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The Effectiveness of Sedentary Behaviour Interventions for Reducing Body Mass Index in Children and Adolescents: Systematic Review and Meta-analysis

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Abstract

Intervention studies have been undertaken to reduce sedentary behaviour (SB), and thereby potentially ameliorate unhealthy weight gain in children and adolescents. We synthesised evidence and quantified the effects of SB interventions (single or multiple components) on body mass index (BMI) or BMI z-score in this population.

Publications up to March 2015 were located through electronic searches. Inclusion criteria were interventions targeting SB in children that had a control group and objective measures of weight and height. Mean change in BMI or BMI z-score from baseline to post-intervention were quantified for intervention and control groups and meta-analysed using a random effects model. The pooled mean reduction in BMI and BMI z-score was significant but very small (standardized mean difference [SMD] = -0.060, 95% confidence interval [CI] -0.098 to -0.022). However, the pooled estimate was substantially greater for an overweight or obese population (SMD = -0.255, 95% CI -0.400 to -0.109). Multicomponent interventions (SB and other behaviours) delivered to children from 5 to 12 years old in a non-educational setting appear to favour BMI reduction. In summary, SB interventions are associated with very small improvement in BMI in mixed-weight populations. However, SB interventions should be part of multicomponent interventions for treating obese children.

Introduction

Worldwide, 42 million children under the age of five are overweight or obese (1). Although the prevalence rates of obesity in developing countries appears to have leveled (2;3), current rates remain high and rates in developing countries **continue to rise** (4).

Overweight and obesity during childhood has been associated with insulin resistance and type II diabetes (5), and can lead to metabolic syndrome which also includes dyslipidemia and hypertension (6). There is evidence of a high degree of BMI tracking across different age groups (<10 years old to \geq 18 years old) (7), and there is moderate evidence to suggest that overweight and obese youths will become overweight adults (8), indicating that there is a low probability of spontaneous weight loss through life if individuals do not receive treatment.

Several interventions have been developed for weight management during childhood including lifestyle interventions (e.g. diet and physical activity) (9) and pharmacological interventions (10). There is some evidence to support that sedentary behaviour (i.e. television viewing) is associated with obesity in children (11-13). However, some argue that there is still mixed evidence for a relationship between sedentary behavior and overweight or obesity, and the association might be small and not clinically relevant (14;15). Nevertheless, several behavioral interventions have included sedentary behaviour in an attempt to target the wide range of factors that are associated with energy balance (16).

Three previous meta-analyses have examined the effect of sedentary behaviour interventions on body mass index (BMI) (17-19). The first review included 6 randomized controlled trials (RCTs) and found no significant difference in mean BMI change (-0.10 kg/m^2 , -0.28 to -0.09) (17). Van Grieken et al. (2012) retrieved 14 controlled trial studies and found a significant difference on post-intervention change in BMI (-0.14 kg/m^2 , CI: -0.23 to -0.05). Finally, the most recent meta-analysis with 25 RCTs, found a small significant effect of sedentary behaviour intervention on BMI reduction (Hedge's $g = -0.073$, $p=0.021$) (19).

Although several meta-analyses have been conducted in this field, the cut-off date for the latest review (19) was July 2012 and 21 new studies have been published since then. Furthermore, we found 19 articles dated before July 2012 which were not included in previous reviews, perhaps due to different inclusion or exclusion criteria: RCTs only (17;19), excluded studies with overweight and obese participants (18); excluded studies in which BMI was adjusted for covariates (19).

Although previous studies (18;19) explored the effect of intervention type (single or multiple behaviour) on BMI reduction, they did not explore the effect of other variables such as age range, weight status (mixed or overweight/obese), duration of intervention, intervention setting and study quality.

Therefore, the aim of this systematic review and meta-analysis was to summarize and compare the effect of interventions that target sedentary behavior (e.g. TV viewing, video gaming) on BMI or BMI z-score in children (0 to 17 years old of any weight status), assessed using either a randomized or non-randomized controlled trial. The secondary aim was to explore if there were subgroup differences according to age, weight status, intervention type, duration, setting, and study quality on intervention outcome (i.e. BMI).

Methods:

We conducted our systematic review using methodological approaches defined in the Cochrane Handbook for Systematic Reviewers (20) and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria (21). An a priori protocol was published in Prospero (registration CRD42013005686) (22).

Study Inclusion and Exclusion Criteria:

Studies were included in this review if they were randomised or non-randomised controlled trials conducted in free living (non-laboratory) settings, and assessed sedentary behaviour (SB) interventions in children aged 0 to 17 years old from all weight status categories. To be classified as a sedentary behaviour intervention, the intervention had to target activities undertaken whilst sitting or lying down, such as

screen-based activities. Studies were included if the SB intervention was delivered as a single (SB only) or multi-component intervention (targeted other behaviours such as physical activity or diet as well as SB). To be included studies must have reported objectively measured weight and height, provided a BMI or BMI z –score, and included a control group that was not exposed to any other type of intervention including sedentary behaviour, physical activity or diet.

We excluded studies which were performed in laboratory settings, had no control groups, targeted active video gaming and defined sedentary behaviour as a failure to meet a physical activity guidelines. Studies were also excluded if they involved children suffering from a critical illness or a secondary or syndromic form of obesity.

Search strategy

The following databases were searched for this study: MEDLINE; Embase, Cochrane Central Register of Controlled Trials (CENTRAL); Cochrane Database of Systematic Reviews; Database of Abstracts of Reviews of Effects (DARE); PsycINFO; CINAHL; ERIC and SPORTDiscus. Databases were initially searched in June and July 2013 followed by two update searches – October 2013 and March 2015.

Searches were limited to papers published from 1980 to present and restricted to articles published in English language only. Where available, search filters for study types were applied and can be seen in an example of search strategy (e.g. MEDLINE) in Supplement File 1. Files were imported to EndNote reference management software (version 7, version 4.0; Niles Software) where duplicates were removed.

Titles and abstracts of potentially relevant articles were screened independently by two reviewers (LA, NI); any disagreements were discussed with a third reviewer (GA) until consensus was achieved. Full text copies were obtained after the initial screening and were examined independently for eligibility by the two reviewers (LA, NI). Discrepancies were resolved by discussions and consensus or by consultation with a third reviewer (GA).

Data extraction

Standardized data extraction tables were created. Data extraction was completed by one reviewer (LA) and checked by other reviewers (JL or IS) for accuracy. The following information was extracted by the reviewers: study information (i.e. authors, year); study design; population (i.e. number of children in the intervention and control groups, age and population weight category); intervention (i.e. type, duration, description of the sedentary behaviour intervention); outcome measures (i.e. baseline and follow-up mean and standard deviation of intervention and control groups: BMI or BMI z-score and sedentary behaviour).

Critical Appraisal

Risk of bias was assessed using the Cochrane Collaboration tool for Assessing Risk of Bias (23). Seven domains were scored: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and 'other' (e.g. bias related to the study design implemented, extreme baseline imbalance).

The seven domains were scored as high, low or unclear and were performed independently by two reviewers (LA and one of JL or IS). Findings were compared and discussed until consensus was achieved. The overall strength of the evidence was determined by the Grading of Recommendations Assessment, Development and Evaluation systems (GRADE pro 3.6). The assessment was rated as high, moderate, low or very low based on the 5 domains of evidence: risk of bias, indirectness, imprecision, inconsistency and reporting bias.

Data Analysis

Means and standard deviations (SD) of BMI or BMI z-score of baseline and the data point closest to the end of the intervention were used for continuous outcomes. When standard error or standard deviation of the mean difference was not presented this was calculated from the reported data (24) following the guidance of the Cochrane Handbook for Systematic Reviews of Interventions (20). The standard deviation of change score was calculated as: $SD = \sqrt{SD_b^2 + SD_f^2 - 2 \times r \times SD_b \times SD_f}$, where SD_b is

the standard deviation at baseline and SD_f is the standard deviation at follow-up, r is correlation coefficient between baseline and the follow-up score. We used a correlation coefficient of 0.8 which represents the correlation of BMI after 1 year follow-up in children over 10 years old (7). If studies reported data separately for boys and girls they were entered separately into the meta-analysis and for studies with more than one intervention arm the data were combined using pair-wise comparisons with the control group (20). If studies did not report baseline and follow-up mean and standard deviation for BMI or BMI z-score, the reported mean difference and pooled standard deviation were extracted and used for the analysis.

To be able to compare BMI and BMI-z score in the meta-analysis, the standardised mean difference (SMD) was chosen to summarise the measure for the meta-analysis. If a study reported both measures (BMI and BMI-z score), we opted for the non-standardised BMI data. This approach, which has been used previously (25-27), helped to increase the number of studies included in the meta-analysis and increase the statistical power to detect a treatment effect. Effect sizes were corrected for bias by transforming the standardized mean difference to Hedge's g before analysis. Effect sizes were determined as: <0.2 = very small; ≥ 0.2 to < 0.5 = small effect; ≥ 0.5 to <0.8 = medium effect; ≥ 0.8 = large effect (28).

We used Comprehensive Meta Analysis version 3.0 (Biostat, USA) for effect size synthesis and subgroup analyses. A random effects model was used to derive a pooled estimate of the effect of sedentary behavior intervention on SMD. Between-study heterogeneity was quantified using I -square (I^2) statistics. Subgroup analyses using mixed effects analysis were conducted to examine the impact of age (0 to 5 years; 5 to 12 years; 12 to 17 years); population weight status (overweight/obese; mixed weight); intervention type (sedentary behaviour, sedentary behaviour and physical activity, sedentary behaviour and other behaviours other than only physical activity); setting (educational, non-educational, combined); duration (≥ 6 months, < 6 months) and study quality (low risk of bias, high risk of bias and unclear) on intervention effectiveness to reduce BMI (SMD).

A second meta-analysis was also conducted for studies which reported BMI data and a subgroup analyses were performed for studies which presented BMI data in an overweight/obese population.

Results

Systematic Review

The searches yielded a total of 7,607 papers of which 67 met the inclusion criteria (Figure 1). Supplement file 2 summarizes the main characteristics and findings of 67 eligible studies. Sixty-one studies conducted an RCT or a cluster RCT and six were non-randomised controlled trials. Seventeen studies were conducted with preschool children (0 to 5 years old), 35 with children (5 to 12 years old) and 15 with adolescents (12 to 17 years old). Eighteen studies were conducted in an exclusively overweight population and 49 studies were conducted in a mixed weight population. The majority of the interventions (N=39) were less than 6 months in duration. Six interventions only targeted sedentary behaviour, 10 interventions targeted exclusively sedentary behaviour and physical activity and 51 interventions targeted sedentary behaviour alongside other behaviour(s) including: diet, sleep, breastfeeding and motor skills. Twenty-three studies were delivered in an educational setting (e.g. school), 25 in a non-educational setting (e.g. home, community, primary care setting) and 19 were delivered in a combined setting (educational and non-educational). The majority reported BMI data (N=51), with the remainder only reporting the data in BMI z-score (N=16) applying different growth chart references (e.g. CDC, WHO, UK 90 and IOTF).

Figure 1 here

Thirty-two studies were considered to have a low risk of bias, 22 were high risk of bias and 13 were unclear (Supplement File 3). Figure 2 reports the aggregated risk of bias of studies using the Cochrane Effective Practice and Organization of Care risk-of-bias tool for randomized controlled trials (23), non-randomized controlled trials, and controlled before-after studies.

Figure 2 here

Nineteen studies reported significant decrease in BMI or BMI z-score (29-47). However, one of these studies reported a significant difference in girls but not in boys (35). From these studies, the majority (N=13) were performed with children (5 to 12 years old) (29;31-35;37-40;42;47). Eight were performed in an overweight population (31;32;34;37;39;41;43;47) while 11 were performed in a mixed weight population (29;30;33;35;36;38;40;42;44-46). Most of the studies which reported significant decreases (N=13) targeted 3 behaviours (29;30;32;33;36;37;39;41-43;45;46;48) which were predominately sedentary behaviour, physical activity and diet (29;30;32;33;37;39;41;43;45;46;48). Nine of the successful interventions were delivered in a non-educational setting (e.g. home, community or primary care setting) (34;36;37;39;39;41;43;46;47). Ten of these studies which reported significant decreases in BMI or BMI z-score (29;31-34;39;42;44-46) also reported significant decreases in total sedentary behaviour or screen-viewing, while eight studies did not find significant differences in sedentary behaviour (30;36;38;39;41;43;45;47) and two have not reported sedentary behaviour data (35;37). Eight of these studies were considered high risk of bias (29;32-34;37;38;45), six were low risk of bias (34;36;40-42;46) and five studies were unclear (29;31;35;43;47).

Meta-analysis

Figure 3 and Table 1 show the pooled standardised mean difference (SMD) between intervention and control groups. There was a very small (<0.2) but statistically significant difference in favour of the intervention group (SMD - 0.060, 95% CI - 0.098 to -0.022). There was evidence of moderate heterogeneity between studies ($I^2 = 50\%$, $p < 0.001$). Furthermore, the asymmetrical funnel plot (Supplement File 4) and results from Egger's test (intercept = -0.771, $p < 0.05$) show that there was publication bias. The quality of the evidence for the pooled SMD outcome was rated as moderate and is summarized in Table 2.

Figure 3 and Table 1 and 2 here

Fifty-one studies included in the meta-analysis measured the change in BMI. There was a small but significant change favouring the intervention for change in BMI (Table 1). A subgroup analysis revealed a mean BMI difference of -0.493 kg/m² (95%

CI -0.681 to -0.304) for the studies which targeted overweight or obese populations and -0.029 kg/m² (95% CI -0.093 to 0.035) for studies with mixed weight populations.

Table 3 shows that interventions were significant when delivered to children but not when delivered to pre-school children or adolescents. Likewise, multicomponent interventions (interventions that target sedentary behaviour plus other behaviours rather than only PA) had significantly lowered BMI or BMI z –score compared with controls, whereas single behaviour interventions and interventions that included only sedentary behaviour and physical activity showed no differences. Similarly interventions in non-educational settings led to significant differences compared to controls, while interventions delivered in an educational setting or combined settings showed no difference. Furthermore, only studies with high risk of bias were statistically significant, while studies with low risk of bias and unclear risk of bias were not significant. The SMD was also statistically different between both short (<6 months) and long term (>6 months) interventions.

Table 3 here

Discussion

This study found moderate quality of evidence that sedentary behaviour interventions are associated with statistically significant but very small improvements in BMI and BMI z-score (SMD data). The reduction in SMD and BMI was greater in an overweight population and likely to be clinically significant at a population level. Likewise, interventions appear to be more effective when implemented in children, as a multicomponent intervention and delivered in a non-educational setting.

There have been a number of studies which explored the minimum clinical important difference (MCID) on BMI z-score to promote health benefits in overweight children (48-53). Some studies reported that a minimum change of 0.5 BMI z-score would be required to improve insulin sensitivity and resistance and atherogenic profile (48;49), while others reported that a minimum change in BMI z-score of 0.25 is required for improvement in cardiometabolic risk factors (50). However, others demonstrated that even a modest decrease of 0.15 BMI z-score (53) or less than 0.1 BMI z-score (51) is

accompanied by significant improvements in health measures. Finally, one study with overweight children reported that changes in weight between -7.55 kg to +3.9 kg were sufficient for an overweight or obese child to achieve a healthy weight after 1 year (52). Despite the variation in estimates of the MCID for BMI to improve health measures in children, previous systematic reviews (19;54) including a previous meta-analysis on sedentary behaviour interventions (19) have used the MCID of 0.25 BMI z-score defined by Ford et al. (50) as the point of reference. Thus, this was also the choice for this meta-analysis.

If BMI z –score defined by Ford et al. (50) is converted to SMD the value would be equivalent to -0.88 (mean change of -0.36 and standard deviation of 0.41). Therefore, to reach clinical significance the effect size of this meta-analysis would need to be very large >0.9 (28). The SMD of this meta-analysis was very low for a mixed weight population (-0.06, 95% CI: -0.098 to -0.022) but increased considerably for an overweight population (-0.255, 95% CI: -0.40 to -0.11). Although this is unlikely to be clinically significant at an individual level, it may produce tangible health benefits for treatment of an overweight and obese population. It is important to note that the SMD results derived from Ford et al. (50) were from a very small population (N=20) of severely obese children (BMI z-score = 3.23 ± 0.49). Likewise, although the effect size of this meta-analysis was small for an overweight population it may still have public health impact at population level. **It has been previously argued (55) that controlling health risk at a population level, as opposed as individual-based (also known as high-risk) can be more effective to shift population health outcomes positively.**

as opposed as a small shift in population can be an effective strategy for a large population at moderate risk rather than a small population with a high risk.

The large difference in effect size between mixed weight and overweight populations observed in this study was also seen in a comprehensive meta-analysis and systematic review on behaviour interventions to treat (56) or prevent (25) overweight in children and young people. According to the latest reviews when the meta-analysis only included studies with overweight children or youth (BMI $> 85^{\text{th}}$ percentile) the overall

SMD was -0.54 (95%CI: -0.73 to -0.36) (56), while for studies with normal weight or mixed weight population the SMD was -0.07 (95%CI: -0.10 to -0.03) (25).

The mechanisms by which sedentary behaviour might affect BMI in an overweight population could be related to displacement of physical activity (57), reduction of total energy expenditure (58), increased general dietary intake (59;60) or of sugar-sweetened beverages (61). There are disagreements in the literature on whether physical activity displaces sedentary behaviour. A recent meta-analysis (62) found a negative but weak association between sedentary behaviour and physical activity in children and adolescents, and the authors concluded that these behaviours do not displace each other. However, other cross-national investigations with school-age children found a negative association between the two behaviours that appeared to be stronger in countries where levels of physical activity are particularly high (57). On the other hand, the evidence related to the association of sedentary behaviour and diet behaviour has strengthened in recent years. A recent updated systematic review found a clear trend towards an association between higher levels of sedentary behaviour, especially TV viewing, with an unhealthy diet (e.g. lower fruit and vegetable intake and greater consumption of energy-dense snacks and sugar sweetened beverages) (63), although this association was less clear in an adult population. Finally, another recent systematic review revealed that TV exposure is related to an increase in energy intake rather than a change in physical activity (64).

Another important finding of our study was that interventions appeared to be more effective in children rather than preschool children or adolescents. This contradicts with previous findings from a meta-analysis on prevention and treatment of overweight and obesity which found no differences between age groups (25;56).

Likewise, our study found that multicomponent interventions (sedentary behaviour and other behaviours rather than only physical activity) and interventions which were delivered in non-educational settings appeared to be more effective in reducing BMI. Conversely, interventions which targeted only SB or SB and PA and in an educational or in combined settings did not change BMI significantly.

Previous sedentary behaviour reviews which looked to the effect of single (SB only) versus multiple behaviour interventions have not found statistically significant differences between these (19;65). This is supported by two recent meta-analyses on treatment and prevention of overweight and obesity which did not find significant differences between single and multiple behaviour interventions (25;56). However, other reviews suggested that multiple behaviour interventions (physical activity and diet) might be more successful than single behaviours at preventing obesity (9;66). A synthesis of meta-analyses and reviews comparing exclusively single and multiple behaviour interventions in adults found that although single behaviour interventions were more effective at changing behaviour, multiple behaviour interventions are more effective at promoting weight loss (67). However, it is important to note that only six studies in our meta-analysis targeted only sedentary behaviour suggesting that more interventions are necessary to clarify this question. Likewise, we also found that studies that target only sedentary behaviour and physical activity do not change BMI, suggesting that a third behaviour (i.e. diet) should be included to promote significant weight changes.

Another important finding of this study was that sedentary behaviour interventions delivered in a non-educational setting (e.g. home, community or primary care) appeared to be more effective than interventions delivered in an educational setting (e.g. school) or combined settings (Table 3, Supplement File 2). Although 23 studies of our meta-analysis sample were delivered in educational settings only 5 showed significant improvements in BMI or BMI z-score. Nevertheless, 10 of the 25 studies delivered in non-educational settings showed significant improvements in BMI or BMI z-score. Although this has not been investigated in previous sedentary behaviour systematic reviews, a recent systematic review (68) which examined the effect of parental influences on screen time in young children (<6 years old) found moderate evidence that parental self-efficacy and parents' own screen time was associated with children's screen time. Likewise, another systematic review found that in fact the level of parental involvement rather than the setting is important to determine the sedentary behaviour intervention success (64). Parental involvement has not been explored in our review but it is expected that interventions delivered at home, community or primary care would have greater involvement of parents rather than the

school or nursery environment which would require a deeper involvement of teachers and carers.

The effect size of this review is similar to previous work which compared the effect of sedentary behaviour on BMI (17-19). Although Wahi et al. (17) did not find a significant difference in the mean difference (-0.10 kg/m², 95%CI: -0.28 to 0.09), this might be due to the small number of studies included in their sample (N=6). Both, Van Grieken et al. (18) and Liao et al. (19) found effect size differences that were statistically significant and very similar to this study for a mixed-weight population. However, the effect size found in this study for an overweight population was substantially higher compared to other meta-analysis in BMI units (Wahi et al: -0.10 kg/m², CI: -0.28 to -0.09; Van Grieken et al: -0.14 kg/m², CI: -0.23 to -0.05; this study: -0.493 kg/m², CI: -0.681 to -0.304) or standardised mean difference (Liao et al. Hedge's g: -0.073, CI: -0.14 to -0.01 ; this study SMD : -0.255, CI: -0.400 to -0.109).

Strengths of this meta-analysis include: the number of studies, subgroup analyses, grading of quality of evidence and strength of recommendations and comparison with MCID reported in the literature. However, it also has some limitations as subgroup analysis revealed that statistical significance was only seen in studies with high-risk of bias and no significance was seen in studies with low-risk of bias. Finally, there were a limited number of studies which used sedentary behaviour as the only targeted behaviour.

Conclusion

Sedentary behaviour interventions have been undertaken in isolation or in combination with other behaviours to prevent or treat overweight and obesity in children. The results of this systematic review and meta-analysis indicate that sedentary behaviour interventions are associated with a very small and clinically irrelevant effect on BMI or BMI z-score when applied to the general population or normal weight population. However, the effect of sedentary behaviour interventions on BMI might be clinically effective at population level for children who are overweight or obese. This suggests that sedentary behaviour should be **targeted in interventions** to treat overweight or obese children. Furthermore, the impact of the interventions appeared to improve when they were delivered to children (5 to 12 years

old), implemented with other behaviours (e.g. diet) and in a non-educational setting. However, a large number of high quality studies and studies targeting only sedentary behaviour are required to clarify these findings further.

Table 1: Effect of sedentary behaviour intervention in BMI and BMI z-score.

| Group or Subgroup | Meta-analysis (95%CI) | Heterogeneity | p value | Number of studies (total sample size) |
|---|------------------------------|----------------------|----------------|--|
| Overall change (SMD) | -0.060 (-0.098 to -0.022) | 50% | <0.001 | 71 (N=29,650) |
| Overall change BMI (kg/m ²) | -0.158 (-0.238 to -0.077) | 88% | <0.001 | 51 (N=18,012) |

SMD = standardised mean difference

Table 2: GRADE evidence profile for the effect of sedentary behaviour interventions on BMI.

| Quality assessment | | | | | | | No of participants | | Effect size (95% CI) | Quality | Importance |
|--------------------|----------|----------------------|--------------------------|-------------------------|------------------------|--|--------------------|---------|---------------------------|------------------|------------|
| No of Studies | Design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Intervention | Control | | | |
| 67 | 91% RCTs | Serious ¹ | No serious inconsistency | No serious indirectness | No serious imprecision | Reporting bias ² dose response gradient | 15,369 | 14,281 | -0.060 (-0.098 to -0.022) | ⊕⊕⊕○ MODERATE | IMPORTANT |

¹ Twenty-three out of 67 studies were considered high risk of bias. Furthermore, results from the meta-analysis show that the effect size were only significant for studies with high-risk of bias.

² Although there was a comprehensive search conducted, the grey literature was not searched and there were language restrictions. Furthermore, there was evidence of funnel plot asymmetry and discrepancies in findings between published and unpublished trial.

Table 3. Subgroup analysis of the effect of sedentary behaviour intervention on BMI or BMIZ-score. Meta-analysis data presented as SMD.

| Subgroup | Meta-analysis (95%CI) | Heterogeneity | Within group differences p value | Number of studies (entries) |
|-------------------------|----------------------------------|----------------------|---|--|
| Age group (year) | | | | |
| 0-5 | -0.057 (-0.149 to 0.036) | 68% | NS | 17 |
| 5- 12 | -0.077 (-0.133 to - 0.022) | 42% | <0.006 | 38 |
| 12-17 | -0.037 (-0.094 to 0.020) | 37% | NS | 16 |
| Weight status | | | | |
| Overweight or obese | -0.255 (-0.400 to - 0.109) | 52% | 0.001 | 18 |
| Mixed weight | -0.037 (-0.073 to - 0.001) | 45% | 0.044 | 53 |
| Intervention | | | | |
| SB | -0.166 (-0.334 to - 0.001) | 0% | NS | 6 |

| | | | | |
|--------------------------|----------------------------------|-----|--------|----|
| SB + PA | -0.075 (-0.203 to 0.054) | 47% | NS | 11 |
| SB + other behaviours | -0.054 (-0.096 to - 0.012) | 54% | <0.05 | 54 |
| Setting | | | | |
| Educational | -0.032 (-0.073 to 0.008) | 16% | NS | 27 |
| Non- educational | -0.211 (-0.328 to - 0.094) | 67% | <0.001 | 25 |
| Combined | -0.025 (-0.077 to 0.026) | 36% | NS | 19 |
| Duration | | | | |
| ≤ 6 months | -0.079 (-0.150 to - 0.009) | 53% | 0.027 | 41 |
| > 6 months | -0.051 (-0.093 to - 0.009) | 47% | 0.018 | 30 |
| Risk of Bias | | | | |
| Low risk of bias | -0.026 (-0.060 to 0.009) | 0% | NS | 33 |

| | | | | |
|----------------------|------------------------------|-----|-------|----|
| High risk of bias | -0.113 (-0.194 to -0.032) | 67% | 0.006 | 23 |
| Unclear risk of bias | -0.065 (-0.172 to 0.042) | 70% | NS | 15 |

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