

# The Role of Built Environments on Children's Sedentary Behavior: A Social Ecological Perspective

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**Abstract** The purpose of this paper is to examine relevant literature that demonstrates the interactions among built environments and children's sedentary behaviors from a social ecological perspective. An overview of the existing body of knowledge relating to children's sedentary behavior will be shared. A social ecological theoretical framework will be used to investigate how built environments in home, school, and neighborhood settings may impact children's sedentary behaviors. Finally, a synthesis of emerging research and implications for practice along with recommendations will be highlighted to demonstrate how children's sedentary behaviors can be altered by modifying built environments in home, school, and neighborhood settings.

**Keywords:** *sedentary behavior, physical environment, childhood obesity, health promotion*

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## 1. Introduction

Sedentary behavior is rapidly emerging as a critical issue affecting today's youth and it shows no signs of abating. Sedentary lifestyles and behavior patterns have been linked to excess body fat, decreased motor coordination, type 2 diabetes, hypertension, cardiovascular disease, higher body mass index (BMI), overweight, obesity, and other metabolic risk factors [1,2]. As an important indicator of childhood obesity, sedentary behavior (i.e., screen time, watching TV or sitting with  $\leq 1.5$  METS energy expenditures) became a significant public health concern. The US national guideline for physical activity levels, Healthy People 2020 [3] recommend for children no more than two hours/day in sedentary activities. Research data estimates that American children and youth spend over seven hours/day being sedentary [1,2]. Sedentary behavior has been defined in various ways under differing contexts. However, for the purpose of this review, sedentary behavior is defined as engaging in any waking activity that produces very low levels of energy expenditure (i.e.,  $\leq 1.5$  METS) and requires minimal work of the large skeletal muscle groups associated with habitual movement [4]. Such activities may include, but are not limited to, sitting, viewing television, talking on the telephone, playing electronic videogames, using the computer, reading, drawing, and lying down. In addition, movement type (i.e., what are people doing) and energy cost (i.e., how much they are doing it) are equally important features that must both be accounted for when attempting to understand the complex sedentary behavior.

A social ecological model has been identified as one of the most effective approaches to capture the complexity of sedentary behavior among children [5]. In particular, Chastin and colleagues demonstrated the influence of built environments including school, home, and neighborhood settings on children's sedentary behaviors [5]. This literature review, highlights how built environments may influence children's sedentary behavior from a social ecological perspective. Ecological models emphasize the influence of environmental factors and recognize that behavior is most likely shaped by the contexts in which it occurs [5,6,7,8]. With the rapid increase seen in childhood obesity, many health scientists propose childhood obesity is linked with built environments more so than biological factors [7,8,9,10,11]. Recently, Nigg and colleagues [12] reviewed 33 intervention studies supporting the effectiveness of multicomponent environmental interventions to prevent childhood obesity and promote health behaviors among children. Understanding the degree to which environmental factors influence decisions of being sedentary is critical to promoting and designing children's physical activity initiatives.

Given that sedentary behavior is highly prevalent in children, that such behaviors are rapidly increasing and become the major health concerns, it is important to explore the impact of environmental determinants on children's sedentary behavior [12]. Such efforts would likely render beneficial information for future development of theory-based interventions, weight gain prevention strategies, and overall health promotion. Recently, a group of scholars [5] developed the Systems Of Sedentary behaviors (SOS) framework of the potential determinants of sedentary behaviors. It was indicated that the influence of the built neighborhood (65% consensus) and institutional

and home settings (78% consensus) was deemed to be the most important areas of research to focus on preventing sedentary behaviors. A review of the literature regarding potential environmental determinants of sedentary behavior in home, school, and neighborhood settings using a social ecological perspective, with school-age children who are under the age of 18, will be shared. A synthesis of emerging research and implications for practice along with recommendations will be highlighted to decrease school-aged children's engagement in sedentary behavior.

## 2. Method

A systematic search of literature was completed through five electronic databases (Academic Research Complete, ERIC, PsycINFO, SportDiscus, and Web of Science). The literature review started with two rounds of literature searches in 2016 and 2017 utilizing the library resources from a major public research university in the United States. The literature searches were based on the following keywords: *sedentary behavior and its synonyms; environmental determinants of sedentary behavior (e.g., built environment, home, school, and neighborhood environment)*.

Two authors initially conducted the literature search based on the identified key words with assistance of an experienced university librarian. Three authors then independently screened the titles and abstracts of retrieved studies identified by the search. Full-text articles in PDF either directly from the library electronic databases or through the inter-library loan service were retrieved. All three authors reviewed all the selected articles and concurred that they met the inclusion criteria. Then, the researchers proceeded with independent coding and reached on the themes. The following themes were selected: social ecological perspective to understand sedentary behavior, the role of built environment and children's sedentary behavior, and key aspects to successfully modify the environment in school, home and neighborhood settings. We summarize these themes and present the implications of the findings for research and practice.

## 3. Synthesis of the Findings

### 3.1. Social Ecological Approach to Understand Sedentary Behavior

Since research has indicated health behaviors in children develop within an ecological niche, applying an ecological model to empirical data is appropriate [13,14]. Furthermore, the literature has primarily focused on individual-level factors such as age, gender, race, body mass index (BMI), parents' educational attainment, and socioeconomic status (SES) [13,15,16,17]. Research has found that sedentary behavior typically occurs in particular social and physical contexts that are apt to influence children's choice to be sedentary; suggesting the relative influences of these contexts (i.e., environments) in which sedentary behavior takes place should receive increased and continued attention [18,19]. The social

ecological perspective provides a strong theoretical framework to understand the complex interactions of multiple levels of factors within specific contexts that affect school-aged children's decisions to be sedentary.

According to the social ecological model [20], correlates of health-related behaviors can be categorized as one of the following: (a) intrapersonal factors, such as personality disposition, knowledge, and values; (b) cultural factors, such as acculturation; (c) environmental factors, such as home, school, and neighborhood accessibility and amenities; and (d) public policy, which includes laws and guidelines at the local, state, and national levels [7,21,22]. Although intrapersonal, cultural, and public policy factors most likely influence sedentary behavior, they will not be further explored in this review. It is encouraged that separate reviews are conducted to examine the effects of the remaining factors on sedentary behavior among children. The social ecological perspective accounts for multilevels of influences on health-related behaviors and may prove promising in explaining school-aged children's motivations and decisions to participate in sedentary behavior.

In order to introduce and cultivate an active lifestyle in children, active-friendly environments must span across the home, neighborhood, and school settings (i.e., multiple ecological levels) [12]. Ideally, this should grant children ample opportunities throughout their days to choose healthy behaviors across various settings. In reducing children's sedentary activities and the aversive health consequences associated with a sedentary lifestyle, it is important to target environments where sedentary activities are most prevalent.

### 3.2. Built Environmental Factors

Built environmental factors are unique to physical locations, cultures, and socioeconomic levels. According to the social ecological model, "environment" is operationally defined as objective factors that are physically external, or outside of an individual [23,24,25]. Sallis and Glanz [25] defined built environment as consisting of "neighborhoods, roads, buildings, food sources, and recreational facilities in which people live, work, are educated, eat, and play" (p. 90). Populations are subjected to the built environment around them. This is especially important when built environmental factors associated with specific populations become promoters of a sedentary lifestyles and/or barriers to physical activity [7,26]. However, Sallis and Glanz [25] argue people have a hand in shaping and creating their environment. They claim a reciprocal and mutual relationships exist between people's behavioral patterns and their environment. Whether people walk to school, work, parks, or recreation facilities are determined, in part, by how neighborhoods and cities are planned and built.

The modern-day westernized culture has seen shifts in environmental "amenities" and features. Examples include, but are not limited to, high quantities of easily accessible fast-food outlets, lower overall cost for foods high in saturated fat and calories, expanding meal portion sizes, rapid technological advancements, increased time spent engaged in media use, and favor inactive travel (e.g., motorized vehicle) as a means of transportation

[13,25,27,28,29]. Consequently, these advancements in the environment may increase daily opportunities for energy consumption while reducing opportunities for energy expenditure based primarily on convenience or accessibility of alternative choices [7,13]. This in part may also explain increased rates of overweight and obesity and increased time spent in being sedentary activities among children. The impact that built environmental factors have on children's decisions to participate in sedentary activities are explored further below.

**Dietary Patterns and Nutrition Choices.** With childhood obesity rates on the rise over recent decades, examining children's food choice and intake patterns has been of particular research interest. Pearson and Biddle [16] synthesized 19 eligible studies examining associations between sedentary behavior and dietary outcomes in children. Three of four studies found television viewing to be inversely associated with fruit and vegetable consumption. Eleven of fifteen studies found that a positive association was reported between television viewing and consumption of energy-dense foods, while the remaining four studies found no association. Finally, three of five longitudinal studies found a positive association between television viewing and total energy intake and consumption of energy-dense fast foods, snacks, and high-caloric drinks. In summary, there was evidence to claim sedentary behavior in children is associated with a less healthy dietary intake and aligns with past research [28].

Approximately one-fourth of a child's weekday is spent at school and most eat at least one meal and snack during that timeframe. School becomes an important nutritional environment for children in addition to home. The modern-day school cafeteria provides children with both healthy and unhealthy food options [30]. Because unhealthy food options are lower in cost and often preferred, it can be assumed not all children are consistently consuming balanced meals at school. Other notable findings include higher frequency of eating fast foods and snacks, skipping breakfast, and engaging in more than one hour of sedentary activities per day were independently associated with excess body weight and higher BMI [31]. Nigg and colleagues [12] reviewed 33 environmental interventions targeted towards childhood obesity prevention and health behaviors in home, school, and community settings. Four out of 33 studies illustrated school healthy eating programs have significant positive effect on children's sedentary behavior.

While there is sufficient and compelling evidence for the association between television viewing/screen time and a less healthy diet among children [16], there are also data claiming no association exists, or at best, the association is small and statistically insignificant. For example, in a review conducted by Rey-Lopez and colleagues [28], they found a positive association between television viewing and risk of obesity in 61.9% and 66.66% of eligible longitudinal studies in boys and girls, respectively. However, results of the review showed a small association or no association when assessing videogame and computer time and risk of obesity.

**Technology Usage and Dependence.** Today's children are constantly exposed to technology within their home, school, and neighborhood environments. Technology has dramatically affected how they plan and spend their

educational and leisure time. For example, approximately half (47%) of all children in the United States currently spend more than two hours per day engaging in screen-based sedentary behavior [32]. As noted above, television viewing was found to be positively associated with obesity and the researchers contended it may have displaced physical activity in the lives of children [12]. The insurgence of electronic media has paralleled the increase in childhood obesity and may be a contributing factor to the rise in sedentary behavior within children [33].

The Henry J. Kaiser foundation conducted a nationwide survey in 2010 examining the specifics of media use among children. They found the average children in 2009 spent a combined total of ten hours and 45 minutes/day engaged in media use, which is up from seven hours and 29 minutes/day in 1999. Furthermore, on average, 11- to 14-year-olds, African Americans and Hispanics, and boys logged more total media time than their counterparts. The study accounted for children's exposure to the following: television content, music/audio, computer, videogames, print material, and movies. It should also be noted that not all media usage time ought to be considered unbeneficial to children. For example, completing schoolwork activities by way of computer software or reading textbook chapters can lead to increases in knowledge and academic performance. For the purposes of this study there are limitations to how we can interpret the information gleaned from the Kaiser Foundation study. However, their main findings are beneficial for better understanding current behavioral trends among children today. Their documentation of continual and progressive increases (across a recent decade) in children's total time spent engaging in media may in part explain why children's sedentary behavior time has also increased over recent years.

Maitland and colleagues [6] cited that three out of 38 studies investigated the association between media equipment and objectively measured sedentary behavior. The influence of media equipment in home was inconsistent and no significant association was reported with sedentary behaviors among children. Compared to television viewing, other sedentary activities (e.g., videogames, computer use) do not appear to present such a high risk for obesity [28]. Videogames may not pose significant risks to children because they are generally associated with a higher energy expenditure than television viewing, especially if the game is of the interactive type [28]. Researchers suggested variation may exist if videogame playing replaced physical activity [33]. These findings may prove important when exploring options to cut and alter sedentary time. Lanningham-Foster and colleagues [34] suggested turning sedentary screen-time into active screen-time (e.g., interactive videogames, walk while watching television) as a means to creatively increasing energy expenditure in children.

Sedentary behavior, such as media and screen time, appears to affect dietary habits as well as fail to promote physical activity, both being important factors in weight management and total energy balance. The American Academy of Pediatrics (AAP) [35] recommends limiting children's total sedentary time, which includes screen-based activities to no more than two hours per day. However, the relationship between one sedentary activity (such as television viewing) and a child's weight status is

independent of the displacement of physical activity, thus television viewing is just one factor among a number of sedentary activity that contribute to weight status [6]. Future interventions must address these particular sedentary activities in order to institute positive change in children's health behaviors.

**Built Environment Design and Inactive Travel.** It has been argued that our health is affected by the places we live, the foods we consume, and the ways in which we travel around [30]. Active travel, or active transport, is defined as traveling by foot (e.g., walking, jogging), bicycle, or any other non-motorized vehicle (e.g., skateboarding, push scooter) [36]. Communities who intentionally design and develop the landscape for active travel grant their citizens additional opportunities to participate in physical activity. Unfortunately, active travel among children has seen a decline over recent decades [37]. Many modern communities have moved away from compact development and instead incorporate "sprawl" designs where homes are further out from other destinations such as, work, shopping, entertainment, worship, and parks [37]. This factor, among others, makes driving the safest, most convenient, and dependable way to get around such communities [38]. Evidence is growing demonstrating built environmental factors significantly influence children's active lifestyle choices [6,12,39].

Given that children spend at least six to seven hours/day at school, school becomes an important avenue for promoting physical activity and eliminating sedentary behavior. Morton and colleagues [39] indicated that the school-based environment (i.e., playground designs, recess time and equipment) was associated with adolescents' physical activity, but limited research has explored its association with sedentary behavior. For children, commuting to school is often times an overlooked opportunity for physical activity. Past research has established that walking or bicycling to school is associated with an increase in children's total physical activity [40,41]. It has been shown that children who live in pedestrian-friendly or highly-walkable neighborhoods are more likely to actively travel to school [7]. Walking and bicycling to school generally require considerable daily energy expenditure in children, which varies depending on total distance traveled. Therefore, children who do not participate in active travel are missing out on significant health benefits that come with additional physical activity. In 2001, the National Household Travel Survey reported active travel to school has decreased from 48% three decades ago to approximately less than 16% today [40,41]. Furthermore, a two to three pound per year positive energy balance (i.e., weight gain) was associated with inactive (i.e., motorized and sedentary) travel to school [40].

Parents indicate their children do not participate in active transportation to school because of one or more of the following reasons: (a) distance covered (i.e., too far for child to walk); (b) insufficient design (e.g., lack of sidewalks, minimal traffic signs); and/or (c) safety (i.e., traffic and personal) [7,9,26]. This is quite paradoxical in that as parents cite traffic hazards as a reason to drive their child(ren) to school, and by driving their child(ren) to school, they increase traffic volume near schools and the risk of accidents to children who elect to walk or bicycle to school [37]. Risk of traffic incidences should decline if

fewer parents elected to drive their children to school. Between societal and environmental demands, car-dependency appears to be on a continual increase with little evidence of the trend slowing [37]. However, when efforts are directed toward making neighborhoods and communities safer, more accessible, and conducive to walkers and bicyclers alike, then in theory, the rate of car-dependency should decrease while the number of children who actively traveling to school should increase.

A key environmental factor receiving research attention and thought to be associated with children's increased risk for obesity is neighborhood safety [7,9,26,39]. According to Lawman and Wilson [9], unsafe neighborhoods are thought to increase the risk of childhood obesity by limiting physical play outdoors and in turn, increasing time spent indoors and engaged in activities such as television viewing, videogame, and computer usage. What's more, perception may be an important construct when determining neighborhood safety [26]. It was reported that personal safety was the most common reason parents gave for regularly driving their children to school [37]. Timperio and colleagues [42] found children's walking or bicycling to school to be associated with parental perceptions of the environment and those parental perceptions of safe travel conditions were negatively associated with ten- to 12-year-olds active travel to nearby locations. Improving travel conditions and features of the local community (e.g., adding sidewalks, crosswalks, traffic lights, curbs, street lighting) may be an important strategy for instilling positive parental perceptions of the environment their children engage in and as a result, increase active travel among children.

Briefly stated above, it has been hypothesized that non-supportive neighborhoods and surrounding built environments may deter outdoor activities, leading to increased time spent indoors and thus greater opportunity to engage in sedentary behavior. Research has found the greater the land area dedicated for public open spaces, the more parents were satisfied with their local parks, and families living in a cul-de-sac were associated with higher reported levels of children's physical activity [7,29]. Community design adversely impacts health behaviors and contributes to negative health outcomes (i.e., obesity and other chronic disease) when they lack development patterns, adequate street connectivity, and destinations within appropriate and safe walking distances [9,39]. Other neighborhood features that appear to promote physical activity include walker- and bicyclist-communities, presence of sidewalks, lower population density, safe intersections, mixed land use (i.e., mix of residential, retail, commercial, and recreation destinations), nearby and accessible destinations, public transit, and appealing green space [7,26,30].

## 4. Summary and Discussion

A variety of factors influence children's health-related decisions. As a consequence, health-related decisions form behavioral patterns over time. Children are at risk for becoming overweight and obese if their patterned behaviors tend toward diets high in fat and total fat intake, insufficient levels of physical activity, and high levels of

sedentary behavior [12]. From this review, it is apparent environmental factors play an important role in determining children's daily health-related decisions such as sedentary behavior.

Associations between built environments and sedentary behavior have been researched; yet, this line of research is still in its infancy [6,7]. An increasing number of school-aged children are adopting sedentary lifestyles, and this may be partially due to the built environments that inhibit physical activity. Increasing our understanding of environmental influences on sedentary living, particularly at different ecological levels (e.g., neighborhood, home, and school settings) is needed in health related research. Currently, within the health promotion field there is a push for improving built environments to be more conducive to physical activity as well as increase accessibility to healthy food options [25,30]. In return, this effort should help researchers develop physical activity interventions that include and strengthen the existing environmental structure to increase physical activity and decrease sedentary behavior.

The social ecological perspective suggests that social, physical, and cultural environmental factors play a key role in increasing health-related behaviors and reducing sedentary behavior. Various reports suggest that the social ecological perspective may be appropriate for addressing childhood obesity and low levels of physical activity among children, and appears applicable for sedentary behavior [3,29,43,44,45,46]. The impact of physical environmental factors on sedentary behavior as well as physical activity has received increased attentions in recent years from researchers, practitioners, as well as health policy makers, and will remain a critical topic in future years if school-aged children's rates of obesity and overall sedentary time continue to rise.

#### 4.1. Implications for Practice

Leading up to the present day, researchers and practitioners have advocated for establishing evidence-based models and interventions to bridge the gap between literature and practical applications. It is well-documented that physical activity interventions designed for children are more likely to be effective when parents and families are included [47]. In addition, interventions that promote simultaneous weight loss in home and school environment have proven more successful in the long-term than interventions that solely focused on a single level [12]. The majority of interventions were school-based and involved only health education or knowledge. This suggests there is a gap in the literature with regards to efficacy of interventions across settings (e.g., home, neighborhood, and community), target subgroups (e.g., children versus adolescents), and techniques (e.g., reward system, after school programs, and rules enforcement). Thus far, previous interventions that promote physical activity in children are generally ineffective. With this in mind, future interventions should evolve toward a multifaceted design that accounts for the various factors that affect children's health behaviors. Furthermore, future intervention programs must be designed with the premise of promoting physical activity in conjunction with reducing sedentary activity [12,48].

Davison and Birch [43] called for the development of frameworks to identify the factors associated with children's physical and dietary lifestyles, parenting practices that determine children's physical activity and dietary lifestyles, as well as parenting environments. Van Sluijs and colleagues [49] conducted a review, which revealed education only interventions have yielded no overall effect on increasing physical activity in children. The review also concluded that among children (i.e., < 12 years), home-, school-, and community-based physical activity interventions resulted in either unsuccessful or inconclusive effects. On the other hand, adolescents (i.e., ≥12 years) reported a significant effect of school-based physical activity interventions with family or community involvement, and inconclusive effects of home- and community-based physical activity interventions. In response, Owen and colleagues [50] recommend designing interventions, which aim at reducing or breaking-up sedentary time as opposed to focusing solely on physical activity. More recently, Epstein, Roemmich, Cavanaugh, and Paluch [51] offered two potential ways in which reducing sedentary behaviors can result in a residual negative energy balance (i.e., weight loss): (1) reductions in energy intake; and (2) substitution of sedentary behavior with physical activity. In addition, Maitland and colleagues [6] found that introducing time-limiting based screen-based devices to a child's physical environment decreased gross television viewing.

**Reductions in Energy Intake during Sedentary Activities.** It has been established that sedentary behaviors are positively associated with consumption of energy-dense foods and therefore practitioners must determine how to counteract the negative outcomes of this relationship. Pearson and Biddle [16] summarized it well by saying, "diet and sedentary behavior in young people is coupled and may better explain associations between sedentary behavior and weight status than other behaviors" (p. 185). The positive relationship between sedentary behaviors, especially television viewing, and dietary intake indicates the more time children spends participating in sedentary activities the higher their total energy intake will be per day. Suggesting, sedentary behavior frequency moderates the relationship between diet and obesity risk, which is often considered the result of mindless eating or grazing [52]. Thus, it is important for practitioners to educate children and their caregivers alike on the dangers and aversive outcomes of diets high in saturated fat and calories that are associated with sedentary lifestyles. In turn, health professionals and educators should consider current research findings and consider the nutritional environment children are exposed to at home, neighborhood, and school (See Table 1). On the other hand, studies have also indicated that while significant positive relations between screen time, sedentary behavior, and obesity existed they were also independent of dietary intake [53]. Suggesting, that these relationships are not yet fully understood and other covariates likely exist. Investigating these suggestions and implementing findings should lead children, and their families, toward more healthy and holistic lifestyles. In order for children to avoid excessive caloric intake, children's exposure to unhealthy food options and sedentary behaviors should be limited.

**Table 1. Recommendations for Creating Healthy Nutritional Environments for Children in Home, Neighborhood, and School**

Recommendation	Setting			Source
	H	N	S	
Allocate and prioritize time to prepare healthy meals and snacks	◆			Davison 2001; Loth 2016 [43,59]
Regularly prepare and serve breakfast	◆		◆	Mushtaq 2011 [31]
Limit consumption of foods and drinks high in added sugar	◆		◆	Welsh 2011; Pearson 2011 [16,60]
Incorporate joint media use to monitor screen-time activities (e.g., family collectively views television sitcom or plays videogame for predetermined amount of time)	◆			Tandon 2012; LeBlanc 2015 [13,61]
Remove television from child's bedroom	◆			Tandon 2012 [13]
Organize and plant a neighborhood garden for greater fruit and vegetable consumption	◆	◆		Rahman 2011 [30]
Reduce dietary portion sizes	◆	◆	◆	Zlatevska 2014 [62]
Provide transportation to healthy markets for low-income families			◆	Sallis 2006; Hirvonen 2017 [25,63]
Physicians and other healthcare providers should promote positive lifestyle modifications and inquire about patients' dietary and physical activity patterns			◆	Raj 2010 [64]
Add or improve nutritional classes within schools			◆	Raj 2010 [64]
Advocate for national, regional, state, city, and local public policies that promote healthy eating and active lifestyles		◆	◆	Al-Hazzaa 2011; Hayes 2017 [48,65]
Encourage schools offer nutritious and balanced meals			◆	Rahman 2011; Hayes 2017 [30,65]
Patron local markets that offer healthy, affordable food			◆	Rahman 2011 [30]
Conduct health fairs which offer free or discounted educational material, access to health-screens, and other vital resources		◆	◆	Rahman 2011 [30]
Fund programs aimed to teach public how to interpret food labels and menus			◆	Katz 2011 [66]

Note. H = Home; N = Neighborhood/Community; S = School

**Table 2. Recommendations for Creating Active-friendly Built Environments for Children in Home, Neighborhood, and School**

Recommendation	Setting			Source
	H	N	S	
Limit, avoid or remove media equipment (i.e., TV and video game consoles) in children's bedroom	◆			Hoyos Cillero 2010; Maitland 2013 [6,67]
Get more physical activity equipment for children to access at home (e.g., balls, bats, basketball rings, bikes, scooters), especially for lower income families	◆			Salmon 2013; Tandon 2012; Tandon 2014; Viitasalo 2016 [8,13,68,69]
Parents make rules to limit children's time on electronic equipment (i.e., handheld video games, cell phones and music devices)	◆			Dumuid 2016; Veldhuis 2014 [70,71]
Parent be familiar with neighborhood facilities and equipment, know good place to play	◆	◆		Salmon 2013 [68]
Providing portable and fixed play equipment at schoolyard and home	◆		◆	Tandon 2014; Van Kann 2016 [8,72]
Encourage to build up a cul-de-sac neighborhood			◆	Laxer 2013; Veitch 2011 [29,73]
Increase the density of public open space and wisely locate the public open space with easier access for families			◆	Veitch 2011 [29]
Increase the safety levels of the neighborhood and create safer routes to school (e.g., less traffic, less crime, less abandoned buildings)			◆	Laxer 2013 [73]
Build up less car-oriented and more pedestrian friendly grid-pattern neighborhood (i.e., high density and diverse destination with combined commercial, residential, and institutional establishments)			◆	Carson 2012; Giles-Corti 2009 [36,74]
Increase the density of youth-related types of destinations and bus stop to raise the walkability			◆	Christian 2017; Katapally 2016; Rahman 2011 [30,75,76]
Providing playground markings to increase the variety and utility of playground			◆	Christian 2017 [75]
Increase the road safety around the neighborhood and school (i.e., install sidewalks, streetlights, and curbs)		◆	◆	Van Kann 2016 [72]
Establish effective programs such as Safe Routes to School (SR2S) to walker- and bicyclist-friendly communities		◆	◆	Rahman 2011; Stierlin 2015 [7,30]
Improve aesthetics (e.g., plant trees and flowers, remove trash, paint over graffiti art)		◆	◆	Boarnet 2005; Van Kann 2016 [40,72]
Creating safer parking and bicycle racks around school zones			◆	Audrey 2015; Giles-Corti 2009 [36,77]
Upgrade and redesign the playgrounds in school to increase its functions			◆	Van Kann 2016 [72]
Lengthen physical activity recess and lunch break time into daily schedule			◆	Van Kann 2016 [72]
Schools provide equipment to children and reduce restriction on bringing sport equipment to school			◆	Morgan 2016 [78]
Decrease the playground density by splitting up the recesses of different groups of children			◆	Veitch 2011 [29]
Decrease the number of children sharing the playground in school			◆	Stierlin 2015 [7]
Replace motor vehicle use with active travel by increasing park and playground renovations, road traffic safety, and multi-component community-based initiatives	◆	◆	◆	Stierlin 2015 [7]
			◆	Whitt-Glover 2009 [79]

Note. H = Home; N = Neighborhood/Community; S = School

**Substituting Sedentary Behavior for Physical Activity.** While there is no consensus among researchers, at a minimum sedentary behavior has the potential to displace physical activities. However, as previously noted, we must be careful as to not simply categorize sedentary behavior as the inverse of active behavior [13,43]. Interventions should focus on increasing children's decisions to replace sedentary behavior with healthy amounts of physical activity. The health benefits from regular physical activity have been well established in the literature and include reduced body fat, protection against coronary heart disease (CHD), prevention or management of high blood pressure, prevention of type 2 diabetes, osteoporosis, and certain cancers [46]. However, it is also well established that most children do not meet sufficient levels of daily physical activity in order to gain healthy benefits [46]. Given that the built environment has the potential to influence daily sedentary behavior or physical activity of entire populations over long periods of time, it is important for community planners to design environments that promote regular participation in physical activity. An active-friendly built environment considers the size, location, safety, and potential barriers to physical activity participation of that space. What follows is a brief list of suggested improvements, modifications, and ideas needed to create an active-friendly built environment for children (See Table 2).

**Modifying Home Environment.** Children spend vast amounts of time at home, which typically makes it their prime setting for experiencing barriers to physical activity and healthy eating. Parents must be active participants in creating a new environment that equally promotes healthy eating and restricts sedentariness for their children. This may require actions such as enforcing daily television allowance, replacing fat-dense snacks with fruits and vegetables, or planning physically active family outings. Families would also benefit from valuable resources and tools on how to make healthful decisions in daily routines such as grocery shopping, planning, preparing, and executing meals and snacks.

Parents' modeling a lifestyle that includes sufficient amounts of physical activity has proved successful in predicting children's activity level throughout childhood [54,55]. On average, children who perceive their parents to be active report higher levels of physical activity than children with perceived inactive parents. Parents have the most influential opportunity to create and set an environment that supports physical activity and healthy eating, and reduces the sedentary behavior. Children are perceptive and could be positively or negatively influenced by their parents' dietary and activity behaviors. In addition, parents have the opportunity to promote outside activities by actively engaging, providing encouragement, or being present in and during neighborhood recreational activities (i.e., playground) [56].

**Modifying Neighborhood Environment.** If the neighborhood setting is deemed most conducive to sedentary behavior and unhealthy eating, then the community and its families must collaborate to provide children with a more active-friendly environment [30]. It is imperative that modifications to the neighborhood consider factors such as safety, equal access, and space for all participants. These changes may entail adding

sidewalks, streetlights, and curbs, or significant projects such as constructing new city parks or renovating neighborhood pools. Overlooking the neighborhood's role in a child's physical activity status would be a mistake. Understanding community features such as accessibility and safety to physical activity is important to enhance children's physical activity. Contacting local governmental entities and policymakers regarding the physical activity environment of your community may be an opportunity to promote children's health [42, 45].

**Modifying School Environment.** School is a place where learning takes place and is celebrated. However, schools may not be doing their part in educating children on the benefits of an active and healthy lifestyle. According to American College of Sports Medicine [57], only three states (i.e., Alabama, Florida, and Louisiana) require children to participate in the recommended 150 minutes of physical education per week. It is unfortunate that the majority of children are not given the opportunity to meet their physical activity needs during school hours. Physical activity and health-based curriculums appear to be diminishing from school systems [46]. Schools could become a part of the solution to the childhood obesity epidemic, but not without the allotment of daily physical activity, recess, and updated health-based curriculum. Within the classroom, teachers could keep children from long stints of sitting by incorporating bouts of physical activities into their daily lessons.

The social ecological perspective states that each behavior setting has environmental characteristics that are relevant to specific types or purposes of activity. Specific elements of built environments may be conducive to promoting sedentary behaviors or physical activity. In accordance with Epstein and colleagues' recommendations [51], to reduce total daily energy intake children must first limit or altogether eliminate sedentary behaviors such as television viewing and all-around screen time usage, as it is associated with a less healthy diet. Secondly, children must choose to replace sedentary behaviors with healthy amounts of physical activity. For optimal healthy development, children must have access to nutritious foods and physical activity.

It has been purported that efforts to change the built environment would prove more successful than efforts sought to educate the public on how to respond to an unhealthy environment [25,58]. More recently, researchers have agreed that effective interventions targeting school-aged children's physical activity and sedentary levels must be comprehensive and include the following: (1) educate and promote physical activity; (2) target overseers of healthful behaviors (i.e., parents, teachers, policymakers); and (3) provide opportunities to be active within the settings regularly frequented by children (i.e., home, neighborhood, school)[36,47,49]. It is highly beneficial for children to receive adequate support and encouragement regarding their health decisions and behaviors from key figures such as parents, caregivers, educators, coaches, community leaders, and the like. If achieved, children may perceive a high sense of social support and self-efficacy, which may promote satisfaction and participation in physical activity and reduce sedentary behavior. Overall, sedentary behavior research is still in its infancy and can benefit from additional research.

## 4.2. Directions for Future Research

There is growing interest in the social ecological perspective, as a more productive framework, to influence the environment on sedentary behavior in children. Providing a supportive built environment may eliminate excessive sedentary behavior in children. Often, built environmental variables are behavior-specific, especially a model that emphasizes the interdependence of environmental conditions within particular settings (e.g., home, neighborhood, school) and the interconnection between those settings. However, little research has investigated specific features of the home (e.g., parenting style, number of household televisions), neighborhood (e.g., road connectivity, perceived neighborhood safety), and school environments (e.g., playground equipment, recess, and physical education) that may affect school-aged children's sedentary behavior. Therefore, future research should examine the degree of influence built environmental factors in home, neighborhood, and school settings have on children's sedentary behavior.

In addition, defining the differentiation between television viewing and general screen time is an important direction for future research as it pertains to assessing sedentary behavior. Further, more research is needed to determine if significant differences exist between environments (e.g., home, neighborhood, and school) and their interdependent level of influence on sedentary behavior in children. In addition, it is unclear whether these specific environments have a greater or lesser influence on sedentary behavior depending on the ethnicity and/or gender of the individual. In summary, to improve our understanding of environmental determinants of children's sedentary behavior, more research grounded in social ecological theory is necessary and would provide important insights for future intervention and application.

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