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Decreasing Sedentary Behaviors in Youth to Prevent and Manage Childhood Obesity: Is It Realistic?

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Abstract

Purpose of Review Decreasing sedentary behaviors has been proposed as one approach to reduce the rate of obesity in youth. This review summarizes the contemporary literature examining the efficacy of these interventions in the school and community along with an additional focus on the role of socioeconomic status in these interventions.

Recent Findings Studies that focus on decreasing sedentary behavior have utilized a wide variety of strategies in a number of settings. The effects of these interventions are often hindered by non-standard outcome measures, study infidelity, and subjective measures of sedentary time. However, interventions that incorporate engaged stakeholders and include younger subjects appear to be the most likely to succeed.

Summary Promising interventions to decrease sedentary behaviors have been shown in recent clinical trials; however, replicating and sustaining these results is challenging. From the available literature, school-based interventions have the potential of reaching the largest group of children. In contrast, interventions in younger children, particularly those with invested parents, seem to be the most effective.

Keywords Sedentary time · Screen time · Obesity · School-based · Youth · Cardiovascular disease prevention

Introduction

Excessive sedentary behavior is currently an epidemic among children and adolescents worldwide [1]. Using accelerometer data from the 2003 to 2004 National Health and Nutrition Examination Survey (NHANES) cohort, adults were sedentary for 6 to 8 h per day, while children and adolescents spent 7 h engaged in sedentary activity [2]. More recent reports show longer daily averages and suggest the problem of sedentary behavior is worsening [3]. Obesity is a known risk factor for premature cardiovascular disease and has been linked to adult sedentary behavior [4, 5]. Strong evidence in adults also links sedentary behaviors with adverse cardiovascular disease outcomes [6–9] and all-cause mortality [10–14]. While evidence for the ill effects of excessive sedentary time is limited in youth [15, 16], it has been associated with obesity, risk factors for cardiovascular disease, decreased cardiorespiratory fitness, worse mental health, and poor academic performance [17–19]. In addition, evidence suggests that excessive sedentary time may be independent of moderate-to-vigorous physical activity [20–22] and that one does not replace the other [23]. Furthermore, sedentary time increases as children get older [17, 24], and it likely tracks into adulthood [25].

In 2020, the World Health Organization (WHO) published guidelines on physical activity and sedentary behaviors, suggesting that "children and adolescents limit the amount of time spent in sedentary behaviors, and especially the amount of recreational screen time" [26]. The WHO graded this recommendation as "Strong" with "low certainty evidence." They cite insufficient evidence to suggest recommendations based on types of sedentary behavior but highlight the importance of some passive activities on education, child development, and cognition. Guidelines from the US Health and Human Services [27], along with recommendations from professional organizations in Canada [28], the UK [29], and Australia [30], have also defined a threshold of no more than 2 h per day of recreational screen time.

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This review aims to summarize the contemporary literature examining the efficacy of interventions to reduce sedentary behaviors and obesity in youth in the school and community along with an additional focus on the impact of socioeconomic status.

Defining Sedentary Time

Historically, sedentary behavior and physical activity have been seen as two sides of a spectrum, but increasingly sedentary behavior has been viewed as a distinct entity. In 2017, definitions (Table 1) were published by the Sedentary Behavior Research Network (SBRN) in response to growing interest in sedentary time and behaviors [31]. The SBRN defines sedentary behavior as "any waking behavior characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting, reclining or lying posture" [31]. This definition has been widely adopted for study in this area and validated in adults [32]. While Saint-Maurice et al. found that METS < 2 was likely a more appropriate threshold for children aged 7–13 years [33], most studies in youth continue to use 1.5 METs as the threshold [34, 35].

Measurement of Sedentary Time

Accurately determining the amount of time an individual spends in sedentary behaviors is challenging and continues to be controversial [5, 16]. Currently, sedentary time can be captured through questionnaires or a device, such as an accelerometer. Self-report, or by proxy, refers to an estimation of sedentary time using questionnaires. Questionnaires such as the US Behavioral Risk Factor Surveillance System Survey use a single question, while the Minnesota Leisure Time PA Questionnaire assesses sedentary time and physical activity using a lengthy interview that assesses physical activity over the past year [36]. In addition to questionnaires, subjects can record the amount and intensity of their physical activity in a diary or log, which allows for more nuanced measurements [36]. Subjective reports of sedentary time have been widely used because of their low cost and accuracy in context-specific situations, such as recreational screen time [37]. However, this method has an inherent bias subject to recall and social desirability biases, which limits its generalizability [38].

Device-based assessment, often using pedometers or accelerometers, is considered a more objective measure of physical activity. These devices convert acceleration into discrete units, referred to as counts, to determine the duration and intensity of activity. These are often designed to be worn on the hip, but devices can also be worn on the wrist or thigh. While this method reduces the previously stated biases of self-reported measurement, a lack of standardized data processing algorithms makes comparing different accelerometers challenging [5, 39, 40].

The decision on whether to capture sedentary time through a qualitative or objective measurement depends on the outcome of interest. Unfortunately, there is a poor correlation between self-reported and device-based measurements. Furthermore, this difference appears to be random. It has been suggested that using a combination of subjective and objective measures of sedentary time may be the most appropriate approach. For instance, while an accelerometer can accurately determine the time spent in sedentary behaviors, it cannot distinguish between the types of behavior. As health outcomes related to sedentary behaviors may be linked to the type of sedentary behavior (e.g., watching television vs. seated in class) [41], capturing this difference would be important to better understand health effects which may be related to sedentary time [42].

Sedentary Behavior Interventions in Schools

Schools are often cited as an ideal location for behavior interventions because of the large amount of time youth spend in school [24, 43, 44•]. Furthermore, students spend over 50% of their time in school seated [44•], either while learning or during social interactions. In addition, interventions potentially can reach more vulnerable populations as most schools are widely available [43, 45].

To reduce sedentary time, seated and standing desks have been a proposed solution. Standing desks are

Table 1 Terms associated with sedentary behavior

Term	Consensus definition
Sedentary behavior	Energy expenditure ≤ 1.5 metabolic equivalents while awake in sitting, reclining, or lying posture
Sedentary time	Amount of time spent in sedentary behavior
Physical activity	Any movement produced by skeletal muscle that requires energy expenditure
Physical inactivity	Insufficient amount of physical activity to meet public health recommendations
Screen time	Quantitative type of sedentary behavior involving screen-based behaviors

(Modified from Tremblay et al. [31])

designed to allow users to stand while working or include an exercise component, such as those equipped with a cycle ergometer [17]. Overall, studies have generally found that standing desks effectively reduce sedentary time, but the effects have been small and inconsistent [17, 45]. While most studies in recent meta-analyses have demonstrated an improvement in a measure of sedentary time, there are conflicting results on whether standing desks increase steps or reduce sitting time [17, 45]. One potential reason is students' differential uptake of standing desks, and there may be a more positive effect if the desk has an active component. In two systematic reviews of cycling desks, the use of these desks reduced sedentary time and increased physical activity [46, 47]. Results of studies outside of the USA have been similar. In Germany, a review of six studies of children and adolescents found varying results, with some studies reporting a reduction and and others an increase in sedentary time. Ultimately, no conclusive evidence supported any significant change in sedentary time.

There are also some potential drawbacks to the use of standing desks. For example, standing for prolonged periods can lead to fatigue and discomfort and may not be suitable for individuals with certain medical conditions [17]. However, in these studies, there were very few complaints. Standing desks were generally well-accepted by staff and students, and there were no reported adverse effects [17, 48]. In addition, there appeared to be no decrease in attentiveness [45, 48].

Additionally, standing desks can be expensive and may not be accessible to all individuals or organizations. While prices vary based on the features of the desk, estimates from the literature suggest that desks cost 20–40% more than traditional desks [17]. These extra costs negate the potential benefit of interventions targeting schools as they may disproportionately decrease sedentary time in higher socioeconomic districts. Furthermore, the cost-effectiveness of standing desks in school needs further investigation.

Including More Opportunities for Physical Activity

Replacing sedentary behaviors with more intense activity is another common approach to school-based interventions. This can be achieved by providing new equipment [49], modifying playground structures (e.g., playground artwork) [50], education on strategies to increase physical activity, or curriculum changes (e.g., scheduled breaks from lessons in which the students are encouraged to move) [24, 51]. For example, Lee, Loprinzi, and Trost [52] found that an intervention that provided opportunities for children to engage in structured physical activities, such as sports teams and dance classes, was effective at increasing physical activity levels in children. A meta-analysis by Neil-Sztramko et al. [53••], however, found the effects to be more mixed. In this review, offering more opportunities for physical activity did not appear to increase the amount of MVPA (mean difference of 0.73 min/day, [95% confidence interval 0.16 to 1.30]), but school-based interventions did decrease the amount of sedentary time, although by very little (mean difference of − 3.78 min/day, [95% confidence interval − 7.80 to 0.24]). Interestingly, despite the relatively small changes in activity, there was an improvement in physical fitness and a reduction in standardized body mass index (BMI) amongst participants.

Overall, there is evidence that school-based interventions have the potential to effectively reduce sedentary time and obesity-promoting behaviors if well-designed and the intervention addresses the specific needs of the target population [24, 43, 44•, 54]. However, the data is not unequivocally positive [51], even when interventions lead to a reduction in BMI [43]. In addition, there is concern that interventions may have a more significant effect on those without obesity than on those with obesity [55].

Non-School-Based (Community) Sedentary Behavioral Interventions

Screen Time

In addition to the time spent during school, youth continue to have a preponderance of sedentary time outside of school. For instance, adolescents were found to spend approximately 60% of their sedentary time viewing screens, mostly outside of time spent at school [56]. Excessive recreational screen time has been demonstrated to be associated with decreased time spent sleeping, increased intake of sugar-sweetened beverages [57–59], and decreased physical activity [58]. Furthermore, an increase in recreational screen time has consistently been associated with obesity in youth [58].

The majority of studies attempting to reduce sedentary time focused on limiting screen time among participants. Strategies included education on the effects of excessive screen time, limiting access to screens, and contingent feedback systems. Typically, the educational material is designed for parents and caregivers and included literature as well as face-to-face counseling. Such studies generally find that counseling by health care providers or members of the research team was most effective.

A second form of intervention is placing time limits on the use of recreational screen devices. This can be achieved with absolute time restrictions, restricting the time in which screens can be viewed (e.g., no screen time during dinner)

[58], or removing devices from bedrooms [58]. Several interventions used contingent feedback mechanisms in which screen time was "earned" by the participants. For instance, subjects could earn screen time by participating in physical activity. Other studies required subjects to be physically active during screen time (e.g., using a stationary cycle or restricting the use of video games to those that have an activity component) [60]. Schimdt et al. [58] found that electronic monitoring devices were the most effective strategy for reducing screen time in youth.

Active Transport Interventions to improve active transport to school include: (1) walking school buses, (2) promoting the use of bicycles to and from school, and (3) educational interventions. Walking school buses are an intervention in which a group of students walks to school accompanied by an adult to help reduce the concern that walking to school is unsafe. Bicycles are another potential intervention that can increase active transport for those who live farther from school as distance has consistently been found to be a significant barrier to active transport to school. However, in one review [61], the authors determined that the evidence was not of sufficient quality to draw conclusions regarding the efficacy of using bicycles to promote active transport. While six of the nine studies reported positive effects on the outcome of interest, determining the characteristics associated with success was not possible. Chillon and colleagues [62] found that the most successful interventions were those that included educational information and strong involvement in the program, similar to other interventions aimed at limiting sedentary time.

When viewed in aggregate, the evidence is generally considered mixed (27). For example, Azevedo et al. [63] found a small, but statistically significant difference (standardized mean difference 0.060, 95% CI: 0.098 to 0.022). Similarly, Wu et al. [64] found that screen-time-based interventions reduced the amount of time interacting with screens by 4.63 h per week and BMI by 0.15 kg/m^2. In the analysis by Downing [65], much smaller reductions in screen time were noted with a standardized mean difference of 17.12 min per day (95% CI − 28.8 to − 5.4). When the outcome was a change in BMI, Wahi et al. [66] did not find a difference in screen time in the intervention groups (mean difference 0.10 kg/m^2, 95% confidence interval − 0.28 to 0.09). Nearly all systematic reviews and meta-analyses acknowledged significant heterogeneity in the methods and results of the studies included [65–67]. Furthermore, previous systematic reviews and meta-analyses have had studies of limited quality, and results have been mixed [16, 66, 67].

Similar to evaluating the evidence for school-based interventions, it also is challenging to reconcile the evidence for community-based interventions targeting sedentary time. The measures of sedentary time varied by analysis and included self-reported measures (e.g., hours of screen time or the total amount of sedentary time) or used objective measurements of sedentary time based on an accelerometer. In addition to the quality of data, there are additional concerns about the sustainability of the interventions used. For instance, stationary bicycles may be unavailable to those with limited resources, and television locking devices may only be effective in the short term. Still, it is promising that several studies did report positive effects of their intervention, albeit small [54].

Special Considerations

The age of the participant is also clearly a significant predictor of success. While the amount of sedentary time tends to increase as the child ages, it is still relatively high in children under 3 years old [24, 56]. Interestingly, interventions targeting sedentary time in younger subjects seem more compelling [16, 60]. For instance, in one meta-analysis [65], the effect of the intervention was slightly more substantial in those less than 3 years old compared to children who were 3–5 years old ($Z = 3.43$, $p = 0.0006$, and $Z = 2.49$, $p = 0.01$, respectively).

It has been suggested that family-based interventions are more effective in these younger age groups because of the greater control over the allocation of the child's time. As children become more independent, parental influence may wane, and interventions, including parents, are thus likely to be effective. Others have suggested that family-based interventions are the single most successful factor determining the effect of an intervention and may be more important than the type of intervention utilized [60, 67]. This is consistent with Family Systems Theory, which suggests that one member's actions are tied into the entire family dynamic and do not act in isolation [60]. Such a finding emphasizes the critical role of parents in the program's success, in part determined by parental buy-in and participation.

Furthermore, family-based interventions appear to be more effective in single-parent households and households with higher baseline television viewing time [60]. This suggests that targeting interventions to the most at-risk groups may be particularly effective. It should be noted that interventions focusing on specific ethnic or racial groups have found that subject buy-in can be improved by understanding the particular group's preferred language, foods, and activities [68].

Interventions to reduce sedentary time in low SES populations may also need to consider potential barriers

to implementation, such as lack of access to resources or limited availability of suitable facilities. For instance, Auhuber et al. [69] reported children with lower SES were less physically active. At the same time, Kim et al. [70•] concluded that living in high-SES neighborhoods was protective against obesity. Results showed that higher-income children in high socioeconomic communities consistently had lower measured BMI z scores and waist circumference and more participation in moderate-to-vigorous physical activity than those in consistently low socioeconomic areas. Opportunities for increased physical activity may be particularly important for more vulnerable populations. Music Milanovic et al. [71] found that children from lower socioeconomic communities were generally less likely to participate in sports clubs and more likely to engage in > 2 h per day of screen time. Conversely, those of lower socioeconomic status had similar rates of active play and were more likely to engage in active commuting [71].

Summary

In summary, there are undoubtedly interventions that show promise in reducing sedentary time and obesity in youth. However, replicating these results and sustaining the effect of the intervention has been particularly challenging. Changing health behaviors requires patience and reinforcement and is often expensive. To be successful, it often requires more than one component, making it hard to decipher which portion of the intervention is most effective. Barriers need to be identified and overcome. From the available literature, school-based interventions would appear to reach the most children. In contrast, interventions that include younger children, particularly those that include invested parents, seem to be the most effective. There is a need for more theory-based interventions, effective and reliable ways of measuring activity, and long-term health outcomes to help guide clinical decision-making with the goal of improving the health and well-being of children.

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Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

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- •• Of major importance

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