**Correlates of sedentary behaviour in university students: A systematic review**

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**Abstract**

High levels of sedentary behaviour are associated with negative health-related outcomes. However, there is limited evidence on the variables influencing sedentary behaviour in university students. The aim of this systematic review was to identify the intrapersonal, interpersonal, environmental, and time correlates of sedentary behaviour in university students. Records from 12 electronic databases were screened by two independent reviewers. Inclusion criteria included: (i) peer-reviewed articles written in English, Spanish, or French; (ii) studies including undergraduate or postgraduate university students; (iii) studies reporting on the association between sedentary behaviour and at least one variable. The protocol is registered in PROSPERO (CRD42017074198). A total of 126 studies published between 1994 and 2017 met the inclusion criteria. The primary measure of sedentary behaviour was self-reported screen time (61%), followed by total sitting time (28%). Most studies were cross-sectional (86%). After excluding high risk of bias studies (58%), only three intrapersonal variables were sufficiently investigated (≥4) to determine an association with sedentary behaviour: physical activity (negative association with sitting time), obesity markers (indeterminate associations with TV viewing), and gender - female (null associations with total sitting time and screen time). Overall, most of the reported correlates of sedentary behaviour were intrapersonal, non-modifiable factors. Further research on modifiable correlates covering all socio-ecologic levels is required to inform future intervention development. In addition, longitudinal studies are needed to enable the identification of determinants. Improvements in designing and reporting future studies are recommended to help strengthen the available evidence and facilitate future reviewing efforts.

**Keywords:** sitting; sedentary time; college students; ecological model; intrapersonal; interpersonal; environmental.

**Introduction**

Sedentary behaviours – defined as any waking activity characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a sitting, reclining, or lying posture (Tremblay et al., 2017) – have become more and more prevalent in modern societies due to changes in the physical, social, and economic environments (Owen, 2010). Evidence suggests that high levels of sedentary behaviour are associated with detrimental effects on health and wellbeing, including an increased risk of colon and rectal cancer (Cong et al., 2014; Schmid & Leitzmann, 2014), metabolic syndrome (Greer, Sui, Maslow, Greer, & Blair, 2015), depression (Teychenne, Ball, & Salmon, 2010; Vallance et al., 2011), diabetes, cardiovascular disease, and mortality (Grøntved & Hu, 2012; Katzmarzyk, Church, Craig, & Bouchard, 2009; Wilmot et al., 2012). Importantly, the health risks of excessive sedentary behaviour have shown to be somewhat independent of reporting a recommended level of moderate-to-vigorous physical activity (e.g., Katzmarzyket al., 2009; Thorp, Owen, Neuhaus, & Dunstan, 2011). A recent meta analyses showed that only a high level of daily moderate-to-vigorous physical activity (60-75 minutes/day) appeared to attenuate the risk of all-cause mortality associated with high levels of sedentary behaviour (Ekelund et al., 2016).

The health risks associated with high volumes of sedentary behaviour have been documented across the life span, from school-aged children (Carson et al., 2016), to working-aged (Van Uffelen et al., 2010) and older adults (Stamatakis, Davis, Stathi, & Hamer, 2012). While sedentary behaviour and public health research among working-aged adults concentrates largely on office workers (Gardner et al., 2016), university students are also a population sub-group at risk of being sedentary as a significant proportion of their time is spent studying or in class (Cotton & Prapavessis, 2016). Although limited, preliminary evidence exists suggesting that undergraduate students are highly sedentary (Farinola & Bazan, 2011; Rouse & Biddle, 2010), and that their sedentary behaviour levels equal or even surpass those of desk-based workers (Moulin & Irwin, 2017). For example, a cross-sectional study conducted in Canada concluded university students spend an average of 11.65 hours of self-reported sedentary time per weekday, with most of these hours (6.18) being dedicated to university-related sedentary behaviours (Prapavessis, Gaston, & De Jesus, 2015).

The scarcity of research on university students leaves an important gap in the literature on adult sedentary behaviour for at least three reasons. First, the number of university students in developed countries constitutes an important portion of the young adult population and a substantial increase is expected in the future (Dragoescu, 2013; Universities UK, 2017). Second, university students might adopt roles such as teacher or health professional where they may influence social norms and others’ health behaviours (Leslie et al., 1999). Third, the university is a critical period for the development of future life patterns; many adult health-related behaviours are established during late adolescence and early adulthood (USDHHS, 2011).

The ‘behavioural epidemiology’ framework (Sallis, Owen, & Fotheringham, 2000) proposes that identifying correlates (i.e., the variables associated with the target behaviour) is a necessary step prior to developing interventions designed to change behaviour. Indeed, behaviours are often not changed by the intervention itself, but by a change in one or more correlates of the behaviour, which act as ‘mediators’ of change (e.g., self-efficacy, social support; Baron & Kenny, 1986; Bauman, Sallis, Dzewaltowski, & Owen, 2002). Non-modifiable correlates (or ‘moderators’), such as age or gender, may assist in identifying sub-groups at risk of being excessively sedentary (e.g., Lakerveld et al., 2017).

Among the different theories that can be used to structure the study of correlates, the socio-ecological model has been extensively used in reviews investigating what variables influence physical activity (Bauman et al., 2012) and, most recently, sedentary behaviour (O’Ddonoghue et al., 2016). The socio-ecological model posits that behaviour is shaped by a dynamic interrelation of variables at multiple levels (McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis, Owen, & Fisher, 2008), including intrapersonal (e.g., attitudes, ethnicity), interpersonal (e.g., modelling, social support), physical environmental (e.g., neighbourhood characteristics, building design), and time variables (e.g., day of the week, time of day). Previous systematic reviews have explored the correlates of adult sedentary behaviour (O’Donoghue et al., 2016; Prince et al., 2017; Rhodes, Mark, & Temmel, 2012). However, to our knowledge, no known specific review has focused on university students. Such a review may be helpful for identifying population-specific correlates of sedentary behaviour and informing future interventions. Therefore, the primary aim of the present study is to systematically review the literature on socio-ecological correlates of total and domain-specific sedentary behaviours in university students.

**Methods**

The research protocol of this study is registered in PROSPERO, an international prospective register of systematic reviews (registration number: CRD42017074198). The PRISMA guidelines were followed (Moher et al., 2009).

**Search strategy**

The following 12 electronic bibliographic databases were searched: EBSCOhost MegaFile Ultimate (including Academic Search Ultimate, CINAHL with Full Text, Education Research Complete, ERIC, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO, and SPORTDiscus with Full Text), Web of Science (including Web of Science Core Collection and MEDLINE), Scopus, and SciELO. Search alerts were set for each database and maintained until the final analyses (January 2018). The search strategy was developed with the assistance of a research librarian and combined the term 'student' with variations on the terms “university” (e.g. undergraduate, higher education), and “sedentary behaviour” (e.g. sitting, screen time). As a more detailed example, the search strategy for EBSCOhost MegaFile Ultimate is available as online supplementary material. Terms in the search were adapted where necessary to meet different database search criteria. In addition to the database search, reference lists of included studies were manually screened to identify studies.

**Inclusion criteria**

Articles were included if they met the following criteria: 1) published in a peer-reviewed journal in English, Spanish, or French; 2) included university students; and 3) investigated the association between at least one potential correlate and sedentary behaviour. Inclusion was not restricted by study design or publication date. University students were defined as undergraduate or postgraduate ('graduate') students, regardless of their mode of enrolment (e.g., full-time, part-time, on-campus, or online). Studies with samples other than undergraduate or postgraduate students were excluded (e.g., students at high school, vocational school, or school of music). Studies with special populations (e.g., students with disabilities) were excluded in order to produce findings generalizable to the broader population. In terms of types of sedentary behaviour, one or more of the following were acceptable: total sedentary or sitting time (e.g., minutes/hours per day), screen time (e.g., television, computer, mobile phone, or video games), occupational sedentary behaviour (e.g., attendance to lectures, private study time), or passive transportation (e.g., driving from/to the university). Sedentary behaviour was assessed either through self-reported or accelerometer-based measures. If sedentary behaviour was reported in terms of frequency rather than amount of time (e.g., TV viewing during X days per week), studies were excluded. Valid measures of association between a potential correlate and sedentary behaviour in quantitative studies included correlations, differences between groups, regression estimates, and odds ratios.

**Selection process**

The study selection process consisted of three phases: first, two reviewers (OC and GB) independently screened articles based on title and abstract to assess whether they met the inclusion criteria. In cases of doubt or disagreement, articles were included in the next phase. Second, the full texts of all articles selected in the initial phase were screened by two independent reviewers (OC and GB). Inclusion checklists were completed for each study, along with details on why exclusion occurred. Third, the reference list of each included study was fully reviewed to ensure that no relevant articles were missed. Any disagreement between reviewers in phases two and three was resolved by discussion (87% agreement in initial screening). If required, disagreement was resolved through a consensus discussion with a third reviewer (SJHB).

**Data extraction**

Two reviewers (OC and GB) independently extracted data from the included studies onto a standardised pre-piloted data extraction form. Discrepancies were identified and resolved through discussion (93% agreement in initial data extraction), with a third researcher mediating where necessary (SJHB). Data extracted included: (i) publication details; (ii) study design, (iii) sample characteristics, (iv) measurement of sedentary behaviour; (v) type of sedentary behaviour; (vi) correlates investigated; and (vii) significant findings.

**Data analysis**

A narrative synthesis was used to describe reported associations between sedentary behaviour and potential correlates in observational studies (prospective cohorts and cross-sectional). Correlates were grouped according to different levels from the social ecological model, including intrapersonal (e.g., attitudes, ethnicity), interpersonal (e.g., modelling, social support), environmental (e.g., neighbourhood characteristics, building design), and time variables (e.g., day of the week, time of day). The methodology for classifying strength and direction of associations follows a model provided by Sallis, Prochaska, & Taylor (2000). In this model, the percentage of findings supporting the hypothesized association between a correlate and a given sedentary behaviour determines its consistency. Specifıcally, associations were coded ‘0’ (null; 0%-33% of studies supporting the association), ‘?’ (indeterminate; 34%-59% of studies supporting the association), or ‘+’ or ‘-‘ (positive / negative; 60%-100% of studies supporting the association). A positive association occurs when the values of one variable tend to increase as the values of the second variable increase. In contrast, two variables have a negative association when the values of one variable tend to decrease as the values of the second variable increase. For categorical variables, a positive / negative association is understood in the context of differences between groups (categories). For example, a positive association between gender (female) and total sitting time means that females reported to sit more than males. Potential correlates were grouped in four groups (i.e., interpersonal, intrapersonal, environmental, or time), aligning with the socio-ecological model (Sallis et al., 2008). In addition, some variables were clustered thematically (e.g., *obesity markers* including BMI, fat percentage, and abdominal obesity). Only potential correlates investigated four or more times were considered for discussion. These variables were coded ‘00’, ‘??’, ‘++’, or ‘--‘ as appropriate. A quantitative synthesis (meta-analysis) was deemed inappropriate due to the heterogeneity of sedentary behaviour measures employed and the limited amount of studies investigating the same variables.

**Risk of bias**

The studies’ risk of bias was assessed using a version of the Cochrane Collaboration’s Tool for Assessing Risk of Bias (Higgins et al., 2011) adapted for observational studies. The modified version has been employed previously in Poitras et al. (2016) and Prince et al. (2017). Observational studies were assessed for potential sources of bias, including selection bias (sampling method), performance bias (measurement of sedentary behaviour), detection bias (measurement of correlate), attrition bias (completeness of outcome data), selective reporting bias (selective outcome reporting), and other bias (control for confounding). Each item was marked as high, low, or unclear risk of bias according to pre-specified criteria (risk of bias instrument available as online supplementary material). Two independent reviewers (OC and GB) assessed the risk of bias, resolving any conflicting results by discussion (84% agreement in initial risk of bias assessment). If required, disagreements were resolved via team discussion with a third reviewer (SJHB). A composite risk of bias score for each study was then calculated by summing the total number of criteria marked ‘low risk of bias’. When three or more of the six risk of bias criteria were met, studies were classified as having a low risk of bias. The rest of the studies were classified as high risk of bias, unless four or more criteria presented an unclear risk of bias due to incomplete reporting. In these cases, studies were classified as unclear risk of bias. The analysis of correlates was restricted to studies at low risk of bias. A sensitivity analysis was performed to explore how conclusions might be affected if all studies were included.

**Results**

**Description of studies**

A total of 129 articles representing 126 original studies met the eligibility criteria (Figure 1). Studies were published between 1994 and 2017 in English (89%) or Spanish (11%), with the majority of studies conducted over the last 5-years (64%). Data from 186,630 participants were included (Median: 278 participants per study; Interquartile range: 146-624). Studies were from North America (30%), Europe (25%), Asia (21%), South America (9%), Africa (8%), and Australia (3%). All studies apart from one (qualitative) were observational, including cross-sectional (86%) and cohort (13%) studies. A detailed overview of all included study characteristics is presented as online supplementary material.

**Risk of bias assessment**

Based on the composite risk of bias score, a majority of studies was classified as high risk of bias studies (58%). The remainder was classified as low risk of bias studies. In relation to the risk of bias per each criterion, over half of the studies (63%) had a high risk of selection bias, as these included convenience (non-probabilistic) samples. Many studies (69%) had a high risk of performance bias, given that in most cases sedentary behaviour was measured through a non-validated tool. In contrast, the risk of detection bias was low for most studies (75%), which was largely attributed to the fact that the majority used validated tools for measuring potential correlates or these were basic demographics. Over one third of the studies (37%) presented less than 10% of missing data (or low loss of participants for cohort studies) and were thus coded as low risk of attrition bias. Notably, risk of attrition bias was unclear for almost half of the studies. Most authors did not report missing data. Selective reporting bias was predominantly low (80%); the studies coded as high risk of selective reporting bias (16%) were in most cases secondary analyses of a pre-existing data set. Finally, two thirds of the studies (66%) had high risk of confounding bias, meaning that authors did not apply a statistical method to adjust for potential confounding factors. Detailed risk of bias results are presented as online supplementary material.

**Measurement of sedentary behaviours**

Most studies (94%) based their measurements exclusively on self-reported sedentary behaviour (e.g., questionnaires or inventories). The remainder relied on either accelerometer-based measures of sedentary behaviour (4%) or a combination of both self-reported and accelerometer-based measurements (2%). The primary measure of sedentary behaviour was screen time (61%), followed by total sedentary behaviour or sitting time (28%), occupational sedentary behaviour (9%), and passive transportation (2%).

**Correlates**

Across the 125 observational studies, 189 variables were examined as potential correlates. Of those, 171 (91%) were investigated just once each, six (3%) were investigated twice, seven were investigated thrice (4%) and five (2%) were investigated four or more times. Studies examined a median of two potential correlates (range 1-13). Of all potential correlates, 144 variables were classified as intrapersonal (e.g. age, self-rated health), 28 as interpersonal (e.g. seeing others in the neighbourhood exercise, being in a relationship), 13 as environmental (e.g. country income, traffic), and four as time correlates (e.g. day of the week, course of the year).

After excluding studies at high risk of bias, three intrapersonal correlates were found to have been studied in a sufficient number of studies (≥4) to determine an overall association: gender, physical activity, and obesity markers (Table 1). Of note, none of the correlates was investigated three times after excluding high risk of bias studies. If all studies were included, two additional variables would have been examined frequently enough (≥4) to determine associations: musculoskeletal symptoms (positive association with computer use) and academic performance (negative association with video games use). Complete results from the sensitivity analysis and an overview of all variables investigated are available as online supplemental material.

**Discussion**

The aim of this study was to systematically review the literature on correlates of sedentary behaviour in university students using the socio-ecological framework. Following the criteria provided by Sallis et al. (2000) and after excluding high risk of bias studies, overall associations between three intrapersonal correlates and various sedentary behaviour domains could be established.

Gender (female) was found to have a null association with total sitting time and screen time (combining TV, computer, and video games). These findings are similar to those found by Rhodes et al. (2012) in a systematic review on correlates of sedentary behaviour in adults. However, associations between gender and other sedentary behaviour domains could not be examined due to the lack of sufficient studies. There is evidence in the literature of a positive relationship between being male and use of video games across students of different ages (Greenberg et al., 2010). Similarly, some studies suggest that females tend to spend more time studying and using mobile phones than males (e.g., Fountaine, Liguori, Mozumdar, & Schuna, 2011; Musaiger et al., 2017). Further research is needed to determine the role of gender in the different sedentary behaviour domains. While gender and other non-modifiable correlates cannot be targeted as part of behaviour change interventions, they can provide information about the groups most in need of sedentary behaviour reduction efforts and possibly for targeting different behaviours between genders.

In terms of total sitting time and physical activity, all studies reported a negative (inverse) association. A systematic review on the relationship between sedentary behaviour and physical activity in adults also found a negative (inverse) association for total and domain-specific sedentary behaviour and physical activity in the majority of included studies (Mansoubi, Pearson, Biddle, & Clemes, 2014). In Mansoubi et al. (2014), the magnitude of the association was dependent on the type of physical activity: small to medium negative associations between sedentary behaviour and moderate-to-vigorous physical activity, and medium to large negative associations between sedentary behaviour and light-intensity physical activity. This could not be examined with university students due to the nature of our review (i.e., only the statistical significance, and not the strength of the association, was examined). Nevertheless, our findings seem to reinforce the idea that sedentary behaviour is displaced by physical activity (and vice versa). As such, promoting physical activity (especially light-intensity physical activity) may be a good way to reduce sedentary behaviour in university students.

Indeterminate associations were found between obesity markers and screen time (TV). The relationship between sedentary behaviour and obesity has been extensively studied in the literature. A recent review of reviews (Biddle et al., 2017) found either inconclusive or small associations between self-reported sedentary behaviour and adiposity in adults, with device-based sedentary behaviour yielding null associations. The authors concluded that ‘evidence is generally not supportive of the association between sedentary behaviour and adiposity and obesity’ (Biddle et al., 2017, p. 144). Given the inconsistency in the sedentary behaviour-obesity relationship found in our review, this conclusion may also apply to university students. Further research is needed to clarify if total or domain-specific sedentary behaviours are somehow associated with obesity in university students. Identifying which variables are consistently associated with obesity should be of concern to researchers, considering the high prevalence of overweight and obesity among university students from both developing and developed countries (Peltzer et al., 2014).

**Directions and recommendations for future research**

As found in previous reviews of sedentary behaviour in adults (e.g., Rhodes et al., 2012), the majority of correlates investigated were intrapersonal, with a limited number of studies having examined interpersonal, environmental, or time variables. In our review, only intrapersonal correlates were investigated frequently enough (four or more times) to determine associations with sedentary behaviour. This underscores the need for further research on potential correlates of sedentary behaviour that cover the full socio-ecological breadth (Sallis et al., 2008). In addition, a special focus on modifiable correlates is required to address the issue of reducing sedentary behaviour in university students. While non-modifiable correlates (e.g., sociodemographic) might be of interest to signal sub-population targets, design of future interventions should be informed by research on modifiable variables that have been consistently and sufficiently associated with sedentary behaviour. In this regard, intervention development also requires evidence on determinants (rather than correlates) of sedentary behaviour. Most of the studies in our review were cross-sectional; therefore, the evidence for true determinants remains elusive. Longitudinal and experimental studies would be necessary to examine whether these variables are in fact determinants causally related to sedentary behaviour.

In terms of sedentary behaviour measurement, there was a predominance of self-reports, with few studies relying on accelerometer-based measures. Self-reports tend to underestimate sedentary behaviour (Chastin, Culhane, & Dall 2014), probably due to the difficulty to recall a behaviour highly prevalent and passive in nature. Accelerometer-based measures, however, are not exempt from flaws. Accelerometers have also been shown to underestimate sedentary behaviour (Kozey-Keadle et al., 2011) and should incorporate an inclinometer in order to differentiate sitting from standing (Byrom, Stratton, McCarthy, & Muehlhausen, 2016). In addition, unlike context specific self-reports, they do not provide contextual information on sedentary behaviour patterns. A combination of both self-reported and accelerometer-based measures is recommended when assessing domain-specific sedentary behaviours (Healy et al., 2011). Given that different sedentary behaviour domains may be influenced by different variables, assessing contextual information is essential in the study of correlates / determinants. Last, most self-reports in our review were non-validated. Even when validated, the majority were not specific to sedentary behaviour, hence information of the context and domain was not examined. The adoption of specific and validated measures in future research should offer a richer picture on sedentary behaviour patterns (i.e., contextual information), facilitate comparisons across studies, and reduce the risk of performance bias (the criterion with the highest risk of bias among the included studies).

In addition to performance bias, sampling methods and confounding have also been important sources of risk of bias among the included studies and deserve special attention in upcoming studies. Using probability sampling (e.g., random sampling, multistage sampling) and statistical methods to eliminate confounding effects (e.g., stratification, multivariate models) will help strengthen the available evidence. This is relevant as a majority of studies in our review were rated as high risk of bias and were therefore not included in the analysis of correlates. Improving the design of future studies as recommended should contribute to reduce the overall risk of bias and, in turn, facilitate the synthesis of all or most of the available evidence in systematic reviews.

Of note, many studies presented an unclear risk of attrition bias due to incomplete reporting, which poses an important obstacle in the assessment of risk of bias. Authors can reduce incomplete reporting by employing standardized reporting guidelines (e.g., STROBE statement for observational studies; Von Elm et al., 2007). In relation to reporting, sample description has likewise room for improvement. Key information such as university students’ major subject of study or enrolment pattern were missing in most studies. These data are important in order to examine sub-group comparisons (e.g., online vs on-campus students, undergraduate vs postgraduate students).

**Study limitations**

Some limitations must be acknowledge for our review. First, only published literature was searched, potentially leading to an over representation of significant findings (publication bias). Second, the key terms from our search strategy were searched only in abstract and title, which may have resulted in missing relevant studies. Few of the included studies were conducted specifically to analyse the relationship between potential correlates and sedentary behaviour, and thus it is possible that other similar studies were missed if associations between potential correlates and sedentary behaviour were explored but not included in the abstract. Last, following the methodology described by Sallis et al. (2000), only the direction between sedentary behaviour and a given variable was coded, excluding its strength. Most of the debates in the area of sedentary behaviour concern the magnitude of the associations with other variables, however. For example, the association between screen time and body fatness has been shown to be significant but small in magnitude, which questions whether such small associations are practically meaningful (Biddle et al., 2017). Future reviewers need to reflect on whether extracting data with regard to the magnitude of the associations is meaningful and how to embed this additional information within current and commonly used methodologies for the study of correlates (e.g., Sallis et al., 2000).

**Conclusions**

The evidence suggests that a large range of correlates of sedentary behaviour for university students has been studied, yet only three intrapersonal correlates were sufficiently investigated to determine an overall association: physical activity (negative association with sitting time), obesity markers (indeterminate associations with TV viewing), and gender - female (null associations with total sitting time and screen time). Further research on variables in the physical and interpersonal environments is needed. In addition, most correlates investigated were non-modifiable variables. Although these may assist in determining the sub-groups at risk of being sedentary, a greater focus on modifiable correlates is recommended in order to identify variables that can be targeted in behaviour change interventions. The majority of studies relied upon cross-sectional design, limiting causal inference. Employing more longitudinal or experimental designs will enable the identification of determinants. Last, over half of the studies were rated as high risk of bias and were not included in the analysis of correlates. Improvements in designing and reporting upcoming studies should contribute to strengthening the available evidence, which will benefit future reviewing efforts.

**Supplemental materials**

Supplemental materials associated with this article can be found, in the online version, at

**Conflict of interest statement**

OC, JB, IV, and GB report no conflict of interest. SJHB received funding in 2016 for consultancy work for Halpern PR Limited. SJHB is an international advisory panel member for the ‘Get Britain Standing’ campaign.

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**Figure legends**

Figure 1. Flow chart for the articles included in the systematic review of correlates of sedentary behaviour in university students.

Table 1. Potential correlates of sedentary behaviour in university students investigated in ≥4 low risk of bias studies.