

Interventions designed to reduce sedentary behaviours in young people:
A review of reviews

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Abstract

Background: Leisure-time is increasingly spent in sedentary pursuits such as screen-viewing (e.g. television/DVD viewing, computer use), motorised travel, school/work, and sitting based socialising (e.g. social media, chatting). Sedentary screen time, particularly TV, appears to play an important role in the aetiology of obesity due to its co-occurrence with other unhealthy behaviours such as snacking on energy-dense foods, low levels of physical activity and inadequate sleep. More information is needed on how to reduce sedentary behaviours. Most interventions have focussed on young people and a number of systematic reviews exist on this topic.

Objective: To synthesise systematic reviews and meta-analyses of interventions aimed at decreasing sedentary behaviours among children and adolescents.

Methods: Papers were located from computerized and manual searches. Included articles were English language systematic reviews or meta-analyses of interventions aiming at reducing sedentary behaviour in children (<11 years) and adolescents (12-18 years).

Results: Ten papers met the inclusion criteria and were analysed. All reviews concluded some level of effectiveness in reducing time spent in sedentary behaviour. When an effect

size was reported, there was a small but significant reduction in sedentary time (highest effect size = -0.29; CI = -0.35 to -0.22). Moderator analyses showed a trend favouring interventions with children younger than 6 years. Effective strategies include the involvement of family, behavioural interventions, and electronic TV monitoring devices.

Conclusions: Results from systematic reviews and meta-analyses show that interventions to reduce children's sedentary behaviour have a small but significant effect. Future research should expand these findings examining interventions targeting different types of sedentary behaviours, and the effectiveness of specific behaviour change techniques across different contexts and settings.

INTRODUCTION

Sedentary behaviour (or sitting) is ubiquitous in the developed world with young people now spending the majority of their leisure time in sedentary pursuits such as screen-viewing (e.g. television/DVD viewing, computer use, internet use), sedentary socialising, and inactive forms of transport. Sedentary behaviour comprises sitting or lying, during waking hours, with low energy expenditure (1). There is a growing public health concern over the effects that sedentary lifestyles are having on the health of children and adolescents. For example, evidence reviewed by Tremblay et al. (2) led to the conclusion that “sedentary behaviour (assessed primarily through increased TV viewing) for more than 2 hours per day was associated with unfavourable body composition, decreased fitness, lowered scores for self-esteem and pro-social behaviour and decreased academic achievement in school-aged children and youth (5-17 years)” (p. 14).. Furthermore, sedentary behaviours have been shown to co-exist with other ‘unhealthy’ behaviours such as increased consumption of energy-dense foods (3), lower levels of physical activity (4) and inadequate sleep (5).

Sedentary behaviour can be assessed with objective monitors and by self-report (6). Matthews et al. (7) have estimated that American young people spend 6-8 hours per day sedentary when assessed with accelerometers, with an increase by age group such that 16-19 year olds average just over 8 hours per day. In addition to this type of assessment, self-reported sedentary behaviours can also be quantified, with the most common being TV viewing or TV with other screen-based viewing, such as computer use. With a sample of 6942 Canadian youth assessed in 2001-02, Mark et al. (8) showed that 34% of boys and 41% of girls watched less than 2 hours of TV per day, but only 14% of boys and 18% of girls met the suggested guideline of 2 hours or less of daily screen time. Temporal trends, at least in

the USA, show a decline in TV viewing for young people but an increase in video gaming and total time using a computer (9).

There is a clear need to reduce the time young people spend in sedentary pursuits. The influence of sedentary behaviours on the health of young people has prompted many countries to establish recommendations for time spent sedentary. For example, embedded in the UK's national physical activity guidelines is a recommendation to reduce sitting time and to break up prolonged periods of sitting (10).

Research on interventions for reducing sedentary behaviour has almost exclusively focussed on young people, with only a handful of interventions on adults now emerging. With the burgeoning interest in sedentary behaviour, a number of systematic reviews and meta-analyses have been published synthesising the interventions that focus on young people. Not all of the reviews tackle the same issues, however, with some focussing on weight status, others on behaviour change per se, and some reporting sedentary behaviour change from studies primarily aimed at increasing physical activity. It is opportune, therefore, to bring these reviews together to ascertain common themes and recommendations for effective sedentary behaviour change in young people.

The purpose of this article is to identify and summarise systematic reviews and meta-analyses of studies aimed at reducing sedentary behaviours in children and adolescents aged 18 years or less. From this analysis, recommendations may be possible concerning the type of interventions and strategies that appear to be the most effective in reducing sedentary behaviours in this population.

METHODS

Search strategy

Search strategies were built around three groups of keywords: sedentary behaviour, study type, and sample type. Key terms for sedentary behaviours were used in combination with key terms for study type and sample type to locate potentially relevant studies. PubMed, PsycINFO, and Web of Science were searched using the key terms. In addition, manual searches of personal files were conducted along with screening of reference lists of primary studies and identified articles for titles that included the key terms.

Inclusion criteria

For inclusion, studies were required to a). be a systematic review or meta-analysis; b). include a review of interventions aimed at reducing at least one aspect of sedentary behaviour; c). include participants aged 18 years or less; d). quantitatively report on an outcome measure of sedentary behaviour; e). be published in English up to and including May 2013.

Identification of Relevant Studies

Potentially relevant articles were selected by a). screening the titles; b). screening the abstracts; and c). if abstracts were not available or did not provide sufficient data, the entire article was retrieved and screened to determine whether it met the inclusion criteria.

Data extraction

Data were extracted on standardized forms developed for this review. This information is summarized in Supplementary Table 1.

Strength of evidence

In the cases where effect sizes were given, criteria were used to evaluate the strength of evidence. Verbal descriptors are provided of 'small', 'moderate' and 'large' by generally adopting the conventions of Cohen's *d* effect size for independent means (small = 0.19-0.49; moderate = 0.50-0.79; large >0.99)(11).

Study quality

All included articles were checked to determine whether study quality of individual studies had been conducted as part of their review. Information on whether study quality was conducted is included in Supplementary Table 2 and summarized below.

RESULTS

The literature searches yielded 1298 titles of potentially relevant articles and 10 were eligible for this review (see Figure 1). Five of the articles included a meta-analysis as part of a systematic review (12-16) and 5 were systematic reviews only (17-21)(see Supplementary Table 1). In eight of the articles, the main focus of the interventions reviewed was on reducing one aspect of sedentary behaviour, whereas in two the focus was on interventions to prevent obesity (17) or interventions to change a number of lifestyle behaviours (13).

Overall, interventions that focused on decreasing sedentary behaviour were associated with a reduction in time spent in these behaviours and/or improvements in anthropometric measurements such as Body Mass Index (BMI) and Body Fat percentage (BF%). Where the effect size was reported, there was a small but significant effect in favour of sedentary behaviour reduction for intervention groups. Two studies (13, 14) reported greater treatment effects when the trial measured outcomes during the trial vs. outcomes measured after treatment at follow-up, suggesting only short duration treatment effects. The effects of interventions in the long term were not easy to judge due to limited data.

Study design

Intervention focus. The studies gave different definitions of sedentary behaviour, thus creating some challenges as to interpreting and quantitatively summarising the results. Some studies measured sedentary behaviour in terms of recreational screen time (television

viewing, watching videos/DVDs) and did not include educational activities such as doing homework or reading (14, 16, 18, 20, 21); other studies included listening to music, reading, sitting around doing nothing or talking on the phone (15, 19); some studies did not clearly define sedentary behaviour (12, 13, 17).

It is well known that there are some difficulties in measuring sedentary behaviour and physical activity, particularly when using self-report. In the reviews, sedentary behaviour was measured through objective instruments (e.g. accelerometer), self-report data (e.g. questionnaire) or a combination of the two. One of the reviews (12) reported a higher effect for studies where sedentary behaviour was assessed through a combination of objective and self-report methods ($k = 6$, $g = -0.30$, $Z = -2.86$). Such a combination seems to be the best solution, given that both objective data and some important behaviour-specific estimates of sedentary time, as well as behavioural context, can be captured using self-report.

Sample differences. It was not possible to draw clear conclusions on sample differences such as gender and ethnicity due to insufficient information. Six reviews reported data on gender (13-15, 18, 19, 21). While two reviews reported differential effects of the intervention between genders, such results were inconsistent across reviews. Three reviews included interventions focused on reducing sedentary behaviour only among specific age groups: 0-5(17), 6-12 (20) and 6-19(19). When the age of children was considered, two reviews reported greater treatment effects when trials enrolled children (younger than 6 years)(13, 16), but another showed no moderating effects for age(15). Some studies also included high risk populations, defined as children or adolescents being overweight or obese. It is possible

that some differences could result from considering studies focused exclusively on non-overweight children.

Delivery and length of interventions. The delivery and length of the interventions received by participants varied across the studies within the reviews. The duration ranged from less than 1 month up to 4 years. Some interventions were delivered weekly, biweekly, or monthly. Some of them were single health behaviour interventions (sedentary behaviour only) and others were multiple health behaviour interventions (e.g., interventions focusing on sedentary behaviour, dietary intake and physical activity). Given this complexity, it was not possible to detect trends concerning the duration of the interventions. One of the reviews (15) investigated if interventions focusing solely on decreasing sedentary behaviour had a stronger effect compared to interventions combining different health behaviours, but no significant differences were found.

Intervention settings. The interventions were delivered through a variety of settings (family/home, community, school, primary care, clinic, research center). Some reviews attempted to analyse which intervention type was most successful. In one review(12), community interventions had the greatest effect ($k = 4$, Hedges' $g = -0.61$, $Z = -3.03$), but the result was not significant. In one of the reviews(20), the largest reductions in TV viewing occurred in home or clinic based settings although in another review there were no moderating effects among the different settings (15).

Intervention components/strategies. The intervention components/strategies used can be summarised as: a). informational (passive information, education) and cognitive (general

cognitive strategies, goal setting, problem solving, relapse prevention); b). behavioural (pre-planning, reminders, prompt for desired behaviours, skill building, monitoring and feedback, reinforcement for behaviour, contingent reward for meeting goals); c). environmental (changes in the environment at home, school and community made to facilitate desired changes and inhibit undesired changes, electronic TV monitoring device), and d). social support strategies (involvement of parents or other significant caregivers). The most frequently cited strategies were goal setting, self-monitoring of progress, pre-planning, problem solving, positive reinforcement and contingent feedback systems.

One intervention component repeated in several of the designs was the involvement of family. Significant results for interventions targeting both the child's and the family's level of sedentary behaviour were found. In some interventions the parents were mailed newsletters to reiterate health messages, while other interventions included having the parents attend workshops/meetings with their children and take an active part in planning healthy events. These study designs and results highlight the importance of having a supportive family environment to promote the targeted behaviour change.

Three reviews (14, 20, 21) mentioned the use of a television control device as the strategy that most effectively reduced TV viewing among children. This limits the amount of screen time allowed. Some interventions were theory based, with social cognitive theory and behavioural choice theory being more commonly deployed, at least as guiding frameworks. One review (13) found a trend favouring interventions that included multiple cognitive components (-0.31; CI = -0.38 to -0.24; vs. one or no cognitive components, -0.09; CI = -0.29 to -0.11; P = 0.06).

A recent trend has been to identify behaviour change techniques (22, 23), with 40 now identified (23). We analysed these from the reviews, as shown in Supplementary Table

2. Seven of the 10 reviews provided some mention of behaviour change techniques used in individual studies. However, such techniques or strategies were not always described in detail or using the same terms as those adopted by Michie et al. (23). Nevertheless, Supplementary Table 2 shows that providing information, goal setting, providing rewards, and prompting self-monitoring were the most frequently mentioned techniques, although it cannot be determined if they were the most successful or whether they were causally associated with behaviour change.

The systematic review by Steeves et al. (21) had a particular focus on behaviour change strategies. They concluded goal-setting and self-monitoring were the most frequently used strategies, with use also reported for pre-planning, problem solving, and positive reinforcement.

Study quality

Three of the included reviews conducted a study quality assessment (15, 16, 18). Two reviews (15, 16) utilised the Cochrane Collaboration tool for Assessing Risk of Bias (24). These reviews suggested that the quality of the studies reporting the interventions varied and that the information needed to evaluate risk of bias, was missing in many studies. One review utilised an independent validity assessment(18). Neither of these three reviews provided a distinction between studies of high or low quality/risk of bias.

DISCUSSION

The aim of this review of reviews was to synthesise findings from 10 systematic reviews of interventions designed to reduce sedentary behaviour in young people. While it may seem unnecessary to have so many reviews when there are not so many primary studies, the reviews themselves often address slightly different issues, such as behaviour change or

change in health outcomes, or different age groups. Moreover, this area of research continues to be highly popular and new studies are emerging at a rapid rate.

Overall, interventions that focus on reducing sedentary behaviour have a small but statistically significant effect when measured after the intervention and a larger statistically significant effect when measured during the intervention (13, 14). The small effect may be due to several factors. First, sedentary behaviours may be difficult to change because of their strong habitual component. Health behaviour change can take place via either a 'deliberative route', with conscious decision making and processing, or a more 'automatic route', where there is less conscious processing and more reliance on habit. Habit itself reflects behavioural patterns that are learned through context-dependent repetition. This repetition of behaviour then reinforces context-behaviour associations. Therefore, when encountering the context, it is sufficient to automatically cue the habitual response. For example, a child may return from school, drop their school bag and slump in front of the TV. This may be much more automatic than conscious if it has been developed in that context over time.

Second, sedentary behaviours could be more overtly reinforcing than some physical activities. When coupled with little or no effort being required, this could explain their appeal. Third, young people are more likely to choose sedentary activities even when physically active alternatives are freely available (25). It has been reported that TV viewing is the most common activity during leisure time with about 30% of children watching more than 4 h/day (12, 26, 27), which is double the maximum dose recommended by the American Academy of Pediatrics (28). In addition, screen time is highly accessible and appealing, and this may be increasing as technological advances continue (12). Accessibility

and reinforcement value are key components of behavioural choice theory (25), thus predicting the greater likelihood of sedentary over active behaviours.

It was not possible to make a full quantitative summary of all of the results for this review of reviews due to the heterogeneity among the studies in the outcome measures, delivery and length of interventions, settings, and study designs. However, a few of the reviews did report effect sizes, reflecting the small effect just discussed.

Sedentary behaviour was defined differently among the studies. Often, interventions examined one or two aspects of sedentary behaviour (e.g., TV or media use only). These behaviours do not fully represent the sedentary opportunities available to children and more activities should be included such as talking, playing quiet indoor games, attending clubs, but where sitting is the main feature. It has been reported that only one third of the total sedentary time consists of TV viewing (29) and youth find many other ways to be sedentary (30). Therefore, taking into consideration a single behaviour prevents a full understanding of what children actually do. Some interventions reported several distinct types of sedentary behaviour, but these were drawn together in the analysis, making the effects indistinguishable and unclear as to which specific media was reduced. Sedentary behaviours can be so reinforcing that it is highly unlikely that a reduction in a specific behaviour will be directly replaced with PA. It is more likely that some time will be allocated to other sedentary behaviours, resulting in no net increase in physical activity, for example (12, 31). Thus, different types of sedentary behaviours should be assessed and it may be useful to compare interventions targeting different behaviours (e.g. computer time vs. screen time) in order to determine their impact on children.

It is acknowledged that there are some difficulties in the measurement of sedentary behaviours. Different methods have been adopted in the studies reviewed, but not all have

been tested for reliability and validity and some may have been inappropriate for the age group assessed. Most of the interventions used self-report measures which are easy to use, less invasive and less expensive, but the validity will vary depending on whether the parent or the child does the reporting. Objective measures can provide more accurate assessments of total sedentary time than self-report, but the latter could provide important behavioural information such as the type of sedentary behaviour (time spent reading, watching TV, etc.) and context (location or social situation).

Moderator analysis revealed a trend favouring interventions that enrolled children under 6 years of age (13, 16). Interventions directed to preschool children may be more effective because parents have more control over lifestyle behaviours at this age. This underlines the importance of having a supportive family environment and suggests that the parental involvement is important, if not essential, for the success of the intervention.

Individuals usually do not change their activities or behaviours when they are simply told to do so. Interventions to reduce sedentary screen behaviours have used a number of theories and strategies to help behaviour change. The majority of the interventions included an information provision component which provided children and/or parents with the skills needed to decrease screen media use. This included strategies such as counselling and tailored feedback, and parents were often involved by means of newsletters or more intensive workshops. These interventions have the advantage to combine the messages on sedentary behaviour with other health information (healthy eating, physical activity recommendations).

Many of the interventions were behavioural interventions which consisted of setting screen-time goals, developing a television viewing plan or letting the child identify alternative activities. Providing children with tangible ideas and giving them the opportunity

to choose how to allocate and organize their leisure time and TV viewing time may increase their control over their activity. This perception of individual control may have had an important role in the reduction of sedentary behaviour observed among the studies.

One strategy that was identified as successful in reducing TV viewing time was restricting access to television using a television-control device. Interventions that used electronic TV monitors reported significant decreases in TV viewing time. It can be hypothesized that family rules that limit television viewing time may have similar effects, but an important difference is the child's perception of control. The use of an electronic device puts the decision of when watching television under the child's control instead of being subjected to parents' rules, and it also limits possible conflicts between parents and children. This way, children may perceive an increased control over their activity options and this may partly explain the reduction in SB observed. Even if electronic monitors seem to be an effective strategy for TV reduction, further research is needed to understand the long-term effectiveness of this and if a reduction in screen time will persist once these devices are removed.

Another strategy that was adopted with success was the use of contingent feedback systems, which consist of using TV as a reward for physical activity. This technique seems quite problematic even if it was successful, given that using something as a reward (TV viewing for example) may contribute to the increased liking of it, and may also undermine intrinsic motivation towards physical activity (32). Longer follow-up periods are needed for studies that include contingent TV and an electronic TV control device.

CONCLUSION

This review of reviews has highlighted that interventions are generally successful in reducing sedentary behaviour in young people although effects appear to be small. Nevertheless, given the ubiquitous nature of such behaviours, if such changes could be implemented on a large scale, the effects may be highly significant. Some possible strategies were identified. However, there is diversity of intervention method and measurement, as well as lack of clarity on moderating variables, that precludes firm conclusions in this regard. Future interventions need to address what strategies might work for specific behaviours and populations and this will need more involvement of children and families.

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REFERENCES

1. Sedentary Behaviour Research Network. Letter to the Editor: Standardized use of the terms “sedentary” and “sedentary behaviours”. *Appl Physiol Nutr Me*. 2012;37:540–2.
2. Tremblay M, LeBlanc A, Kho M, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phy*. 2011;8(1):98.
3. Pearson N, Biddle SJH. Sedentary behaviour and dietary intake in children, adolescents and adults: A systematic review. *Am J Prev Med*. 2011;41(2):178–88.
4. Melkevik O, Torsheim T, Iannotti R, et al. Is spending time in screen-based sedentary behaviors associated with less physical activity: a cross national investigation. *Int J Behav Nutr Phy*. 2010;7(1):46.
5. Foti KE, Eaton DK, Lowry R, et al. Sufficient sleep, physical activity, and sedentary behaviors. *Am J Prev Med*. 2011;41(6):596-602.
6. Atkin AJ, Gorely T, Clemes SA, et al. Methods of measurement in epidemiology: sedentary behaviour. *Int J Epidemiol*. 2012;41:1460-71.
7. Matthews CE, Chen KY, Freedson PS, et al. Amount of time spent in sedentary behaviors in the United States, 2003–2004. *Am J Epidemiol*. 2008;167:875-81.
8. Mark AE, Boyce WF, Janssen I. Television viewing, computer use and total screen time in Canadian youth. *Paediatr Child Health*. 2006;11:595-9.
9. Iannotti RJ, Wing J. Trends in physical activity, sedentary behavior, diet, and BMI among US adolescents, 2001 -2009. *Pediatrics*. 2013;132:606-14.
10. Chief Medical Officers of England, Scotland, Wales and Northern Ireland. Start active, stay active: a report on physical activity from the four home countries' Chief Medical Officers. London: Department of Health (http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_128209); 2011.
11. Cohen J. A power primer. *Psychol Bull*. 1992;112(1):155-9.
12. Biddle SJH, O’Connell S, Braithwaite RE. Sedentary behaviour interventions in young people: A meta-analysis. *Brit J Sport Med*. 2011;45:937-42. doi:10.1136/bjsports-2011-090205.
13. Kamath CC, Vickers KS, Ehrlich A, et al. Behavioral interventions to prevent childhood obesity: A systematic review and meta-analyses of randomized trials. *J Clin Endocr Metab*. 2008 December 1, 2008;93(12):4606-15.
14. Maniccia DM, Davison KK, Marshall SJ, et al. A meta-analysis of interventions that target children's screen time for reduction. *Pediatrics*. 2011 July 1, 2011;128(1):e193-e210.
15. van Grieken A, Ezendam N, Paulis W, et al. Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *Int J Behav Nutr Phy*. 2012;9(1):61.
16. Wahi G, Parkin PC, Beyene J, et al. Effectiveness of interventions aimed at reducing screen time in children: a systematic review and meta-analysis of randomized controlled trials. *Arch Pediat Adol Med*. 2011;165(11):978-86.
17. Campbell KJ, Hesketh KD. Strategies which aim to positively impact on weight, physical activity, diet and sedentary behaviours in children from zero to five years: A systematic review of the literature. *Obes Rev*. 2007;8(4):327–38.
18. DeMattia L, Lemont L, Meurer L. Do interventions to limit sedentary behaviours change behaviour and reduce childhood obesity? A critical review of the literature. *Obes Rev*. 2007;8:69-81.
19. Leung M, Agaronov A, Grytsenko K, et al. Intervening to reduce sedentary behaviors and childhood obesity among school-age youth: a systematic review of randomized trials. *J Obes*. 2011:doi:10.1155/2012/685430.

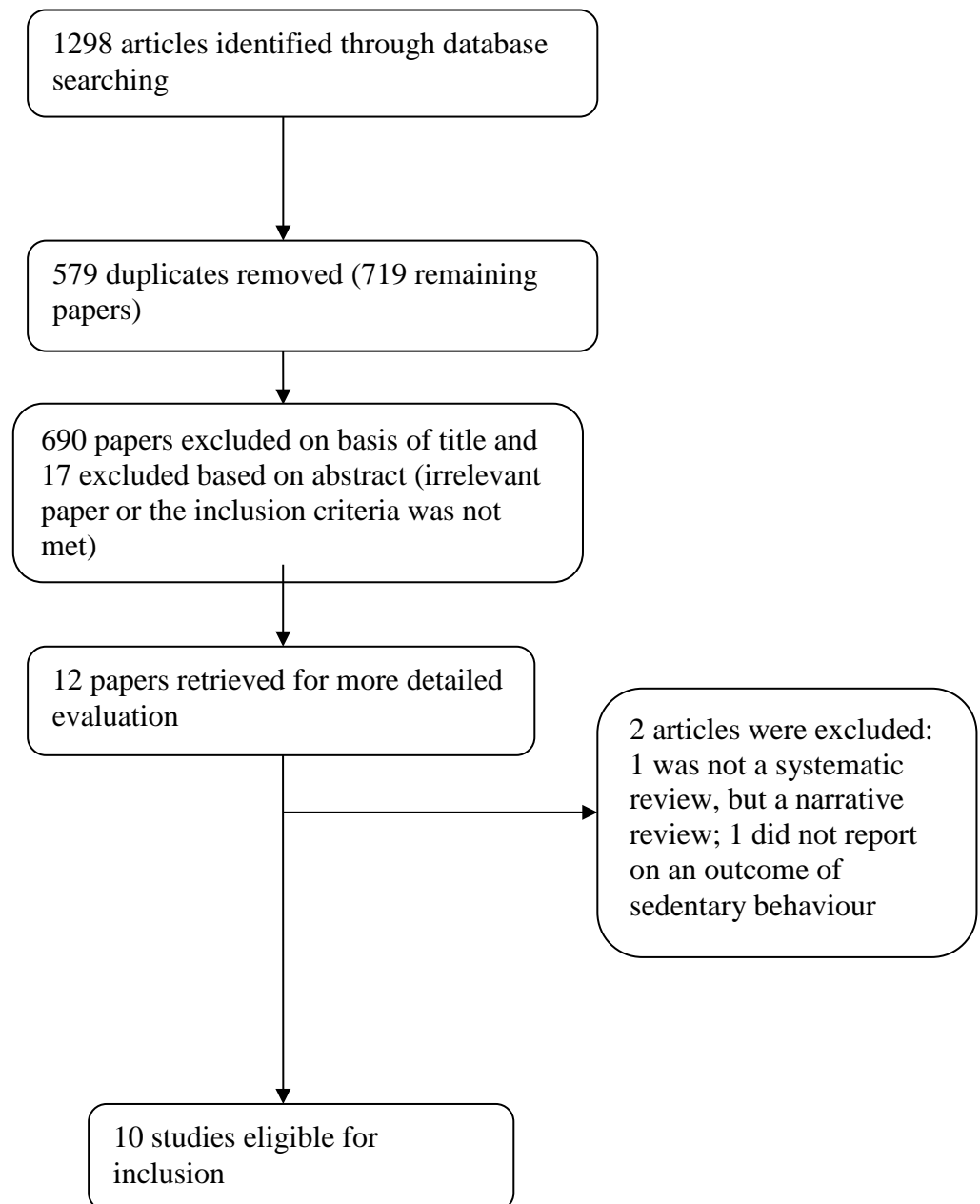
20. Schmidt ME, Haines J, O'Brien A, et al. Systematic review of effective strategies for reducing screen time among young children. *Obesity*. 2012;doi:10.1038/oby.2011.348.
21. Steeves JA, Thompson DL, Bassett DR, et al. A review of different behavior modification strategies designed to reduce sedentary screen behaviors in children. *J Obes*. 2012:Article ID 379215.
22. Abraham C, Michie S. A taxonomy of behavior change techniques used in interventions. *Health Psychol*. 2008;27(3):379-87.
23. Michie S, Ashford S, Sniehotta FF, et al. A refined taxonomy of behaviour change techniques to help people change their physical activity and healthy eating behaviours: The CALORE taxonomy. *Psychol Health*. 2011;26(11):1479-98.
24. Higgins JP, Altman DG, Gotzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ*. 2011;343:d5928.
25. Epstein LH, Roemmich JN. Reducing sedentary behaviour: Role in modifying physical activity. *Exercise Sport Sci R*. 2001;29(3):103-8.
26. American Academy of Pediatrics. Prevention of pediatric overweight and obesity. *Pediatrics*. 2003;128:201.
27. Marshall SJ, Gorely T, Biddle SJH. A descriptive epidemiology of screen-based media use in youth: A review and critique. *J Adolescence*. 2006;29(3):333-49.
28. American Academy of Pediatrics. Children, adolescents, and television: Committee on Public Education. *Pediatrics*. 2001;107(2):423-6.
29. Salmon J, Tremblay MS, Marshall SJ, et al. Health risks, correlates, and interventions to reduce sedentary behavior in young people. *Am J Prev Med*. 2011;41(2):197-206.
30. Marshall SJ, Biddle SJH, Sallis JF, et al. Clustering of sedentary behaviours and physical activity among youth: A cross-national study. *Pediatr Exerc Sci*. 2002;14:401-17.
31. Epstein LH, Paluch RA, Gordy CC, et al. Decreasing sedentary behaviors in treating pediatric obesity. *Arch Pediat Adol Med*. 2000;154:220-6.
32. Deci EL, Koestner R, Ryan RM. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. *Psychol Bull*. 1999;125:627-68.

Summary box

What are the new findings?

- Sedentary behaviour change in young people can be successful but shows small effects
- A trend favours interventions with children younger than 6 years
- Effective strategies include the involvement of family, behavioural interventions, and electronic TV monitoring devices.

Figure 1. Flow of information through different phases of the review of reviews



Supplementary Table 1. Characteristics of included reviews

| Author and date | Years of search | Systematic review or meta-analysis | Search terms used by review | Databases searched | Setting / Target group | Sample age range and mean age | Sample gender and numbers | Number of studies included in review | Focus of interventions | Primary outcome of interventions | Strategies identified | Results |
|--------------------------------|-----------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------------|-------------------------------|----------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------|
| Biddle et al., 2011 (12) | up to 2010 | meta-analysis | adolescent, youth, television, video games, screen based media, sedentary behaviour | ERIC, MedLine, PsycInfo, SportDiscus, Cochrane Library | clinical, community, counselling, education, laboratory | 18 years of age or younger | 4976 participants in total | 17 studies | sedentary behaviours alone or in combination with physical activity | an outcome measure of sedentary behaviour (TV or screen-time behaviours) | - | -0,192 (SE=0.056; CI= -0.303, -0.082; p=0.001) |
| Campbell and Hesketh 2007 (17) | Jan 1995 to June 2006 | systematic review | intervention studies, communication s media, early intervention, primary intervention, health education, overweight, child nutrition, diet, feeding behaviour, physical activity, play, exercise, television, sedentar*, inactivity | MedLine, PsycInfo, Academic Search Premier, Communication, CINAHL | family/home, group, primary care, pre-school/childcare, mixed settings | 0 - 5 years old | not clearly quantifiable | 9 studies (only 2 studies focused on reducing screen time) | prevent obesity, promote healthy eating and/or physical activity and reduce sedentary behaviours | change in at least one obesity behaviour | - | One study showed no effect on reducing TV viewing and one showed some evidence of a reduction in TV viewing |

| Author and date | Years of search | Systematic review or meta-analysis | Search terms used by review | Databases searched | Setting / Target group | Sample age range and mean age | Sample gender and numbers | Number of studies included in review | Focus of interventions | Primary outcome of interventions | Strategies identified | Results |
|----------------------------|------------------|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------|-------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| DeMattia et al., 2007 (18) | 1966 to Feb 2005 | systematic review | obesity, child-preschool, child, adolescent, television, video games, sedentary behaviours, inactivity | MedLine, PsycInfo, Health Star, Cochrane Database of Systematic Review, CINAHL | clinic based and population-prevention based studies | Not stated – children and adolescents as subjects of study | 3126 participants | 12 studies | reducing sedentary behaviour (recreational screen time) | an outcome measure of sedentary behaviour or weight | rewards for meeting goals for reduction of SB and/or increase PA; TV watching linked to pedalling a cycle ergometer (2' of TV to 1' cycling); counselling and written materials on risk of SB; electronic TV managers to aid self-monitoring; lessons integrated into curricular subjects | less time engaged in sedentary behaviour and/or modest improvements in weight |
| Kamath et al., 2008 (13) | Up to Feb 2006 | systematic review and meta-analysis | overweight, obesity, children, behavioural modification, nonpharmacological treatments, prevention, randomized trials | Medline, ERIC, EMBASE, CINAHL, PSYCInfo, DISSERTATION abstracts, Science Citation Index, Social Science Citation Index, Cochrane CENTRAL Database of controlled clinical trials | home, school, clinic, community settings | 2 - 18 years old | 3033 participants included in the intervention to decrease sedentary activity | 47 studies included in the systematic review, of these 10 studies were intervention to reduce SB | changing in lifestyle behaviours (physical activity, sedentary activity, healthy dietary habits, unhealthy dietary habits) and BMI | change in each lifestyle variable and BMI | 1) strategies that reduce unhealthy behaviours are more effective than those promoting positive behaviours 2) greater treatment effect when treatment duration was longer than 6 month, when trials enrolled children and when multiple cognitive component were included in the intervention | -0.29 (-0.35, -0.22) |

| Author and date | Years of search | Systematic review or meta-analysis | Search terms used by review | Databases searched | Setting / Target group | Sample age range and mean age | Sample gender and numbers | Number of studies included in review | Focus of interventions | Primary outcome of interventions | Strategies identified | Results |
|-------------------------|----------------------------|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------------------------------------|-------------------------------|---------------------------|--------------------------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Leung et al., 2012 (19) | from 1980 up to April 2011 | systematic review | sedentary behaviour, sedentary lifestyle, physical inactivity, television, video games, children, adolescents, intervention | MedLine, PubMed, PsycInfo, Cochrane Library | community, school, home, clinic settings | 6 to 19 years of age | not clearly quantifiable | 12 studies | decreasing sedentary behaviour and/or BMI or other anthropometric changes | an anthropometric measure and/or physical activity and/or screen time | workshop/lessons/family meetings focused to reduce screen time or combination of reducing SB and increasing PA; newsletters; plans of alternative activities in place of SB; web-based tailored PA advice; intervention to increase PA focused on influencing intrapersonal, social and environmental determinant of PA and SB | interventions were associated with reduction in sedentary behaviour and/or improvements in anthropometric measurements |

| Author and date | Years of search | Systematic review or meta-analysis | Search terms used by review | Databases searched | Setting / Target group | Sample age range and mean age | Sample gender and numbers | Number of studies included in review | Focus of interventions | Primary outcome of interventions | Strategies identified | Results |
|----------------------------|--------------------------|-------------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------------|---------------------------|--------------------------------------|-----------------------------------------------|----------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| Maniccia et al., 2011 (14) | from 1986 up to Dec 2008 | systematic review and meta-analysis | television, media use, recreational media, screen time, trial, program, intervention, experiment | Centre for review and dissemination, Cochrane Library, CRISP, Dissertation and thesis, MedLine, EBSCO, PubMed, National Academy of Medicine Gray Literature, Papers first and proceeding first, PsycInfo, Science Direct, Scirus, Social Sciences Abstracts, Social Works Abstracts | school, home, other (includes unclear) | 0 to 18 years old | 7455 participants | 29 studies | reducing screen time | screen time (television, video/DVD, computer, videogame) | most included an information provision component or were behavioural interventions; television-control device; goal setting; planning media use; contract in which children agreed to a specific amount of screen time; | -0.144 (CI - 0.217, -0.072) |
| Schmidt et al., 2012 (20) | from 1947 to June 2011 | systematic review | intervention, television, media, screen time | MedLine, PubMed, Academic Search Premier, RePort, ERIC, NHS, EED, Cochrane Database of Systematic Review, Cochrane Register of Controlled Trials | schools, homes, community settings, clinics | children under 12 years of age | not clearly quantifiable | 47 studies | reducing TV viewing or total screen-media use | TV viewing or screen-media use and in some studies BMI | electronic TV time monitors; contingent feedback systems; parenting advice; school-based student information programs; parent and child family counselling | 29 studies achieved significant reductions in TV viewing or screen-media use |

| Author and date | Years of search | Systematic review or meta-analysis | Search terms used by review | Databases searched | Setting / Target group | Sample age range and mean age | Sample gender and numbers | Number of studies included in review | Focus of interventions | Primary outcome of interventions | Strategies identified | Results |
|-------------------------------|--------------------------|-------------------------------------|-------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------------|---------------------------|--------------------------------------|----------------------------------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| Steeves et al., 2012 (21) | from 1985 to 2010 | systematic review | sedentary, screen time, television viewing, television watching, reduce, reduction, limit | PubMed | research centers, school, community, clinic, home | 1 to 12 years of age | 4621 participants | 18 studies | reducing sedentary behaviours | sedentary screen behaviour and /or multiple health behaviours | goal setting, self-monitoring, preplanning, problem solving, social support, positive reinforcement, electronic TV monitoring devices, contingent TV devices | the magnitude of the significant reductions varied from (-0.44 to -3.1 h/day) |
| Van Grieken et al., 2012 (15) | Dec 1989 until July 2010 | meta-analysis | overweight, obesity, intervention, sedentary, television, video, games, children | PubMed, EMBASE, Web of Science, PsycINFO, Cochrane Database of Systematic Reviews | family/home, school, community | 0 to 18 years old | 18142 participants | 34 studies | reducing the level of sedentary behaviour | sedentary behaviour and/or a weight related outcome | goal setting, physical education lessons, workshops, information materials, tokens to reduce TV time, school transportation by bicycle or foot | significant decreases in sedentary behaviour; post intervention mean difference: -17,95 min/day |
| Wahi et al., 2011 (16) | up to April 2011 | systematic review and meta-analysis | television, videogame, computer, overweight, obesity, physical activity | OVID-Medline, EMBASE, Cochrane Central Register of Controlled Trails, PsycInfo, ERIC, EBSCOHost-CINAHL | schools, medical clinics, community centre, community settings | 18 years of age or younger, mean age from 3.9 to 11.7 years | 1008 participants | 13 studies | reduction of screen time (i.e. television, videogames and/or computer use) | change in body mass index (BMI) and screen time | - | -0.90 h/wk (CI -3.4, -1.66 h/wk; p=0.49) |

Table 2. Matrix of strategies used in interventions to reduce sedentary behaviour in young people and behaviour change techniques identified by Michie et al. 2011 (strategies are numbered in same way as by Michie et al.).

| Behaviour change techniques identified by Michie et al. 2011 | | Biddle et al. 2011* | Campbell and Hesketh 2007* | De Mattia et al. 2006 | Kamath et al. 2008 | Leung et al. 2011 | Maniccia et al. 2011 | Schmidt et al. 2012 | Steeves et al. 2012 | Van Grieken et al. 2012 | Wahi et al. 2011* |
|--------------------------------------------------------------|--------------------------------------------------------------------|---------------------|----------------------------|---------------------------|--------------------|-------------------|----------------------|---------------------|---------------------|-------------------------|--------------------|
| Study quality assessed? | | No | No | Yes (validity assessment) | Yes | No | No | No | No | Yes (risk of bias) | Yes (risk of bias) |
| 1 | Provide information on consequences of behaviour in general | | | X | X | | | X | | | |
| 2 | Provide information on consequences of behaviour to the individual | | | X | X | X | X | | | | |
| 5 | Goal setting (behaviour) | | | | X | | X | | X | | |
| 7 | Action planning | | | | | | X | | X | | |
| 10 | Prompt review of behavioural goals | | | | | | | | X | | |
| 12 | Prompt rewards contingent on effort or progress towards behaviour | | | | | | X | | | | |
| 13 | Provide rewards contingent on successful behaviour | | | X | | | X | X | | | |
| 16 | Prompt self-monitoring of behaviour | | | X | | | X | | X | | |
| 17 | Prompt self-monitoring of behavioural outcome | | | X | | | | | | | |
| 19 | Provide feedback on performance | | | | | | X | | | X | |
| 24 | Environmental restructuring | | | | | X | | | | X | |

| Behaviour change techniques identified by Michie et al. 2011 | | Biddle et al. 2011* | Campbell and Hesketh 2007* | De Mattia et al. 2006 | Kamath et al. 2008 | Leung et al. 2011 | Maniccia et al. 2011 | Schmidt et al. 2012 | Steeves et al. 2012 | Van Grieken et al. 2012 | Wahi et al. 2011* |
|---------------------------------------------------------------------|-------------------------------------|----------------------------|-----------------------------------|------------------------------|---------------------------|--------------------------|-----------------------------|----------------------------|----------------------------|--------------------------------|--------------------------|
| 29 | Plan social support / social change | | | | | | | | X | | |
| 37 | Motivational interviewing | | | | | | | X | | | |
| 38 | Time management | | | X | | X | | | | | |

* no intervention strategies discussed in the paper