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Sedentary behaviour and health: mapping environmental and social contexts to underpin chronic disease prevention

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ABSTRACT

The time that children and adults spend sedentary—put simply, doing too much sitting as distinct from doing too little physical activity—has recently been proposed as a population-wide, ubiquitous influence on health outcomes. It has been argued that sedentary time is likely to be additional to the risks associated with insufficient moderate-to-vigorous physical activity. New evidence identifies relationships of too much sitting with overweight and obesity, type 2 diabetes, cardiovascular disease, some cancers and other adverse health outcomes. There is a need for a broader base of evidence on the likely health benefits of changing the relevant sedentary behaviours, particularly gathering evidence on underlying mechanisms and dose–response relationships. However, as remains the case for physical activity, there is a research agenda to be pursued in order to identify the potentially modifiable environmental and social determinants of sedentary behaviour. Such evidence is required so as to understand what might need to be changed in order to influence sedentary behaviours and to work towards population-wide impacts on prolonged sitting time. In this context, the research agenda needs to focus particularly on what can inform broad, evidence-based environmental and policy initiatives. We consider what has been learned from research on relationships of environmental and social attributes and physical activity; provide an overview of recent-emerging evidence on relationships of environmental attributes with sedentary behaviour; argue for the importance of conducting international comparative studies and addressing life-stage issues and socioeconomic inequalities and we propose a conceptual model within which this research agenda may be addressed.

INTRODUCTION

In the context of the major ‘diseases of inactivity’,¹ sedentary behaviour—*too much sitting*—has emerged as a significant additional element of the chronic disease prevention agenda. The Sedentary Behaviour Research Network² proposes the following definition: ‘any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents (METs; put simply, multiples of the basal metabolic rate) while in a sitting or reclining posture’ (p.540). A rapidly developing body of recent evidence has identified prolonged sitting time as a population-wide, ubiquitous health risk.³ In adults, too much sitting is related to risk for type 2 diabetes, cardiovascular disease, breast and colon cancer and poor mental health outcomes.^{3–5} In children, sedentary

time is related to overweight and obesity, some cardiovascular risk factors (eg, elevated systolic blood pressure) and poorer cognitive development (eg, language delay).⁶ Less is known about cardiometabolic health consequences for older adults, but preliminary findings suggest a likely importance.⁷

As illustrated in figure 1, sedentary time is ubiquitous. It accumulates each day while commuting, at school, in the workplace, at home and in leisure contexts. There are deleterious metabolic consequences of the 6–10 h of *sitting* to which children and adults can be exposed to each day.^{8–9} Sitting time, together with reduced requirements for physical activity,^{10–11} has increased significantly over the past several decades, due to a range of economic, social, environmental and technological changes, including the increased use of screen-based entertainment and communication devices, more outer suburban development and increased motorised transport.¹²

There is now a need to address the nexus of new research perspectives on the adverse health outcomes of sitting time, within a broader understanding of environmental influences on health behaviours,³ taking an ecological^{13–14} and socioeconomic inequalities¹⁵ perspective across life stages.

We provide a basis for taking this agenda forward, through considering what has been learned from research on environmental attributes and physical activity relationships; and provide an overview of the recent evidence on relationships of environmental attributes with sedentary behaviour; argue for the importance of international comparative studies and addressing life-stage and socioeconomic inequalities and propose a conceptual model (illustrated in figure 2) within which this research agenda may be addressed.

Recent lessons from research on environment–physical activity relationships

There has been consistent evidence over the past decade for the built environment as a significant correlate of physical activity. Different environment attributes have been found to be associated with physical activity for recreation and transportation-related activity.^{16–18} For example, for transport-related walking, built environmental attributes have been conceptualised around the notion of ‘walkability’, which takes into account street connectivity, residential density and land-use. For recreational walking, among other things, neighbourhood aesthetics are more important. There are lessons from this body of research that can guide the future research on the role of the built environment on sedentary behaviour



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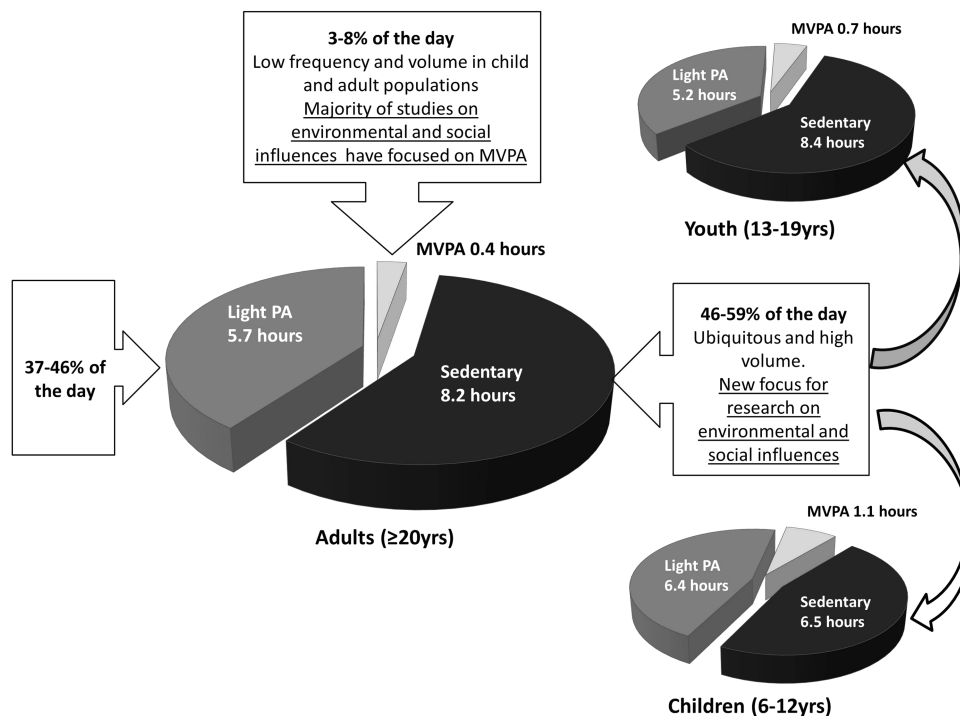


Figure 1 How adults and children typically allocate their time spent sedentary, in light-intensity physical activity and moderate-to-vigorous intensity physical activity (based on population data from the 2003–2006 NHANES survey).⁵⁸

particularly related to use of behaviour and context-specific measures.^{19–21}

However, variability in physical activity for different population subgroups also raises several questions for future sedentary behaviour studies. For example, high-walkable neighbourhoods

—that have higher residential density and more destinations—often have more traffic, and exposure to traffic is negatively associated with active forms of transport in children.^{22–24} In the context of physical activity research, there is a paucity of age differences in response to environmental exposures.^{25–26} Frank

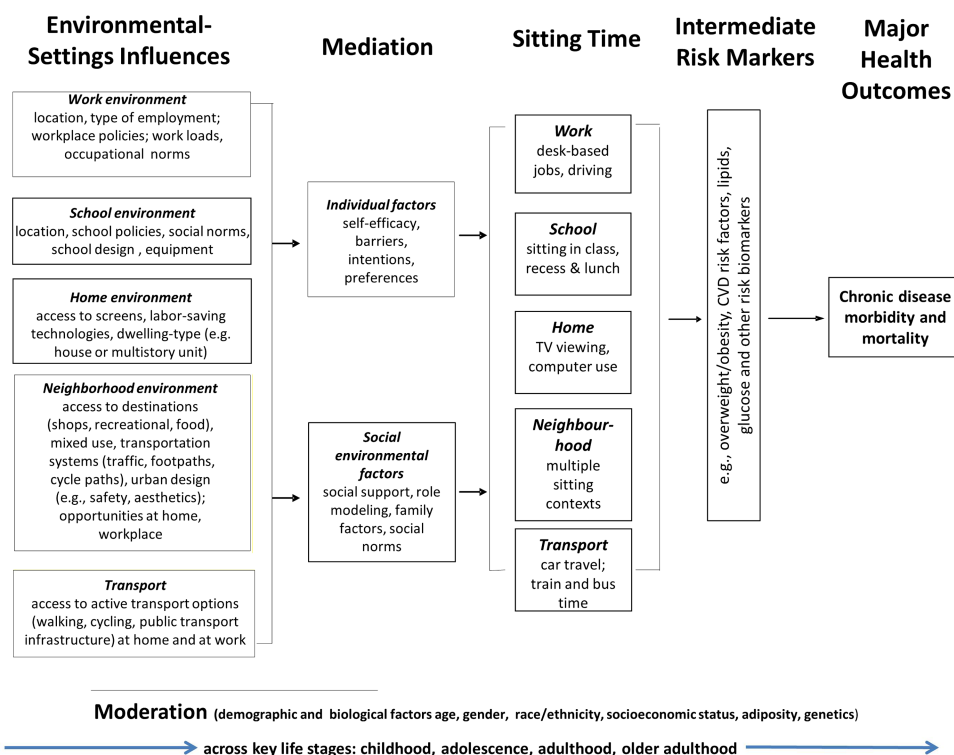


Figure 2 Overview of relationships that need to be identified—between the built, policy and social environments, prolonged sitting in particular settings and chronic disease risk (modified from Villanueva *et al*²⁶).

*et al*²⁷ examined urban form relationships with walking among youth aged 5–20 years, stratifying the sample by age group. They found significant differences in walking frequency and distance by age group, and differential relationships between the built form and behaviour by age. In a recent study in Belgium, Van Dyck *et al*²⁸ examined the influence of perceived environmental attributes on active transportation among adults and adolescents. They found perceived residential density, land-use mix, safety for cycling and walkability to be associated with active transportation in adults but not adolescents. Inconsistencies in previous physical activity research findings may at least in part be explained by differential responses to the environment by different population segments. For example, proximity from home to parks and recreational facilities is commonly associated with higher levels of physical activity²⁹ but the role of particular attributes appear to differ by population subgroups. For example, while the use of public open space almost halves as distance doubles, various studies involving adults have found that the quality and size of public open space rather than its proximity was positively associated with higher levels of walking in adults.^{30–31} Similarly, facilities within parks have also been found to be more important than proximity for children's physical activity.³²

Consistencies and variations in such relationships by life-stage for sedentary behaviours are highly likely. For example, older adults and children tend to spend larger parts of their daily lives in their neighbourhoods than do working-age adults. On the other hand, working adults are more mobile and have easier access to facilities and services in surrounding areas or near work locations; older adults and children may rely more on local opportunities for spending time outdoors.

The built environment and sedentary behaviour

To date, only a small number of studies have focused on how the built environment is associated with sedentary behaviour and have primarily examined TV viewing time. In Australia, Sugiyama *et al*³³ found that low levels of objectively assessed neighbourhood walkability (poorly connected streets, low levels of residential density, limited land-use diversity and large parking spaces for retail access) were positively associated with TV viewing time. For older women in Japanese cities, Kikuchi *et al*³⁴ found TV viewing time to be associated with contextual factors such as location of residence, living with others and non-driving status. Women living in low-walkable communities reported significantly more minutes of daily TV viewing time, after controlling for the influences of area level socioeconomic status and relevant sociodemographic attributes.³⁴

Evidence from prospective studies with adults and children suggests that the built environment is an important determinant of TV viewing time and other screen behaviours. In a recent 4-year follow-up study, Ding *et al*³⁵ identified that adults in low-walkable neighbourhoods increased their TV viewing time compared with those who lived in high-walkable neighbourhoods. In another longitudinal study of associations between the neighbourhood environment and child and youth screen time, Timperio *et al*²⁵ and Veitch *et al*³² found that relationships varied depending on the neighbourhood features being examined and on the screen behaviour of interest (eg, TV viewing time, computer use or electronic games use).

A recent review of child and youth sedentary behaviour reported that neighbourhood environmental factors such as topography, living in urban areas and perceived neighbourhood safety to be key correlates.⁶ Living in suburban versus traditional neighbourhoods, limited public transport availability and lower

population density have been found to be associated with greater time spent sitting in cars.¹⁶ A study of 10–12-year-old children living in inner West Sydney found that 40% were driven to and from school every day, and of those children just under 50% lived within 1.5 km of school.³⁶ Among primary and secondary school children and their parents living in Melbourne, Carver *et al*³⁷ found that parental concerns regarding traffic injury were positively associated and social trust was inversely associated with parental chauffeuring of their children. Research with primary and secondary school children has found similar variables associated with parental chauffeuring of their children (eg, household car access, distance to school) as well as social trust, concerns about injury while crossing a road, age and sex of the child, one parent not in full-time work and urban/rural location.⁶ Aspects of neighbourhood design around schools and distance from home to school have been shown to significantly impact whether children walk, cycle or whether they are driven to school, highlighting the importance of better-informed urban-transport policy for influencing sitting time en-route to and from school.^{23–38}

This emerging body of evidence on sedentary behaviour/environment relationships includes more extensive evidence for children than it does for adults or older adults. There is a particular need for evidence from observational studies—particularly prospective studies—examining environmental and social determinants of sedentary behaviour for adults at different life stages.

Maximising variations in environmental exposures through international studies

Bauman *et al*³⁹ reported striking differences in prevalence and gender variations in adults' overall sitting time within 21 countries that they examined. While the authors are cautious not to speculate, their findings suggest the merit of examining findings from countries that have differing built environment, transportation infrastructure and cultural and social attributes, and that vary in their stage of economic development. These initial findings make clear that a central problem for understanding how environmental and social factors can influence sedentary behaviours is that there may be too little variation in social, environmental and policy variables across units of study in single countries.

In contrast to the Australian findings described above³³ and findings from the USA,⁴⁰ for the Belgian sample, those living in high-walkable neighbourhoods reported significantly more sitting time than those from low-walkable neighbourhoods (472 vs 418 min on weekdays, respectively; 440 vs 403 min on weekend days, respectively). Notably, the Belgian findings are on self-reported overall sitting time and accelerometer-measured total sedentary time, which may explain the differences in findings.^{41–42} However, it may also suggest that built environmental attributes influence sedentary behaviour differently in older European cities; point to potential social and cultural differences that warrant further examination; and highlight the complexities of urban planning policy advice to avoid 'unintended consequences'.

Given that much of the evidence on the relationship of environmental attributes with sedentary behaviour comes from studies in Australia, Belgium and the USA, the full range of these environmental exposures and their impacts remain to be examined. There is considerable potential for greater explanatory power in identifying the relevant environment/behaviour relationships.

Addressing life-stage and socioeconomic factors within and across studies

Where life-stage and socially related comparisons are made within studies, the usual focus is on how various built environmental features may affect a specific population segment, rather than how the impact of these features may differ across social groups. Studies thus tend to focus on a particular population segment (most usually the general adult population), or the analysis methods used will filter out variability by adjusting the findings for age, sex and other personal characteristics (eg, socioeconomic status) that are likely to cause differences in outcome variables.

There have been a number of studies on the social correlates of TV viewing time^{6 43 44} and the role of socioeconomic inequalities has to some extent been explored. For example, Hesketh *et al*⁴⁵ found that maternal education and children's TV viewing were partly mediated by aspects of the family television environment. Salmon *et al*⁴⁶ reported that enjoyment of television and perceived barriers to physical activity (cost, work commitments) were predictors of high TV viewing time (>14 h/week) among a large sample of Australian adults. Clark *et al*⁴¹ showed that Australian adults with lower levels of educational attainment and living in rural areas were more likely to be in the highest TV viewing time categories. Using the American Cancer Society data from a large population-based study, King *et al*⁴⁷ identified clusters of adults in the 4 h or more per day category of TV time who had low levels of educational attainment.

The future research should address the knowledge-gap on associations of socioeconomic inequalities with sedentary behaviours and their adverse health outcomes from a multilevel, longitudinal and life-course perspective.^{48 49} There is a need for area-level social inequalities to be better understood—for example, those living in areas with low perceived social capital or those who are fearful of local crime may constrain their physical and social activities and be more likely to stay indoors and watch TV.⁵⁰ Broadly, there is a need to examine how associations between socioeconomic inequalities and sedentary behaviour are influenced by the contributions of neighbourhood-level, household-level and individual-level factors, how these multilevel factors and sitting time change over time and how these factors shape and circumscribe inequalities at different time points across the life course.⁵¹

These new directions will yield important findings relevant to the role of environmental attributes at different life stages. For example, there are likely to be important differences in environmental factors and their relationships with socioeconomic inequalities, which may either similarly or differentially influence children, adults or older adults.⁵² There is a compelling need for such relationships to be fully explored^{53 54} and for new conceptual approaches, measurements and methodological strategies to address explicitly the role of socioeconomic inequalities.^{55–57}

Conclusions: comprehensive, policy-relevant evidence on sitting time and chronic disease prevention

Figure 2 depicts a conceptual framework that can guide future studies to identify the determinants of sedentary behaviour in multiple settings. Evidence is needed to map the links between each of the elements within this framework. There is a need to examine the potential mediating roles of sitting time in particular contexts (school, workplace, transportation and domestic environments) between the attributes of those environments,

biomarkers of health risk and health outcomes. Furthermore, evidence is needed on the potentially moderating roles of socioeconomic inequality in these contexts.

Figure 2 illustrates the comprehensive body of evidence that is now needed to inform future environmental and policy initiatives needed to reduce sitting time, thereby expanding the options for chronic disease prevention—not only through public health, but also through urban planning, transport and other sectors. The conceptual model in figure 2 highlights the need for quantitative rigour within this research agenda. In particular, there is the need to apply the relevant analytical methods for understanding the likely moderating roles of social factors on sedentary behaviour, as well as the factors that may operate to mediate the relationships of environmental attributes with prolonged sitting in particular contexts—the 'behaviour settings' provided by school, occupational, commuting and domestic-entertainment contexts in which children and adults spend large proportions of their waking hours.^{13 14}

The future research also needs to examine the differences in these relationships as a function of key life stages—childhood and adolescence, adulthood and older adult life—identifying the common and distinct influences of environmental, social and other relevant determinants of sitting time in relevant settings.

Pursuing a comprehensive and well-coordinated research agenda on environmental attributes, sedentary behaviour and health outcomes has great potential to inform research translation in the context of chronic disease prevention. There is an urgent need to develop interdisciplinary research methodologies and identify where specific opportunities for evidence-informed environmental and policy initiatives may be pursued. For policy makers and practitioners in public health, urban design and planning, transport and other sectors, these findings will identify additional opportunities for interdisciplinary and intersectoral collaboration that are directed at reducing sedentary time, leading to broad-reaching health and social benefits.

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