Chapter 23
Sedentary Behaviour at the Community Level: Correlates, Theories, and Interventions

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Abstract This chapter provides a succinct overview of sedentary behaviour correlates, theories, and interventions in youth communities (schools), adult communities (worksites), and neighbourhoods. Within each community, we identify and discuss (a) observational and experimental studies examining the correlates of sedentary behaviour; (b) demographic, psychosocial, and environmental factors that influence sedentary behaviour; and (c) intervention designs and outcomes targeting sedentary behaviour. How technological advances and media influence may impact public awareness and intervention design is discussed. We also highlight the roles and responsibilities of both research and public health organizations to promote healthy behaviours. Finally, we evaluate community-based interventions to provide recommendations and future directions. We conclude that the barriers and challenges faced at the community level for reducing sedentary behaviours may vary per community setting and type. Ultimately, multilevel strategies and collaborative practices, across multiple settings that target sedentary behaviour as an independent risk factor, are needed to improve the efficacy of community-level interventions and increase the potential for future dissemination.

23.1 Models and Theories of Community-Level Sedentary Behaviour

Community-level settings—schools, worksites, neighbourhoods and other public spaces—have been re-engineered to minimize human movement and muscular activity [1]. Ultimately these changes have caused people to move less and sit more. The factors of sedentary behaviour influence have previously been divided into five categories: demographic, biological, psychosocial, behavioural, and environmental [2]. We discuss numerous demographic, psychosocial, and environmental factors that influence community-level sedentary behaviour within three main

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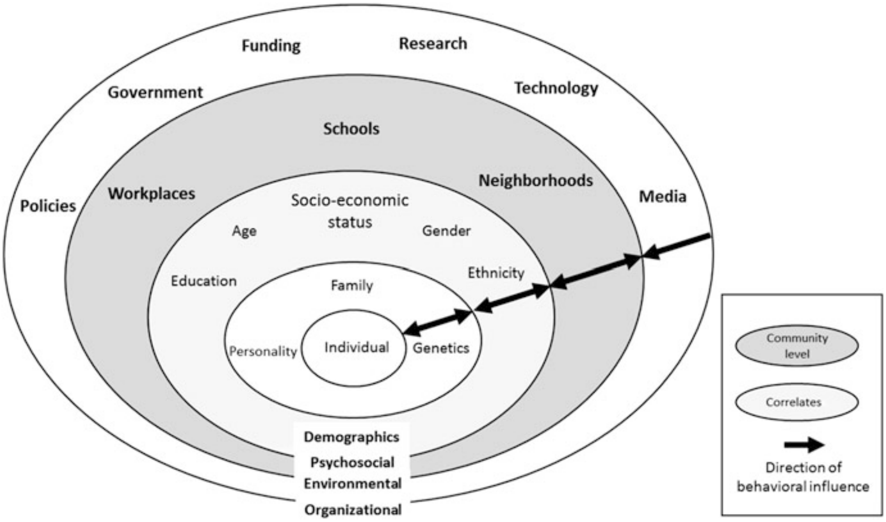

Fig. 23.1 A summary of the community correlates and determinants of sedentary behaviour

environments—youth communities (schools), adult communities (worksites), and both adult and child communities (neighbourhoods) [3]. For biologic and behavioural factors at the individual level, please refer to Chaps. 5 and 16. It is important to clearly distinguish sedentary time, the exposure of interest in this chapter, from overall physical activity. This distinction forms the foundation of sedentary behaviour evolution that is prominent at the community level and has shaped measures and interventions in recent years. We posit correlates and determinants of community-based sedentary behaviour across schools, worksites, and neighbourhoods (Fig. 23.1), which may play a pivotal role in the feasibility and efficacy of future community-level interventions.

23.1.1 Theoretical Overview: What Is Sedentary Behaviour?

In the free-living, fully functional, healthy population, sedentary behaviour can be defined as spending time in a seated or reclining posture with low levels of energy expenditure, <1.5 metabolic equivalents [METs] [4]. Activities that involve sitting are most often assessed for estimating the quantity of time an individual is sedentary. Most common sedentary activities are sitting while watching television (TV); using a computer; playing video games, board games, and cards; sewing; talking on the telephone; reading; working in sedentary occupations that require sitting while doing paperwork, computer work, phone calling, business meetings, etc.; and sitting while transporting by care, bus, train, plane, ferry, etc. Due to measurement challenges, it is often difficult to distinguish sedentary time from light physical activity that includes standing and "fidgeting", "moving about" intermittently. It is suggested that increases in sedentary lifestyles, urbanization, and changes in modes of transportation, each have a contributory effect to the rising rates of sedentary behaviour [5], all of which can be targeted at the community level.

23.1.2 Schools: Youth Communities

Children are naturally born active [6] but are exposed to opportunities and environments that cause them to be sedentary on a daily basis [7, 8]. Sedentary behaviour for children may include sitting in the classroom, sitting during lunch time, watching television, playing computer games, completing homework, and passive transport [7, 8]. Most commonly, childhood sedentary behaviour is measured in relation to "screen time"; however, non-screen time sedentary behaviour accounts for 60% of overall sedentary time in school-aged children [9]. The education system is influential during the early stages of psychosocial and physical development as children spend 30–40% of their time in school [10, 11]. Approximately 95% of American children are enrolled in schools and spend ~30 h per week at school [12]. Two recent studies observed that primary schoolchildren spend 62–70% of their school time in sedentary behaviours and only 9–16% of their school time in moderate or vigorous physical activity in the United Kingdom and Canada, respectively [13, 14]. Synonymous with the adult workplace, time at school is responsible for the highest proportion (47%) of all non-screen sedentary time in children [15]. Therefore, the school environment presents an opportune community setting for sedentary behaviour reduction strategies [16–18].

23.1.3 Workplaces: Adult Communities

Sedentary behaviour is still a widely unrecognized risk in many worksites as the design of those environments has evolved to facilitate excessive bouts of prolonged sedentary time. Moderate-to-vigorous physical activity has been engineered out of many workplaces by shifting work towards service economies (away from manufacturing) and associated technological advances (e.g. email, telephones, computer networks). Over the past 50 years, as the percentage of private jobs involving moderate-to-vigorous physical activity has fallen by more than 58%, occupational physical activity has decreased by an estimated 142 kcal/day [19]. American adults currently spend over 7.5 h/day engaged in sedentary behaviour, most of which occurs at work where 70–90% of their time is spent sitting [20–26]. Despite a 110 min/day differential between occupational and leisure-time sedentary behaviour, adults do not appear to compensate for excessive sedentary time during work by increasing light physical activity or moderate-to-vigorous physical activity outside of work [21, 22]. Despite what is known about the correlates of moderate-to-vigorous physical activity [27] and to a lesser extent sedentary behaviour in general [28], very little is known regarding specific correlates of occupational sedentary behaviour.

23.1.4 Neighbourhoods: Adult and Child Communities

The neighbourhood around which the individual resides has many important characteristics that may influence the individual's physical activity. Neighbourhoods, by definition, pertain to a formed community within a town or city and can therefore be used as a platform for community-level sedentary behaviour reduction strategies targeting both adult and youth populations. There have been three recent extensive review papers written on theoretical models of how neighbourhood characteristics impact physical activity and/or sedentary behaviour [29–31]. A common model discussed is the socioecological model with the individual at the centre and a number of layers of influence extending outward. For more details on the ecological model as applied to sedentary behaviour, please refer to Chap. 15. Theoretically, environmental characteristics that limit opportunities to sit and promote opportunities to stand and move about are key parameters that need to be examined as important environment stimuli towards reducing sitting and increasing light activity, while not necessarily increasing physical activity in the traditional sense as defined above. The design and social and cultural structure, including many aspects of the built environment, natural environment, government policies, crime rates and perceived safety, economic factors, and weather/climate are all examples of neighbourhood and surrounding community characteristics that can influence sedentary time, independent of any influence on physical activity.

Theoretically, if an environmental feature, however, specifically or broadly defined, is hypothesized to trigger, whether in subtle or more direct/obvious ways, opportunities to sit or lie down, or opportunities to stand and move, then that feature needs to be given attention when we assess ways that our environment might be importantly impacting sedentary behaviour. We can then move forward to inform the design of possible interventions at the neighbourhood level to influence the sedentary behaviour of the neighbourhood population. We discuss the potential demographic, psychosocial, and environmental factors stemming from schools, workplaces, and neighbourhoods, such as the community climate or culture [18], grade level [32], socio-economic impacts [33], and more indirect factors such as attitudes towards active transport [34] and climactic barriers [3], which may influence sedentary behaviours at the community level.

23.1.5 Demographic Factors

At the school community level, recent research has identified several demographic associations between sedentary behaviour and the school environment. A study of primary schoolchildren ($n = 1025$) aged 10–12 years in Belgium, Greece, Hungary, the Netherlands, and Switzerland wore accelerometers for at least 6 consecutive days [35]. The results indicated that European schoolchildren spent 65% of their time at school in sedentary activities and 5% in moderate-to-vigorous physical activity, with small differences between countries. Gender differences were apparent. Girls spent a significantly larger amount of school time in sedentary activities (67%) than boys (63%), and spent less time in moderate-to-vigorous physical activity (4% versus 5%). These observations are supported by previous research that identified gender as a main predictor of weekday sedentary behaviour in adolescents; higher levels of objective sedentary behaviour levels were detected in girls compared to boys. A similar relationship was also observed in countries such as Estonia [13] and England [36]. Progression into higher education is also associated with increased pressure to study and accompanying prolonged periods of sitting [18, 32]. Conversely, curriculum activities at lower grade levels may change from interactive motor skill learning and development (that may require more movement) to more traditional academic learning at higher grade levels.

In a recent study, desk-based employees reported more than half of their daily sitting being accrued during occupational pursuits [37]. While this is slightly lower than previous studies [21, 22], it represents a substantial amount of overall sitting being accounted for within this context. Among demographic correlates, younger age appears to be an important correlate of sedentary behaviour. Two recent cross-sectional studies have reported younger age being associated with higher reports of overall occupational sitting [37, 38], while another [39] reported younger age being associated with fewer breaks for sitting while at work [39]. Furthermore, individuals of higher body mass index (BMI) reported greater occupational sitting [37]. Men, individuals of higher education, individuals of higher income, and individuals with more poorly self-rated health all appear to be more likely to engage in higher levels of occupational sitting. A recent study of randomly selected Australian adults has identified occupational status and job classification characteristics associated with occupational sitting [38]. Part-/full-time employees reported higher levels of occupation sitting than casual employees. Also, white-collar/professional employees reported higher levels of occupational sitting than blue-collar employees [38]. Finally, time during the workday also appears to be associated with sitting and standing time. In a sample of UK office-based workers, temporal associations with activPAL-derived standing were examined on both weekday and weekend days. Standing time was most commonly observed from 07:00 to 10:00 and 17:00 to 20:00 h on weekdays (presumably during commuting to and from work hours), whereas standing time was consistent from 10:00 to 18:00 on weekend days [40].

The resources available to a community (money, time, space, and staffing) may affect sedentary behaviours. It is reported that schools in low socio-economic communities have a distinct lack of resources [33] and exhibit high migration rates of the best-qualified teachers [41]. Such resource constraints may restrict the time, space, and staffing available to implement innovative teaching, workplace, or neighbourhood strategies that aim to reduce sedentary behaviour. Interestingly, a study investigating the prevalence of sedentary behaviour in public versus private schools in Ghanaian adolescents found that students from private schools exhibited significantly higher sedentary behaviour levels to those from public schools [9.91 ± 6.37 versus 4.78 ± 5.71 h/day, respectively] [42]. However, a distinction between school and afterschool time was not made; instead it was concluded that private school students were from families of higher socio-economic status (SES) (77.4% vs. 31.3%) and therefore had access to screen devices, the internet, and computer games at home. Whether the private versus public school environment has a direct impact on sedentary behaviour during the school day would provide much needed insight and should be a consideration for future research. Other demographic comparisons are more inconsistent. In a cohort of primary schoolchildren, parental education or ethnicity was not associated with time spent in sedentary or physical activities [35], which is in contrast to previous work reporting differences between subgroups based on parental education and ethnicity [43]. For example, grade level and the school gender ratio (mixed-gender or same-gender schools) may have an impact on gender differences within the school environment and should therefore be a consideration for future research.

23.1.6 Psychosocial Factors

Understanding and changing behaviour at the community level is highly dependent on what is considered “acceptable behaviour”. The social norms and policies in a school or workplace environment are highly dependent upon the “school climate” [44] or worksite culture. The school or worksite climate is dictated by the attitudes of all community members. Historically, the school classroom is seen as a place for children to remain seated at their desk, and often children are instructed to “sit still” [18]. Remaining seated and present at your desk may also be considered a desirable characteristic in the workplace. Conversely, both in the workplace and school environment leaders or teachers may use standing as a tool to direct attention to a staff member or student. Fewer psychosocial correlates have been identified for occupational sitting. Duncan et al. [39] found that perceptions of greater job autonomy were associated with increased sitting breaks. Other beliefs and attitudes related to occupational sitting have been associated with reported sitting. Individuals who viewed sitting less at work as valuable reported less sitting, and individuals who perceived greater control over their ability to sit less at work also reported less sitting. Interestingly, the relationship between perceived control and occupational sitting was only present among part-/full-time employees and white-collar/professional employees and not blue-collar or casual employees [38]. Modifying these communal perceptions and social norms is a clear challenge in community environments [45].

The learning and working environment is also evolving. Advances in technology have changed the way children, adults, and employees may interact. Many schools are embracing interactive e-learning tools and activities that replace or supplement more traditional teaching methods. However, it is unknown whether a reliance on e-learning may reduce social interaction and opportunity to move in the classroom more than traditional teaching methods. It is also reported that approximately 5.2 million students take at least one online course of any kind [46]. Whether introducing further “screen-time” to a learning environment may be detrimental is not yet known. Although the prevalence of e-learning may reinforce “screen-time”, it may also provide an opportunity to incorporate breaks to sitting time. The structure of the class and how it is delivered could be designed to promote breaks to sitting time (i.e. segmented lectures <30 min). Additionally, students are less exposed to the social norms of the school climate and may feel more comfortable standing or moving while learning. Further research is needed to investigate such causal relationships.

23.1.7 Environmental Factors

At the environmental level, correlates and determinants of sedentary behaviour exhibit a complex and multi-faceted relationship. For example, methods of transport to school and work are directly related to the neighbourhood. Additionally, changing the environment so that it is conducive to standing and moving more has considerable cost implications. A possible solution that is already being adopted in the adult workplace is the installation of sit-stand desks. Microenvironmental features within the workplace are increasingly being recognized as important factors associated with occupational sitting. Local connectivity (i.e. ability to use different routes to travel through a workplace) has been positively associated with more frequent sitting breaks. Visibility of co-workers across a range of office spatial configurations—private-enclosed, shared, and open plan—was positively associated with more frequent breaks from sitting. However, in open-plan spatial configurations, closer proximity to other co-workers was negatively associated with more frequent breaks from sitting [39]. A recent study using proximity sensors and activPAL-derived sedentary time analysed patterns of sitting by workplace locations in UK office buildings [47]. Not surprisingly, the majority of sitting occurred at the employee’s primary desk, with additional sitting occurring at other desks in the workplace. Most sit-to-stand transitions and standing occurred at the employee’s primary desk with additional standing occurring at other desks and in the kitchen area. The vast majority of stepping behaviours occurred in the corridors of the workplace. Environmental changes such as sit-stand desks are also extending to the school community. However, funding such large-scale environmental changes is dependent on support from educational and governmental bodies that extends beyond the provision of traditional resources and is a major challenge for environmental community strategies. Acceptance and understanding the value of such changes is reliant upon successful interventions that demonstrate health and educational benefits.

One of the few studies to examine correlates of child sedentary behaviour other than screen time reported that parents' travel to work and parental attitudes to their child walking to school were strong correlates of children being driven to school [35]. Such factors may indirectly impact the hypothesized innate activity set point (termed the "activitystat") [48]. This theory suggests that children compensate for reduced sedentary behaviour by increasing it at another time point that has no effect on overall sedentary time. Therefore, transport to school (whether active or passive) may influence sedentary behaviour levels throughout the school day both in the classroom and during recess. A report conducted by The National Center for Safe Routes to School (2011) [49] indicated that in the 50-year time period between 1969 and 2009, the number of children aged 5–14 years walking or cycling to school has decreased by 35%. A survey conducted by the Centers for Disease Control and Prevention (2005) [50] indicated that six barriers (distance to school, traffic-related danger, weather, "other" barriers, crime, school policy) prevented parents from allowing their children from walking to school. Distance to school was identified as the primary barrier. There are numerous neighbourhood-based contributing factors to this barrier such as increasing land costs, school siting standards, school funding formulas, existing land use policies, and lack of coordination between planners and school officials. Building schools on the edge of the community became a solution to increased inner city land costs [51]. This has also led to larger schools and larger catchment areas. Traffic danger is reported as the second parental barrier. As communities have accommodated increased motor vehicle traffic volumes, opportunities to walk and cycle have suffered. Many places have no sidewalks, and where they are present, they may be in need of maintenance [49, 50].

Private vehicle use has grown exponentially in the past 50 years. Therefore, the contemporary social norms in the United States and being accustomed to driving have made it easier to avoid active transport. Crime prevalence (both perceived and real) and school policies were also identified as parental barriers to active transport. Whether schools allow children to walk or bike to school and availability of secure bicycle sheds could prevent children from walking or cycling to school. It is important to note that transport to and from school may only be an appending component of overall school-based sedentary behaviour. According to the "activitystat" theory, active transport may in fact increase sedentary behaviour levels during school hours. Alternatively, school policies that encourage active transport may also be more likely to enforce policies that reduce sedentary behaviour throughout the school day. More research is needed to fully understand the relationship between community-level policies and behaviour. Research also suggests that climate conditions may influence sedentary behaviour [52]. A recent review revealed equivocal seasonal effects due to methodological inconsistency [53]. However, another study investigated specific climate correlates such as daily ambient temperature or rainfall. Ambient temperature emerged as a main predictor in all sedentary behaviour models, with lower sedentary behaviour levels being associated with higher ambient temperature levels. Higher ambient temperatures may encourage children and adults to substitute indoor leisure behaviours with other less sedentary outdoor activities. Therefore, seasonality and climate may be considered as an important factor to consider in sedentary behaviour reduction programmes in schools, workplaces, and neighbourhoods. This influence may differ in climate-extreme countries or periods of the year, so cross-cultural comparisons across different seasons are warranted [3].

A majority of the health evidence relating to sedentary behaviour at the community level stems from studies of self-reported TV viewing and relationships with overweight and obesity [16]. Research on sedentary behaviour independent of physical activity and focusing on measures other than screen time is lacking [35]. Similarly, research conducted during school or work hours is largely dominated by the correlates and determinants of physical activity rather than sedentary behaviour [7]. Despite these research gaps, we anticipate that the ongoing paradigm shift will lead to an increase in interventions specifically dedicated to objective measures of sedentary behaviour in school, workplace, and neighbourhood settings [8].

23.2 Community-Level Sedentary Behaviour Interventions

Publications regarding physical activity interventions at the community level are prevalent; however, more recently, interventions focusing on reducing sedentary behaviour are emerging. To demonstrate the evolution of sedentary behaviour research at the community level, we first use the school community as a case example to discuss the varying strategies and outcomes when measuring sedentary behaviour as an indicator of insufficient physical activity levels. We suggest that the evolution of community-level intervention experimental design (illustrated in Fig. 23.2) is a good representation of the paradigm shift towards the focused study of sedentary behaviour independent of physical activity. Finally, we migrate to more recent community interventions that specifically implement sedentary behaviour reduction strategies and have increased in very recent years (Fig. 23.2). For the purpose of the chapter, we do not discuss all interventions listed in Fig. 23.2 in detail but identify them to illustrate the evolution and to facilitate further reading.

23.2.1 Measuring Sedentary Behaviour as an Indicator of Insufficient Physical Activity Levels in Schools

Early research in the school environment primarily focused on measuring sedentary behaviour as an indicator of insufficient physical activity. Traditional methods were implemented, such as adapting the curriculum to include lessons dedicated to increasing physical activity and reducing sedentary behaviour. Findings have proved to be inconsistent. A study conducted by Robinson [54] randomly assigned

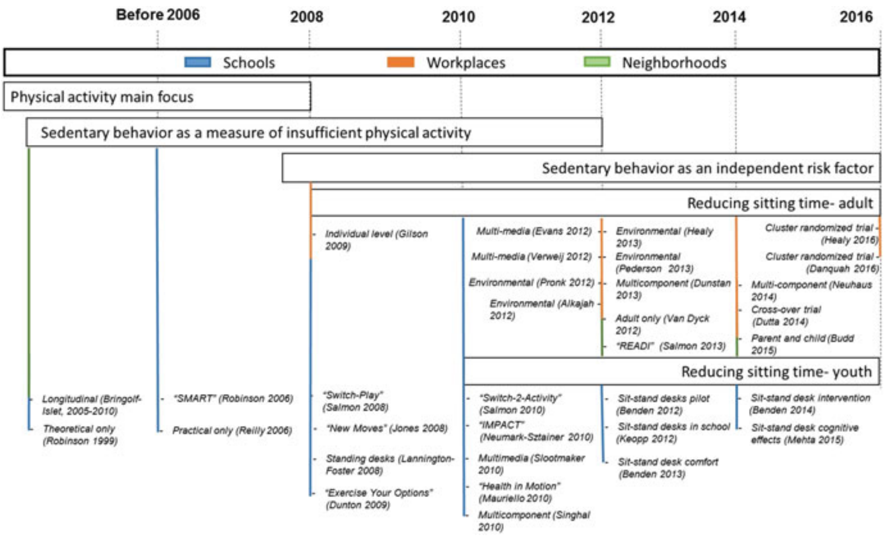

Fig. 23.2 The evolution of sedentary behaviour interventions

third and fourth graders in one of two public elementary schools to receive an 18-lesson, 6-month classroom curriculum to reduce TV, videotape, and video game use, in addition to lessons promoting physical activity. No structured practical lessons (sedentary behaviour or physical activity based) were implemented; all content was delivered via traditional teaching methods in the classroom. The intervention group consisted of 92 children (8.95 ± 0.6 years) vs. 100 children (8.92 ± 0.7 years) in the control group. Overall, reduced levels of TV use were reported (8.80 versus 14.46 h/week); however, no significant changes were reported in video tape and video game use. A subsequent classroom curriculum follow-up study with the same experimental design (Student Media Awareness to Reduce Television—SMART) supported these findings [55]. Children in the treatment group significantly decreased their weekday TV viewing (1.14 vs. 1.96 h/day), weekday video game playing (0.19 vs. 0.52 h/day), and Saturday video game playing (0.31 vs. 0.9 h/day) compared to the control. Greater effects were also detected among boys and adult-supervised children. Although no practical sedentary behaviour techniques were used, we suggest that reinforcement (required for behaviour change) for this experimental design was high due to the regular face-to-face interaction with the teacher, a home device seen daily and the newsletter content that may be reinforced at the parental level.

In contrast, a classroom-based group-randomized trial called "Switch-Play" was delivered to 311 children in grade level 5 [56]. Within three primary schools, classes were randomly assigned to one of four groups: (1) control group, (2) behavioural modification group (BM), (3) fundamental skills group (FMS), and (4) a combined behavioural modification and fundamental skills group

(BM/FMS). In this section, we focus on the BM results. The BM consisted of 19 lessons based upon social cognitive theory [57] and targeted self-monitoring, decision-making, identifying alternative activities, intelligent viewing, and advocacy (via posters and role playing) to reduce TV viewing time [56]. However, compared to the control, the BM group reported higher levels of TV viewing post intervention. As children learned more about TV viewing and how to monitor it, reporting accuracy may have improved over time. This phenomenon is known as a "response shift bias" and suggests that based on learning effects, there is a differential favourable shift in the accuracy of reporting among children in the intervention group compared with those in the control group [58]. To further investigate teaching methods solely reliant on behavioural modification content, Salmon et al. (2011) conducted a follow-up intervention "Switch-2-Activity" [16] based on the BM arm of the "Switch-Play" intervention [56]. This translational study aimed to determine real-world feasibility and efficacy of the BM intervention. A total of 908 children aged between 9 and 12 years were exposed to an abbreviated six-lesson curriculum over a 7-week period, delivered by classroom teachers. Although no significant intervention effects were detected, gender emerged as a significant moderator of the intervention. Small but positive effects on boys' self-reported weekend screen time were shown (20 min difference between arms). No significant effects were detected for girls. Using practical sessions only (with no theoretical teaching) has shown similar low levels of success. A preschool level, 24-week intervention aimed to reduce TV viewing time among 545 Scottish children (aged 4.25 $\pm$ 0.3 years) using practical sessions with no theoretical lessons [59]. The intervention strategy included three blocks of increased activity each week across 24 weeks. Accelerometer data indicated no significant differences in total sedentary time between the intervention and control. It is suggested that although a direct measure of TV viewing may have yielded a different result, the inability to show an intervention effect on overall sedentary time suggests that children may have replaced TV viewing with other sedentary actions [60].

There is a need to consider cohorts within communities based on factors such as age and gender, which may influence the type of strategy and content delivered theoretically and/or practically. Furthermore, age and gender may also be associated with different levels of risk. For example, it is documented that physical activity decreases during adolescence [61] and youth spend a great deal of their time both at home and in school being sedentary [35, 62]. Therefore, interventions that aim to reduce sedentary behaviour and increase physical activity among adolescents in a school-based environment are urgently needed. However, current findings show conflicting results. In a systematic review conducted by Hynynen et al. [17], only four studies that targeted sedentary behaviour in adolescent populations (15–19 year olds) were identified [63–66]. Of the four, only one objectively measured sedentary behaviour via accelerometry [63]. The remaining three utilized measures of TV viewing time [64, 65], board games and tuition classes [65], and the 3-Day Physical Activity Recall (3-DPAR) questionnaire previously mentioned [66]. Although very different in experimental design, both Neumark-Sztainer et al. [66] and Slootmaker et al. [63] reported significant treatment effects. Slootmaker et al. [63] utilized an alternative method of intervention delivery to 87 students (63% female; 15.1 years ± 1.2 years). Rather than conventional teaching methods, an accelerometer and web-based service was used to encourage behaviour change. Using a gadget combined with internet interaction (a popular medium for adolescents) successfully reduced sedentary behaviour levels.

We posit that for the aforementioned research, awareness and consideration of sedentary behaviour as an independent risk factor was still in its infancy and effective strategies were only just emerging (Fig. 23.2). It was not until more recent years that research conducted in adult-based populations reported the importance of changing posture, moving more, and avoiding long periods of sitting [67–70]. Such findings initiated a paradigm shift that primarily identified sedentary behaviour as an independent risk factor to that of insufficient physical activity. Additionally, sedentary behaviours have been reported to track from childhood to adolescence and into adulthood [71], which has further initiated a gradual transition from adult- to youth-based populations. Ultimately, the need to design interventions that target sedentary behaviour as the *primary aim* in school environments has emerged. We discuss this paradigm shift in the following section.

23.2.2 The Emergence of Interventions Targeting Sedentary Behaviour as a Primary Aim

The evolution of school-based intervention experimental design is a clear representation of the paradigm shift currently in effect. As depicted in Fig. 23.2, until recently, school interventions were dominated by increasing physical activity levels and measuring sedentary behaviour as an indicator of insufficient physical activity. Interventions also focused on the ability to reduce sedentary behaviour outside of school hours and measuring TV viewing time. However, following the trend exhibited in the adult workplace, and the need to reduce prolonged periods of sitting, sit-stand desks have emerged as feasible solutions to the sedentary school environment. As a relatively new concept and given the cost implications, completed studies are exploratory in nature and of smaller sample sizes; however, initial results are promising. One of the first studies to implement standing desks (not height adjustable) in a traditional classroom was conducted by Lanningham-Foster [72]. In a three-arm comparison, the researchers aimed to compare an "activity-permissive" environment referred to as the "neighbourhood" and a traditional classroom with standing desks to a traditional classroom. No significant differences were reported between the traditional classroom settings; however, detecting changes in posture to reduce prolonged periods of sitting was not the primary aim. Although sedentary behaviour was emerging as a concern at that time, increasing physical activity was the goal of that study. More recently, a pilot study conducted by Benden et al. [11] monitored nine children (ages 6–8) across two semesters (each semester = 5 months). One semester utilized traditional desks, while the other utilized sit-stand desks in the classroom. The purpose of this study was to determine if a difference existed in energy expenditure within children when using traditional classroom desks compared to sit-stand desks [11]. The results indicated a mean difference of 0.29 kcal ± 0.12 kcal·min^{-1}. Ultimately, this study found a 25.7% increase in average energy expenditure within subjects using a sit-stand desk compared to the traditional desk. In addition, there was a 17.6% increase in steps within subjects with the use of sit-stand desks. Another pilot study investigated the feasibility of sit-stand desks in a school environment among eight children (aged 11.3 ± 0.5 years) [73]. Although a 19% increase in pedometer activity was recorded and no negative behavioural effects were detected in the classroom, results were not statistically significant. Statistical significance may have been detected in a larger sample size, which highlights the need for larger-scale studies. In response to this need, a larger intervention ($N = 374$) was conducted by Benden et al. [74]. The results supported preliminary research and indicated that sit-stand desks elicited a higher mean step count (+1.61 steps/min) compared to the control group. The conclusions drawn from these studies is that giving children the opportunity to stand throughout the school day encourages them to move more which may provide several additional benefits related to increasing energy expenditure levels.

Postural and comfort effects of sit-stand desks have also been documented by Benden et al. [75]. The results indicated no significant differences between traditional desk and sit-stand desk use on evaluated ergonomic support and discomfort. Finally, feasibility and acceptability of sit-stand desks are highly dependent on maintaining an environment that is still conducive to learning and does not inhibit concentration, focus, or cognitive performance. Although exploratory in nature, initial results are promising. Results from the pilot study conducted by Benden et al. (2012), indicated that teachers reported a positive effect on classroom behaviour and focus in those using standing desks. As part of the larger study conducted by Benden et al. [74], neurocognitive effects were also evaluated using a comprehensive battery. Positive effects for reaction times, response times, and error rates were detected [76]. However, the cognitive results were not compared to a control group, reducing the ability to draw conclusions from these findings. Replication of large-scale experimental designs that include cognitive effects as a primary outcome is required.

23.2.3 Workplace Interventions to Reduce Sedentary Behaviour

Individual-level approaches to reduce sitting in the workplace have typically included strategies such as behavioural counselling, use of computer prompts, or use of walking or other physical activity-based interventions. A recent meta-analysis of physical activity-focused interventions to reduce sedentary behaviour concluded a lack of evidence to support the efficacy of these approaches for modifying sedentary time [77]. More specific to the workplace, Gilson et al. [78] conducted a 10-week pedometer-based intervention to increase incidental walking at work in white-collar university employees. Results indicated significant increases in overall steps; however, there was no concurrent reduction in workplace sitting time. The use of computer prompts (i.e. point-of-choice prompts on a computer) has received mixed results. Two short-term studies evaluated the use of computer prompts + standardized information, relative to information alone. Evans et al. (2012), following a brief 10-day intervention, investigated the effects of point-of-choice (PoC) prompting software, on the computer used at work (PC), to reduce long uninterrupted sedentary periods and total sedentary time at work. Results reported non-significant reductions in sitting time but significant reductions in number of 30 min continuous bouts of sitting [79]. Pedersen et al. (2013), which focused on prompts to increase sitting breaks with walking in a longer 13-week intervention, reported significant reductions in sitting time of 55 min per day [80]. Finally, a single study tested the effects of five brief sessions of motivational interviewing by occupational physicians that focused on reducing sedentary time, increasing physical activity, increasing fruit and vegetable consumption, and reducing energy intake from snacks [81]. Significant reductions were observed for sedentary time at work and fruit and vegetable consumption—but not other behavioural targets—at the 6-month follow-up.

23.2.4 Physical Changes to the Workplace Environment

The use of multilevel, ecological approaches to reduce sedentary time is ideal for the workplace given the opportunity for more robust and comprehensive changes to the environment that are possible. The most common environmental approach to reduce occupational sedentary time has been the use of “activity-permissive” workstations (i.e. treadmill desks, pedal desks, height-adjustable workstations). There has been a rapid increase of laboratory- and field-based studies on this topic, with the majority published in the past 10 years. Neuhaus et al. (2014) reported the results of a meta-analysis of 38 studies with a pooled effect size of 77 min reduction in sedentary time/8-h workday [82]. Other health-related outcomes showed no impact. The efficacy of the interventions reviewed was highly variable, and the authors noted large variations in study quality, and the vast majority of the studies only reported short-term outcomes ($\leq$3 months). More recently, Tew et al. (2015) conducted a more exclusive systematic review of controlled trials (both randomized and non-randomized) of the efficacy of height-adjustable workstations only on occupational sitting time. The authors identified five studies, four of which were non-randomized designs [83–86] and one was a crossover trial [87]. All studies included a control condition with no environmental change, and all studies showed significant reductions in occupational sitting relative to control. However, it should be noted that the authors rated all of the studies of low methodological quality with high risk for selection bias (i.e. due to non-randomized designs). Furthermore, a Cochrane review in 2016 [88] reviewed the effects of sit-stand desks and concluded there were significant reductions in total sitting and sitting episodes lasting 30 min or longer. A sit-stand desk alone decreased workplace sitting by about 0.5–2 h per day. When combined with information and counselling, sit-stand desks reduced sitting at work in the same range. Sit-stand desks also reduced total sitting time (both at work and outside work) and the duration of sitting episodes that last 30 min or longer. The preliminary, yet promising, results of these trials suggest studies with randomized designs of longer duration are needed to provide more solid evidence for the use of activity-permissive workstations. A number of these studies are ongoing in Finland, Australia, the United Kingdom, and the United States, with the majority of these studies conducting group-randomized trials of multiple worksites with study durations of 1 year or longer. Two of these studies have recently reported their initial findings. Both studies delivered programmes that targeted individual, social, environmental, and policy factors, alongside the installation of sit-stand workstations, to reduce sedentary time. Danquah et al. [89], in a 3-month intervention among Danish public and private health workers (n worksites = 19; n subjects = 317), observed 48-min/8-h workday reductions relative to a usual practice control. Healy et al. [90], in a 12-month intervention of Australian public health workers (n worksites = 14; n subjects = 231), observed 45-min/8-h workday reductions relative to a usual practice control. These studies provide the strongest evidence for the effect of sit-stand workstations and underscore the value of including environment and policy-level interventions to support their implementation. Additional questions remain with respect to the translation of this approach to a more diverse set of workplace sectors, the sustainability of this approach in the long-term (e.g. beyond 12 months and when intervention is withdrawn), and its impact on cardiometabolic health, healthcare savings, and workplace productivity.

23.2.5 Workplace Policy Approaches

Few studies have explicitly examined the effects of policy-level approaches to reducing occupational sitting time. Policy approaches include formal actions by the organization to change the social or physical environment to support reductions in sitting or increases in walking. These changes might include the formation of walking groups, walking meetings, provision of short breaks, use of standing meeting rooms, or similar efforts. While a number of studies are evaluating the use of multilevel approaches to reducing occupational sitting [91, 92], which may include policy- and organizational-level approaches named above, it is difficult to identify the unique impact these approaches may have on sitting. Gilson et al. [78] conducted a randomized controlled trial testing two approaches—a route-based walking group or an incidental walking group—relative to a control, on steps/day and self-reported occupational sitting. The route-based group was asked to walk briskly on predefined routes during work breaks. The incidental walking group was asked to engage in walking during work through informal means, including the use of standing/walking meetings and walking to talk with co-workers instead of sending emails or making telephone calls. Both intervention groups, during the 10-week intervention, increased overall step count/day while control decreased. Self-reported occupational sitting showed very small and non-significant reductions during the intervention period. There is a need for more formal studies testing the unique and combined effects of policy-level approaches to reducing occupational sitting.

23.2.6 Observational Studies of the Neighbourhood Environment and Sedentary Behaviour

Bringolf-Isler et al. [93] examined the association between the objectively assessed built and social environments of neighbourhoods and physical activity and sedentary behaviour of 1742 children between the ages of 4 and 17 years in Switzerland. Data were pooled from seven studies conducted between 2005 and 2010. Physical activity and inactivity was assessed by accelerometers and each child's home address was linked to the objective environmental data. The amount of green space around the child's home, expressed as hectares of parks, playgrounds, and meadows, was inversely associated with sedentary time and positively associated with total physical activity, with adjustment in the model for the confounding effects of age, sex, season of data collection, accelerometer wear time, and all other neighbourhood attributes under investigation. While "building density" was also positively associated with physical activity, its inverse association with sedentary behaviour did not reach statistical significance. Several other neighbourhood characteristics examined in these studies did not appear to have a significant independent association with physical activity or sedentary time, including main street density, population density, intersection density, mixed land use, woods, schoolchildren density, and socio-economic neighbourhood position. A limitation of the analysis was that physical activity and sedentary time did not appear to be included together in the same model.

Aside from objectively measured neighbourhood characteristics, perceptions of the environment may influence sedentary behaviour. The Resilience for Eating and Activity Despite Inequality (READI) study examined the perceived home and neighbourhood environment in association with children's activity and sedentary behaviour in urban and rural areas of Australia [94]; 613 children and their mothers were included in the study. Physical activity and sedentary time were objectively assessed with the Actigraph accelerometer. Urban/rural location moderated the associations between having a strong perceived neighbourhood social network and road safety concerns with children's screen time. As neighbourhood social network perception increased, screen time increased for urban children but decreased for rural children. The opposite was true for neighbourhood road safety concerns, which had a positive association with the rural children's screen time but inverse for the urban children's screen time. Very similar results for total sedentary time were observed for neighbourhood road safety concerns. These findings, along with others in this study, are important for understanding differences in how perceptions of the environment can influence physical activity and sedentary behaviour differentially between urban and rural settings, which may be particularly helpful in planning interventions or influencing policy.

While the READI study just discussed was aimed at urban vs. rural differences, a study by Budd et al. [95] hypothesized that race may modify the association between parental perceptions of the neighbourhood and children's physical activity behaviour. This study included 196 parents in St. Louis, Missouri, USA. Data were collected by a mailed survey. Among white parents, but not among non-white parents, the perception that drivers exceed speed limits was a positive predictor of children's sedentary behaviour time. On the other hand, only among non-white parents was perceived neighbourhood crime rate a positive predictor of children's sedentary behaviour time. It would appear that race, and also urban vs. rural neighbourhoods, as we learned from the READI study, are important fixed characteristics that need to be taken into account in further research in this area.

Another study of perceived neighbourhood environmental characteristics included sedentary behaviour of adults in the United States, Australia, and Belgium [96]. Across all regions, 6014 adults were recruited from high- and low-walkability neighbourhoods and high- and low-income neighbourhoods. Thus, this project had a great deal of diversity in geography, infrastructure, and socio-economic factors. Transport-related sitting and total time spent sitting were assessed with the International Physical Activity Questionnaire (IPAQ), while environmental perceptions came from the Neighbourhood Environmental Walkability Scale. Motorized transportation time, one measure of sedentary time, was predicted (inversely) by an index including number of destinations with a 20-min walk of home, perception of few cul-de-sacs, good walking and cycling facilities, and traffic safety. Perceived aesthetics and proximity of destinations had an inverse association with total sitting time. No clear differences emerged between men and women or, interestingly, across countries.

Heterogeneity of results for sedentary behaviour reduction strategies at the community level is prevalent and continues to inhibit our understanding. Although insightful results are presented in earlier interventions, a fundamental component missing is demonstrating how to practically reduce sedentary behaviour by simply "standing and moving more". Tackling this both theoretically and practically has now become the new challenge. The lack of environment-level techniques may be related to financial resources and difficulty to implement change at a macro level. Initiating major changes in the school's physical environment without efficacious evidence may be considered too risky and costly [17]. Understanding the costs related to recruitment and implementation of an intervention and its potential cost-effectiveness are important aspects to consider to determine how best to utilize the often-limited resources that are available in community or school settings [97]. It should be considered that not all the interventions discussed in this review are feasible in practice given the typical time and budgetary constraints. Similarly, this is not an exhaustive list but is instead designed to demonstrate the evolution of sedentary behaviour interventions. Nonetheless, these findings provide a starting point to reduce sedentary time at the community level.

23.3 The Role of Communication Technologies and the Media in Decreasing Sitting Time

Technological advances have enabled effective, motivational applications for monitoring sedentary time, causing behaviour change techniques (BCTs) to evolve. Contemporary elements of BCTs include self-monitoring, feedback, and social support [98] and are now used in several forms, such as activity monitors, web-based applications, and mobile phones [99]. With the abundance of technological strategies, there has been a shift from face-to-face interventions towards multicomponent interventions to reduce sedentary behaviour using self-monitoring devices, web-based support, and sophisticated mobile media [100]. Self-monitoring is rapidly becoming a popular and effective method for reducing sedentary behaviour due to the associated portability, cost-effectiveness, convenience, accessibility, and sense of user control [101]. As a result, we have seen a burgeoning industry for accelerometer-based wearable activity monitors [102], online support platforms, online feedback platforms, and mobile apps targeting the consumer market [103]. These platforms vary in medium (wrist-worn device, phone, email), delivery (textual, visual, sound, vibration), and content (personalized, generic, short, long, motivational, educational, feedback), but all aim to reduce sedentary behaviour.

23.3.1 Electronic Activity Monitors

The most prevalent of self-monitoring technologies are electronic activity monitors (EAMs), more commonly known as “fitness trackers”, such as those manufactured by Garmin [Garmin Ltd., Canton of Schaffhausen, Switzerland], Jawbone [Jawbone, San Francisco, CA, USA], Nike [Nike, Inc., Beaverton, OR, USA], Fitbit [Fitbit, San Francisco, CA, USA], and Gruve [Gruve Technologies, Inc., Anoka, MN, USA]. Although originally designed to track physical activity and energy expenditure, increased awareness regarding the detrimental effects of sedentary behaviour (or sitting too much) has generated a new set of user requirements that the industry is pursuing. More specifically, in addition to physical activity data, these devices now include feedback features to communicate information related to sedentary behaviour. Commercially available EAMs are growing in popularity, with an estimated 3.3 million units sold in 2014 [99]. Based on the growth rates recorded in 2014 [104], it is anticipated that almost 60 million fitness trackers will be in use by 2018, and the smartwatch category will become the most-worn wearable device. EAMs can now objectively measure physical activity and periods of inactivity and provide feedback, beyond the display of basic activity count information, via the monitor display or through a partnering application to elicit continual self-monitoring of activity behaviour [99]. Feedback strategies include simplistic prompts that serve as a "reminder" to stand up or move at a set time and frequency (Table 23.1). More sophisticated devices are able to detect periods of uninterrupted sitting and serve as an "alert" to communicate to the user that they have been sitting too long (Table 23.1). Users may receive the alert or prompt using vibration, sound, or visual feedback to instruct the user to stand or move. It should be noted that the vast majority of these consumer-based devices—with the exception of Lumoback (Lumo Bodytech, Inc., Mountain View, CA, USA)—currently rely on movement-based algorithms and not postural inclinometers. This technical consideration may limit their utility for reducing sitting behaviours.

There is supporting data to show that EAMs may be an effective tool to reduce sedentary behaviour. A recent study conducted by Barwais et al. (2015) evaluated the effectiveness of wearing a commercially available EAM [Gruve, Gruve Technologies, Inc., Anoka, MN, USA] for 4 weeks. The multidimensional behavioural intervention utilized an online personal activity monitor with a built-in vibrating function to notify the user when they had been sedentary for longer than the set threshold. The reminder to stand up and move provided a helpful prompt for behaviour change and to achieve the set goals. The online software enabled participants to visualize sedentary patterns with simple 24 h/day graphs and charts. Motivational support was provided via a personalized homepage and goal setting based on baseline results. The results indicated a 33% reduction in sedentary time (3.1 h/day) at the end of the 4-week intervention (6.3 ± 0.8 h/day) compared to baseline (9.4 ± 1.1 h/day). Another 4-week intervention assessed breaking up prolonged periods of sedentary behaviour time with brief physical activity breaks (e.g. walking). Thirty overweight and obese adults were regularly prompted via an Android smartphone [105]. Results indicated that the smartphone-based intervention reduced sedentary time by 2 h/day from the average 9.8 h/day. A study involving overweight and obese office workers examined the feasibility of reducing the amount of time spent in sedentary activities by using targeted messages. These targeted messages contained information about potential health risks associated with sedentary behaviours and recommended they replace time spent in sedentary activities with standing and light-intensity activity [106]. Time spent in sedentary activities was measured using wearable monitors and self-reporting tools. The findings showed that participants reduced the amount of time they spent in sedentary activities by 48 min/day over a 16-h waking day [106]. These results suggest that EAM use may be an effective sedentary behaviour reduction strategy; however, the longevity of the effects is still unknown.

Table 23.1 Technology designed to reduce sedentary behaviour available at the consumer level

Electronic activity monitors (EAMs)				
Platform	Detects inactivity	Period of inactivity	Type of alert	Feedback
Garmin vivosmart	Yes	1 h	Vibration and alert	Numerical display on the device
Garmin vivofit	Yes	1 h	Alert and visual display	Real-time "move bar" display to show how long you have been inactive
Jawbone UP/UP24	Yes	Can manually set the period as "idle alert"	Vibration	No display, pairs with app and mobile device
Apple watch	Yes	At least 1 min each hour	Tap on the wrist and a notification	Has display and user interface. Goal setting—set number of hours to stand per day (default 12). Feedback graph to show hours you missed
iFit Active	No	Manually set inactivity interval	Vibration	Syncs via Bluetooth to iFit app
Nike Fuelband	Yes	At least 5 min each hour	Move reminder visually flashes at 45 and 50 min of inactivity	Links with iOS app, send reminder to mobile device. If you move at least 5 min that hour, you "win the hour". Can see how many hours you "won" by the end of the day
Fitbit Surge	No	N/A	Visual display to show your inactivity but no "move" reminders	Continual visual feedback
Fitbit Zip	No	Manually set inactivity interval	Vibrating alarm, must be manually set by the user	No objective inactivity feedback
MUVE Gruve	Yes	From 45 to 90 min	Vibrates	Display changes colour based on progress, but data must be uploaded via a USB cable
Mobile apps				
Platform	Detects inactivity	Period of inactivity	Type of alert	Feedback
Move More app	No	Manually set inactivity interval and alerts	Tap the app to record data—e.g. sitting and log it	Graphical User Interface. Links with iPhone or iPad. Serves aa a log not a sensor
Break Time app	No	Manually set inactivity interval and alerts	Alert only	For iOS and Mac. Serves as an alert system, does not provide feedback or GUI

(continued)

Table 23.1 (continued)

Electronic activity monitors (EAMs)				
Platform	Detects inactivity	Period of inactivity	Type of alert	Feedback
Get Moving app	Yes	Manually set inactivity interval and alerts	Customizable alerts of your mobile phone	Tracks as a pedometer, the clock starts when inactivity is detected. Provides weekly summaries on how long you were inactive, where and when
Email and software				
Platform	Detects inactivity	Period of inactivity	Type of alert	Feedback
Point-of-choice software (Evans 2012) [79]	No	Reminder sent every 30 min	Simple reminder	Does not provide objective "sitting time" feedback
Email	No	Daily, weekly, biweekly	Motivational, educational	Varied—may provide feedback on the number of times a user read or viewed email. Does not provide objective "sitting time" feedback

23.3.2 Mobile Apps

Currently 90% of Americans own a cell phone, of which 64% own a smartphone [107]. The features and functions of a cell phone have long surpassed that of telecommunication alone. The advent of mobile communication technologies has thus created a vast potential for collecting and delivering time and context sensitive sedentary behaviour information [103]. The ability to collect and deliver "just-in-time" information and the advances in built-in smartphone activity sensors (i.e. accelerometers) have seen an explosion in mobile applications—"apps" geared towards reducing sedentary behaviour [103]. A recent study compared three different apps (analytic, social, and affect apps) designed to reduce sedentary behaviour [103]. Distinct elements of each were as follows: *analytic app*, user-specific goal setting; *social app*, avatars representing other participants allowing for comparison; and *affect app*, an avatar used to reflect how active/sedentary the user was. A reduction in sedentary behaviour was achieved using all three apps; however, the *affect app* was least effective. Understanding why and when such interventions are effective is reliant on systematic user-centred experimental studies.

23.3.3 Email and Software

Email- and software-based strategies designed to alert and prompt users to avoid prolonged sitting are most applicable to the workplace environment. The prevalence of desk-bound work has unveiled an opportune setting for sedentary behaviour interventions [21]. Email strategies can be tailored to provide motivational and educational support that exploits habitual email interaction. Software lends itself more to regular reminders [79]. Email-based strategies show inconsistent results. An intervention to reduce sedentary behaviour among obese women utilized face-to-face sessions combined with email messages and pedometer information for informed self-evaluation and goal setting. Significant decreases in sedentary time were reported [108]. Kaiser researchers also conducted a 16-week trial of the A Lifestyle Intervention Via Email (ALIVE) programme on 787 employees, 351 of them in the email intervention group and 436 in a control group. All participants took a short, online questionnaire at the beginning of the study and received immediate feedback on their diet and exercise habits. Participants in the intervention group set small health-improvement goals for themselves. Once per week, they received an email containing individualized suggestions on ways to get closer to that goal. Each email contained a link to a Web site where participants could get extra tips, learn more, and track their progress. In addition to weekly suggestions, participants also received reminder emails. According to the survey completed post intervention and during a follow-up 4 months later, the people in the email intervention group had increased their activity-level intake more than those in the control group. However, a study recently conducted by Bort-Ruig et al. [100] indicated that in the workplace environment, email-only strategies were not effective. As previously mentioned, the workplace intervention conducted by Evans et al. [79] indicated that point-of-choice prompting software on work computers that recommended breaks from sitting in addition to education was superior to education alone in reducing long uninterrupted sedentary periods at work [79]. This suggests that multicomponent strategies are most effective. Combining both reminders with educational support (via email) is required to educate but also prompt the user. Although wrist-worn devices, mobile platforms and apps, and software/email support may each show some individual promise, research suggests that multicomponent strategies are more effective than single component [109]. This may prove particularly key for long-term interventions as the user progresses through various stages of behaviour change [110]. It would therefore be prudent to examine the health benefits of decreases in the amount of time spent in sedentary activities in a longitudinal study comparing various multicomponent strategies.

23.3.4 The Role of the Media

The Center for Disease Control recently affirmed the influential role that the media can play in health behaviours [111]. Commercial marketing principles of combining mass media with product distribution were well established long before their adoption into the public health domain [112]. Over time, refinement of communication theories and campaign strategies and their application to an extensive range of health behaviours have led to more sophisticated campaigns. A systematic review indicated that combining mass media health communication campaigns with distribution of health-related products related to the behaviour is likely to be effective in influencing the intended health behaviours [111]. Health communication campaigns apply integrated strategies to deliver messages designed to inform, influence, and persuade target audiences' attitudes about changing or maintaining healthful behaviours [113]. Messages can be transmitted through a variety of channels, such as traditional mass media (e.g. TV, radio, newspapers), the internet and social media (e.g. websites, Facebook, Twitter), small media [114] (e.g. brochures, posters, fliers), group interactions (e.g. workshops, community forums), and one-on-one interactions (e.g. hotline counselling) [115].

Media coverage on the topic of sedentary behaviour is rising rapidly. News networks, newspapers, and online media are now discussing the independent effects of sedentary behaviour to that of physical activity. To gauge the evolution of sedentary behaviour as a media concern, we ran a systematic, advanced Google search using the exact phrase "negative effects of sitting". The search dates were restricted to each individual year from 2005 to 2015. The total number of results found and the total "news" results found per year were documented and are presented in Fig. 23.3. In the last 10 years, the number of online news articles on "the negative effects of sitting" has increased from just 1 in 2005 to 81 in 2015. Overall results (websites, news articles, blogs, images, videos) show an increase from 2 to 913 search results with content denoting the "negative effects of sitting". Although a simplistic technique, the results clearly show how the detrimental effects of sedentary behaviour are now being reported more commonly. As this trend continues, the opportunity to design multicomponent interventions is

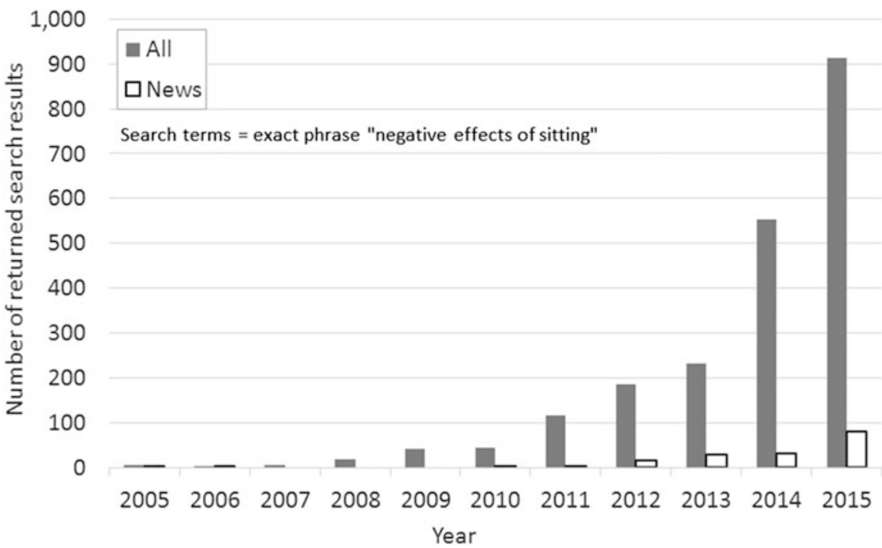

Fig. 23.3 The evolution of media coverage on sedentary behaviour interventions

pertinent. In particular, the continued rise of social media as a communicative platform also lends itself well to health interventions and creating awareness. According to a new eMarketer report, “Worldwide Social Network Users: 2013 Forecast and Comparative Estimates”, nearly one in four people worldwide will use social networks in 2013 [116]. The number of social network users around the world will rise from 1.47 billion in 2012 to 1.73 billion this year (an 18% increase). By 2017, the global social network audience will total 2.55 billion. We suggest that rather than being considered a barrier, it instead poses an opportunity to harness the reach and effectiveness of social media as a tool to communicate the detriments of sedentary behaviour to the abundant target audience. Such high levels of social media interaction may instead provide the most opportune platform for intervention strategies and employment of prompts/alerts.

The combination of public awareness, mass media reach, interaction with people who may be employing sedentary behaviour reduction strategies and/or actively using devices to track their sedentary behaviour may have a substantial and influential effect on behaviour. It is suggested that as awareness regarding sedentary behaviour as an independent risk factor continues to grow, mass media campaigns with a strong social media focus should be employed to strengthen intervention strategies that aim for long-term behavioural change. Development of new health communication and social marketing campaigns and programmes could play an important role in reducing sedentary behaviours. Health-related behaviours are determined by an interplay of personal, behavioural, and environmental factors. Given the unique attributes of sedentary behaviour (e.g. ubiquitous, habitual, socially reinforced), understanding the factors that underpin sedentary behaviour is critical and is a required step to effectively design interventions to reduce sedentary behaviour. Applying advanced user-centred design approaches to deliver “just-in-time” prompts and interventions to reduce sedentary behaviour should be a primary concern to industries when designing devices and supporting communicative platforms. Future work should focus on assessing “in the moment” contextual factors related to sedentary behaviour. Such findings would provide a basis for developing devices that detect the ecological conditions that coincide with or predict sedentary behaviour. Long-term interventions are also needed to determine how strategies perform over extended periods of time. Chronic effect results would provide invaluable data regarding how adaptive the technology may need to be to withstand likely fluctuations in user interest over time.

23.4 Organizations Promoting Health Behaviour

Changing attitudes and behaviours is reliant upon organizational research, funding, and support at local, national, and international levels. Governing bodies and policymakers that influence health, education, and welfare each provide the most influential platform for population change and therefore need to understand and communicate the importance of sedentary behaviour. We discuss those that may impact policies and understanding that may be disseminated at the community level. Ultimately, these include research institutions, health, welfare, and neighbourhood organizations.

23.4.1 Research Institutions

There is a broad research agenda that must be pursued by research institutions, including understanding the unique and shared contribution of sedentary behaviour on health outcomes and developing effective strategies to reduce sedentary behaviour in various subgroups and contexts. Research institutions must endeavour to pursue translational research in real-world settings to design interventions that have scalable public health impact. Research in the behavioural science field must aim to be both “contextual” and “practical” [117]. Worksites, schools, and neighbourhoods pose numerous challenges within different contexts—environmental, organizational, social, and cultural. The research purpose and design must be applicable to the context for which it is intended to ensure that it is both practical and effective. Collaboration between institutions is crucial to conducting such large-scale, impactful studies and may be facilitated by organizations such as the Sedentary Behaviour Research Network (SBRN). The SBRN is the only organization for researchers and health professionals that focuses specifically on the health impact of sedentary behaviour. SBRN’s mission is to connect sedentary behaviour researchers and health professionals working in all fields of study and to disseminate this research to the academic community and to the public at large. Continuing to develop such powerful networks will broaden understanding and outreach across organizations and communities.

23.4.2 Funding Organizations

Funding organizations such as the National Institutes of Health (NIH) have the power to dictate the type of research that can be conducted and therefore are major influencers in promoting health. Findings can shape government recommendations that may directly or indirectly facilitate changes in public health. By leveraging current knowledge and growing momentum, funding organizations such as the NIH should continue to provide access to small- and large-scale funding that aims to establish preventative measures particularly in high-risk populations. Increased awareness and adoption of preventative measures hinges upon the strategies that have demonstrated feasibility, efficacy, and effectiveness. Considering the real-world barriers is vital to future studies. Funding organizations such as the NIH must continue to fund longitudinal experimental designs that tackle “real-world” settings in order to truly impact public health.

23.4.3 Health Organizations

One of the most notable health organizations with an extensive reach and influence in all aspects of health is the World Health Organization (WHO). The WHO is a specialized agency of the United Nations (UN) that is concerned with international public health. In an effort to increase awareness regarding sedentary behaviour, they have formed and funded several collaborative programmes. At the school level, Health Behaviour in School-aged Children (HBSC) was formed as part of a WHO initiative. This is a cross-national, school-based research study to collect information on health-related attitudes and behaviours of young people. These studies are based on nationally independent surveys in as many as 30 participating countries and are conducted every 4 years since the 1985–1986 school year. With the emergence of sedentary behaviour as an independent risk factor, sedentary behaviours are now included in the survey battery. This not only aids research understanding, but it reinforces the importance of monitoring sedentary behaviour in the target population. Such findings may inform future research directions to ultimately support more efficacious strategies to reduce the associated risks of sedentary behaviour and may lead to policy changes at a national level. For example, in Finland, recent national recommendations on the reduction of sedentary time explicitly identified schools as one of the key influential settings [17]. Similarly, in 2011, the Canadian Society for Exercise Psychology revised the Physical Activity and Sedentary Behaviour Guidelines for children (5–11 years of age) and youth (12–17 years of age) and in 2012 released the first guidelines for younger children (0–4 years of age) [118, 119]. The WHO has the ability to reach an expansive population. Ensuring that scientific research is communicated effectively and appropriately should be a main focus. Working with funding organizations to prioritize and define issues of major public health concern is crucial. Transferring intervention effects to the real-world setting is the only way public health will be positively impacted.

23.4.4 Health Coalitions

Coalitions are aptly defined as an "organization of individuals representing diverse organizations, factions or constituencies who agree to work together in order to achieve a common goal" [120]. For example, collaboration between HealthPartners and Ergotron facilitated the occupational sitting "Take-a-Stand" project (2011) [91]. Such collaborative relationships across academia and industry enable the pooling of resources, expertise, and funding. Reducing sedentary behaviour on a global scale is reliant upon the continued growth and development of coalitions that merge different areas of expertise and access to populations. The number of funded community health projects that rely on coalitions represents a considerable investment of resources. There are opportunities to gain research efficiencies by leveraging existing epidemiologic cohorts and health systems. Health systems can provide an excellent setting for pragmatic trials and observational studies examining relationships of sedentary behaviour with health outcomes, health costs, and utilization [121].

23.5 Evaluation of Community-Based Interventions

Overall, it is clear that addressing the correlates of sedentary behaviour at the community level may be one method to slow the significant impact of sedentary behaviour on both child and adult health. By identifying socio-demographic correlates of work-time, school-time, and leisure-time sedentary behaviour, higher-risk subpopulations may be identified. Community-level interventions provide access to large numbers of adults and children from differing backgrounds, varied social, economic, or ethnic minority families. Therefore, they have the potential to have an extensive impact on public health.

While demographic, psychosocial, and environmental correlates of occupational sitting are emerging and provide potential insight into key intervention strategies, there are a number of limitations worth noting. First, the vast majority of studies continue to rely on self-reported sitting. Since context of sitting remains challenging to sense with an objective monitor, and many cross-sectional studies rely on retrospective recall in large samples, this will likely continue to be a key limitation to future studies. Second, most studies report an under-specified set of demographic, psychosocial, and micro- and macro-environmental factors to understand the unique contribution of each level of the social ecological spectrum of potential influences on sedentary behaviour. For example, notably lacking in the reviewed workplace studies (with the exception of Duncan et al. [39]) was careful documentation of micro-level environmental features, such as office spatial configurations as well as worksite policy and social determinants (e.g. implantation of standing/walking meetings, cohesion in the workplace). Furthermore, the vast majority of recent studies reviewed have focused on either Australian or UK samples of desk-based employees. These samples may not be generalizable to other developed or developing countries as school and work practices are likely to differ substantially from one country to another. Future community-level interventions should focus on the direct impact of sedentary behaviour during school and work hours and investigate specific sedentary activities (rather than screen time) in relation to gender, grade level, occupation, location, public vs. private schooling, worksite leadership, and teaching strategies. Future interventions must focus on multilevel approaches that unify various local coalitions and influence health, education, welfare, and government policies. Initial results indicate that both objectively measured neighbourhood characteristics as well as individual perceptions of characteristics appear to be important. Furthermore, findings may differ depending on socio-economic status, race, and urban vs. rural settings. These observational studies are critical to inform the design of interventions and policies.

Across multiple settings, it is still largely unknown how dose and frequency of breaks to sitting time may reduce the potential negative effects of prolonged sedentary periods. Understanding the dose-effect relationships at community levels is crucial to intervention success and will inform future national and international guidelines around sedentary behaviour. Such findings also may improve the feasibility and acceptability of community-based interventions which face more complex organizational, socio-economic, cultural, and political barriers. It is also important to note that individual-level factors influencing sedentary behaviour and intervention success may become more or less effective at the community levels due to a number of other influencing factors. For example, age may not play a significant role at the individual level; however, in a school environment, correlates and determinants may differ based on grade level. Such knowledge may help develop more efficacious strategies. Overall, at the community level, there is a predominance of cross-sectional studies, which may inhibit the determination of causality between variables. More randomized controlled trials should be conducted to confirm deleterious effects attributed to some sedentary behaviours. Future epidemiologic studies need to assess multiple sedentary behaviours as there is growing epidemiologic evidence that certain sedentary activities are more detrimental for health than others. To increase the current knowledge of sedentary behaviour, future studies must incorporate emergent objective and more accurate methods (i.e. geolocation data combined with acceleration signals in mobile phones, small video cameras, and inclinometers) to obtain an accurate measure and contextual information of sedentary behaviour [122]. Finally, in contrast to early research, physical activity should be measured as a confounding and/or interactive factor in all experimental designs.

23.6 Summary

The "drivers" of sedentary behaviour include both elements of conscious decision-making and habitual responses cued or required by public policy. Thus, interventions should take advantage of changes in the built and social environments, the use of social networks, and the promotion of relevant public policy changes that are all accessible at the community level [123]. The acceleration of new and innovative technology also presents a need to determine how new technologies can be integrated with principles of behavioural science to reduce sedentary behaviour at the community level. The ability to track sedentary behaviour and communicate it to the user is a potential effective sedentary behaviour reduction strategy. The magnitude of chronic effects and how to optimize the design in various environments and contexts is still unknown. The technological capability to alert or remind the user to stand or move is no longer a novel feat. However, understanding the underlying contexts of sedentary behaviour to determine when and how to use prompts effectively continues to be a challenge. Technology industries and researchers alike must now generate context-driven approaches that consider both opportunity and receptivity of the user to optimize intervention strategies. Integrating behavioural science theory with an iterative user-oriented design process is needed to optimize multicomponent strategies that can adapt over time. Conversely, identifying strategies associated with less promising interventions can ensure that intervention designers do not devote time and resources to developing unhelpful strategies. Advances in technology should be utilized at multiple intervention levels to accommodate the determinants of sedentary behaviour across the life course.

There is a need to evaluate the feasibility, acceptability, and effectiveness of different sedentary reduction strategies across the life course. The power of qualitative information must not be overlooked as it is vital in understanding causes of excessive sedentary behaviour. Such information is needed to help researchers understand community barriers, beliefs, attitudes, and acceptability of different intervention and measurement approaches. Sedentary behaviour is a complex epidemic with various contributing factors at multiple levels. Although conclusive evidence is lacking, it is suggested that multilevel approaches that include individual, community, and organizational levels, across and within different settings, will produce longer-lasting results [97]. Ultimately, a combined effort of strategies that target sedentary behaviour as an independent risk factor, across multiple settings, such as schools, workplaces, and local neighbourhoods, is required.

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