, identification of a possible correlation was determined. A Spearman's rank-order correlation test was used as the data did not meet parametric assumptions (Shapiro-Wilk: $p < 0.05$). The purpose of conducting a correlation test was to investigate if there was a relationship between complexity and effectiveness in terms of strength of association (r-value) and significance (p-value).

2.5.2. Statistical analyses of intervention effectiveness

Continuous data were synthesised using random effects meta-analysis (RevMan v5.3, Cochrane Collaboration). Differences in outcomes between the intervention and controls at follow-up were compared. As a variety of outcomes measures were used, standardised mean difference was calculated. Separate meta-analyses were conducted for continuous measures of active travel (e.g. minutes per week), frequency of active travel (e.g. active travel journeys per week) and continuous measures of physical fitness (e.g. aerobic capacity). Within these outcome types, studies were further sub-divided by outcome type for subgroup and overall effect analysis. Heterogeneity using the I^2 statistic was calculated for all analyses. Publication bias of the studies included in the meta-analysis was assessed using a funnel plot.

Study data, regardless of data type, were further synthesised by the calculation of Cohen's d effect size. The effect size between intervention and control groups and baseline and follow-up was calculated using standardised mean/proportion difference. Cohen's D classified effect size as trivial ($d < 0.2$), small ($d = 0.2$–0.5), moderate ($d = 0.5$–0.8), large ($d = 0.8$–1), and very large ($d < 1$) (Chillon et al., 2011; Kim, 2015).

3. Results

3.1. Study selection

The electronic search of the selected databases produced a total of 3431 potentially relevant studies (Medline ($n = 266$), EMBASE ($n = 320$), PsycINFO ($n = 358$), Web of Science ($n = 2403$), TRIS ($n = 84$)). Duplication checks resulted in the removal of 248 studies.

A total of 3183 potentially relevant studies remained for title, abstract and key word screening. 3099 studies were excluded, leaving 84 studies for full-text screening. The screening of reference lists of potentially relevant studies and reviews identified 19 additional potentially relevant studies. After full-text screening and eligibility assessments of 103 studies, 17 studies met the inclusion criteria and were included in the review (Coombes and Jones, 2016; Villa-Gonzalez et al., 2017; Villa-Gonzalez et al., 2015; McMinn et al., 2012; Bungum et al., 2014; Goodman et al., 2016; Groesz, 2008; McKee et al., 2007; Ming Wen et al., 2008; Sirard et al., 2008; Heelan et al., 2009; Mendoza et al., 2009; Mendoza et al., 2011; Borrestad et al., 2012; Ducheyne et al., 2014; Ostergaard et al., 2015; Hoelscher et al., 2016). Any disagreements during screening were discussed by the investigators for a jointly agreed decision. Fig. 1 represents the selection and review process in flow diagram format in line with PRISMA guidelines (Moher et al., 2009).

3.2. Study characteristics

The characteristics of the included review studies are included in Supplement B. Whilst the participant groups were relatively similar across studies, the interventions were significantly heterogeneous in terms of study duration, intervention type, outcome measures and duration of follow-up.

Eight quasi-experimental studies, four randomised control trials, three controlled trials, one cluster randomised control trial and one controlled cohort analytic study have been included in this review. Seven studies were conducted in United States and four studies were conducted in the United Kingdom. The remaining studies were conducted in Australia, Norway, Belgium, Demark and Spain.

Intervention types across studies were diverse. Four interventions were walking school buses, and seven focused on education and encouragement of active travel. One study involved both education and encouragement alongside a one-day active travel event. Two studies provided cycling training, and one study utilised modern technology through street sensor activation. The remaining two interventions were in the form of infrastructure changes, with one of these studies also incorporating funding allocation as part of the intervention. Intervention duration also varied greatly across the included studies ranging from a 1-day event to 2 year interventions. The majority of interventions lasted between 4 and 12 weeks.

The majority of studies included children at the upper end of the age

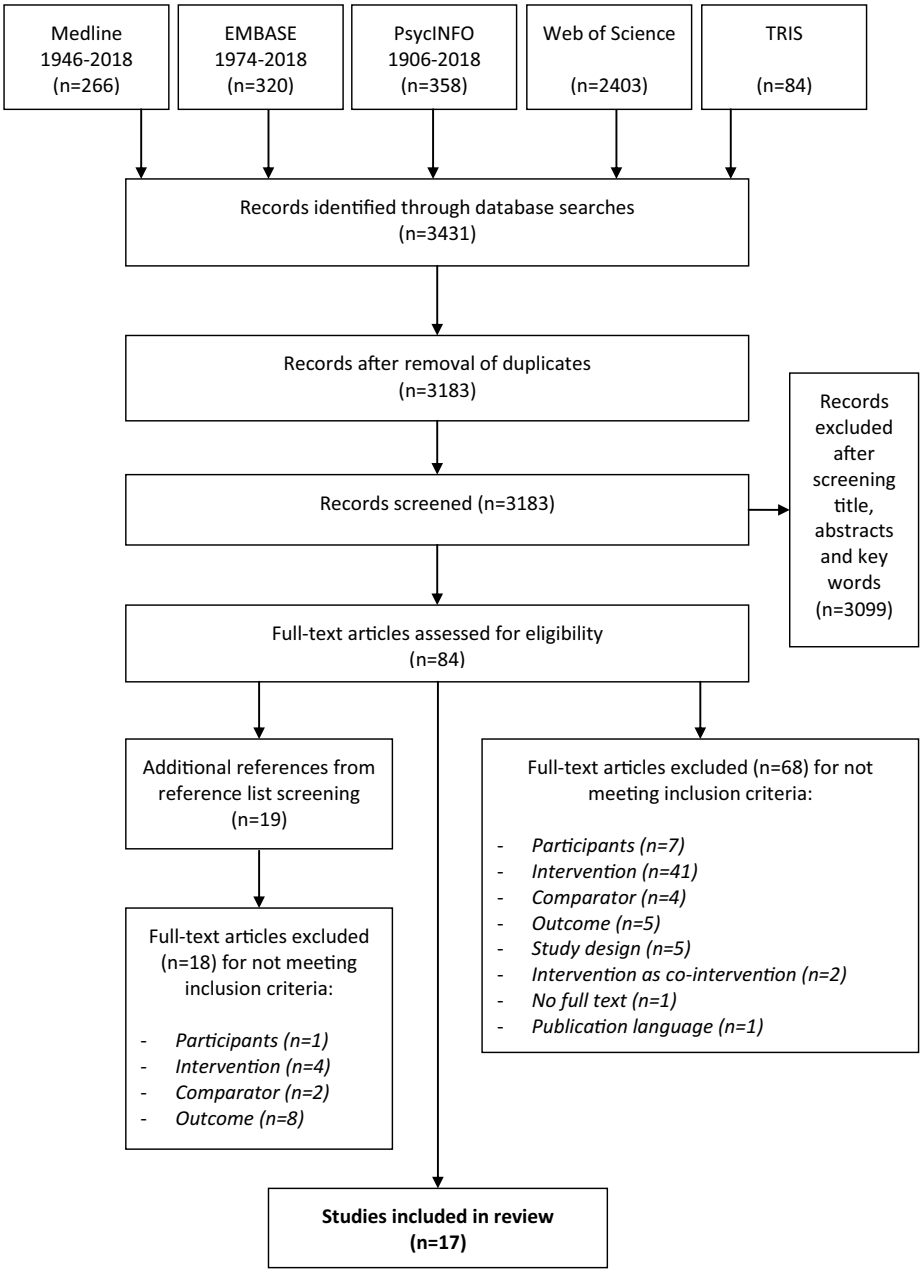

Fig. 1. Flow diagram representing the selection and review process.

range (8–11 years old), with only one study including children as young as 5 years old. The outcome measures varied significantly, increasing the difficultly of study comparisons. All studies, excluding one, provided an outcome measure of active travel with only one study providing only a measure of fitness (maximal oxygen consumption (VO^2_{max})).

Many studies used self-report methods completed by the student or parent, increasing the likelihood of response recall or social desirability bias (National Collaborating Centre for Primary Care (UK), 2009). Despite many studies using these methods, some studies used valid and reliable objective forms of measurement (e.g. Actigraph (McKee et al., 2007), cycle ergometer (Mendoza et al., 2009)), evidencing the feasibility of using more sensitive and accurate methods (Sirard et al., 2008; Mendoza et al., 2011).

3.3. Qualiy of included studies

The methodological quality of included studied was completed using the EPHPP tool. All studies, excluding one, were concluded to be of weak overall quality (global rating). Despite the inclusion of only controlled experimental designs, nine studies scored weak quality for study design. Quasi-experimental studies were all rated as of weak quality as they were rated as weak in both the study design and blinding domains. The EHPP tool defines weak quality studies as those with a rating of weak in two or more domains. Supplement C presents the quality of each included study for each component and global rating of quality. Fig. 2 presents the summary of methodological quality of included studies.

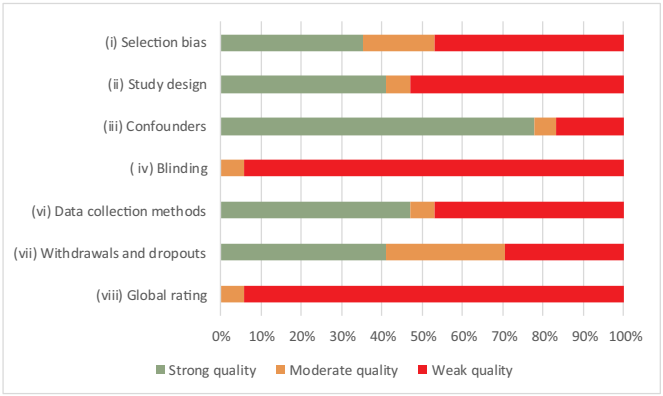

Fig. 2. Summary of methodological quality of included studies.

3.4. Intervention strategy assessment

None of the review studies included all five of the Active Living by Design strategies from the model. Two studies included four strategies; Mendoza et al. (2009) did not include a 'policies' component, and Ostergaard et al. (2015) did not include a 'preparation' component. The majority of interventions used three strategies, and the most commonly used strategies were 'preparation', 'promotion' and 'programs'. The least used strategy was 'policies', closely followed by 'physical projects'. Two studies used one strategy, 'promotion', each.

3.5. Effectiveness

Of the 17 studies included in the review, 11 studies provided data for inclusion in the meta-analysis. The remaining studies outcome measures were inappropriate data types for meta-analysis. Figs. 3 and 4 show forests plots of continuous and frequency data for active travel outcomes. Fig. 5 shows a forest plot of the continuous data for physical fitness outcomes. Funnel plot asymmetry suggested publication bias may be present.

Assessment of the effect of interventions on continuous active travel outcomes resulted in a statistically significant difference in favour of the intervention (SMD 0.78, 95% CI 0.11–1.46, $n = 550$) (Fig. 3). The majority of studies had standardised mean differences in favour of the intervention, with only two study's results favouring the control (Coombes and Jones, 2016; Borrestad et al., 2012). The confidence interval and p-value ($p = 0.02$) for overall effect shows a statistically significant effect favouring the intervention. The heterogeneity of the results was very high ($I^2 = 92\%$), reducing the confidence in the consistency of the findings.

Frequency active travel outcomes (Fig. 4) had a range of standardised mean differences from 0.00 (−0.08, 0.08) to 4.77 (4.20, 5.33) (Villa-Gonzalez et al., 2017; Bungum et al., 2014). All studies favoured the intervention, with only one study showing no difference (McMinn et al., 2012). The overall standardised mean difference for frequency active travel outcomes significantly favoured the intervention (SMD 1.87, 95% CI 0.88–2.86, $n = 4770$). The heterogeneity of the frequency outcomes was very high ($I^2 = 99\%$), decreasing the sureness of the consistency of the findings.

Continuous physical fitness outcomes (Fig. 5) had standardised mean differences ranging from −9.38 (−10.29, −8.46) to −0.30 (−0.88, 0.28) (Villa-Gonzalez et al., 2017; Mendoza et al., 2011). The overall standardised mean difference favoured the control (SMD -4.83, 95% CI −13.73–4.07, $n = 271$). The overall effect was not statistically significant, indicated by the confidence intervals and p-value ($p = 0.29$). Both study's intervention included in this analysis focused upon education and encouragement. There were only two studies measuring cardiovascular fitness, reducing the applicability of these results to future public health practice. The heterogeneity was very high ($I^2 = 100\%$).

3.6. Cohen's D effect size

Due to the large heterogeneity of the studies, few studies were able to be included in a meta-analysis at once. The calculation of Cohen's D effect size allowed the comparison of 14 included studies. It was not possible to calculate effect size for three studies due to missing data (Bungum et al., 2014; Sirard et al., 2008; Ostergaard et al., 2015). The method of calculation and effect sizes are shown in Supplement D. The

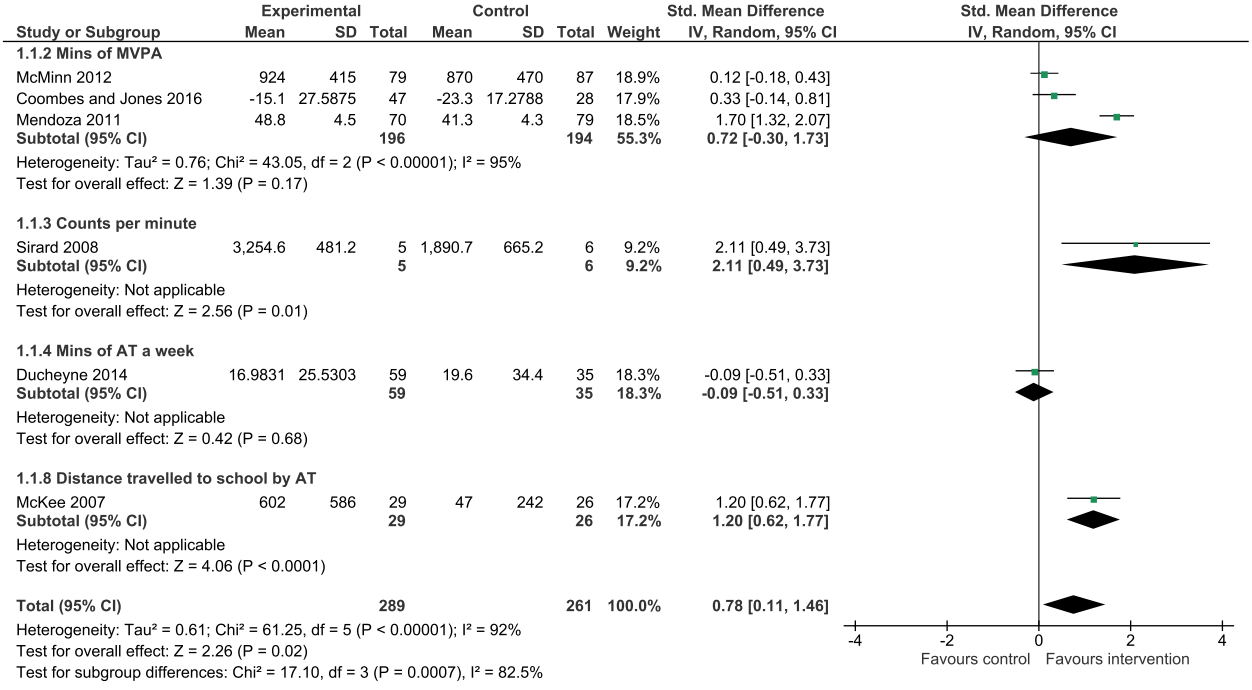

Fig. 3. Forest plot of continuous active travel data (6 studies).

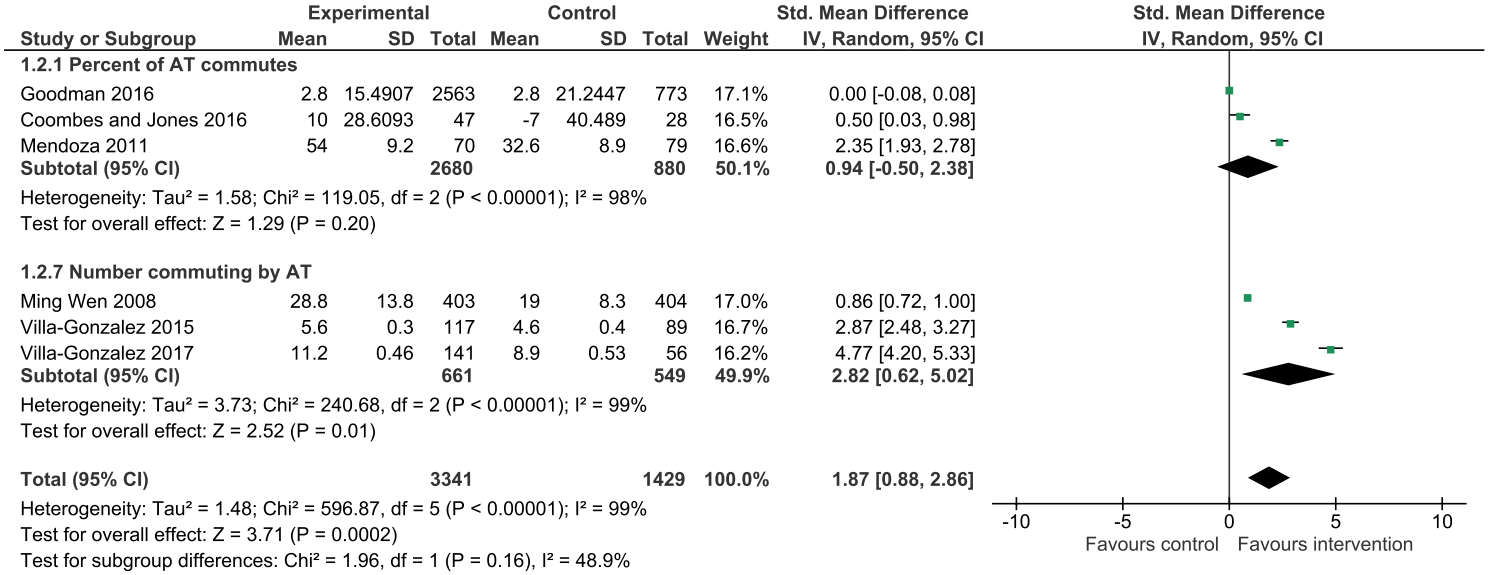

Fig. 4. Forest plot of frequency active travel data (6 studies).

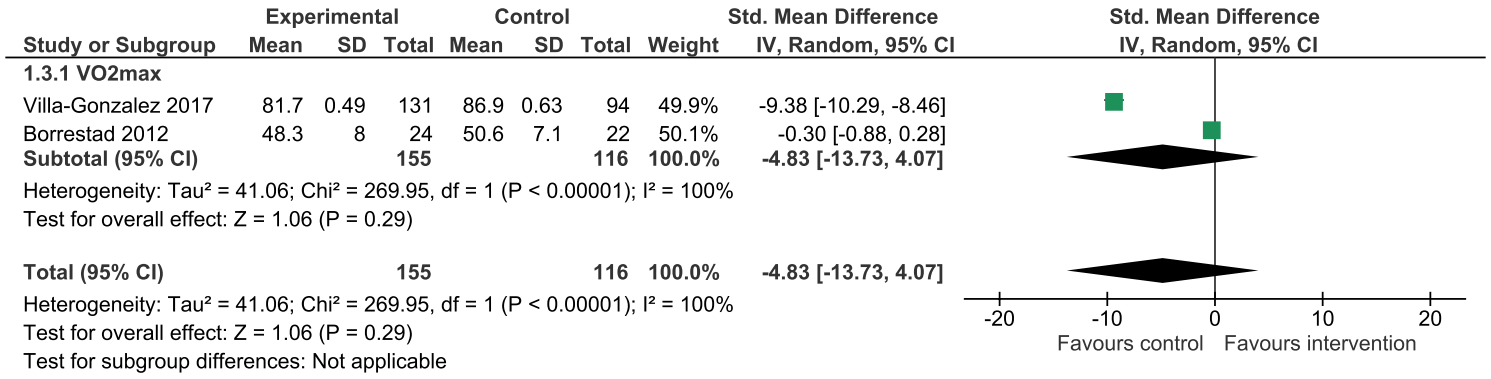

Fig. 5. Forest plot of continuous physical fitness data (2 studies).

Table 1
Complexity summary graph.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	Global score (/30)
Borrestad et al. (2012)	1	1	1	1	1	2	1	2	1	3	14
Bungum et al. (2014)	2	1	1	3	1	1	1	1	2	1	14
Coombes and Jones (2016)	3	1	1	1	1	2	2	1	1	1	14
Ducheyne et al. (2014)	2	2	2	1	1	1	1	3	1	1	15
Goodman et al. (2016)	2	2	1	1	3	1	3	1	2	2	18
Groesz (2008)	2	3	2	1	3	1	3	3	1	2	21
Heelan et al. (2009)	1	1	1	1	1	1	1	3	1	1	12
Hoelscher et al. (2016)	1	1	1	3	1	1	1	3	1	3	16
McKee et al. (2007)	1	1	1	1	1	1	1	2	2	1	12
McMinn et al. (2012)	2	3	1	3	2	1	1	1	2	2	18
Mendoza et al. (2009)	3	1	1	1	1	1	1	3	1	1	14
Mendoza et al. (2011)	1	1	1	1	1	1	1	3	1	1	12
Ming Wen et al. (2008)	3	1	2	2	2	2	3	3	3	2	23
Ostergaard et al. (2015)	3	2	1	3	1	2	1	2	2	3	20
Sirard et al. (2008)	1	1	1	1	1	1	1	2	1	1	11
Villa-Gonzalez et al. (2015)	3	3	1	1	1	1	1	2	1	3	17
Villa-Gonzalez et al. (2017)	3	2	1	1	1	1	1	1	1	3	15
Mean	2	1.6	1.4	1.5	1.4	1.2	1.4	2.1	1.4	1.8	15.7
Mode	1	1	1	1	1	1	1	3	1	1	14

Key: 1 – simple; 2 – moderately complex; 3 – complex.

(i) Number of discrete, active components.
(ii) Number of behaviours or actions of intervention recipients or participants to which the intervention is directed.
(iii) Number of organisational levels targeted by the intervention.
(iv) The degree of flexibility or tailoring permitted across sites or individuals in intervention implementation/application.
(v) The level of skill required by those delivering the intervention.
(vi) The level of skill required for the targeted behaviour when entering the study by those receiving the intervention in order to meet the intervention's objectives.
(vii) The degree of interaction/independence between intervention components of intervention components.
(viii) The degree to which the effects of the intervention are dependent on the context or setting.
(ix) The degree to which the effects of the intervention are modified by participant or provider factors.
(x) The length of the causal pathway between the intervention and the outcome.

majority of study outcomes showed positive effect sizes ranging from trivial to very large. The range of effect sizes across all included studies was from −9.48 to 12.24, with a mean effect size of 0.50 (±3.44) in favour of the intervention.

3.7. Complexity assessment

The complexity of each intervention was assessed using iCAT_SR (Table 1). There was significant diversity in the level of complexity of the included studies, global scores for complexity ranged from 11/30 to 23/30, with mean of 15.7 (±3.32). The most 'simple' intervention was a walking school bus, whereas the most complex intervention provided multiple components directed at varying levels (students, teachers, parents) (McKee et al., 2007; Ming Wen et al., 2008). The most common complexity rating was simple, with exception of component 8 (the degree to which the effects of the intervention are dependent on the context), which received the highest rating of moderately complex or complex.

Fig. 6 presents the relationship between complexity and effectiveness by Cohen's D effect size, showing that there is no correlation. A Spearman's rank-order correlation assessed the relationship, resulting in a moderate negative non-significant relationship ($r = -0.270$; $p = 0.351$) suggesting, that for these interventions, there was no increased effectiveness with more complex interventions.

4. Discussion

This review concluded that active travel interventions are effective at increasing PA in children. The effect was not observed for physical fitness, hypothesised to be due to the extremely limited available evidence. Active travel intervention studies included in this review were strongly heterogeneous in terms of intervention type and were of weak quality. Walking school buses and educational strategies were the most effective intervention types, with very few interventions using 'policies' despite strong evidence of effectiveness (de Nazelle et al., 2011). No relationship between complexity and effectiveness was observed.

Conclusions of effectiveness and the overall weak quality of included studies are in line with the findings of the reviews conducted by Chillon et al. (2011) and Villa-Gonzalez et al. (2018). Comparison of review findings must be considered with caution due to the differing eligibility criteria such as the age of participants included and eligible study design types. Furthermore, the current review differed from previous as studies with a PA co-intervention were excluded to ensure the findings were the result of active travel promotion only. The included studies therefore differ greatly between the current and previous reviews. Chillon et al. (2011) evaluated 14 studies of children aged 6–18 years old; Villa-Gonzalez et al. (2018) followed the same procedure as the previously mentioned reviewed and included 23 studies. The current review included 17 studies despite applying more restrictive criteria, highlighting the increase in research in this field since 2011.

The current review shows that despite diversity of intervention types in individual studies, the overall effect is a promising increase in active travel to school, and this effect does not seem to be related to the complexity of the intervention. The included studies varied greatly in many aspects, including intervention type and duration, outcome measures, follow-up duration, and study locality. Review findings of effectiveness must be interpreted with caution due to the heterogeneity in the included studies. It should be noted that heterogeneity of the included studies was high (99–100%), similar to the previous systematic review (Chillon et al., 2011; Villa-Gonzalez et al., 2018).

A number of successful interventions provided a walking school bus

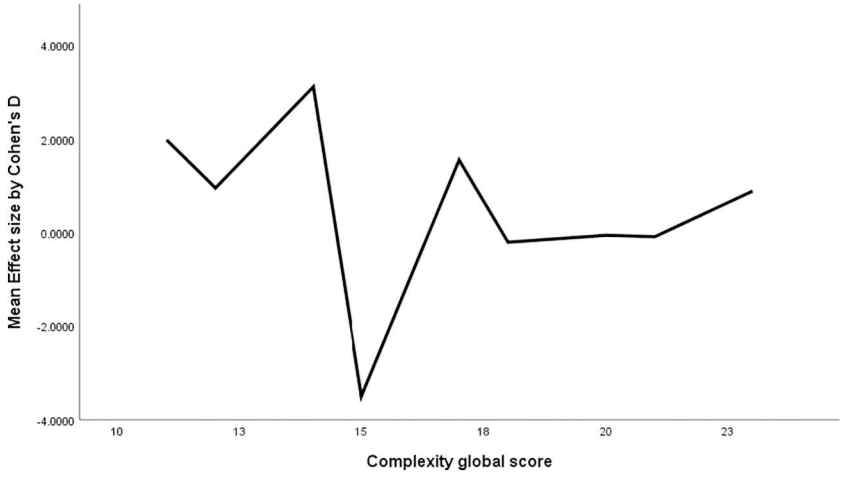

Fig. 6. Scatter graph presenting complexity global score against effectiveness by Cohen's D effect size.

(WSB), varying from simple WSB programme to a walking school bus alongside other activities/materials. Sub-group meta-analysis of WSB studies was not possible as one study did not provide sufficient data. Future research should ensure to provide complete data to allow the analysis of the pooled effect. Education based interventions (e.g. story reading, knowledge lessons) found success in improving active travel behaviours. Sub-group analysis (Fig. 4) concluded a pooled effect of 2.82 (0.62–5.02) in favour of the intervention. The success of these programmes was limited in comparison to walking school buses, possibly due to limited attention to the complex range of determinants (e.g. family, social, environmental). Future studies are needed to assess the additional benefit of combining the successful elements of WSBs and educational interventions to increase the impact on active travel outcomes.

Assessment of the intervention strategies concluded that intervention research to date is insufficient at including the recommended 'Active Living by Design' elements. No consistent relationship could be determined between intervention strategy (5Ps) use and effectiveness. The inconsistent relationship indicates a need for further research. The framework used lacks the capacity to distinguish between 'active' or 'inactive' intervention strategies. Future research should consider the 'active' or 'inactive' nature of an intervention component as this may play an important role in effectiveness. The most commonly used strategies were 'preparation', 'promotion' and 'programs', with 'policies' and 'physical projects' as the least used strategies. Only two included studies explicitly referred to the use of active travel policy, despite active travel policies being shown to be highly likely to produce large individual health benefits, as well as reductions in air and noise pollutions (de Nazelle et al., 2011).

No previous research has explored the complexity of active travel interventions. Assessing the relationship between effectiveness and complexity suggested that there was no significant correlation. Therefore complexity may not be a key indicator of success within active travel interventions. The conclusion regarding the relationship between complexity and effectiveness must be considered with caution due to limitations of assessment. Further research is necessary to explore this relationship further, utilising rigorous techniques and controlling for external influences.

The review findings have the potential to influence the field of public health. Although the decline in childhood PA may not be solely addressed through enhanced active travel, the findings show promise to positively impact children's behaviours. Walking school buses are a promising method of increasing PA and active commuting rates in children, with educational strategies also showing success.

It is recommended for schools aiming to increase active commuting rates to implement walking school buses alongside educational strategies. More research is required in the field to allow stronger and more reliable review findings. Future studies should compare the effectiveness of active travel intervention components and durations to determine those that are most successful. Future research should assess the effectiveness of active travel policies, as well as investigating sustainability of health effects. All future intervention studies should seek to use robust controlled methodology.

4.1. Study limitations and strengths

The review findings add substantially to the active travel intervention evidence base. The previous reviews included non-experimental designs due to a lack of high quality research at the time (Chillon et al., 2011; Villa-Gonzalez et al., 2018). The growth of active travel research allowed the current review to include only controlled experimental designs, increasing the strength of the review findings. However there were a number of limitations to be noted. The high heterogeneity in study designs and outcomes increases the complexity of summarising effectiveness, whilst weak study quality and the use of self-reported methods to assess changes in PA reduces the strength and reliability of study findings. The wide ranging types of intervention made comparison of study findings difficult. Generalisation of the review's summary evidence is limited by these factors. Furthermore, the exclusion of non-English language studies may result in incomplete representation of the relevant literature.

5. Conclusions

The review's primary aim was to summarise the effectiveness of active travel interventions on active travel rates and physical fitness in primary school children. The review found that active travel interventions are successful at increasing rates of active commuting to school in primary school children, yet did not find success for increases in physical fitness, hypothesised to be due to the extremely limited available evidence. Further research is required to strengthen review findings. Studies of active travel policies, intervention types, active intervention ingredients and outcome sustainability are necessary. Future intervention studies should apply more rigorous methods to improve research quality. Representative samples, larger sample sizes, randomised controlled designs and valid and reliable measures should be a priority within future active travel research.

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Conflicts of interest

None.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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