Chapter

Sedentary Behaviour: Definition, Determinants, Impacts on Health, and Current Recommendations

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Abstract

This chapter aims to present an overview of the scientific background and current recommendations for sedentary behaviour. We have presented the current sedentary behaviour definition and defined other terms related to sedentary behaviour. The determinants of sedentary behaviour were discussed, and the ecological model was presented. Based on the recent data from the literature, the relationship between sedentary behaviour and health indicators was presented and discussed. Finally, we discussed the recommendation regarding sedentary behaviour, and presented the daily guidelines involving physical activity, sedentary behaviour, and sleep routine.

Keywords: sedentary behaviour definition, physically inactive, health outcomes, sedentary behaviour determinants, 24-hour guidelines

1. Introduction

Sedentary behaviour (SB) is a health risk independent of age, population, sex, or clinical condition [1, 2]. Evidence highlights a negative association of prolonged sedentary time, and patterns of sedentary time, with cardio-metabolic risk biomarkers and health outcomes [1, 3]. However, studies in recent years have presented inconsistency related to the sedentary behaviour definition. This has made some difficulties for studies in the field itself [4]. This chapter clarifies SB definition based on the information from the Sedentary Behaviour Research Network (SBRN).

A comprehensive research agenda on SB also includes measurement studies, and evaluating the outcomes of environmental and policy initiatives. The conceptual basis for these studies includes an ecological model of behavioural determinants [5]. These models recognise how individual behaviours are affected by environmental and policy factors [5]. This conceptualisation of SB leads to explicit consideration of multiple complex levels of influence, such as: intrapersonal (biological, psychological), interpersonal (social, cultural), organisational, community, and physical environment.

This chapter aims to contribute to the existing evidence, and to clarify and discuss the following important aspects of SB: the current definition, the definition of related terms, the determinants of SB, the relationship between SB and health outcomes, and the current guidelines worldwide regarding SB. We expect to

contribute to public health initiatives designed to develop more feasible interventions that focus on diminishing SB among all age groups.

2. Definition of sedentary behaviour

Society has encountered rapid and significant physical, economic, and social environment changes, leading to increased inactivity among individuals in the workplace, in transportation, in communication, and at home. These changes have had significant negative consequences on health-related behaviours.

The study of sedentary behaviour (SB) started with a study by Morris and colleagues in 1953. They investigated bus drivers and desk-bound workers in the United Kingdom, concluding that those who were more active presented significantly reduced cardiovascular disease risk than those who were less active [6]. Although these findings refer to the level of physical activity (PA), it can be speculated that SB was also a relevant factor that should have been assessed [7].

As interest in SB research has increased, what has emerged is a lack of consistency and agreement in SB, as well as the definition of related terms. Over the past few decades, the term "sedentary" has been used in different ways (e.g., to define those who do little or no PA, or those who do not fulfil the PA guidelines) [8]. The SB definition has been based on two aspects: postural and energy expenditure. SB has been generally defined as the time spent in a sitting or reclining posture. This definition stems from the Latin origin of the word sedentary, *sedere* (to sit). From the energy expenditure aspect, SB is usually defined as the time spent in any waking behaviour that requires low levels of energy expenditure (e.g. ≤1.5 METs).

Although postural and energy expenditure aspects are crucial to determine SB, research in this field typically includes only one of these components. One of the reasons is related to the methods used to measure SB. Assessment methods of SB include subjective and objective measurements, each one providing different information. Studies analysing SB from the postural aspect usually employ questionnaires, direct observation, or inclinometers, The energy expenditure aspect is commonly estimated indirectly by accelerometry. In contrast with these aspects, many studies described their participants as sedentary when they did not achieve a recommended amount of PA. The variety of measurement methods, and conflicting definitions of SB, has generated misunderstanding, making it difficult to not only compare studies, but also to understand the real impact of SB on health outcomes. Consequently, researchers have begun to call for clearer and more precise definitions and measurements [9].

To prevent contradiction and consternation, in 2012, the Sedentary Behaviour Research Network (SBRN), an organisation of researchers and health professionals, published a letter to define the differences between "sedentary behaviour" and "physical inactivity" [10]. In this first consensus publication, the SBRN suggested that SB should be defined "*as any waking behaviour characterised by an energy expenditure ≤ 1.5 metabolic equivalents (METs), while in a sitting or reclining posture*" [10]. This definition included both postural (sitting or reclining), and energy expenditure (<1.5 METS) aspects. In addition, the term "inactive" should be used to describe those who "*...are performing insufficient amounts of moderate to vigorous PA (i.e. not meeting specified PA guidelines)"* [10]. According to these terms, a person can be active when meeting PA guidelines, but also spend a large amount of their day in SB.

The distinction between SB and physical inactivity terms has provided important progress on the SB field. However, there remains a need to refine, and establish a consensus for, various other SB terms (e.g., screen time, sedentary behaviour pattern, bouts, and breaks). Moreover, some terms were considered inappropriate when

applied to different age categories (e.g. infants, before learning to sit and stand) or populations with different physical capacities (e.g. people with mobility impairment). In this context, the SBRN developed a project to provide a consensus definition for terms related to SB research for all age groups and all physical abilities. The results were published in 2017 [4] and define several concepts related to SB.

Sedentary behaviour. General population: Any waking behaviour characterised by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining, or lying posture [10]. Infants (<1 year or pre-walking): Any waking behaviour characterised by low energy expenditure while restrained or when calm. Time spent in the prone position ("tummy time") is not considered a sedentary exposure.

Sedentary time. The time spent for any duration or in any context in sedentary behaviours.
Sedentary bout. A period of uninterrupted sedentary time.
Sedentary interruptions/breaks. A non-sedentary bout in between two sedentary bouts.

Physical inactivity. Insufficient PA level to meet present PA recommendations [11, 12].

Stationary behaviour. Any waking behaviour performed while lying, reclining, sitting, or standing, with no ambulation, irrespective of energy expenditure. This definition applies to all age and ability groups except infants.

Stationary time. The time spent in stationary behaviours.
Stationary bout. A period of uninterrupted stationary time.
Stationary interruptions/breaks. A non-stationary bout in between two stationary bouts.

Standing, A position in which one has or is maintaining an upright position while supported by one's feet.

Active standing. Any activity in a standing posture characterised by an energy expenditure >2.0 METs, while standing without ambulation, whether supported or unsupported.
Passive standing. Any standing position without ambulation characterised by an energy expenditure ≤2.0 METs.
Standing time. The time spent for any duration or in any context while standing.
Standing bout. A period of uninterrupted time while standing.
Standing breaks. A non-standing bout in between two standing bouts.

Screen Time. Time spent on screen-based behaviours [13, 14]. These behaviours can be performed while being sedentary or physically active.

Recreational screen time. Time spent in screen behaviours that are not related to school or work [15].
Stationary screen time. Time spent using a screen-based device while being stationary in any context.
Sedentary screen time. Time spent using a screen-based device while being sedentary in any context.
Active screen time. Time spent using a screen-based device while not being stationary in any context.

Non-screen-based sedentary time. Refers to the time spent in sedentary behaviours that do not involve the use of screens.

Sitting. A position in which one's weight is supported by one's buttocks rather than one's feet, and in which one's back is upright.

Active sitting. Any waking activity in a sitting posture characterised by an energy expenditure >1.5 METs.
Passive sitting. Any waking activity in a sitting posture characterised by an energy expenditure ≤1.5 METs.

Reclining. Reclining is a body position between sitting and lying.

Active reclining. >1.5 METs.
Passive reclining. ≤ 1.5 METs.

Lying. Refers to being in a horizontal position on a supporting surface.

Active lying. >1.5 METs.
Passive lying. ≤ 1.5 METs.

Sedentary behaviour pattern. It is how sedentary behaviour is accumulated throughout the day or week while awake [16, 17].

In summary, the definition of SB and related terms has evolved. Currently, much progress has been made. However, studies are needed to validate the proposed terms. Also, much discussion still exists about MET values thresholds, and future studies are needed to determine values that best represent SB at different ages, and physical and health conditions. Also, standardisation of assessment and analysis of SB by accelerometry is necessary.

Difference between physical activity and sedentary behaviour.

To reduce the risk of developing chronic disease, and to maintain a healthy life-style, public health interventions focus on improving PA and reducing SB. Despite both constructs being similar in their objectives, they present differences regarding interventions that should be highlighted. These relate mainly to the frequency and duration of the two behaviours. Interventions on PA usually aim to encourage participants to accumulate more moderate to vigorous PA (MVPA). Interventions on SB are designed to support people to shift some of their sedentary time to light intensity activities [18]. It is essential to highlight the difference between being inactive and being sedentary. Inactive individuals present low/insufficient levels of MVPA, while sedentary individuals show a high level of sitting [19]. It is possible, for example, to be highly active (go to the gym five times a week for one hour) and sedentary (work in an office setting for more than 6 hours, without break times).

To standardise the PA intensity, in the late 1980s, the Compendium of PA was developed and was updated in 2011 [20]. The Compendium standardises the MET (metabolic equivalent) intensities used in a variety of PA. It does not correct the MET levels for age, body mass, and gender. The Physical Activity Guidelines Advisory Committee [21] defined PA intensity as:

Light-intensity activity *is non-sedentary waking behaviour that requires less than 3.0 METs; examples include walking at a slow or leisurely pace (2 mph or less), cooking activities, or light household chores.*
Moderate-intensity activity *requires 3.0 to less than 6.0 METs; examples include walking briskly (2.5 to 4 mph), playing doubles tennis, or raking the yard.*

> **Vigorous-intensity activity** *requires 6.0 or more METs; examples include jogging, running, carrying heavy groceries or other loads upstairs, shovelling snow, or participating in a strenuous fitness class.*

This guideline was updated in 2018, but the intensity defined for energy expended was maintained. Through the guidelines, four levels of aerobic PA were made: inactive, insufficiently active, active, and highly active [22].

> **Inactive** *is not getting any moderate- or vigorous-intensity PA beyond basic movement from daily life activities.*
> **Insufficiently active** *is doing some moderate- or vigorous-intensity PA but less than 150 minutes of moderate-intensity PA a week or 75 minutes of vigorous-intensity PA or the equivalent combination. This level is less than the target range for meeting the key guidelines for adults.*
> **Active** *is doing the equivalent of 150 minutes to 300 minutes of moderate-intensity PA a week. This level meets the key guideline target range for adults.*
> **Highly active** *is doing the equivalent of more than 300 minutes of moderate-intensity PA a week. This level exceeds the key guideline target range for adults.*

This classification of PA intensity is the same as the one used by the World Health Organisation to make guidelines regarding PA and health for adults [23]. The difference between SB and PA is critical to recognising the distinct determinants of SB and PA, and to designing public health interventions that are most suitable. Interventions focusing on SB should not follow the same approach used for PA interventions. They must be more specific and must emphasise SB's determinants.

3. Determinants of sedentary behaviour

It is essential to comprehend the modifiable determinants of PA and SB, and to translate that knowledge into practical actions to benefit public health. The simple cause and effect pathway of health behaviours (e.g. SB and health outcomes) is an unwise approach to take. Motivating or educating individuals to change their behaviour is likely to be restricted if their physical and socio-cultural environments do not enable and support the behaviour [24].

3.1 Ecological model of sedentary behaviour

The ecological approach considers multiple levels of influence on a specific behaviour, such as: individual, social, organisational/community, environmental, and public policy [25]. The ecological model distinguishes itself from individual-level models by focusing on the interaction of person-level attributes (e.g. motivation, self-efficacy) with physical and socio-cultural environments [26]. Ecological models have been used to explore and address several different health behaviours (e.g. PA, healthy eating, and tobacco smoking) [25]. Regarding SB, it is crucial to understand which physical attribute is in focus, and the context in which the SB occurs. The ecological model of SB, highlighting the influence of particular contexts or domains in which behaviours occur, considers four domains: leisure, household, transport, and occupation [5]. Each domain presents a range of potential influences.

The key of the Ecological Model of SB is to understand which social and environmental factors could influence the SB. Various factors are likely to influence an individual's choice and risk of engaging in SB. Also, it is important to consider the population target and the settings. For example, for working adults with sedentary

jobs, making changes in the workplace must diminish SB at the workplace [27]. The Torbeyns et al. study concluded that a standing desk intervention increase the HDL cholesterol, and decrease postprandial glucose when compared with a seated workstation [28]. For older adults and retirees, SB's main setting is in the home. Interventions should therefore focus on this setting [29]. For children and adolescents, it is important to look for the main SB, which is screen viewing in different settings [30]. Also, there are some SB's that occur in a specific setting, which must be considered. For example, TV viewing frequently occurs at home. This correlation is important for the purpose of targeting an intervention focused on the setting, beyond the behaviour. Understanding SB's correlates in a specific setting is thus important to develop more effective interventions [5]. Workplace furniture is growing in popularity as an intervention tool for the purpose of decreasing SB. For example, employees with long-term access to sit-stand desks sit less, and sit upright more often, than employees with sitting desks [31]. **Figure 1** shows the variables that could be studied for each domain.

A systematic review among adults aged 18–65 years found seventy-four studies that aimed to identify individual, social, environmental, and policy-related determinants or correlates of SB [32]. The results indicated that individual-level factors (e.g. age, PA levels, body mass index, socioeconomic status, and mood) were significantly correlated with SB. A trend towards increased leisure screen time was identified in those married or cohabiting, while having children resulted in less total sitting time. Also, the proximity of green space, neighbourhood walkability and safety, weather, and other environmental factors were correlated with SB [32]. Although this systematic review is an important contribution to the SB field, most included studies were observational. No longitudinal study was performed, which makes it difficult to make a causal inference. Only longitudinal studies allow for the establishment of a causal relationship.

Another systematic review conducted to better understand factors associated with SB among older adults found twenty-two high quality studies (median of 82%, IQR 69–96%, using Qualsyst tool), almost all of which were cross-sectional and observational [33]. Their results showed older and retired individuals were seated often. Some studies considered environmental determinants. This conclusion suggests a possible association with mode of transport, type of housing, cultural opportunities, neighbourhood safety, and availability of places to rest [33]. However, the systematic review included only studies from high-income countries. More evidence is needed from lower- and middle-income countries. In addition, there is minimal causal evidence for the association of environmental determinants

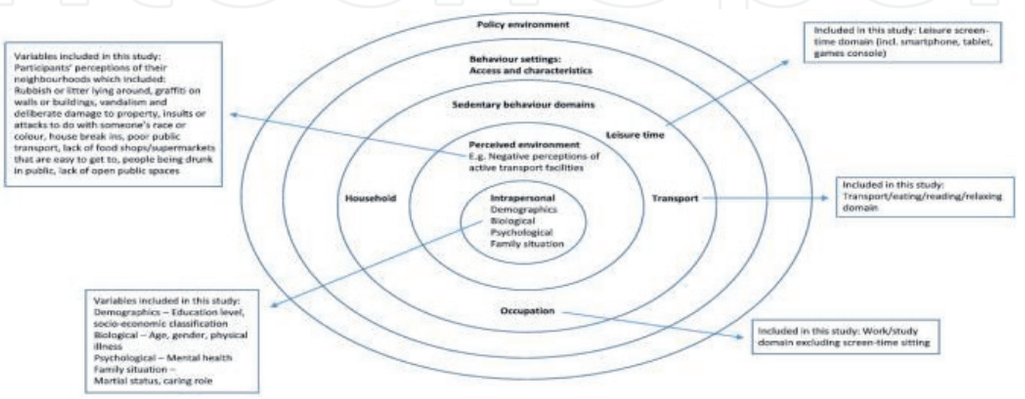

Figure 1.
Mapping of the domains and correlated variables of the ecological model of sedentary behaviour. Published on Nicolson, Hayes [24] with permission.

and sedentary behaviour, as the vast majority of information comes from quantitative cross-sectional studies. Longitudinal and experimental approaches would be necessary to identify potential levels that could be used to design innovative interventions, for older adults, to diminish the SB.

Among youth, more studies are available. Stierlin et al. reviewed thirty-seven studies; only high quality longitudinal, intervention, and observational studies were included (median of 82%, IQR: 74–91%, using the Qualsyst tool) [34]. Determinants were found at the individual, interpersonal, environmental, and public policy levels. Age and weight status were positively associated with total SB. Also, baseline assessment of screen time was positively associated with screen time at follow-up. A higher playground density, and higher availability of play and sports equipment at school, was consistently related to an increased total SB, although these consistent findings come from single studies. Other study reported the association of the proximity of safe places to crossroads, and lengthening morning and lunch breaks, with less total SB [34].

All cited systematic reviews were essential to a better understanding of the determinants of SB. However, across the studies, we learn more about the "who" of SB engagement, and less about the "why" of their SB engagement. To make substantial advancements in intervention design, and to gain insights into important and modifiable mediators of behavioural change, researchers need to know the motivational and contextual reasons for engaging in SB [35]. Information about the various levels and types of influences and contributors to SB may help develop multi-level interventions that expand the chances to decrease sedentary behaviour. More studies, focusing specifically on motivation, abilities, and opportunities, as well as unconscious processes that may induce and sustain changes in SB, are crucial [35].

4. Sedentary behaviour and health

Sedentary behaviour has been a big concern of public health and prevention medicine. Over the last decades, a growing interest has been placed on the health impact of SB. Wise public health recommendations about SB can only be made if there is a clear understanding of its relationship with various health impacts. In this respect, many studies have shown that higher amounts of SB are associated with harmful health outcomes such as metabolic syndrome, obesity, diabetes, cardiovascular diseases, and mortality [1, 3].

The Physical Activity Guidelines Advisory Committee Scientific Report (PAGAC) provided an overview of relationships between SB and mortality; it exposed the weight status of SB among several non-communicable diseases [36]. The conclusion was that there was strong evidence that high amounts of SB increase the risk for all-cause and cardiovascular disease (CVD) mortality, also incident CVD and type 2 diabetes. In addition, it showed, with moderate evidence, that SB was associated with incident endometrial, colon, and lung cancer. There was limited evidence which demonstrated that SB was associated with cancer mortality and weight control. Considering PA status, the study concluded that SB's hazardous effects are more pronounced in physically inactive participants [36]. A prospective cohort study showed that greater sedentary time was associated with all-cause mortality [37].

Along with the relationship between SB and mortality, it is important to analyse other health parameters such as: pain, quality of life, mental health, function and disability. An overview, of systematic reviews that examined the relationship between SB and a range of health indicators among the adult population, was done in 2020. The main findings are summarised in **Table 1** [51].

Outcome	Studies (systematic reviews)	Main findings
Health-related quality of life (HRQOL)	Boberska et al. (2018) Castro et al. (2018) Ramalho et al. (2018)	Higher levels of SB are associated with lower physical HRQoL [38]. Total screen time was negatively associated with social quality of life. There were no significant associations observed between SB and environmental, personal, or overall quality of life [39]. Significant and negative associations between SB and quality of life [40].
Brain health	Falck et al. (2017)	The odds of developing Alzheimer's increased 1.32 (95% CI: 1.08, 1.62) for each 1-h increase in daily TV viewing [41].
Cognitive function (CF)	Falck et al. (2017) Castro et al. (2018) Ramalho et al. (2018) Sui et al. (2019)	Negative associations between SB and CF [41]. Executive function was negatively associated with total sedentary time. Working memory capacity was not associated with self-reported sitting, screen time, or passive transportation. And, perceived cognitive ability was negatively associated with total sitting time, but not associated with device-measured sedentary time [39]. CF was negatively associated with TV viewing. CF was positively associated with Internet/computer use. CF was not associated with device-measured sitting [40]. No difference between seated and non-seated workstations, non-seated workstations were associated with improved cognitive performance, and non-seated workstations were associated with reduced cognitive performance [42].
Depression	Zhai et al. (2015) Teychenne et al. (2010) Ramalho et al. (2018)	Participants reporting high SB had a 1.14 (95% CI: 1.06, 1.21) relative risk of depression [43]. Positive associations between SB and depression or depressive symptoms. Total sedentary time and TV viewing were generally positively associated with depression or depressive symptoms, while Internet and computer use often demonstrated beneficial associations with depression or depressive symptoms [44]. 4/6 studies observed null associations between SB and depressive symptoms [40].
Musculoskeletal pain	Castro et al. (2018) Shrestha et al. (2018) Josaphat et al. (2019)	Positive associations were observed between musculoskeletal symptoms and a total sitting time (3/3 studies), computer use (8/10 studies), video games (1/3 studies), and mobile phones (2/6 studies). No associations were observed between musculoskeletal symptoms and TV viewing (1/1 studies), total screen time (1/1 studies), or studying (3/3 studies) [39]. Lower prevalence of musculoskeletal symptoms in participants using sit-stand desks when compared with sit-desks [45]. Reduced discomfort when alternating sitting and standing when compared with sitting for 8 h [46].

Outcome	Studies (systematic reviews)	Main findings
Accidents and injuries	O'Donoghue et al. (2016) Rezende et al. (2014) Shrestha et al. (2018)	No association between self-reported sitting time (n = 4) or device- measured sedentary time (n = 1) and disability, illness, or injury. A positive association between transport sitting time and disability, illness, or injury [32]. No eligible studies were identified [47]. Excluding the musculoskeletal pain described previously, no adverse events were reported [45].
Biomarkers of cardiometabolic risk	Torbeyns et al. (2014) Wirth et al. (2017) Josaphat et al. (2019) Saunders et al. (2018)	Standing desk intervention reported an increase in HDL cholesterol, and a decrease in postprandial glucose, when compared with a seated workstation, treadmill desk intervention reported a significant reduction in total and LDL-cholesterol [28]. Significant reduction in fasting insulin levels in favour of the intervention group (targeting reduced SB), with no changes observed for total, HDL- or LDL cholesterol, or fasting glucose [48]. Standing workstations resulted in improved measures of glycaemic control when compared with seated workstations (3/4 studies). Treadmill workstations resulted in lower HbA1c levels (2/3 studies). Improved total and LDL-cholesterol levels (1/3 studies). Improvements in HDL cholesterol (1/3 studies). No changes in cholesterol levels (1/3 studies). No changes in fasting insulin, glucose, or triglycerides in response to treadmill desk use (3/3 studies) [46]. Breaking up sitting time was associated with benefits in postprandial glucose [49].
Body composition	Neuhaus et al. (2014) Josaphat et al. (2019) Wirth et al. (2017)	Significant improvement in waist circumference (3/3 studies using a treadmill or pedal desk). Reported no change (2/2 studies using sit-stand desk). Significant improvement in BMI following the introduction of an activity permissive workstation (1 study) [50]. Significant improvement in at least 1 measure of body composition (3/3 studies using a treadmill desk). 2/2 randomised studies failed to detect any changes in body composition. 2/2 randomised studies using a sit-stand desk reported no change in body composition [46]. No change in waist circumference (1/1intervention study targeting reduced SB in older adults) [48].

Abbreviation: BMI, body mass index; CF, cardiorespiratory fitness; CI, confidence interval; HDL, high-density lipoprotein; HRQoL, health-related quality of life; LDL, low-density lipoprotein; SB, sedentary behaviour; TV, television.

Table 1.
Overview of systematic review regarding the relationship between SB and a range of health indicators among the adult population. Adapted from Saunders et al. [21].

Another important consideration about SB's impact on health is the relationship between different elements of SB, such as bouts, frequency, duration, and timing. The PAGAC Scientific Report (2018) showed insufficient evidence to determine if

bout length or breaks in sedentary behaviour are associated with health outcomes [36]. However, other studies suggest that SB patterns may be associated with an increased risk of mortality, among other health outcomes. Longer mean sedentary bout duration was associated with all-cause mortality [37]. Prolonged sitting resulted in moderate elevations in postprandial glucose and insulin responses when compared to sitting interrupted with activity breaks [49, 52]. Also, the sedentary break on sitting behaviour was associated to attenuate cardiometabolic risk markers [53].

5. Guidelines and recommendation of sedentary behaviour

There is a global consensus regarding the need to reduce SB, but some questions still need to be clarified. How much sedentary time might be unsafe or detrimental to health? How frequently should SB be broken up, and what type and intensity of PA would be desirable in doing so?

For the first time, in November 2020, the World Health Organisation (WHO) provided evidence-based public health recommendations on the amount of PA, in association with SB, to offer health benefits and mitigate health risk [54]. It was the first time that SB has appeared in a WHO guideline. Although it was a significant step forward, the recommendation falls short with respect to specificity; it did not provide a threshold of SB or sedentary time. The WHO guideline is intended for policy-makers in high-middle and low-income countries, and in ministries of health, education, youth, sport, and/or social or family welfare. Local authorities should be responsible for elaborate feasible plans to improve PA and reduce SB. In this sense, the recommendations are a good step.

In a national setting, Canada was the first country to make specific recommendations regarding SB and screen time for adults and older adults [55]. The guidelines follow the 24-hour SB Research Network movement guidelines [4]. A systematic review provided evidence that the daily movement behaviour composition was associated with health outcomes, such as adiposity and cardiometabolic biomarkers, in addition to being associated with all-cause mortality [56]. Also, reallocating time into other movement behaviour from SB was associated with positive changes to all-cause mortality [56].

The Canadian 24-Hour Movement Guidelines for Adults aged 18–64 years, and Adults aged 65 years or older, integrates recommendations for a healthy day (24 h) comprised of a combination of PA, SB, and sleep. The guidelines were generated based on the best available evidence, and should be updated every 10 years (or whenever important new evidence is identified that could inform and/or suggest revisions to the existing guideline recommendations). The guidelines are for adults (18–64 years) and older adults (65 years or older), irrespective of gender, cultural background, or socioeconomic status. The exceptions to the guidelines are for pregnant women or persons living with a disability or medical condition. The guidelines recognise that individuals should be engaged in different PA during the day (e.g. weight bearing/non-weight bearing, sport, and recreation) in a variety of environments (e.g. home/work/community; indoor/outdoor, land/water) and contexts (e.g. leisure, transportation, occupation, household). Moreover, the guidelines highlight that adults should limit long periods of SB and should practice healthy sleep hygiene. For adults, a healthy 24-hours includes; (1) PA (150 minutes per week of moderate to vigorous aerobic PA, twice a week of muscle strength and several hours of light PA, including standing); (2) sleep (7–9 hours of good quality sleep); (3) SB (limited to 8 hours or less, no more than 3 hours' recreation screen time and breaking up long periods of SB as often as possible. Also, the guidelines

suggest replacing SB with additional PA and trading light PA for more moderate to vigorous PA. The difference in the guidelines for older adults regards the addition of PA, beyond the adult recommendation, that addresses balance [55].

The breakthrough of the Canadian 24-Hour Movement Guidelines was that, for the first time, guidelines identify specific threshold values for daily SB and recreational screen time. The value was based on meta-analyses which suggested that the risk of all-cause mortality increased more rapidly above the threshold value range from 7 to 9.5 h/day for daily SB [1, 57]. Self-reported measures had a lower threshold when compared to device-based measures of SB. Concerning screen-based SB studies, there was a variety of thresholds that increased the risk of all-cause mortality (i.e., 3 h/day [57, 58], 3.5 h/day [1], and 4 h/day of TV viewing [59]). The authors found that it would be impractical to provide a range of thresholds, indicating that 8 h/day of SB and 3 h/day of TV viewing would be most appropriate.

Before these guidelines, in 2017, Canada had already developed 24-h movement guidelines for early years (0–4 years) [11] and children and youth (5–17 years) [15]. Other countries also follow the same principle, and have presented 24-h movement guidelines for children up to 5 years of age, including Australia [60], New Zealand [61], and South Africa [62]. In 2019, the WHO presented similar recommendations for 24-hour PA, sedentary behaviour, and sleep for children under the age of 5 [63].

6. Conclusion

In our technological society, people progressively change their behaviour, increasing the time spent in activities with low energy expenditure. This change in behaviour has had a significant impact on public health. Currently, studies have associated excessive SB with adverse health outcomes. Therefore, to better comprehend the relationship between health outcomes and sedentary behaviour, and to make advancements in this field, it is essential to present a standardised operational definition of SB and related terms. The Sedentary Behaviour Research Network (SBRN) coordinated a comprehensive effort to develop further consensus definitions for terms related to SB. We have presented, in a table, a summary of this information. The standardisation of research, in the SB field, is vital.

It is critical to understand which factors influence SB among children, adolescents, adults, and older adults. The ecological model of SB presents an approach that considers multiple levels of influences, while addressing four main domains in which SB can occur (each sharing similar characteristics). These domains are: leisure, household, transport, and occupation. Research in the SB field must consider individual factors, and their interaction with environmental factors, in each of these domains (and for each age group).

This chapter provided data from current studies that investigated the association between SB and different health outcomes, such as: health-related quality of life, brain health, cognitive function, depression, musculoskeletal pain, accidents and injuries, biomarkers of cardiometabolic risk, and body composition. Beyond that, we discussed SB's association with all-cause mortality, while considering such elements as total time, bouts, frequency, and intensity.

Finally, we presented the World Health Organisation guidelines regarding PA in association with SB. The last guidelines, from 2020, did not provide a threshold of SB, but national ones, from Canada, provided guidelines based on the 24-hour model, dividing the recommendation into PA, sleep and SB, while offering, for the first time, a specific time-limit for SB and screen recreation time.

With this current information, we expect to help researchers to make advancements in the SB field. More studies are needed, not only to provide specific

guidelines considering the bouts, frequency, and intensity of SB, but also to better understand the association between SB bouts and all-cause mortality. Experimental studies are needed on: the dose–response relationships and underlying mechanisms of SB and health outcomes, the feasibility of changing prolonged sedentary time, how best to promote maintenance of the relevant SB changes, and the health benefits to be realised.

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