Chapter 16
Sedentary Behaviour at the Individual Level: Correlates, Theories, and Interventions

Stuart J. H. Biddle

Abstract Sedentary behaviour is highly frequent in individuals, and this chapter concerns sedentary behaviour with a focus on the individual level of analysis. Using the behavioural epidemiology framework, the chapter summarises issues concerning individual-level knowledge and approaches. It focuses mainly on correlates, theoretical frameworks, and behaviour change. Correlates discussed include whether sedentary behaviour and physical activity are associated, and the co-existence of other health behaviours. Barriers to sedentary behaviour change are considered. A number of psychological theories and frameworks are covered that have been popular in wider physical activity and health behaviour research alongside alternative perspectives, including notions of behavioural economics, habit, and nudging. Theories are conceptualised through reflective, automatic, and dual-process approaches. Coverage is given to sedentary behaviour interventions, including recent systematic reviews for young people, adults, and in the workplace. Behaviour change techniques are considered, especially those that seem to be most useful for successful sedentary behaviour change.

What Is New?
- There is an increasing recognition given to the complexity of sedentary behaviours in contemporary society, including the diversity of screen-based devices.
- However, 'newer' devices, such as smartphones, remain under-studied in the context of sedentary behaviour.

(continued)

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- The interdependence between sedentary and active behaviours is increasingly being recognised, and this has implications for the study of health effects and interventions.
- Dual-process approaches, including the use of automatic processing frameworks, are emerging as important theoretical developments in the study of sedentary behaviour.
- The COVID-19 pandemic has increased sedentary behaviour, creating even greater urgency in finding effective behaviour change interventions.
- Sedentary behaviour research has made good inroads into the workplace, especially with a greater recognition and acceptance of sit-to-stand desks for ambulatory office staff.

16.1 Introduction

Sedentary behaviour is ultimately undertaken by individuals. However, any analysis of an individual behaviour cannot be done properly without due recognition of wider social and environmental contexts and influences. The ecological model puts the individual at one of many levels, including social, environmental, and societal levels of behavioural influence [1]. For the purposes of this chapter, the focus will be on the individual. This will include individual-level:

- Correlates of sedentary behaviour
- Barriers to being less sedentary
- Theories and frameworks
- Interventions to reduce sedentary behaviour that have included individual-level factors

It is recognised that it is not always easy to separate individual from social and environmental approaches. They can operate along a continuum of distal and proximal influences. One framework, however, that is helpful in understanding the landscape of the individual in the context of sedentary behaviour is the behavioural epidemiology framework [2]. This has five phases:

1. Measuring sedentary behaviour
2. Establishing the association between sedentary behaviour and health outcomes
3. Understanding the correlates of sedentary behaviour
4. Interventions to change sedentary behaviour (usually to decrease)
5. Translating findings into policy and practice.

For the current chapter, the main focus will be on phases III (correlates) and IV (interventions), with an emphasis on the individual.

An important issue to recognise is that individuals undertake a variety of sedentary behaviours across many different settings. This, along with other issues, shows the complexity of sedentary behaviour (see Fig. 16.1). Indeed, it could be claimed

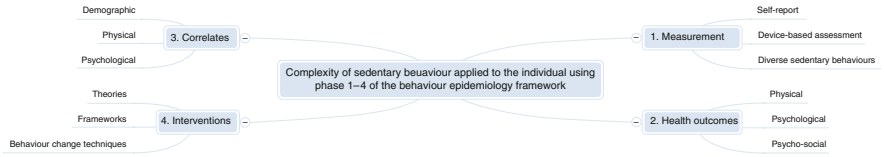

Fig. 16.1 An illustration of the complexity of sedentary behaviour at the individual level, using the behavioural epidemiology framework

that this complexity has increased in recent years as we adopt more diverse methods of measuring behaviour and recognise that sedentary behaviours can take many different forms in diverse social and environmental contexts. We also acknowledge that nearly all of the research literature has been with ambulatory individuals without disabilities. For others, such as those who use wheelchairs, the constant reference to the need to reduce sitting is inappropriate and 'ablelist' [3, 4]. In this chapter, therefore, we draw on research addressing ambulatory adults and young people unless otherwise indicated. More research is needed on sedentary behaviour and physical activity for those living with disabilities [5, 6].

16.2 Individual Correlates of Sedentary Behaviour

Correlates refer to factors that are associated (correlated) with the behaviour of interest. Determinants should be referred to when there is a causal, or near causal, association. Most of the time, we are studying and referring to correlates. Several systematic reviews of the correlates of sedentary behaviour have been published from the mid-2000s, including those investigating young people, adults, and older adults [7]. The findings for children and adolescents highlight significant gaps in our knowledge concerning the correlates of sedentary behaviour [8]. Review authors for this age group note that although many potential correlates have been studied, few of these have been investigated frequently enough to be able to draw firm conclusions. It is also evident within the reviews that the correlates of sedentary behaviours other than screen-viewing behaviours (usually referred to as 'screen time' although 'screen use' may be a better term; [9]) have received little attention, and many studies reviewed are cross-sectional. In addition, the findings suggest that the majority of correlates identified are unmodifiable correlates (moderators). These include body weight, body mass index (BMI), ethnicity, age, and sex. More work with better designs is required to identify the modifiable correlates (mediators) of sedentary behaviour.

In a review of likely 'determinants' of sedentary behaviour in young people, Stierlin et al. [10] excluded cross-sectional studies from their synthesis. They found good evidence for age being a determinant, with increasing age being associated with greater sedentary behaviour, including screen use. Evidence concerning sex

was inconsistent. Weight status tends to be associated with screen time but not overall sedentary behaviour, possibly reflecting dietary effects ([11] see later).

Data on correlates of sedentary behaviour in adults are quite limited and rely largely on self-reported estimates of only a few sedentary behaviours, such as television (TV) viewing. O'Donoghue et al.'s review revealed 74 studies of which 62 focused on individual-level correlates, categorised as behavioural, physical (biological and genetic), psychological, and socio-economic [12]. Moreover, they identified correlates of sedentary behaviour across the domains of screen use, transport, and leisure, as well as total sedentary time from self-reported or device-assessed measures. Many correlates were studied too infrequently to draw conclusions. However, trends were evident for higher levels of sedentary behaviour to be associated with lower physical activity, greater consumption of high energy snacks (see later), greater adiposity, and worse mental health. Demographic indicators included older age as a correlate. However, for other individual correlates, such as sex and socio-economic status, associations were dependent on the nature of the sedentary behaviour in question. For example, leisure screen use was negatively associated with educational attainment, while the reverse was true for total sedentary time (with work time included). These findings reflect the complexity of sedentary behaviours and that not all types will be driven by the same influences. This recognition has been an important advance in recent years.

From a review of 22 studies reporting correlates of sedentary behaviour in older adults, Chastin et al. [13] reviewed evidence on the individual-level correlates of age, sex, marital status, employment and retirement status, educational attainment, and health. They found significant effects for age, but these varied such that total sedentary time seemed to increase with age, but TV viewing and car travel decreased after around 65 years. Evidence was inconsistent for the two correlates of sex and marital status. TV viewing was less for those in employment, including those volunteering. Chastin et al. also found that lower levels of educational attainment were associated with more sedentary behaviour. Unsurprisingly, those reporting poorer health also had higher sedentary behaviour levels.

One criticism of the study of correlates of sedentary behaviour is that they focus too much on TV viewing and computer use, to the neglect of more recent technological devices, such as mobile phones [14]. In a review of young people's uses of devices, Thomas et al. [14] found that only 5% of large epidemiological studies reported data on mobile phone use. Moreover, Leask and colleagues [15], when reporting data obtained from older adults using wearable cameras, found that 84% of screen time was in front of a TV. That said, 62% of sedentary behaviour identified via camera images did not involve screens at all. For these older adults, only 6% of their screen use involved the use of small devices such as phones.

In summary, many correlates identified across the lifespan, at the individual level, tend to show somewhat inconsistent trends—probably due to the complexity of this field, as stated—and reflect correlates that are not modifiable. However, they could be used as moderators in analyses. Additional consideration needs to be given to whether physical activity is a correlate of sedentary behaviour, and how time in one

behaviour affects time in another [16–18]. Moreover, further research is needed concerning other health behaviours coexisting with sedentary behaviours (see later).

16.3 How Do Sedentary and Physically Active Behaviours Coexist?

Until the early 2000s, most researchers referred to 'sedentary behaviour' as being equivalent to low levels of physical activity. But in the context of the contemporary sedentary behaviour literature, it has become accepted that sedentary behaviour refers to periods of sitting/reclining/lying with low energy expenditure, during waking hours. It excludes nighttime sleep [19]. This means that it is best seen as part of a continuum of 'movement' behaviours across a 24-h period—that is, if a person is doing one (e.g. sedentary behaviour), then they cannot be doing another (e.g. light physical activity). However, some behaviours on the continuum will be more highly correlated than others over, say, a 24-h period. It is far more likely that time spent being sedentary, such as passive sitting, will detract from light physical activity than moderate-to-vigorous physical activity (MVPA). The reason for this is that elements of light physical activity, such as standing or light ambulation, are more or less the opposite of sitting. The act of standing negates the act of sitting. It is more complicated, however, when analysing moderate-to-vigorous physical activity. To what extent do high levels of sitting detract from taking part in, say, 1 h of moderate-to-vigorous physical activity daily? Given that there are 24 h in the day, it is logical to assume that any combination of sedentary and moderate-to-vigorous physical activity could be possible, that is, high MVPA with high sitting, high MVPA with low sitting, low MVPA with high sitting, and low MVPA with low sitting [20]. The latter might be reflected in someone who is on their feet most of the day but does little or no moderate-to-vigorous physical activity, or 'exercise'.

There have been two approaches in studying the association between sedentary behaviour and physical activity. First, researchers investigated whether the two behaviours were associated, such that high sedentary behaviour might be a correlate of low physical activity, or whether high levels of physical activity were associated with less sedentary behaviour. Given that most studies are cross-sectional, the direction of influence cannot be ascertained.

Pearson et al. [21] conducted a comprehensive meta-analysis of 254 independent samples from 163 papers. With the exception of reading, all sedentary behaviours were inversely associated with physical activity, but most associations were small. Where a composite measure of sedentary behaviour was used, the association was larger and considered small to moderate in magnitude. In moderator analyses, stronger associations were shown for studies using device-based measures of sedentary behaviour and in studies judged as higher quality. These authors concluded that while sedentary behaviour and physical activity were associated in young people, the association was weak. The two behaviours appear to be somewhat

independent of each other. Similar findings were reported in a review of adults. Mansoubi et al. [22] reviewed 26 studies where associations were reported between sedentary behaviour and physical activity. TV viewing was the most commonly assessed sedentary behaviour and showed inverse associations with physical activity that were small (50%), moderate (25%), and, in one paper only, large. TV viewing was inversely associated in all five papers studying 'exercise'. Total sedentary time was inversely associated with light physical activity and MVPA. Additional analyses showed that larger associations were evident for studies using device-based measures, and studies of higher quality, similar to Pearson et al. [21]. However, most associations across the full review revealed small-to-moderate associations only.

From these two reviews, sedentary behaviour and physical activity seem to be associated, but this association is generally small, somewhat dependent on measurement and study quality, and may be a function of context or type of sedentary behaviour.

A second, and more recent, approach is where studies have investigated what the consequences might be for replacing one behaviour with another. Such 'compositional analyses' are predicated on the view that sedentary behaviour, alongside light, moderate, and vigorous physical activity, as well as sleep, is part of a 24-h composite—that is, they are interdependent across the full day. Most of the studies using this approach tend to focus on the health outcomes of replacing sedentary behaviour with more active behaviours [16, 18]. These studies suggest that individual behaviours, such as low energy sitting, cannot be seen in isolation of different intensities of physical activity. For example, Chastin et al.'s [18] analysis of the 2005–2006 National Health and Nutrition Examination Survey accelerometer data showed that different combinations of time spent in sedentary behaviour and various intensities of physical activity were associated with similar risk for all-cause mortality. They concluded that 'producing evidence on different combinations of physical activity and sedentary behaviour associated with the same health benefits could open the door to more flexible recommendations to suit an individual's circumstances and abilities' (p. 635).

In summary, while early studies showed that the association between sedentary and active behaviours was small, more recent approaches show the interdependence of the two types of behaviours across the continuum of movement behaviours during a finite period of time, such as 24 h.

16.4 Sedentary Behaviour and Associations with Other Lifestyle Factors

Extensive epidemiological research, as well as laboratory studies, shows that higher levels of sedentary behaviour can have adverse health consequences [23–25]. However, one question is whether this link is mediated by the co-existence of other health behaviours. For example, do those who watch a great deal of TV also have high

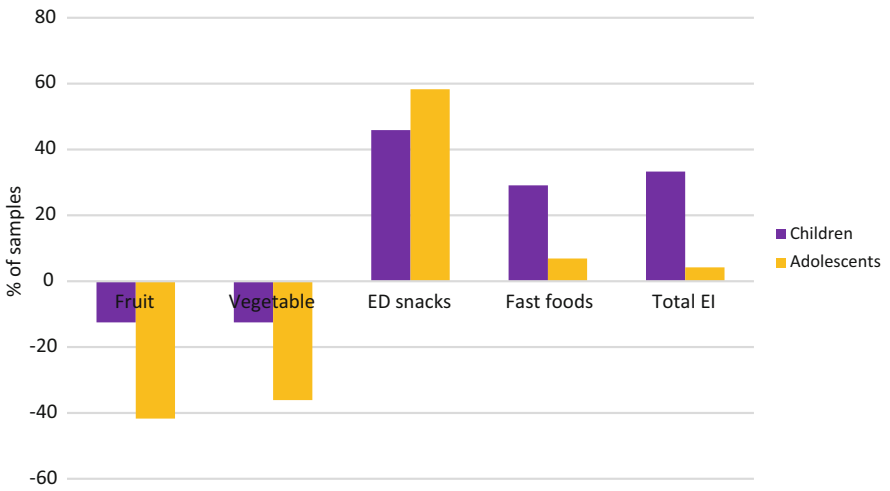

Fig. 16.2 Relationships between sedentary behaviour and dietary patterns in young people (data from Ref. [26])

levels of unhealthy snack consumption? The first review summarising the association between sedentary behaviour and diet was reported by Pearson and Biddle [26]. A total of 53 studies and 111 independent samples were analysed for adolescents (72 samples), children (24 samples), and adults (14 samples). Studies predominantly had a measure of screen time (mainly TV viewing) or total sedentary behaviour. A range of dietary outcomes was assessed, including fruit and vegetable consumption, energy-dense snacks, fast foods, and total energy intake.

Figure 16.2 shows the results for children and adolescents for five key dietary outcomes. This figure is drawn to show the direction of association between dietary variables and time in sedentary behaviours. Higher levels of sedentary behaviour are associated with a less healthy diet, including lower fruit and vegetable consumption, higher consumption of energy-dense snacks and fast foods, and a higher total energy intake. The strength of association between sedentary behaviour and diet across all age groups, including adults (not shown in Fig. 16.2), was mainly small to moderate. Moreover, many studies only assessed TV viewing, although this particular sedentary behaviour does seem to be a key context for unhealthy eating, such as snacking; hence, it is recommended to eat meals away from the TV set. More evidence is needed on whether changes to sedentary behaviour produce changes in healthy eating.

One possible explanation for these associations centres on the nature of TV viewing. This is a behaviour that is quite passive and may encourage energy consumption in the form of 'mindless eating' or 'grazing'. Other screen use behaviours, such as computer use, are slightly more 'active', such as the use of hand movements and requiring more cognitive effort, and may encourage less of these eating patterns. Consistent with this, a review by Ghobadi et al. [27] found that eating while watching TV was positively associated with being 'overweight' in

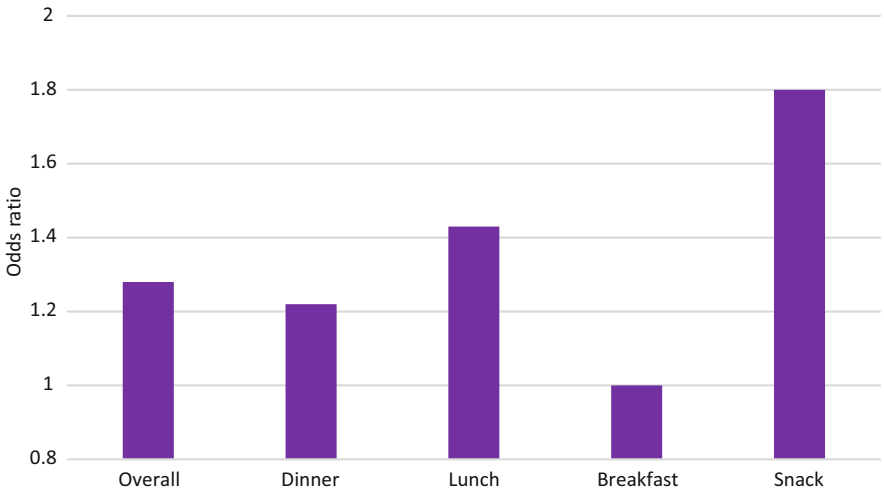

Fig. 16.3 Odds of being overweight when engaging in sedentary behaviours while eating different meals (data from Ref. [27])

children and adolescents. The odds ratios for this overall effect, and additional sub-group analyses, are shown in Fig. 16.3. The largest associations were for snacking, with no effect suggested for breakfast.

Less evidence is available on the association of sedentary behaviours with other health behaviours. However, there is indicative evidence concerning alcohol consumption and smoking. Keadle et al. [28] reported large-scale population-level data from the NIH-AARP Diet and Health Study. This is a prospective cohort study of over 220,000 Americans aged 50–71 years with 14-year follow-up. Associations were analysed for TV viewing and various health markers, including alcohol consumption. At baseline there was higher alcohol consumption for those who watched more TV, increasing from 11 g/day for those watching less than 1 h/day to 13.6 for those with 7 or more hours per day. The increase was linear, and showing a similar trend for smoking prevalence. However, the variability around the mean alcohol values was very high, leading to a very small effect size when comparing the lowest with highest TV viewers.

The COVID-19 pandemic has been implicated in increased sedentary behaviour [29, 30], and this may be particularly associated with restrictions during 'lockdowns' and an increased prevalence of conducting work from the home environment and home schooling of children (see Section 'A Health Economic Perspective on Sedentary Behaviour'). Deterioration in mental health has also been implicated during this period, including increased consumption of alcohol and recreational drug use [31]. At this stage, it is not possible to link these trends, but they are noteworthy. Other issues also require consideration, such as socio-economic status and its known association with some sedentary behaviours and co-occurring health

behaviours [32]. The importance of finding practical and sustainable solutions to these recent trends in sedentary behaviour becomes more acute (see Sect. 16.7).

16.5 Individual Barriers to Reducing Sedentary Behaviour

The study of the correlates or determinants of sedentary behaviour is now quite extensive, but somewhat surprisingly there is a paucity of well-documented evidence concerning the barriers to doing less sedentary behaviour. Minges et al. [33] conducted a qualitative 'metasynthesis' of research regarding the barriers to reducing screen time in young people. Three main themes emerged: youth norms of use, family dynamics and parental roles, and resources and environment. The first theme—youth norms of use—suggested that screen time is a routine part of the lives of young people and not necessarily seen as 'excessive'. That said, there was also evidence for the addictive nature of some screen time activities. Similarly, screen time was perceived as enjoyable and entertaining and was seen to have elements of developing confidence and communication. This theme, therefore, shows that sedentary screen viewing in young people is highly routinised and 'ingrained' in their lives, suggesting it is a habit that may be difficult to change. Moreover, the other two themes reported by Minges et al. show that powerful social and environment pressures are also at play.

A recent interview-based study by Thomas et al. [34] supported some of these findings. Data from interviews with nine girls and seven boys in Australia, aged 14–16 years, revealed time spent on contemporary screens such as smartphones and tablets. Extensive engagement was evident in varied, and somewhat newer, forms of digital media (e.g. communicating online, social networking, and streaming online). It was also reported that less time was spent using conventional TV sets. Interviews suggested that the high amount of time spent on smartphones was partly related to the multiple functions that these devices offered. For example, one 14-year-old girl said that 'I use my smartphone for everything; take photos, contact friends, watch YouTube videos, scroll through social media and play games.' This suggests that while screen use can be seen as problematic, although not necessarily sedentary, devices such as smartphones provide multiple functions, some of which may have positive uses. Equally, the ubiquitous nature of smartphones will be a barrier to reducing overall sedentary screen use.

There seems to be a paucity of systematic evidence concerning barriers to reducing other sedentary behaviours or in diverse contexts, such as the workplace. In a study of the feasibility and acceptability of changing sedentary behaviour at work, De Cocker and colleagues [35] said that several barriers were reported. These included productivity concerns, impracticality, awkwardness of standing (see [36] for a qualitative study on this), and the habitual nature of sitting for ambulatory adults [37].

16.6 Application of Models and Theories to Sedentary Behaviour at the Individual Level

Individual-level theories of health behaviours have been applied to physical activity but less so to sedentary behaviour. A theory has been defined as 'a set of interrelated constructs (concepts), definitions, and propositions that present a systematic view of phenomena by specifying relations among variables, with the purpose of explaining and predicting the phenomena' ([38], p. 9); it is a 'coherent description of process' ([39], p. 22). Indeed, guidelines concerning the development and conduct of complex behavioural interventions propose that a theoretical understanding of the likely process of change is needed in the early stages of planning an intervention, and will help in the understanding of 'how change is brought about, including the interplay of mechanisms and context' ([40], p. 3). A review of theory-based interventions designed to increase physical activity showed that small-to-medium size effects were evident for such approaches but with no one theory being superior. Interventions using a single theory tended to achieve stronger effects than those using multiple theories [41].

In physical activity research, it has been common to adopt intra-individual and inter-personal theories that have a cognitive and reflective focus—utilising the so-called type 2 cognitive and reflective approach. Social and environmental theories are less commonly used [7, 42–45], but more automatic approaches are becoming better recognised. The latter adopt the 'type 1' approach that is less cognitive and more automatic, with cues to action from the environment and affect.

It is questionable whether reflective intra-individual theories are wholly applicable to sedentary behaviour, but some theories or elements may have utility [46]. Nevertheless, recent trends show a greater recognition of the more automatic processing models alongside the conventional cognitive approaches. This 'dual-process' approach (reflective and automatic) seems highly relevant for the study of sedentary behaviour where an interaction of individual and environmental influences is evident, alongside greater recognition of affective processes [47–49].

Overviews of the key theories applied to physical activity are available elsewhere [7, 44]. This section summarises key approaches, and comments will be provided about their applicability to sedentary behaviour.

16.6.1 Reflective Approaches

While the Health Belief Model could be considered a key historical approach to health behaviour theory [50], it has been more common in physical activity research to use social cognitive theory (SCT; [51]), the transtheoretical model (TTM; [52, 53]), the theory of planned behaviour (TPB; [54]), self-determination theory (SDT; [55]), and the health action process approach (HAPA; [56]). Behavioural choice theory (BECT; [57, 58]) has also been identified as having good applicability

to sedentary behaviour as well as physical activity. Each of the approaches listed has a particular emphasis, such as beliefs and attitudes (TPB) or perceptions of competence (SCT), while others are based on different stages of decision-making or behaviour, while retaining elements of other theories (e.g., TTM, HAPA).

Social Cognitive Theory Bandura's social cognitive theory (SCT) [51] suggests that we learn and modify our behaviours through an interaction between personal, behavioural, and environmental influences. We reflect on the consequences of our behaviours ('outcome expectancies') and our own capabilities ('efficacy expectancies'). Thinking about consequences in sedentary behaviour could be simply considering the benefits and costs of being less sedentary. For capabilities, we could ask ourselves 'can I do this behaviour?'—this reflects one's self-efficacy, which is a key element of SCT.

Bandura [51] defines perceived self-efficacy as 'people's judgements of their capabilities to organise and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with judgements of what one can do with whatever skills one possesses' (p. 391). The main sources of self-efficacy beliefs include prior success and performance attainment, imitation and modelling, and verbal and social persuasion. For example, modelling of non-sedentary behaviour, such as seeing others stand in a meeting, may influence behaviour. In a recent review of children's screen time interventions [59], social cognitive theory was applied in 41% of studies.

Theory of Planned Behaviour The TPB proposes that intention is the immediate antecedent of behaviour and that intention is predicted from attitude, subjective norms (normative beliefs), and perceptions of behavioural control. Ajzen and Fishbein [60] suggested that the attitude component of the model is constructed from the beliefs held about the specific behaviour, as well as the value perceived from the likely outcomes. Such beliefs can be instrumental (e.g. 'being less sedentary helps me feel more alert') and affective (e.g. 'moving more and sitting less is satisfying'). It is important to recognise that attitudes have both cognitive and affective elements. The affective elements of attitude have usually been shown to be superior for behaviour change [61]. To this end, we need more work on testing how we can elicit positive feelings associated with less sedentary behaviour when many such behaviours are designed for apparent 'pleasure', such as comfortable chairs and interesting or even 'addictive' TV programs and series. In Australia, for example, the TV and movie streaming service 'Binge' claims that a subscription allows you to 'binge over 10,000 h'!

Normative beliefs ('subjective norm') comprise the beliefs of significant others and the extent that one wishes to comply with such beliefs. Perceived behavioural control (PBC) is defined by Ajzen [62] as 'the perceived ease or difficulty of performing the behaviour' (p. 132). Sedentary behaviour is seen as very easy to do with few obstacles, hence the challenge of achieving successful behaviour change.

The TPB has been applied to sedentary behaviour. For example, Prapavessis and colleagues [63] conducting a web-based survey of over 350 adults in which they were asked a number of questions reflecting the main constructs of the TPB as well

as questions concerning their 'general' sedentary behaviour and weekday and weekend contexts. The authors concluded that their finding 'indicates that cognitive/rational processes play an important role in sedentary behaviour and that sitting is not solely a habitual behaviour engaged in by "default"' (p. 29). However, no measure of habit was included.

Self-Determination Theory Self-determination theory (SDT) has become a popular approach in physical activity and health psychology [45, 64, 65], but little has been said about its likely use or relevance to sedentary behaviour other than computer gaming [66]. It is a multi-faceted theory concerning reasons for adopting a behaviour (intrinsic and extrinsic motivation) and the satisfying of psychological needs. An optimal intrinsic motivational state is derived from various intra-individual and social contextual influences, including an autonomy-supportive environment, the satisfying of the needs for competence, autonomy and social relatedness, and reasons for behavioural involvement that are more self-determined rather than controlling [67, 68]. These might all apply to a range of leisure-time sedentary behaviours, such as computer use. For sedentary screen behaviour, however, we need to know more about what functions screens and devices serve to better understand these motivational processes.

Transtheoretical Model and HAPA The transtheoretical model is a stage-based approach, whereas SCT and TPB are best described as more continuous or 'linear' theories. The TTM proposes that behaviour change involves moving through a set of stages and is a framework that encompasses both the 'when' (stages) and the 'how' of behaviour change. Elements of the TTM include both 'processes' (strategies) of change and 'moderators' of change, such as decisional balance (weighing up the pros and cons of change) and self-efficacy. Research concerning the TTM in sedentary behaviour is lacking.

The HAPA framework also uses stages (non-intentional, intentional, action), alongside continuous constructs from other theories. The model combines stages with self-efficacy, pros and cons, risk perception, intentions, and goal-setting, and has been tested in physical activity research [69] but not sedentary behaviour.

Behavioural Choice Theory Behavioural choice theory (BECT) is based on behavioural economics and is a theoretical approach that attempts to understand how time and resources are allocated given a choice between two or more alternatives [57]. Taking the example of a ubiquitous sedentary behaviour, TV viewing, BECT contends that choosing to watch TV is a function of (a) the accessibility of the behaviour, (b) the availability of alternatives, and (c) the reinforcement value ('appeal' or 'enjoyment') of the behaviour. For example, when physically active and sedentary options are equally accessible, children tend to select the sedentary option. According to Epstein [57], the choice of sedentary behaviours is very responsive to 'cost' and effort, and therefore making access more difficult, such as keeping video games machines in the box when not being used, or removing devices from the room, may lead to reductions in sedentary behaviour.

Availability of alternatives refers to whether or not there are attractive and positively reinforcing alternative behaviours available. Although people may choose the sedentary option, a different decision may be made if the alternative behaviour (s) are highly desirable (e.g. trip to the park). Reinforcement value refers to the appeal of the behaviour. This could be targeted through rewards and praise for choosing alternative non-sedentary behaviours.

The challenge of health behaviour interventions is often to shift the choice from an unhealthy but highly reinforcing behaviour (e.g. sedentary screen viewing) to potentially less immediately reinforcing but healthier alternatives (e.g. physical activity). Under the BECT perspective, it is considered possible to shift behaviour from sedentary screen viewing by making non-screen viewing activities more appealing (reinforcement value) and easy to do (accessible and available) relative to sedentary screen viewing.

Epstein and colleagues have used BECT as a framework for the study of sedentary behaviour and physical activity in children [70]. This work has shown that by making alternative active behaviours more accessible, and sedentary pursuits less reinforcing, reductions in sedentary behaviour and increases in physical activity are possible [70, 71]. However, with the rapidly changing technological landscape, this remains a challenge.

16.6.2 Dual-Process Approaches

As stated, dual-process theories or approaches recognise both reflective and automatic processes. This is illustrated in Fig. 16.4. The emphasis in physical activity research has been on reflective approaches, but this is now changing and includes greater use of automatic approaches for sedentary behaviour too [72] (see the next section). In fact, it could be argued that it makes even more sense to adopt automatic approaches (or at least dual-process models) for sedentary behaviour given that these behaviours appear to have a high degree of automaticity and environmental cueing. Indeed, automatic approaches have strong links to both 'habit' and affective processing. Quick, relatively automatic, actions can take place due to ingrained environmental cues (akin to habit), and relatively unconscious affective processing or 'likes' and 'dislikes'.

The affective-reflective theory (ART) of physical inactivity and exercise is a dual-process model that is firmly grounded in exercise psychology research [49]. The theory has been proposed to explain behaviour in situations in which people remain in a state of inactivity or they initiate physical activity. These authors claim that the ART differs from other theories in at least three ways: it has a focus on affect and automaticity, it is based on the known affective reactions to exercise, and it can explain the 'thoughtless maintenance' of physical inactivity or sedentary behaviour (see Fig. 16.5).

The automatic affective valuation is a result of prior experiences which may be mediated by cognitive appraisals (e.g. pride, embarrassment). Automatic affective

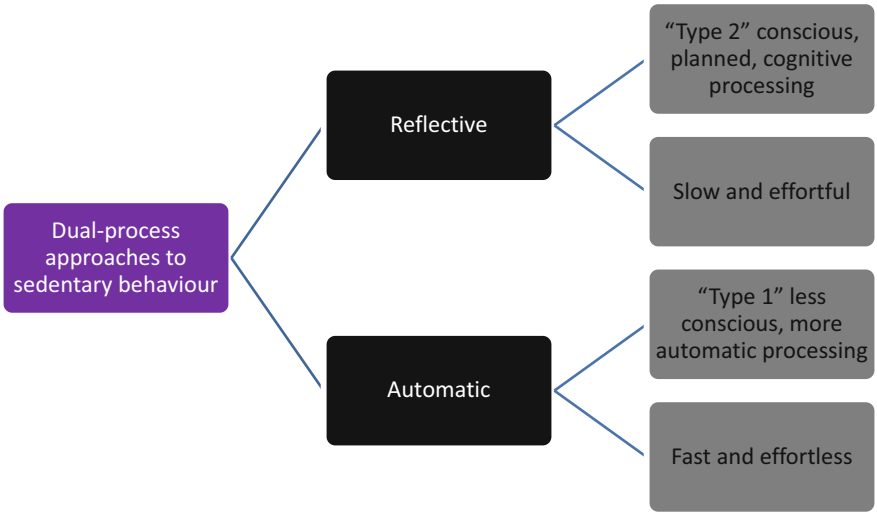

Fig. 16.4 Dual-process approaches to sedentary behaviour

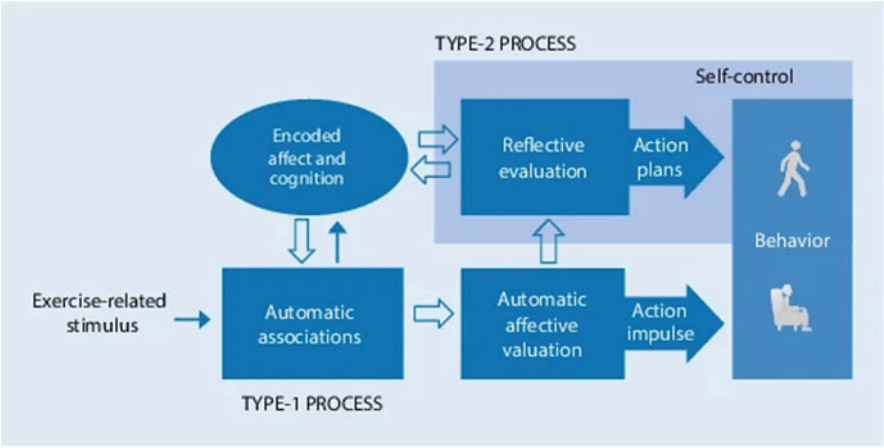

Fig. 16.5 The affective-reflective theory of physical inactivity and exercise. From [49]. Reproduced under terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0)

valuation is the fast inherently type 1 process mentioned earlier (see Fig. 16.4). Importantly, this theory suggests that the reason for why many people are physically inactive reflects this issue—'the core affective valence associated with being physically inactive is more positive than the affective valance associated with exercise' (Brand and Ekkekakis [49], p. 56). This 'gut feeling' potentially delivers a strong action impulse to move or not move.

The automatic affective valuation can serve as the basis for a slower, controlled, reflective evaluation (type 2 process; see Fig. 16.4) if self-control resources are available. This reflective evaluation draws on propositions about exercise and physical inactivity derived from previous experience and recall (e.g. anticipation of the affective consequence of physical activity). Higher-level cognitive operations, such as thoughts about self-efficacy, may also contribute to this process. This is where traditional social-cognitive based theories could be applied (e.g. social cognitive theory).

This theory assumes that the action impulse will generally prevail when sufficient motivation, opportunities, or self-regulatory resources (e.g. willpower) are low [49]. Brand and Ekkekakis conclude by saying the ART 'is a dual-process theory that emphasises the importance of automatic positive and negative associations of subsequent physical inactivity or exercise' (p. 56).

Another dual-process approach applied to active and sedentary behaviours is that of TEMPA—'theory of effort minimisation in physical activity' [47]. As the authors of this framework state, 'humans have evolved to be physically active but, more importantly, physically efficient. TEMPA integrates the processes underlying these opposite forces acting on human movement-based behaviours in a single framework' ([47], p. 172). TEMPA proposes that internal and external cues, such as the movement itself and physiological effort needed, will lead to both reflection and automaticity regarding perceived effort. Decisions are made as to whether effort is expended or not. Consistent with more automatic approaches that might rely on environmental cues, TEMPA recognises that 'promoting physical activity requires the development of an environment that triggers a spontaneous engagement in behaviours associated with higher rather than lower energy expenditure' (p. 176). This means that reductions in sedentary behaviour should consider environmental manipulation or restructuring for substituting in more active behaviours. This can then reduce the cognitive effort required for behaviour change (see Sect. 16.7).

16.6.3 Automatic Processing Approaches

Automatic processing is associated with notions of 'habit' [73]. The goal of nearly all health behaviour change is to make the desired behaviour a 'habit', or we wish to eliminate 'bad habits', such as excessive sedentary behaviour. Habits involve behavioural patterns learned through context-dependent repetition. A mental association is made between the situation and behaviour. Sedentary behaviour is an obvious example where the behaviour is strongly driven by habit. When a particular context is encountered, such as arriving home after work, it is often sufficient to automatically cue the habitual response of, say, sitting on the sofa and turning on the TV.

In novel contexts, behaviour is more likely to be regulated by conscious decisions through intentions (reflective processing), but in familiar contexts behaviour will be much more affected by habit (automatic processing). Given the high frequency of

many sedentary behaviours, such as passively sitting at a desk at work or in front of the TV, it is easy to see how habitual such behaviours become. Moreover, these behaviours might also be driven by having them appear to be attractive and accessible. For example, contemporary home-based entertainment is exactly that, including modern furniture and wide-screen, multi-channel, high definition TVs. This will make the behaviour of sedentary sitting more habitual and will lessen the need for reflective decision-making.

These arguments and examples are consistent with behavioural choice theory, as already discussed. Behavioural choices are made on the assessment of the accessibility of the behaviour and the liking (reinforcement value) of the behaviour. Kremers et al. [74] demonstrated that sedentary behaviour in the form of screen viewing has a habitual component. Dutch adolescents completed questionnaires assessing screen viewing and 'habit strength' for screen viewing, and there was a moderately strong correlation between the two. As habits are formed through repetition, it is going to require time and repetition to break one habit and replace it with another. Lally and Gardner [75] have made some suggestions on how to do this, including identifying the cues for specific behaviours through self-monitoring. This way they can identify situations in which they perform unwanted sedentary behaviour. The cue can then either be avoided or strategies can be developed so that when the cue occurs, the behavioural response to the cue is something less sedentary.

Based on behavioural economics, the concept of 'nudging' has been proposed [76]. Behavioural economics is closely aligned with what psychologists understand as behaviour analysis, with its roots in Skinnerian conditioning. Behavioural economics 'seeks to combine the lessons from psychology with the laws of economics' ([77], p. 12) and is 'designed to understand factors that influence choice among alternatives' ([78], p. 1011).

Nudging is when behaviours are encouraged through little or no incentives rather than through highly directive or so-called nannying approaches, such as government policies and legislation. Nudging is referred to as the influence of 'choice architecture' and affective judgements and responses (essentially 'gut reactions' of likes and dislikes). Choice architecture often involves altering small-scale social and physical environments to cue desired behaviours [79]. This approach might not be considered 'individual' in its orientation, although it is difficult to separate environmental drivers from individual responses.

A typology by Hollands et al. [79, 80] proposed that choice architecture interventions could involve altering properties or the placement of objects or stimuli, or both of these in combination. Altering properties, for example, might involve changing the physical ambience, labels (e.g. food), or size of a product. Altering placement might involve changing the availability or proximity of a product. Priming and prompting could involve changes to both properties and placement.

In an analysis of various health behaviours using a choice architecture approach, Hollands et al. [79] found that over 70% of studies focused on diet, with just under 20% on physical activity, the majority of which tried to nudge behaviour through changes to the ambience and design of the environment. Little has been done on

sedentary behaviour, although the use of sit-to-stand desks is an environmental manipulation that could be seen, in part, as a choice architecture strategy.

Nudging and behavioural economics informs us that affective responses are also important. Delayed consequences of our behaviour, such as long-term health benefits, are often 'discounted' and seen as less important, whereas more immediate reinforcement can powerfully shape behaviour [81]. More automatic forms of motivation can be strongly influenced by simple 'likes' and 'dislikes'. This is where behaviours follow quick and less reflective processes. For example, we may choose to buy a product (e.g. smartphone) based on looks and 'feel' as much as functionality. In the same way, we may choose a certain sedentary behaviour, such as TV viewing, based on little conscious decision-making but a simple 'liking' for this leisure-time pursuit alongside alternatives. Of course, if alternatives are highly attractive, TV viewing may be less likely. This is why we must seek to find ways of making physical activity attractive and 'affectively pleasing', and sedentary alternatives less so. A reduced emphasis on longer term health outcomes is also recommended [82, 83], thus questioning the 'exercise is medicine' mantra.

16.7 Individual-Level Approaches to Reduce Sedentary Behaviour

Interventions designed to reduce sedentary behaviour have proliferated over the past decade [84–87]. Early work focused on young people's leisure time, and primarily TV viewing and then screen use [88], and subsequent intervention work has expanded into the community [89], workplace [90, 91], schools [92], and use of technology [93]. Some adopt strategies that are more environmental, such as provision of a sit-to-stand desk, while others focus on individual behaviour change techniques, such as self-monitoring.

16.7.1 Interventions for Young People

One of the first randomised controlled trials (RCT) for sedentary behaviour reduction in children was reported by Robinson [94] more than two decades ago. This has been an influential paper with over 1500 citations (as of September 12, 2023). The rationale for the study was obesity reduction. Children aged 8–9 years were randomly allocated by school to intervention and control conditions, with 92 and 100 participants respectively being available for post-intervention assessments. The intervention comprised a mix of educational, behavioural, and environmental strategies. The main strategy was education, with the children being exposed to 18 classroom lessons in standard school time. Self-monitoring was included and the children were challenged to take part in a 10 day period of screen time abstinence.

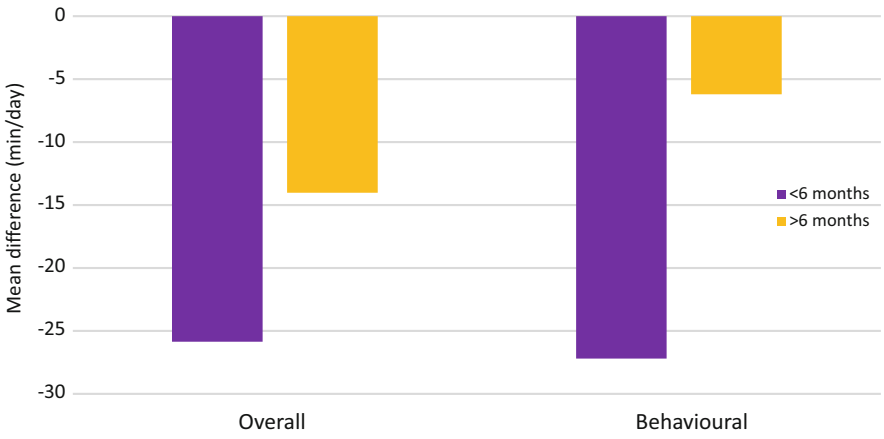

Fig. 16.6 Shorter and longer intervention effects on sedentary behaviour in young people (data from Ref. [85])

Although no formal process evaluation was undertaken, 90% of the children available at baseline participated in some days of screen time abstinence, with 67% completing all 10 days. In addition, the intervention group children were provided with a TV monitoring device, although data suggested that its use was mixed.

This RCT showed a clear reduction in TV hours per week for the intervention group, although the effect size just for this group was moderate due to large variability in the data. Raw BMI data showed that both intervention and control groups increased their BMI over the time course of the trial, which is not an unexpected trend for this age group. However, an effect in favour of the intervention group was shown through differences in BMI change between the two groups after adjustment for baseline and confounders. Overall, however, while the trial showed changes in sedentary behaviour, the intervention itself is very extensive, with many weeks of education and participation in total avoidance of screen time. Therefore, it is questionable how feasible this is to roll out. Nevertheless, this was an important initial trial in the field and appeared to have influenced further interventions designed to reduce screen time in young people.

The majority of interventions for young people have been with children rather than adolescents, and with a focus on TV viewing and screen time. There is very little on 'newer' devices such as smartphones. A review of reviews has shown that intervention effects are modest across a range of interventions [88]. A recent systematic review by Blackburn et al. [85] included both children (84 interventions) and adults (77 interventions). For children's interventions that compared intervention groups to inactive controls, sedentary behaviour was reduced by 27 min/day overall when assessed within 6 months, but only 14 min/day after 6 months follow-up. These effects were broadly similar for interventions that were 'behavioural' in focus at <6 months (e.g. reminders, prompts, planning, and reinforcement), but greater than longer term follow-ups, as shown in Fig. 16.6. This suggests that

behavioural interventions require additional strategies, or more follow-ups, for behavioural maintenance.

A comprehensive meta-analysis of 186 studies on screen time interventions in young people reported a small overall intervention effect [59]. Similar effects were seen across intervention clusters grouped by behaviour change techniques (BCTs)—social comparison, knowledge and consequences, behavioural repetition/practice, and goals, feedback, and planning. The most frequently reported individual BCTs were social support, information on the behaviour–health link, and instruction. All showed similar effects. It is not yet known whether such small effects are meaningful in a practical or clinical sense.

16.7.2 Interventions for Adults

There has been a considerable increase in interest concerning interventions for reducing sedentary behaviour adults. Much of this has centred on the context of the workplace, including changes to the office environment, such as provision of sit-to-stand desks. Interventions have also used a number of individual approaches. The increase in research on sedentary behaviour interventions for adults has led to a concomitant increase in relevant systematic reviews.

Martin et al. [84] conducted a review of 51 sedentary behaviour interventions, including 36 suitable for meta-analysis. Conclusions drawn were (a) sedentary behaviour in intervention groups was reduced by 22 min/day; (b) interventions focusing on sedentary behaviour only showed the greatest reduction in sedentary time of around 42 min/day, although there were few studies and quality was low; (c) intervention durations up to 3 months and interventions targeting men and mixed genders showed significant reductions in sedentary behaviour; and (d) intervention effects were evident up to 12 months.

The large review reported earlier by Blackburn et al. [85] also included data on adults. Behavioural and environmental interventions showed good effectiveness over 6 months, compared to inactive controls, with about a 1 h reduction for intervention groups. Blackburn et al. suggested that 'interventions based on environmental restructuring, persuasion or education were most effective' (p. 12). For older adults, it has been reported that 'individual behaviour change interventions show promise for reducing sedentary time in the short term' [95].

A popular setting for conducting sedentary behaviour reduction trials is the workplace. An early approach was to employ prompting software on desk computers with 'pop-up' advice windows timed to appear at regular intervals reminding users to either sit less or move more, or both. But the most popular approach has been the use of sit-to-stand workstations, or 'standing desks'. A Cochrane review by Shrestha et al. [90] synthesised evidence for 37 workplace interventions designed to reduce sedentary behaviour. The most successful type of intervention was the sit-to-stand workstation which showed a reduction in sitting of about 100 min/workday over three months.

Neuhaus et al. [96] reviewed evidence for the use of 'activity-permissive' workstations. These included treadmill desks, cycle ergometers, and pedal devices fitted underneath a desk. All can be used while typical desk-based tasks are undertaken. Sit-to-stand workstations were also investigated. An overall reduction in sedentary time of about 77 min/day was reported. Whether substituting physical activity in place of sedentary time has sufficient acceptability and feasibility is yet to be tested. Replacing sitting with standing may be more acceptable to ambulatory office workers, but further work is required on this to achieve a balanced combination of sitting, standing, and moving at work [97].

The 'Stand More at Work' ('SMArT Work') study was a cluster RCT using a multicomponent intervention designed to reduce workplace sitting [98, 99]. Desk-based workers were recruited. At baseline, participants sat for 73% (6 h) of their working day. The intervention group ($n = 77$) were offered intervention approaches and multicomponent strategies derived from developmental work using the behaviour change wheel (see [100]). In addition to organisational strategies (e.g. management support through newsletter and encouragement) and environmental strategies (e.g. sit-to-stand desk), individual and group strategies were implemented. These included a 30-min educational workshop, feedback from participant's baseline data using the activPAL accelerometer device (data on sitting, standing, and stepping), an action plan and goal-setting booklet, self-monitoring/prompting using an office chair 'Darma cushion' synced through Bluetooth to the participant's mobile device, and brief coaching sessions throughout.

The intervention group reduced their occupational sitting time at 12 months by 72 min/day while controls showed a slight increase in work time sitting. Some measures associated with job performance, musculoskeletal conditions, and mental health showed small positive changes. Process evaluation data suggested that behaviour change was facilitated by the sit-to-stand desk, the educational workshop, behavioural feedback, and regular contact with research staff [101].

16.8 Use of Behaviour Change Techniques

BCTs are important 'active ingredients' that individuals may use to reduce their sedentary or other health behaviours. A review has synthesised data on the use of BCTs in 26 sedentary behaviour interventions in adults [102]. Interventions were also rated as being 'very promising' (39%), 'quite promising' (21%), or 'non-promising' (39%), depending on the outcomes of the intervention.

Results showed that several individually focused techniques might be effective, including problem-solving, self-monitoring, feedback, and information on health consequences. These elements can act as part of a feedback loop whereby people monitor their sedentary time and receive feedback as part of their engagement in problem-solving. Given the earlier discussion, it is noteworthy how 'reflective' these BCTs are.

16.9 Translation of Individual-Level Approaches

Individual-level interventions are important as they represent the proximal interface between an intervention strategy and the individual attempting behaviour change. However, such changes will only occur in the context of social and physical environments, and the success of interventions will be affected by all levels. For example, the success of a technology-based individual intervention, such as through self-monitoring, will be less successful if individuals are trying to reduce their sedentary behaviour in the face of a non-supportive social climate or physical environment. Fortunately, sedentary behaviour is an inherently practical issue—it involves a high-frequency behaviour that is embedded in social and cultural norms. This makes it open to many possible issues of 'translation' from research labs into ecologically valid settings. The barriers discussed in this chapter suggest that there are challenges in achieving widespread behaviour change, but equally there is a groundswell of interest and change that continues to make inroads into individual, social, and environmental changes, thus allowing for some success, including at the individual level. The adoption of sedentary behaviour reduction strategies in work and school environments is testament to this momentum. However, most of these strategies only manage to achieve a transition from sitting to standing; increases in light ambulation or MVPA remain more difficult to achieve [99]. Changes to physical activity without disrupting work or learning time continue to be a challenge.

16.10 Summary

Sedentary behaviour research has gained huge momentum over the past two decades [103]. We have good data on many aspects of the topic relevant to this chapter, including measures, documentation of health outcomes, correlates, interventions, and translation. Of course, more can be done, and the main challenge appears to be how we secure initial and ongoing individual behaviour change in the face of social, cultural, and physical environments that encourages long periods of passive sitting and lack of movement.

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