Methods of Assessing Sedentary Behaviour

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Abstract

Increasing amounts of time spent in sedentary behaviour (SB), during occupation or recreation activities, is considered a global health problem. SB has been associated with several non-communicable diseases and all-cause mortality. Thus, it is essential to assess SB through the most accurate and suitable measurement tools. This chapter presents an overview of different methods for assessing SB and highlights the importance of determining the best measurement tool. In choosing an appropriate and accurate method, it is relevant to consider multiple factors, such as population characteristics, context, validity and reliability of measurement tools, and potential research and participant burdens. Subjective measurements, such as self-reported questionnaires, are widely used in epidemiologic studies because they are easy to administer at low cost. However, there is a large variety of questionnaires, which makes it difficult to select a single questionnaire to assess SB. Device-based measurements are more accurate for assessing SB as well as determining bouts and breaks. Both methods present strengths and limitations, and when possible, researchers should use a combination of device-based and subjective methods to improve SB assessment.

Keywords: sitting time, sedentary time, measurement, wearables, self-reported questionnaires

1. Introduction

When James A. Levine[1] said for the first time "sitting is the new smoking," his statement seemed to be dramatic and exaggerated. Still, building evidence contributed to show that he was not entirely wrong. Sedentary behaviour (SB) is systematically associated with numerous health issues, such as prostate cancer [1], breast cancer [2], mental health [3, 4], diabetes, cardiovascular disease [5], and obesity [6]. In addition, SB is associated with all-cause mortality. There is still discussion about whether moderate-to-vigorous physical activity (MVPA) can counteract the

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[1] James A. Levine is the co-director of the Mayo Clinic/Arizona State University Obesity Solutions Initiative and the inventor of the treadmill desk. He has published more than 100 scientific papers, worked on dozens of corporate programs, and served as an advisor for schools on how to make the classroom a more active place. He is the author of *Get Up!* He won the Invention of the Year Award from NASA, the Platinum Award at the World Fair, and Entrepreneur of the Year in the state of Minnesota. His work has been featured on Rock Center, 60 Minutes, BBC, and all major network US morning shows, as well as in *The New York Times* and *The Times of London*. https://us.macmillan.com/author/jamesalevine/

deleterious effects of SB. However, some investigations show that MVPA and SB are two independent risk factors for mortality rates [7, 8].

The World Health Organisation (WHO) recently updated physical activity (PA) guidelines, considering the minimum amount required to prevent health risks. The recommendations are specific for children, adolescents, adults, and older adults. In addition, subpopulations such as pregnant and postpartum women and people living with chronic conditions or disabilities are included in these new guidelines. For the first time, beyond PA, SB was taken into consideration [9]. Even though SB risk is cited in the PA guidelines, a threshold value is yet to be provided. The WHO points out the importance of periodically reviewing the existing global and national instruments for assessing PA and SB [9]. Therefore, it is essential to accurately measure SB to better understand its role in health outcomes and provide accurate data to update public health guidelines.

SB manifests in different domains (e.g. leisure time, work, transport) and as different types (e.g. working on the computer, watching TV, and playing video games), making it difficult to assess all forms of SB simultaneously. Thus, a clear definition of SB must be provided. In this sense, the Sedentary Behaviour Research Network defined SB as any waking behaviour with energy expenditure ≤1.5 metabolic equivalents (METs) while in a sitting, reclining, or lying posture [10]. **Figure 1** is an interactive figure of the final conceptual model of movement-based terminology arranged around 24 h [10].
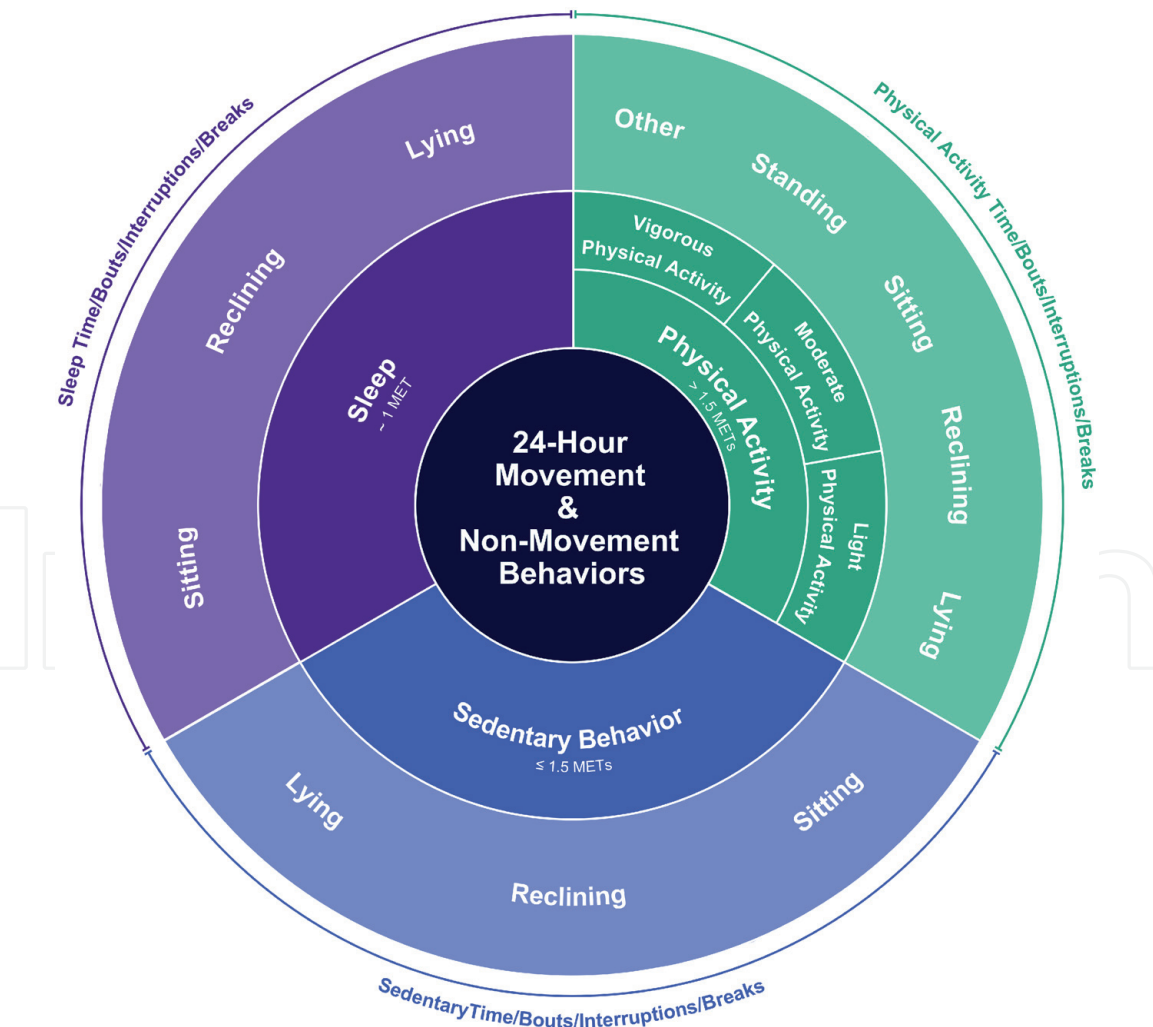

Figure 1.
The conceptual model of movement-based terminology arranged around a 24-h period. The movements are divided into two components. The inner ring represents the main behaviour categories using energy expenditure. The outer ring provides general categories using posture. Source: www.sedentarybehaviour.org/sbrn-terminology-consensus-project/ [10].
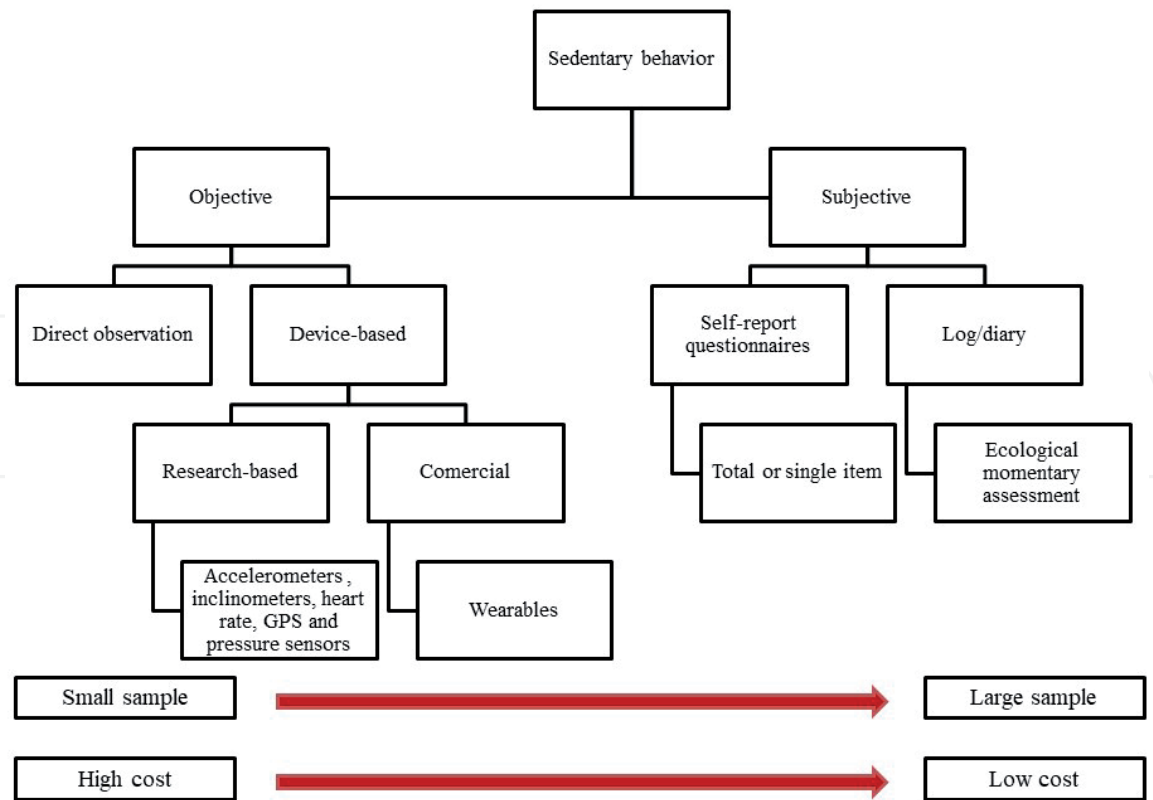
Figure 2.
Flow chart of different methods to assess SB.

Meanwhile, it is quite difficult to adequately assess SB. What parameters of SB should be assessed? Descriptive parameters of SB used frequently are duration, frequency, intensity, and context domains (e.g. leisure, work, transport) [11]. For accurately assessing SB, one must consider not only energy expenditure but also body posture. There is a relatively small absolute difference in energy expenditure between sitting and standing posture, confusing interpretation of the data [12, 13]. Studies show that time spent in continuous prolonged bouts of SB may have the worst health consequence [14–19] and that assessing SB accumulation patterns is paramount.

Device-based measures or subjective methods can assess SB. Both present strengths and limitations that must be considered according to the purpose of the assessment. **Figure 2** summarises the two types of methods and the potential cost and sample size of each. Device-based methods have the greatest validity and are the gold standard for assessing total SB and patterns of SB accumulation. However, these methods alone cannot provide contextual details such as the type of SB, with whom the participant is engaging in the SB, or whether the participant is multi-tasking. Subjective methods, such as self-report questionnaires, give detailed information about the task but are subject to measurement error and response bias. The authors believe that the key to choosing the best assessment approach is to consider the research question and the aim of the study. In this sense, this chapter presents the different methods to assess SB and guides the reader in choosing the appropriate one.

2. Objective methods to assess sedentary behaviour

Table 1 presents an overview of the main objective methods of assessing SB.

Designation	Strengths	Limitations
• To validate novel SB techniques, such as device-based motion sensors • To assess SB in particular sub-population (e.g. Alzheimer's patients)	• Low equipment requirement • Describe with detail the context (activity, posture, breaks in SB) and distinguish the postures (e.g. chair-sitting, ground-sitting, kneeling, and squatting) • High validity and reliability	• Depends on intra- and inter-rater reliability • Quite inconvenient for all those involved • The participant can change their routine, reducing ecological validity • Feasible only with limited sample size, space, and time

Table 1.
Direct observation: designation, strengths, and limitations.

2.1 Direct observation

Direct observation is the gold standard and the most basic method to assess SB. The method consists of two or three trained specialists observing the participant during the timeframe of interest and recording all behaviours and categorising them according to a predetermined list [20]. **Table 2** shows the direct observation details.

2.2 Device-based methods

2.2.1 Methodological considerations

2.2.1.1 Continuously worn devices

Nowadays, it is common for individuals to wear monitoring devices 24 hours per day. Participant compliance is substantially greater with these devices because they do not have to remember to put the device back on after a period of removal. In addition, the risk of bias is reduced when compared to traditionally wearing the devices only while awake. By wearing the devices for 24 h, participants may simply forget that they are using the devices, which can reduce the effect of increasing the usual PA levels.

2.2.1.2 Minimal criteria for having valid data

The protocols are distinct according to the population studied and the device used. For accelerometers, it is common to adopt ≥10 h/day on at least 4 days, including at least one weekend day [22].

2.2.1.3 Acceleration and postural standpoint

It is important to distinguish between "true" SB and other behaviours, such as sleep or non-wear time. To minimise this issue some alternatives are presented: manual evaluations, participant diaries, and automated algorithms.

2.2.1.4 Participants' adherence

It is essential to stimulate the participant to adhere to the assessment. In this sense, it is important to consider the practice to wear and how discreet the device

Characteristics	Accelerometers	Inclinometers	HR monitoring and combined HR and movement monitoring	Multi-sensor monitors
Validity	Medium to high (depending on the processing method)	Very high (≥95% agreement with direct observation)	Low	Low (correlation between activPAL and SenseWear: r = 0.37 (95% CI 0.13, 0.56)
Reliability	Very high	Very high (inter-device reliability >0.99)	Very high	Very high
Participant and research burden	Moderate	Moderate	Participant—low/moderate Researcher—moderate/high	Participant—potentially high Researcher—moderate/high
Cost	Moderate	High	High	High
Strength(s)	A substantial literature on application and analysis.	Able to distinguish sitting/standing, small and discreet underneath clothing, possibility for continuous 24-h wear protocol	Combined movement and physiological data aid the identification of monitor wear time	Able to identify behaviour mode/type
Limitation(s)	No consensus regarding data processing	Validation studies in free-living conditions lacking Adhesive can irritate the wearer's skin	Formal validation studies lacking	Untested in large-scale research settings

Table 2.
Overview of the main device-based methods to assess SB (adapted by Atkin et al. [21] and Aunger and Wagnild [20]).

is. For example, the wrist-worn GENEActiv and Axivity accelerometer devices resemble sport watches, whereas the ActiGraph device is larger and bright red, which may make it less appealing to participants. The activPAL inclinometer is generally inconspicuous on the thigh. Despite common protocols, most of these devices can be positioned in different places, such as on the thigh, potentially increasing the accuracy in measuring SB [23].

2.2.2 Research-based

2.2.2.1 Accelerometers and inclinometers

An accelerometer is a tool that measures the frequency and amplitude of acceleration (counts) of the body in three orthogonal planes (anteroposterior, mediolateral, and vertical) [24]. Time in SB is assessed by two different ways to detect body posture (standing, sitting, or lying): (1) posture by tri-axial sensors using gravitational components or (2) spinal curvature by three uni-axial gyroscopes orthogonally aligned [11]. Alternatively, posture monitors (i.e. inclinometers)

seek to distinguish standing, sitting/lying, or sleep/no wear. Considering the definition of SB [10], posture monitors can measure a closer behaviour to SB than accelerometers, and previous studies reported greater agreement for inclinometers with direct observation than accelerometers [25–27]. Although accelerometers are suitable for the fast movement of body segments [28], they are usually used to assess SB in free-living contexts. In addition, they can assess specific segments of the day, such as after school or after work. It is a common method used in epidemiological studies to access PA with the periods of non-movement being interpreted as SB.

Sedentary time has been determined as <100 counts per minute (cpm) on the waist [23] or <1853 cpm on the non-dominant wrist [29].

Accelerometers can be used to detect short breaks in SB. The key issues in the use of accelerometry are the lack of consensus regarding the most appropriate data-processing protocol, limiting comparability between studies and hindering evidence synthesis [21]. For example, the choice of cut-points to distinguish physical behaviours, the allowance or not of momentary interruptions (i.e. seconds) in sedentary bouts, the minimal amount of time to be considered a break in SB, the application of different filters that change the sensitivity of the data, or simply the epoch choice will significantly impact the results and limit comparability among different studies.

There are important considerations regarding the agreement and comparability of SB measurements from accelerometers and inclinometers. Different studies tested the agreement between SB measured through accelerometers and inclinometers and found that accelerometer-based measures of SB can be overestimated, especially in short bouts [30–34]. The overestimation of SB by accelerometers is, in general, low, but this bias can influence the findings of interventions [30]. However, there are potential differences according to placement site. In this sense, a recent investigation examined the agreement between two accelerometers (Actigraph GT3x and Axivity AX3) with the activPAL inclinometer, all placed on the thigh, and found an elevated agreement for sitting time [35].

Accelerometers are generally unobtrusive to wear, quite small, and consume low battery. However, there is reactivity in the use of devices; in other words, the use of a device can change the behaviour, stimulating the practice of PA and/or reducing SB time [36]. In addition, there is an intrinsic error of estimation as accelerometers' estimations (used on the hip or wrist) are based on accelerations and not posture. Consequently, some motionless standing activities can be erroneously classified as SB. Although these devices are very practicable to use in the field, the costs and operationalisation of device-based methods can be a limitation in large population-based studies, especially in middle- and low-income countries.

2.2.2.2 Heart rate monitoring and combined heart rate and movement monitoring

Heart rate (HR) monitoring is the oldest and most recognised method for assessing PA. It estimates the total energy expenditure or time spent at higher PA intensities. HR monitoring uses two different types of technology: the electrical signal (chest belt) and optical sensor (wristwatch or armband) [37]. These sensors are cheap, discrete, and comfortable. The measure is based on the individually calibrated thresholds that differentiate rest from higher-intensity movement (flex-HR method). SB is estimated as daily time spent below the flex-HR threshold.

The relationship between HR and energy expenditure is not linear for the high intensity of PA or at rest and low intensity [38]. Moreover, a similar HR may represent different internal intensities depending on participant age or fitness level, which is another limitation of using HR solely to estimate PA.

The validity of HR to characterise PA intensity is low when low-intensity movement is aimed. This measure of SB generally has high specificity but low sensitivity [21]. Devices that combine HR and accelerometry are available. This makes possible the evaluation of non-movement periods, although in practice these devices have demonstrated poor validity for measuring SB [34].

2.2.2.3 Multi-sensor monitors

Multi-sensor monitors combine accelerometers and physiological sensors (e.g. heat flux, skin temperature). Examples of this type of monitor include the SenseWear Armband and the Intelligent Device for Energy Expenditure and Physical Activity (IDEEA). Their utility in epidemiological domains is unknown, but has been examined in clinical settings [39]. Usually, these devices use multiple sensors attached to various points of the body. The accuracy of these devices was examined in controlled settings, however, the validity and feasibility under free-living conditions have not been extensively tested [21, 40]. These devices are valuable as criterion measures in validating other SB measurement tools but not a good alternative in free-living conditions, as they entail a burden to the participant.

2.2.2.4 Global positioning system (GPS)

The global positioning system (GPS) is the gold-standard, device-based measure to derive location-based data (latitude and longitude) from individuals. It is useful to understand the relationship between varied contexts and active living [41]. In addition, some GPS systems deliver information regarding speed, elevation, and indoor-outdoor activities [11]. However, GPS presents some limitations in assessing indoor activities, especially in tall buildings with small windows. Recent smartphones and smartwatches are equipped with all the mentioned sensors.

2.2.3 Commercial

A wide range of technical specifications is available from wearables. Overall, commercial, wearable devices are small and unobtrusive devices attached and initiated by the users. Acknowledging some differences in the type of sensor embedded in the wearable, the devices usually assess and provide output parameters of general PA and inactivity, energy expenditure, posture, and body movement [42]. The issue with these commercial devices is that the algorithms behind the generated outcomes are never provided to the user, which does not allow a further understanding of how exactly the outcomes are determined.

2.2.3.1 Wearable cameras

These instruments combine device-based measures about the time spent in SB or PA with information about the context and activity. This is especially useful to identify the combined behaviour, for example, watching TV while eating. Although they seem like an ideal method, wearable cameras present ethical/privacy issues that have to do with obtaining consent from third parties to capture images [20].

2.2.3.2 Smartwatches and smartphones

Smartwatches have the potential to help health care by supporting/evaluating health in everyday living. Among other functions, smartwatches can assess SB. Generally, smartwatches tend to underestimate energy expenditure compared to

laboratory reference measurements [11]. Due to the ease of access, smartphones are a good alternative to smartwatches or other wearable devices. Currently, smartphones can combine many sensors, such as GPS or Global Navigation Satellite Systems (GLONASS), accelerometers, e-compasses, gyroscopes, proximity sensors, or ambient light sensors [43]. However, the problem is that people not always have their smartphones, so many activities may be missed, which can create bias.

3. Subjective measurements of SB

Table 3 presents an overview of the main subjective methods to assess SB.

3.1 Self-reported questionnaires

Questionnaires are the most popular method to assess SB, but they depend on participant ability to recall. They are mostly used in epidemiologic studies due to their low cost and ease of use, both for researchers and participants. Questionnaires can assess multiple domains of SB, such as duration, frequency, context (e.g. leisure, work, transport), and time of recall (e.g. last week, over the last month). Questionnaires that seek to assess habitual levels of SB are susceptible to random and systematic reporting errors. These tools vary from single-item questions (sometimes asked separately for weekends and weekdays) to extensive questionnaires about SB considering various behaviours or domains. In addition, the assessment can be conducted via different methods, such as on paper, on a computer, or face to face, which impacts the response quality [20].

3.1.1 Single-item questionnaires

Participants should report their SB retrospectively. The most used questionnaire is the International Physical Activity Questionnaire (IPAQ) Short Form, which asks: "During the last 7 days, how much time did you spend sitting on a weekday?" [44] Participants should report the answer in hours and minutes per day. However, this kind of assessment has been demonstrated to underestimate SB. Those questionnaires are subject to social desirability bias or simply reflect the difficulty that participants have in recalling their SB [45, 46]. In large scale, the one-item questionnaire may be preferred, as it showed similar validity and reliability compared to longer questionnaires [47]. If possible, however, researchers must choose multi-item questionnaires to obtain more detailed information, not simply one metric for SB.

3.1.2 Domain-based questionnaires

Domain-based questionnaires ask about specific SB types and estimate total SB by the sum of the time spent in each SB. One example is the Sedentary Behaviour Questionnaire (SBQ), which asks about the time spent in nine SB types (e.g. watching tv, playing games, and seven others) [48]. The composite measure of SB tends to produce more accurate estimates of total SB than single-item recalls. The problem with these questionnaires is they tend to erroneously exceed the SB time when considering multi-tasks. For example, the individual listens to music while using the computer and considers the time of these two activities separately instead of considering a single task (the main one).

The domain-based questionnaires can also ask about specific domains of SB, and in these cases, the validity is usually high [49, 50]. But one must understand that this is a good metric for a single behavior but does not inform about the overall SB.

Characteristics	Total assessment or single-item questionnaires	Domain-based questionnaires (composite)	Domain-based questionnaires (specific behaviour)	Previous-day recall	Diaries	Ecological momentary assessments	Proxy-report methods
Validity	Low (correlation with device-based measures: r = 0.34 (95% CI 0.30, 0.39)	Low for questionnaires with 2–9 items, r = 0.35 (95% CI 0.29, 0.41) compared to device-based measures For questionnaires with ≥10 items r = 0.37 (95% CI 0.30, 0.43) compared to device-based measures	Generally high	High (correlation ρ > 0.75 compared to activPAL)	High (correlation r = 0.87)	Low (correlation r = 0.29 compared to activPAL and 0.16 compared to ActiGraph)	Validity largely depends on the validity of the questionnaire being used
Reliability	Variable (intraclass correlations range from 0.41 to 0.86).	Variable (intraclass correlations range from 0.44 to 0.91)	Variable	Medium (lack of evidence, intra-class correlation of 0.75).	Medium (intraclass correlations range from 0.65 to 0.75).	Unknown	Reliability largely depends on the reliability of the questionnaire being used
Participant and researcher burden	Low	Low	Low	Medium	High	High	Low to medium
Cost	Very low	Very low	Very low	Low	Low	Low to high, depending on devices used (e.g., mobile phones)	Very low

Characteristics	Total assessment or single-item questionnaires	Domain-based questionnaires (composite)	Domain-based questionnaires (specific behaviour)	Previous-day recall	Diaries	Ecological momentary assessments	Proxy-report methods
Strength(s)	Easy to administer information on behaviour type and context useful for intervention design.	Easy to administer, provides information on time spent in specific contexts, slightly better estimates of total SB than single-item questionnaires.	Easy to administer	Smaller chance of recall bias Allows inclusion of behaviours relevant to each participant without the imposition of pre-specified behaviours as in a questionnaire	Allows participants to list their activities rather than imposing a structure like in questionnaires Low risk of recall bias if the diary is completed prospectively	Intermittent prompts allow insights into the context of behaviours, including where and with whom they are occurring	Allows measurement of SB in populations who might have difficulty with self-reporting (e.g. adults in need of special care, young children)
Limitation(s)	Typically leads to under-reporting, especially due to difficulty recalling a total sitting time without prompts or possible social desirability bias	Possible recall bias or social desirability bias, concurrent behaviours can lead to double-counting, included behaviours may not be relevant outside of industrialised contexts	Possible recall bias or social desirability bias	More labour-intensive for both participants and researchers compared to questionnaires	Subject to recall and reporting bias, validation studies lacking	Burdensome to participants, prompts can disrupt the actual activity of interest, difficult to gather total SB	Subject to recall and reporting bias, validation studies lacking

Table 3.
Overview of the main subjective methods to assess SB (adapted by Atkin et al. [21] and Aunger and Wagnild [20]).

Another relevant point is that one must use the entire validated questionnaire and not simply use just one question of a valid questionnaire, which will lose validation. Finally, considering that people tend to underestimate SB, and some may not understand the true meaning of the term "sedentary behaviour" due to lack of literacy, these domain-based questionnaires help people to easily identify the time spent in these pursuits, so in this sense they represent an advantage.

3.2 Previous-day recall

Through a semi-structured interview, participants should report in a chronological format the time spent in SB. Activities must last more than 5 minutes to be recorded. Previous-day recall presents a strong correlation ($\rho > 0.75$) with activPAL-measured SB [51, 52]. The biggest limitation of this method is that the previous day may not necessarily be a typical day, thus not representing the typical SB of a participant.

3.3 Diaries and ecological momentary assessments

In diaries, participants must report their daily activities throughout the day. The problem is that if they forget to fill out the questionnaire, they may do it at the end of the day as a retrospective report, which entails more error. The Bouchard Activity Record showed a strong correlation with activPAL-measured SB [53].

Ecological momentary assessment (EMA) is also a prospective record; the difference is that several prompts are sent throughout the day for participants to report their current behaviour. The advantage is that it allows collecting other contextual information, for example, where the participant is carrying out the behaviour and with whom. Both are subject to participants changing their behaviour in response to being monitored. The validity is low, with a weak correlation compared to activPAL [54]. However, EMA showed better correlation and agreement to accelerometer estimates than traditional self-report methods [55].

3.4 Proxy-report methods

Proxy-report methods are useful when participants present some difficulties reporting their behaviours. This occurs with children and adults with cognitive incapacity, so proxy reporting by a third party (usually a parent) can be a good alternative [56]. Proxy-report can be a single-item questionnaire, a diary, or domain-based technique [20]. A systematic review evaluated the reliability and validity of proxy-report methods to assess SB and the results indicate that this measure has acceptable validity (less than 5% of data outside the limits of agreement) [57].

4. Combined device-based and subjective methods

The complexity of SB necessitates more integrated and comprehensive assessment techniques that assess multiple aspects of SB. Device-based methods provide a way to quantify time spent in SB, energy expenditure, position, and other physiological signals but do not inform about contextual features of SB and the type of behaviour that is being partaken. Alternatively, reported methods provide a way to understand the domain, the context, and type of SB. Still, their validity is necessarily lower, as they depend on people's memory and perception. Each method provides unique information, thus neither method alone provides complete information.

In this sense, device-based and subjective methods are potentially complementary, once they capture different aspects of SB. The limitation of one method can be met to some degree by the strength of the other. Whenever feasible, the combination of device-based and subjective assessments will provide the most valid and reliable method to assess SB [47]. The most powerful and useful data collection approach of SB is to integrate the use of reported and device-based methods [56]. For example, HR monitors or accelerometer monitors can be linked wirelessly, with ecological assessment applications on smartphones, and at the same time assess both reported context and perception of SB as well as movement characteristics or physiologic indicators of SB [56] (**Table 4**).

Questionnaire	Summary
Bouchard Physical Activity Questionnaire	A 3-day activity record (including a weekend day). Every 15-min period, participant should report the main activity performed and quantify in terms of energy cost on a 1–9 scale corresponding to a range of 1.0–7.8 METs and higher. Intraclass correlation of 0.96
Previous-Day Recall of Active and Sedentary Behaviours	Participants should report chronologically through the previous day (midnight to midnight) their behaviour using a semi-structured interview. Validation study concluded that: *correlations between the PDR and the activPAL were high, systematic reporting errors were low, and the validity of the PDR was comparable with the ActiGraph.* More information: https://pubmed.ncbi.nlm.nih.gov/23863547/
International Physical Activity Questionnaire (IPAQ)	Participants should report the time spent on different sedentary behaviours. The questionnaire also can be administered over the phone and is available as a short- or long-form and in more than twenty languages/dialects.
Marshall Sitting Questionnaire	A domain-specific sitting questionnaire. Five items assess time (hours and minutes) spent in five different sitting domains. Validation study concluded that: *reliability coefficients were high for a weekday sitting time at work, watching television, and using a computer at home (r = 0.84–0.78) but lower for weekend days across all domains (r = 0.23–0.74). Validity coefficients were highest for weekday sitting at work and using a computer at home (r = 0.69–0.74). With the exception of computer use and watching television for women, the validity of the weekend-day sitting time items was low.* More information: https://pubmed.ncbi.nlm.nih.gov/19997030/
Sedentary Time Questionnaire (SIT-Q)	Asks about the amount of time spent sitting or lying down in different settings over the last 7 days. Validation study concluded that: *ICCs for test–retest reliability ranged from 0.31 for leisure-time computer use to 0.86 for occupational sitting. Total daily sitting demonstrated substantial correlation (ICC = 0.65, 95% CI: 0.49, 0.78).* More information: https://www.sedentarybehaviour.org/wp-content/uploads/2013/12/Lynch-Friedenreich-Khandwala-et-al-2014-2.pdf
The Sedentary Behaviour Questionnaire (SBQ)	Assesses the amount of time spent on nine different behaviours. The validation study concluded that: *ICCs were acceptable for all items and the total scale (range = .51–.93).* More information: https://pubmed.ncbi.nlm.nih.gov/21088299/
The Adolescent Sedentary Activity Questionnaire (ASAQ)	Designed for adolescents. Asks for information regarding different activities: watching television/videos/DVDs, using computers, e-games and e-communication, studying, reading, sitting with friends, using the telephone, listening to or playing music, motorised travel, hobbies and crafts, all performed out of school hours. Validation study concluded that: *test–retest correlations for time total spent in sedentary behaviour were ≥ 0.70, except for Grade 6 boys (Intraclass correlation coefficient (ICC) = 0.57, 95%CI: 0.25, 0.76). Repeatability was generally higher on weekdays compared with weekend days. ICC values for travel and social activities tended to be lower than for the other categories of sedentary behaviour.* More information: https://journals.humankinetics.com/view/journals/jpah/7/6/article-p697.xml

Questionnaire	Summary
Rapid Assessment Disuse Index (RADI)	A questionnaire designed for primary care patients. Validation study concluded that: *RADI was temporally stable (intraclass correlation coefficients 0.79), and a higher score was significantly correlated with greater sedentary time (ρ = 0.40; p < 0.01), fewer sedentary to active transitions (ρ = −0.42; p < 0.01), and less light-intensity physical activity (ρ = −0.40; p < 0.01). The ability of RADI to detect patients with high levels of sedentary time was fair (AUC = 0.72).* More information: https://bjsm.bmj.com/content/48/3/250.abstract
Measure of Older Adults' Sedentary Time (MOST)	A questionnaire designed to assess time spent on behaviours common among older adults. Validation study concluded that: *test–retest reliability was excellent for television viewing time (ρ (95% CI) = 0.78 (0.63–0.89)), computer use (ρ (95% CI) = 0.90 (0.83–0.94)), and reading (ρ (95% CI) = 0.77 (0.62–0.86)); acceptable for hobbies (ρ (95% CI) = 0.61 (0.39–0.76)); and poor for socialising and transport (ρ < 0.45). Total sedentary time had acceptable test–retest reliability (ρ (95% CI) = 0.52 (0.27–0.70)) and validity (ρ (95% CI) = 0.30 (0.02–0.54)). Self-report total sedentary time was similarly responsive to change (RS = 0.47) as accelerometer-derived sedentary time (RS = 0.39).* More information: https://pubmed.ncbi.nlm.nih.gov/21448077/
Past-day Adults' Sedentary Time (PAST)	A seven-item questionnaire about time spent sitting/lying on the previous day for work, transport, television viewing, nonwork computer use, reading, hobbies, and other purposes (summed for total sedentary time). Validation study concluded that: *the PAST had fair to good test–retest reliability (intraclass correlation coefficient = 0.50, 95% confidence interval [CI] = 0.32–0.64). At baseline, the correlation between PAST and activPAL sit/lie time was r = 0.57 (95% CI = 0.39–0.71). The mean difference between PAST at baseline and retest was − 25 min (5.2%), 95% limits of agreement = −5.9 to 5.0 h, and the activPAL sit/lie time was − 9 min (1.8%), 95% limits of agreement = −4.9 to 4.6 h. The PAST showed small but significant responsiveness (−0.44, 95% CI = −0.92 to −0.04); responsiveness of activPAL sit/lie time was not significant.* More information: https://pubmed.ncbi.nlm.nih.gov/23274615/
LASA Sedentary Behaviour Questionnaire	A 10-item questionnaire to assess total sedentary time in older adults. Validation study concluded that: *mean total self-reported sedentary time was 10.4 (SD 3.5) h/d and was not significantly different from mean total device-based sedentary time (10.2 (1.2) h/d, p = 0.63). Total self-reported sedentary time on an average day (sum often activities) correlated moderately (Spearman's r = 0.35, p < 0.01) with total device-based sedentary time. The correlation improved when using the sum of six activities (r = 0.46, p < 0.01), and was much higher than when using TV watching only (r = 0.22, p = 0.05). The test–retest reliability of the sum of six sedentary activities was 0.71 (95% CI 0.57–0.81).* More information: https://bmcgeriatr.biomedcentral.com/track/pdf/10.1186/1471-2318-13-80.pdf
Occupational Sitting and Physical Activity Questionnaire (OSPAQ)	A questionnaire for estimating time spent sitting and standing at work. Validation study concluded that: *the test–retest intraclass correlation coefficients for occupational sitting, standing, and walking for OSPAQ ranged from 0.73 to 0.90, while that for the modified MOSPA-Q [a separate questionnaire] ranged from 0.54 to 0.89. Comparison of sitting measures with accelerometers showed higher Spearman correlations for the OSPAQ (r = 0.65) than for the modified MOSPA-Q (r = 0.52). Criterion validity correlations for occupational standing and walking measures were comparable for both instruments with accelerometers (standing:r = 0.49; walking:r = 0.27–0.29).* More information: https://pubmed.ncbi.nlm.nih.gov/21659903/
NIGHTLY-WEEK-U (adapted from the Past-day Adults' Sedentary Time-University (PAST-U))	Adapted from the Past-day Adults' Sedentary Time-University (PAST-U): the PAST-WEEK-U and the NIGHTLY-WEEK-U. Validation study concluded that: *the average sedentary time (ST) captured using the NIGHTLY-WEEK-U was 0.21 h lower than the criterion measure activPAL4™ (i.e., 10.50 vs 10.29 h per day), with a 95% limit of agreement ranging from −1.75 to 2.17 h. The NIGHTLY-WEEK-U provides a superior measure of ST compared with the PAST-WEEK-U and potentially other weekly measures of ST.* More information: https://onlinelibrary.wiley.com/doi/full/10.1002/tsm2.123

Available: /www.sedentarybehaviour.org/sedentary-behaviour-questionnaires/).

Table 4.
Validated questionnaires for sedentary behaviour (based on sedentary behaviour research network).

5. Conclusion

Accurate methods to assess SB are essential to promote a more comprehensive advantage in the epidemiological field. In this chapter, we described the various methods of measuring SB and highlighted their limitations and strengths. Assessment of SB by subjective methods is limited by the ubiquitous nature of the SB and therefore difficult to recall. However, questionnaires are the most practical and economical means for large samples. Alternatively, device-based measurements extinguish the possibility of recall bias or subjective overestimation/underestimation depending on the population group and even acknowledging some limitations. They provide more accurate and reliable information on posture, movement (or lack of movement), and accumulation patterns.

To select the most suitable method to assess SB and correctly interpret the measures obtained, researchers must consider the aim of assessment, SB constructs of interest, time factors, and the characteristics and size of the population to be investigated.

Conflict of interest

The authors declare no conflict of interest.

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