Abstract

The health benefits of children engaging in at least 60 min of moderate-to-vigorous physical activity (MVPA) daily are well documented, including improved musculoskeletal health, cardiovascular risk profiles, and aerobic fitness and better psychological well-being. Many Western countries have indicated a decline in physical activity over recent decades.

Emerging research shows that children who engage in outdoor activities and travel to destinations using active modes (i.e., walking, cycling) accumulate higher levels of physical activity than those that do not. Over recent decades, research interest has focused on children's independent outdoor play and active travel to destinations within their neighborhood, including journeys to and from school without adult accompaniment.

Engaging in independent mobility has two important benefits for children. Firstly, engaging in non-formalized activity practices helps children attain daily physical activity recommendations, which in turn, generates significant health benefits. Secondly, independent mobility has an important role in fostering children's physical, social, emotional, cognitive, and spatial development; this carries into adult life.

A growing body of evidence suggests that the use of public open spaces, including parks and green spaces, is associated with many health and well-being benefits of urban dwellers. Public open spaces are also recognized as important settings to promote physical activity and children's independent mobility, not only because of purpose-built infrastructure (e.g., playgrounds) but also as easily accessible destinations for unstructured activities such as walking, cycling, and informal outdoor play.

This chapter first provides an overview of children's independent mobility and thereafter synthesizes the literature related to public open spaces within the context of children's activity and independent mobility.

Keywords

Children's independent mobility • Public open space • Neighborhoods

1 Introduction

1.1 Definition of Independent Mobility

The term independent mobility was conceptualized by Hillman and colleagues in the early 1990s, as the freedom to move around to destinations outside the home by active travel (e.g., walking and cycling) and engaging in outdoor play without an accompanying adult (Hillman et al. 1990; O'Brien et al. 2000). van Vliet (1983) described these destinations as the "fourth environment," being the setting outside the home, including playgrounds, and child-orientated institutions. Broadly, the investigation of children's independent mobility has fallen into three categories:

studies of parental license for children's independent mobility, accompaniment status, and "true" independent mobility. Parental license is conceptualized as parents allowing children the freedom to do certain activities without the presence of an adult. Hillman et al. (1990) study devised a set of behavioral indicators related to risks to children in the local environment. They examined the licenses and parental proxy reports for what children were allowed to do "on their own" including crossing roads, going to leisure places, coming home from school, and going out after dark and also what forms of transport they were approved to use independently by parents (i.e., walking, cycling, cycling on roads, buses). Hillman refined this to using "six licenses" as the basis for establishing the level of children's independent mobility afforded, as described above. The higher the number of parental licenses a child held, the higher the levels of children's independent mobility. Generally, children's independent mobility increased as children aged.

Accompaniment status has been defined as a child travels, be it with a parent, adult, sibling, peer, or alone, with "true" independent mobility considered as situations where the child travels without any accompaniment (Hillman et al. 1990; O'Brien et al. 2000). Although these definitions exist, Mikkelsen and Christensen (2009) suggested a more theoretical perspective is needed to define children's independent mobility. They identified that children navigating environments "on their own" and "alone" described the behavior, but the concept in itself was not defined. Their findings suggested that the concept of children's independent mobility should not be focused solely on the presence or absence of adults but should be broadened to include "invisible actors," such as peers, friends, pets, and animals. In particular, they found Danish suburban children entertained companionship with other children to and from school, and around their neighborhood, while mobility of rural children principally involved the family, pets, and animals. More recently, the use of telecommunication technology such as mobile phones has allowed parents to monitor their independently mobile children and is thus an additional factor to consider when defining children's independent mobility (Mikkelsen and Christensen 2009).

The terms "independent" and "mobile" have been interpreted in a variety of ways in health research to describe how these relate in childhood. Mikkelsen and Christensen (2009) argued that "independent" implies freedom of control/not dependent (on people or things). However this definition is unclear if it intends to focus on a power struggle between child and parent, dependence, or physical distance between parent and child at any given time. For example, a child attending an adult-controlled afterschool club, yet engaging in outdoor play with no direct adult supervision during this time, is considered to be independently mobile based on this construct. Pooley et al. (2005a) discussed how the word "mobility" can be characterized into three levels. Level one encompassed practical functions including those undertaken on a temporary basis such as journeys to school, shopping, and visiting friends. Level two included everyday mobility as a social function including interaction – allowing development of social networks, friendships, and local

communities. Level three incorporated mobility as a cultural function to construct personal identity.

It is important to note that children's independent mobility is fundamentally a social construct; therefore its definition will need to reflect on-going societal changes. As shown from this literature, it is evident no precise definition of children's independent mobility exists, leaving it open to interpretations. In the interest of focusing on the diversity of mobility patterns, a combination of "true independent mobility and accompaniment by siblings and peers and active travel behavior" will form the definition of children's independent mobility in this chapter. This chapter uses a blend of these concepts whereby children's independent mobility is defined as whether a child undertakes active travel that is unaccompanied by an adult to school or other destinations during leisure time in the neighborhood environment.

1.2 Trends in Children's Independent Mobility

Globally, children's independent mobility engagement has seen a radical decline over time (Hillman et al. 1990; Shaw et al. 2013). The seminal report by Hillman et al. (1990), "One False Move," investigated children's independent mobility in England and Germany in 1971 and 1990. The survey areas in these two countries were deemed geographically and socially compatible in a number of ways including residential density, range of urban and rural environments, and car ownership. The study was revisited 39 years on in the same areas in the two countries in 2010 (Shaw et al. 2013). As mentioned earlier, Hillman's work was based on six parental licenses which were given to children aged between 7 and 15 years (juniors aged 7–11 years; seniors aged 11–15). In 1971, 86 % of parents of English primary children reported their children were allowed to travel home from school alone; however, this had declined to 35 % by 1990. By 2010, the proportion of children allowed to independently travel home from school had reduced to 25 %. On closer examination by age, this reduction was due to a decrease in parental license given to 7–8-year-olds to travel from home to school alone. In 1971, 80 % of parents allowed children to travel alone to school, but by 1990 this had declined to 19 %. In 2010 the proportion was only 6 %. In the 1971 report, German children reported greater freedom than their English counterparts across all six licenses for independent travel.

O'Brien et al. (2000) replicated Hillman's work in the Childhood, Urban Space and Citizenship project with English primary (10–11 years of age) and secondary (13–14 years of age) school children in the late 1990s. Compared with Hillman's findings in the 1990 report, this study also revealed a decrease in children's independent mobility. There are limitations when interpreting the results of these three studies. The measurement of children's independent mobility was limited to parent report of licenses to travel to school unaccompanied, and mobility to other destinations was not considered. The use of parental license was also a subjective,

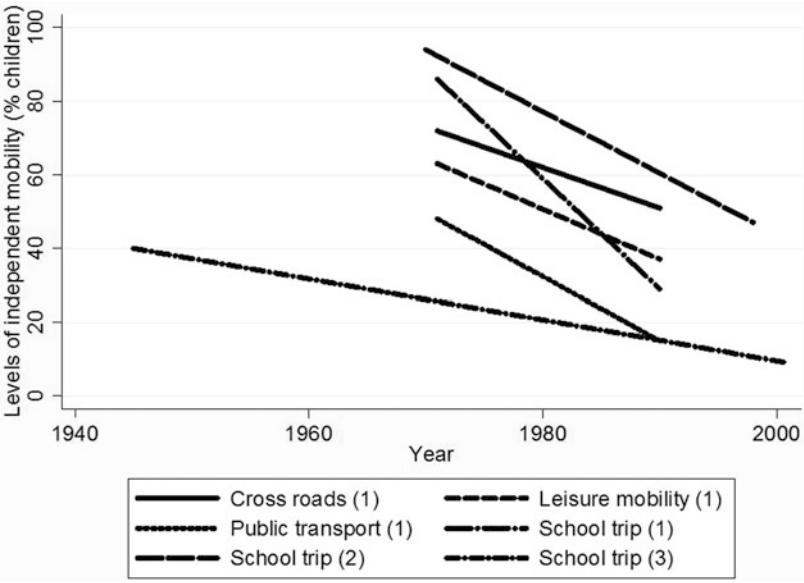

Fig. 1 Prevalence of independent mobility in children (% children over years 1940–2000). Notes: Cross roads = allowed to cross roads on own, leisure mobility = independent mobility during leisure time, public transport = allowed to use public transport on own, school trip = independent mobility to school. (*1*) Hillman 1990); (*2*) O'Brien et al. (2000); (*3*) Pooley (2005b) (Figure reprinted with permission; Badland and Oliver (2012))

proxy measure of children's independent mobility and thus was not an assessment of children's actual behaviors.

Through in-depth oral life-history interviews, Pooley et al. (2005b) compared children's journey to school in urban areas in England since the 1940s. For 10–11-year-olds born in the oldest cohort (1932–1941), 40 % traveled to school alone compared with 9 % in 10–11-year-olds born in the youngest cohort (1990–1991). Figure 1 shows this decline in children's independent mobility over 1940–2000.

Similar independent mobility trends have been reported in other countries, including Denmark, Finland, Norway, and the United Kingdom (Fyhri et al. 2011), Italy, and Australia (Shaw et al. 2013). Interestingly, studies from Finland and other Scandinavian countries have reported children engage in higher levels of children's independent mobility than children from other European countries, albeit overall decline has been observed over time (Kyttä 2004).

Many of the accounts of children's independent mobility and more recently the concept of walkability research have come from study notions of space, and of journeying from place to place across a number of interdisciplinary researchers (e.g., public health, urban planners, environmental psychology, social epidemiologists), looking at distances walked and maps of spatial ranges. However little attention has been drawn to alternative perspectives in particular from the view point of health geographers, for example, practices of walking itself. This could

further contribute knowledge on movement activities, different forms of embodiment, their relationship to health, and their places, experiences, agency, and cultures involved (Christian et al. 2012). As Horton and Evans (2013) suggest, this could be particularly important to know what happens during those distances walked and within those mapped ranges and how such practices matter.

Obesity/fatness is a major concern not only for public health researchers, and globally among policy maker, but across other multidisciplinary researchers. For example, among geographical research there is a shift in obesity policy and understanding obesogenic environments away from an individualistic model of obesity to a more ecological model at population level (Colls and Evans 2014).

1.3 Theoretical Framework

1.3.1 Socio-ecological Model

In determining what influences children's independent mobility, no specific behavioral model has been published that provides a theoretical framework for emerging research in this area (Mikkelsen and Christensen 2009). One of the most common models used in health promotion research to look at health behavior is the socio-ecological model (Stokols 1996). The socio-ecological model developed out of work of a number of prominent researchers (Glanz et al. 2008, pp. 468–469). The core concept of a socio-ecological model is that behavior has multiple levels of influences, including individual, social environment, physical environment, and policy. Original work on the socio-ecological model stems from Bronfenbrenner's work on ecological systems theory in the 1970's, which identifies five environmental systems with which an individual interacts. His work saw the influences on behavior as a series of layers, where each layer had a resulting impact on the next level (Bronfenbrenner 1994). All levels of the socio-ecological model impact on the behavior of the individual (Stokols 1996). As Stokols addresses, the socio-ecological approach integrates person-focused efforts to modify health behaviors with environment-focused interventions. While the components remain the same, the socio-ecological model needs to be tailored to suit particular behaviors and population groups within each level. Figure 2 features the basic socio-ecological model linking the individual with their social, physical, and political environments.

In light of the lack of a theoretical framework for children's independent mobility, Badland and colleagues have recently developed a conceptual multilevel framework to understand the multiple influences on the behavior (Fig. 3; Badland et al. 2016). Figure 3 highlights the relationships within the conceptual framework, for example, children's independent mobility behavior may be influenced by factors associated within the built environment, which in turn are influenced by environmental policies and social norms, and these relationships may be causational or bidirectional.

The focus on children's independent mobility by many social science researchers, over the last three decades, has concentrated mainly within urban neighborhood setting. Drawing conceptual-methodological frameworks from

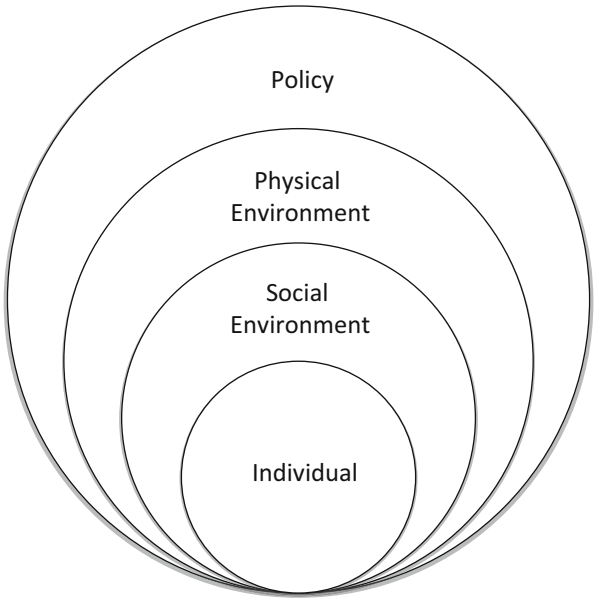

Fig. 2 Illustration of model made up of the individual, social environment, physical environment, and policy components

transport geography and environmental psychology has afforded research exploring children and young people's everyday walking in diverse context including walking routines, behavior, and patterns. Together with new terminologies and the development of a number of techniques and technologies, researchers have contributed to understanding children and young people's geographies (Trapp et al. 2012).

1.3.2 Societal Changes

Over the last few decades, a number of societal changes have likely influenced children's independent mobility, including change in family structure, greater use of structured childcare, increasing number of dual income and working households, families living further away from schools and places of employment, and increased and multiple car ownership per household (Fyhri et al. 2011). Also, parental (O'Brien et al. 2000; Prezza et al. 2005) and children's (Hume et al. 2005) perceptions of safety in neighborhood risks, including stranger danger (Rudner 2012), outdoor play (Veitch et al. 2006; Wen et al. 2009), and increased road traffic (Hillman et al. 1990; Zwerts et al. 2010), are contributing factors that have influenced children's independent mobility.

Fyhri et al. (2011) examined datasets from national travel surveys and other types of available data and surveys for active travel and children's independent mobility in the United Kingdom, Norway, Denmark, and Finland. Not all data sources were directly comparable between the countries; however the same patterns were found in all four countries. Data from the United Kingdom sample showed that parental accompaniment for school travel increased among children aged 7–11 years from 78 % in 2002 to 86 % in 2008 (Department of Transport 2009). In the

same age group, traffic danger (58 %), fear of assault/molestation (29 %), convenience (21 %), and distance to school (22 %) were the leading four reasons given by adults for accompanying children to school. In Norway, parents taking the same route to the workplace as their child's route to school was the main reason children were driven to school by car (58 %), followed by concerns of traffic safety (21 %) and the car being the fastest travel mode (18 %). In the Danish and Finnish studies, the main parental concerns for accompanying children to school were road traffic and fear of molestation from adults (Fotel 2007).

1.4 Active Transport

Active transport can contribute to children's independent mobility and encompasses traveling by non-motorized travel modes, such as walking, cycling, scootering, and skateboarding. There is a large body of evidence reporting the significant contribution of active transport to or from school (Cooper et al. 2005; Salmon et al. 2007) and other nonschool travel destinations (Mackett et al. 2005) in overall children's physical activity. Active travel to school has been shown to be an important source of physical activity in young children (Schoeppe et al. 2012). Walking is free and convenient and has been described as a "near-perfect exercise." Cooper et al. (2005) used accelerometry with Danish primary school-aged children to study walking, cycling, and motorized transport to school. The authors found walking to school was associated with higher levels of overall physical activity compared with motorized transport. Cycling was also associated with higher levels of physical activity, but only among boys. Furthermore, a national survey of the US youth has shown a steep decline from 1969 to 2001 (41–13 %) in children's active commuting to school, while motorized transport (by car) to school has increased in this period from 17 to 55 % (McDonald 2008; Shaw et al. 2013). Following on from Hillman's earlier work (Hillman et al. 1990), active transport from home to school among English children decreased between 1971 and 2010 (86–25 %) (Shaw et al. 2013). The decline in active transport has been observed in many countries in Europe and elsewhere (Fyhri et al. 2011). Although the US national survey data are not directly comparable to those presented by Fyhri et al. (2011), it is clear that the overall picture of active travel, particularly walking and cycling, is on the decline, and in contrast transport by vehicular modes has become a predominant form of personal mobility (van der Ploeg et al. 2008).

Apart from a "near-perfect exercise," active transport has been targeted as a way of increasing energy expenditure in children and combating rising levels of obesity in children (Harten and Olds 2004). There are also a number of positive health and social benefits from active transport including mental health, cognitive development self-esteem, improved behavior, and relationship building (Jan 2011). The decline in active transport is particularly well documented in relation to trips to school. The shift in active travel to school may be explained by a number of reasons, for example, parent's negative perception of the neighborhood, including

concerns of stranger danger and traffic safety, the increasing distances to schools, and time pressures (Oliver and Schofield 2010). Though globally on the decline, it should be acknowledged that children's active travel practices vary by country and geographic region.

Distance and trip duration, such as home to school journeys, are the main factors which influence whether one uses active and passive transport modes (Oliver and Schofield 2010). Furthermore, distinct differences can be found for walking and cycling, distance to location being greater for children who walk (Schlossberg et al. 2006), while increased trip duration may affect cycling more than walking (Ewing et al. 2004). Findings from studies in the early 2000s from the United Kingdom and Australia reported that distance to school was the main factor affecting the likelihood that a trip would be active (Black et al. 2001; Harten and Olds 2004). In Harten and Olds' (2004) study on Australian children aged 11–12 years, trip data were collected on two school days and one nonschool day. They reported that children made an average of one active trip per day, with median trip length of 0.63 km and the mean total distance per child per day being 0.61 km. In the Black et al.(2001) study of English children aged 5–10 years, 50 % of the trips to school were by active commute up to a distance of 2.0 km. Urban planning literature suggests that key destinations should be with 400–450 m (approximately 5 min walking) of residential areas and within 800 m of public transportation. In Metcalf et al. (2004) study of 275 younger English children (year one, aged 5 years), the median time taken to walk to school was 6min and the median distance accompanied actively travel distance was 0.7 km.

More recent studies are finding similar results to this early research. A recent review by Wong et al. (2011) identified 17 studies between 1960 and 2010, of which 15 studies reported negative associations between distance to school by either walking or cycling to school or both. No study reported a positive association between distance to school and active transport. McDonald (2007) reported a negative association with active school travel when the trips were short (i.e., less than 1.6 km); no associations were found for trips greater than 1.6 km. A summary from current literature provided conclusive evidence that increasing distance is negatively associated with active school travel (Wong et al. 2011). Promotion of active travel modes such as walking and cycling, with peers or independently in the built environment, has greater prospects if school catchment area is explicitly considered (Black et al. 2001). A handful of studies have measured children's independent mobility in the form of children's (unsupervised) active travel to various destinations (Page et al. 2009; Wen et al. 2009), and one study has looked at unsupervised outdoor play as an indicator of children's independent mobility (Floyd et al. 2011). Schoeppe et al. (2012)recently reviewed the associations between children's independent mobility and active travel. The systematic review reported a vast majority of active travel studies focused on children's transport behavior (active/motorized) to and from school. The review noted that only five studies examined active transport to nonschool locations, suggesting a gap in research that needs to be addressed.

1.5 Associations Between Children's Independent Mobility and Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that result in energy expenditure. This behavior is not limited to sport and exercise, but it is classified as any activity that raises the heart. Children that engage in active transport behavior are more likely to be physically active overall and have higher levels of energy expenditure. The benefits of different types of physical activity differ across life stages. While morbidity and premature mortality increase into adulthood and older age, exposure to risk through inactivity begins in childhood. Participating in 60 min of moderate-to-vigorous physical activity daily in children has significant health benefits, including improved muscular and bone strength and aerobic fitness and reduced risk of adiposity (Strong et al. 2005). In addition, long-term benefits include reducing risk for chronic diseases such as cardiovascular disease, obesity, type 2 diabetes, high blood pressure, and some cancers (Banks et al. 2012) and improved mental health. Time spent outdoors by children is a consistent correlate of physical activity (Wen et al. 2009), and reductions in active travel and in children's independent mobility may be contributors to the decline in physical activity levels (Page et al. 2009).

1.6 Children's Independent Mobility Associations with Health and Social Outcomes

The benefits of children's independent mobility can be seen as twofold. Firstly, being independently mobile allows a child to engage in non-formalized physical activity, which has been shown to be important for children achieving daily physical activity requirements (World Health Organization 2010). Secondly, children's independent mobility has an important role in fostering children's physical, social, emotional, cognitive, and spatial development (Kyttä 2004). Additionally, engaging in children's independent mobility provides opportunities to develop life-long skills including social connectedness, to contribute to community social capital, and to make calculated judgments to safely navigate risky situations, such as crossing busy roads or encountering strangers (Rudner 2012).

1.7 Children's Independent Mobility and the Environment

The design of the neighborhood built environment can have an impact on children's independent mobility. In the review by Davison and Lawson (2006) which focused on the relationship between the built environment and children's physical activity, they reported a positive association with traffic density, speed, and local conditions such as crime rates. Similarly, one Australian study found that perception of unsafe round environments was negatively associated with walking and cycling among 10–12-year-olds (Timperio et al. 2004).

Attributes in the urban built environment may explain some of the changes documented in children's independent mobility behavior. Environmental features that may influence children's independent mobility include distribution, accessibility, aesthetics, and quality of destinations such as public open space, presence of green space/greenery (Giles-Corti et al. 2005a), size of public open spaces such as parks, perceived neighborhood safety (Pooley et al. 2005a; Rudner 2012), and increased motorized traffic (Hillman et al. 1990; Zwerts et al. 2010). More walkable neighborhoods (i.e., those with high street connectivity, residential density, and mixed use) have positive associations with walking activity among adults; however better street connectivity means more exposure to vehicular traffic, which may not be conducive for active travel behavior in children.

Evidence suggests that neighborhoods with parks, play areas, recreational facilities, pedestrian infrastructure, and sporting venues available facilitate higher active travel among children (Pont et al. 2009); these may also be appropriate locations to support children's independent mobility.

1.8 Definition and Importance of Public Open Space

Public space and public open spaces include parks, green spaces, plazas, sidewalks, shopping malls, community centers, and schoolyards. There are a number of subjective definitions of what constitutes a public space or public open space within the built environment literature with overlapping features as described. Furthermore public open spaces can include land space areas for playgrounds and "blue space" areas of water including rivers, canals, lakes, and reservoirs. Crucially, public open spaces are spaces freely accessible to all and may have multiple uses by multiple users, including sport and recreational opportunities. In this chapter, public open spaces have been defined as "parks and green space that can be freely accessed by the public" (Badland et al. 2010).

Public open spaces are recognized as important settings to promote physical activity engagement in the neighborhood built environment (Timperio et al. 2008). This is not only by use of purpose-built infrastructure (e.g., playgrounds) but because they operate as potential destinations to actively travel to and as destinations to travel through. Public open spaces may also confer health and well-being benefits by fostering social connectedness, communication skills, and friendship development (Lachowycz and Jones 2013; Sugiyama et al. 2008). Evidence also suggests that children's body mass index is lower when they have access to more green space (Lachowycz and Jones 2011).

Multidimensional physical characteristics of the neighborhood may contribute to various forms of activity engagement among youth in their immediate environment. The relationship between child and neighborhood environment needs to be further explored to add to the existing body of knowledge of what contributes or hinders children's independent mobility.

1.9 Public Open Space Use by Children

Simply providing green space in a neighborhood is not enough for individuals in the community; attention needs to take place in its design and qualities for it to be beneficial for all groups (Villanueva et al. 2013). Access to good quality green space has positive associations with physical and mental health and well-being (Francis et al. 2012). The use of green space also provides an area for social contact with others, freedom for play, and destinations to walk or cycle and engage in physical activity (Veitch et al. 2008). Access to appropriate facilities for physical activity and active play has been previously identified as a key determinant of activity participation (Sallis et al. 1993), and public open spaces need to be flexible to accommodate a diverse community and populations (Cabe Space 2004). What is not well known is how public open space availability, safety, and accessibility are conducive for children's independent mobility and children's active play. For example, safety features of a public open space have been identified as important contributors to their use. Lighting, dog fouling, graffiti, vandalism, and unmaintained areas all contribute to a perceived lack of safety, which reduces the use of green space in children and adolescents (Cabe Space 2004).

Availability and quality of public open spaces are used widely in health research to determine relationships among the physical environment, physical activity, and health. Availability and access to parks near home are associated with higher levels of physical activity in youth (Cohen et al. 2006). Quality of public green space is an important determinant of health and influences their use for children; key considerations include safety, toilets, drinking water, lighting, and pathways (Sallis et al. 1997; Veitch et al. 2006). Crawford et al.(2008), when looking at features of public open spaces in contrasting socioeconomic neighborhoods, found those in more disadvantaged areas had more amenities (e.g., toilets, drink fountains) and better shading from trees, walking and cycling paths, and lighting than public open spaces in more advantaged areas. Similar results have been reported elsewhere (Giles-Corti et al. 2003).

Park proximity, size, and features have been minimally investigated among children (Kaczynski and Henderson 2007). Giles-Corti et al. (2005a) indicated that among similar-sized parks, those public open spaces rated "higher quality" versus "lower quality" were more likely to attract users to engage in physical activity. Having good access to larger public open spaces was also associated with higher levels of walking in adults. Conversely, Kaczynski et al. (2008) reported size and distance of park were not significant predictors for use among adults, although specific features inside the park (e.g., paved trails) were positively related with use.

Though most public open space studies have focused on physical activity and active play, it is thought that attention needs to be paid to measuring children's independent mobility, an important contributor for daily physical activity. To date very few studies have attempted to relate environmental attributes to children's independent mobility in specific locations.

1.10 How Have Public Open Spaces Been Measured?

A number of direct observational methods have been employed in health research to code attributes of physical activity environments, and a summary of these can be found by Sallis (2009). The chapter discusses observational tools used to measure physical activity behavior in specific settings (e.g., schools, stairways) and auditing of specific environments.

Largely, direct observation audits have been used to audit public open spaces (parks and green space). Audit tool examples include the Bedimo-Rung Assessment Tool, Environmental Assessment of Public Recreation Spaces Tool, Community Park Audit Tool, and Public Open Space Audit Tool (Giles-Corti et al. 2005a). These inventories all vary in length and type of environmental information collected. Other tools collect data objectively on both individual and environmental levels, for example, System of Observing Play and Leisure Activity in Youth and System for Observing Play and Recreation in Communities. Details of these tools and resources can be found elsewhere (Active Living Research 2014).

Taylor et al. (2011) measured the quality of public open spaces using a new remote-assessment approach, Google Earth Pro. The study assessed the correlation between remote assessment of quality of public open spaces using Google Earth and direct observation using a shortened version of the Public Open Space Audit Tool. Fifty parks were selected to be assessed by the remote method and scores compared with some parks using Public Open Space Audit Tool. Strengths of the remote method were the speed at which audits could be completed, facilitating a larger number of environmental audits without the need of in-person visits. Limitations of this remote-assessment method were that some items could not be accurately scored due to obstructed view or poor resolution, particularly regarding aesthetic features. Additionally, satellite imagery data may not be current in some areas, as images may be up to 3 years old and thus not accounting for spaces where redevelopment has occurred. Advantages of these direct observation audits are that they are user-friendly tools to measure different environmental characteristics, with no participant bias, and they are easy to conduct. Disadvantages include the cost and need to train auditors, and depending on length of audit, it may be time consuming to collect the data.

1.11 What Is the Relationship with Children's Independent Mobility and Public Open Space

Within the built environment, places where a child engages in physical activity and active play are important to study to establish factors affecting youth physical activity (Ellaway et al. 2007; Giles-Corti et al. 2005b). Play areas are potentially important areas for children's mental, social, and physical health and for social contact with other children (Ellaway et al. 2007). There is limited data on the relationship between children's independent mobility and public open space as the majority of children's independent mobility studies have investigated physical

activity in school locations (including active travel to school), neighborhood streets, and parks (Grow et al. 2008). However, Giles-Corti and King (2009) suggest most individuals obtain physical activity from more than one context, which includes walking and cycling and free play.

Past research in children aged 10–12 years reported that absence of nearby parks and sports venues was related to decrease walking and cycling trips (Timperio et al. 2004). Children spent less time in engaging in sedentary activities (i.e., computer/e-games and watching television) when living near a larger-sized park with a water feature and/or whose parents reported greater satisfaction with park quality (Veitch et al. 2011). Similarly, Grow et al. (2008) showed that regardless of age, living closer to a larger public park and public open spaces increased the likelihood of being active.

It is also possible that sex differences exist for utilizing public open spaces. Some studies have indicated that in youth, boys tend to roam more freely and independently in public open spaces in their neighborhood than girls (Page et al. 2009; Villanueva et al. 2012; Wen et al. 2009). Villanueva et al. (2012) examined how far children traveled from home within the neighborhood; parental perceptions reported in favor of boys being more able to safely negotiate traffic conditions better than girls. Stronger association between access to green space and physical activity has been found for boys (Page et al. 2009; Villanueva et al. 2012). For example, in a cross-sectional study by Page et al. (2009), in the neighborhood, boys aged 10–11 years reported higher children's independent mobility compared to girls.

1.12 What Is the Relationship with Public Open Space and Area-Level Disadvantage

The relationship between individual and environmental characteristics in influencing health and health-related behaviors is well established in literature (Strategic Review of Health Inequalities in England 2010). Living in a disadvantaged neighborhood compared to living in a more advantaged neighborhood has been linked to poorer health outcomes in individuals (including children), with higher rates of chronic disease, and associated risk factors such as obesity (Diez-Roux 2001). This has been shown for total and coronary heart disease mortality (Diez-Roux et al. 1997), coronary heart disease prevalence and risk factors (Smith et al. 1998), and depression (Yen and Kaplan 1999). Macintyre (2007) described this as "deprivation amplification." These variations in health are explained as compositional (individual level) and contextual (area level) (Diez-Roux 2001; Macintyre 2007).

Conflicting evidence exists where some populations exposed to more green environments report lower levels of health inequalities (Mitchell and Popham 2008), and several studies in New Zealand have shown that socioeconomically deprived urban communities have better access to parks (Badland et al. 2010; Pearce et al. 2008). Yet other research suggests communities in more disadvantaged

neighborhoods have poorer green space availability than more affluent neighborhoods (Estabrooks et al. 2003). Nevertheless, access, location, and quality are important attributes for determining public open space use within a neighborhood. In contrast, Richardson et al. (2010) suggest the availability of public green space in New Zealand may not be as an important determinant of health as found elsewhere.

The Strategic Review of Health Inequalities in England 2009 Marmot Report advocated that there should be green space within 4 min of every family home (2010). Using international data, the report found a significant lack of green spaces and play spaces for children in disadvantaged neighborhoods. Other empirical research suggests that the relationship between area-level disadvantage and public open space access varies nationally.

Studies of the locations of children's outdoor playgrounds have found them more common in and closer to poorer areas in Scotland and the USA (Cradock et al. 2005; Ellaway et al. 2007). However in Australia, Crawford et al. (2008) found no difference in number of playgrounds and recreational facilities between higher and lower disadvantaged neighborhoods, and most of their participants (aged 8–9 years) lived about 300 m to their closest public open space. Veitch et al. (2008) addressed the importance of park proximity to home within Australian neighborhoods. They reported that children living in low socioeconomic outer-urban neighborhoods had to travel a greater distance to access local parks for active free play compared with higher socioeconomic areas. Together, this work highlights the conflicting findings presented thus far.

In addition, researchers have looked at the quality of parks and playgrounds for children's play with regard to their safety and availability by area-level disadvantage (Cradock et al. 2005; Curtice et al. 2005; Ellaway et al. 2007; Ellaway et al. 2001). Ellaway et al. (2001) reported people who lived in poorer areas of Glasgow were more likely to report a lack of safe places for children to play in their neighborhood. Similarly in 2005, a Scotland-wide study found 45 % of people living in deprived areas compared to 4 % of those in affluent areas reported a problem with the availability of safe places for children to play (Curtice et al. 2005). Cradock et al. (2005) found that in Boston, USA, young people from poorer areas lived closer to playground facilities than those in more advantaged areas; however the playground equipment in poorer areas was unsafe and poorly maintained. The quality of public open space for influencing children's use is also important. Badland et al. (2010) analyzed public open spaces in 12 urban neighborhoods in New Zealand and found no difference in quality of public open space by area-level deprivation; however public open space safety score was greater in more disadvantaged areas compared with least disadvantaged areas. However, this study did not look at the association between quality of public open space and individuals' use of public open space.

A 2007 Scottish study investigated the provision of outdoor play areas for children in relation to area disadvantaged per 1000 total population. The results of the study pointed toward more play areas being available in more disadvantaged areas compared with less disadvantaged areas (Ellaway et al. 2007). Similar findings were reported in a Danish study (Karsten 2002); however this study did

not assess the quality and use of the playgrounds. An Australian study revealed a reduction in active travel to school (by foot and cycle) among 9–13-year-olds between 1985 and 2001 in contrasting neighborhoods. In higher socioeconomic areas, this reduction was 50 %, while in lower socioeconomic areas active travel declined by 77 % among children (Salmon et al. 2007).

It is not yet clear whether quality, quantity, or a measure of both is most important for public open space use; several studies have started to investigate these associations with various health outcomes. One Australian study explored the relationship between quality and quantity of public open space attributes and mental health among adults. The authors found that quality of public open space within a neighborhood was more important than quantity (Francis et al. 2012). This warrants further investigation as to the relationship of quality and quantity together with public open space by neighborhood disadvantage among children has not been examined.

2 Conclusion

1. The evidence of the potential health and well-being benefits of public open spaces have increased immensely over the last decade along with the growing research interest in public open space in the urban built environment.
2. Most public open space studies have focused on physical activity and active play; more attention needs to be paid to measuring children's independent mobility, an important contributor of daily physical activity.
3. The evidence base linking public open space attributes with children's independent mobility is limited, for example, mobility in specific locations, and to date very few studies have explored this relationship.
4. Multidimensional physical characteristics of the neighborhood may contribute to various forms of activity engagement among youth in their immediate environment. The relationship between child and neighborhood environment needs further exploration.

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