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Review

Cognitive and Motivational Factors Associated with Sedentary Behavior: A Systematic Review

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Abstract: Excessive time spent in sedentary behavior (SB) is associated with numerous health risks. These associations remain even after controlling for moderate-to-vigorous physical activity (PA) and body mass index, indicating that efforts to promote leisure time physical activity alone are insufficient. Cognitive and motivation variables represent potentially modifiable factors and have the potential of furthering our understanding of sedentary behavior. Hence, a systematic review was conducted to synthesize and critique the literature on the relationship between cognitive and motivational factors and sedentary behaviors. In April 2016, four electronic databases (Psych info, Pub Med, SPORTDiscus, Web of Science) were searched and a total of 4866 titles and abstracts were reviewed. After meeting inclusion criteria, study characteristics were extracted and the methodological quality of each study was assessed according to the Downs and Black Checklist. PRISMA guidelines for reporting of systematic reviews were followed. Twenty-five studies (16 cross-sectional, 8 longitudinal and one examining two populations and employing both a cross-sectional and prospective design) assessed 23 different cognitive and motivational factors. Seventeen studies were theory-based and 8 did not employ a theoretical model. Results showed that among SB-related cognitions, risk factors for greater sedentary

time included having a more positive attitude towards SB, perceiving greater social support/norms for SB, reporting greater SB habits, having greater intentions to be sedentary, and having higher intrinsic, introjected, and external motivation towards SB. Protective factors associated with lower sedentary time included having greater feelings of self-efficacy/control over SB and greater intentions to reduce SB. Among PA-related cognitions, protective factors for lower SB included a more positive attitude towards PA, having greater social support/norms for PA, greater self-efficacy/control for PA, higher PA intentions, and higher intrinsic and identified motivation towards PA. In addition, feeling more supported and empowered in general was related with lower levels of SB. The average methodological quality score for included studies was 69% (SD = 9.15%; range 35–80%). In conclusion, a number of cognitive and motivational factors were identified that were associated with sedentarism. These findings have come from reasonably high quality studies. To further extend our understanding of the relation between cognitive and motivational factors and SB, more longitudinal, theory-driven studies examining cognitions and motivation from a sedentary perspective are required.

1. Introduction

Excessive time spent in sedentary behavior is associated with numerous health risks. An overview of 27 systematic reviews found that among adults, sedentary time is positively associated with all-cause mortality, fatal and non-fatal cardiovascular disease, type 2 diabetes, metabolic syndrome, and several types of cancers [1]. Among children and youth, the risks include obesity, increased blood pressure and total cholesterol, poorer self-esteem, social behavior problems, poorer physical fitness and lower academic achievement [1]. These associations remain even after controlling for moderate to vigorous physical activity and body mass index (BMI), indicating that efforts to promote leisure time physical activity alone are insufficient.

Sedentary behavior has been defined as "any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" [2]. Sedentary behaviors permeate all domains of life, including work, school, transportation, leisure/recreation, and spiritual/contemplative pursuits. The pervasiveness of sedentarism is evident through population-based studies, which indicate that Canadian and US adults spend an average of 9.7 and 7.7 hours per day, respectively, being sedentary [3,4]. The high prevalence of sedentarism and its adverse outcomes has added a whole new paradigm to the physical activity field focused on understanding and reducing sedentary time.

Over the past few decades, there has been an increase in interest in ecological models as the guiding framework for understanding public health issues, including sedentary behavior [5,6]. According to this approach, human health is viewed as the result of an interplay between a broad range of individual, social, environmental and policy factors [6]. At the individual level, intrapersonal factors such as psychological, biological, and demographical factors have been emphasized; social factors include those related to relationship, culture, and community; environmental factors refer to the organization, safety, attractiveness, and comfort of the physical environment; and policy factors refer to regulations, health care policies or incentives, the economic climate, and any governmental policies which have health implications [6]. Although ecological models emphasize the importance of intervening at multiple levels, a comprehensive understanding of the role of individual factors represents the first step towards a more complete appreciation of the issue in question. One such area of focus is the relationship between psychological factors and sedentary behavior.

Historically, psychological factors have been divided into three distinct faculties: affect, cognition, and conation [7]. The term "affect" refers to the emotional, or feeling aspects of human nature, and "cognition" refers to the rational, or intellectual aspects. "Conation" the third proposed part of the mind, is concerned with action, or volition, the mental effort and motivation required to carry out a proposed behavior [8]. Various formulations of the latter two aspects of psychological functioning are contained within current social-cognitive and motivational models of health behavior including the Health Belief Model [9], Theory of Reasoned Action [10], Theory of Planned Behavior (TPB) [11], Protection Motivation Theory (PMT) [12], Social Cognitive Theory [13], Health Action Process Approach (HAPA) [14], and Self Determination Theory (SDT) [15]. Individual constructs within these theories include attitudes, beliefs, knowledge, perceived barriers, self-efficacy, intention, and motivation. The link between these psychological variables and a number of health behaviors, including physical activity [16] is well established. Given the increased interest in sedentary behavior research, the aim of this systematic review was to synthesize and critique the current evidence on the association between cognitive and motivation factors and sedentary behavior and discuss avenues for future research.

The relationship between sedentary behavior and cognitive and motivational factors merits investigation for a number of reasons. First, even a cursory examination of a few studies examining cognitive factors and sedentary behavior shows that a significant link between the two does exist. For example, in a review on the correlates of sedentary behavior, Rhodes, Mark, and Temmel [17] identified several studies which found a significant relationship between psychological factors and sedentary time. At the same time, these authors pointed out the need for more research in this area and since their review was published in 2012, the number of studies examining cognitive factors has certainly grown. Second, cognitive and motivational constructs have proven to be useful for understanding numerous health-related behaviours such as physical activity [58]. Thus, it is likely that an examination of these factors also has the potential to increase our understanding of sedentary behavior. Third, while a number

of published reviews have examined sedentary behavior correlates [5,17–20], none have focused exclusively on psychological determinants from a cognitive and motivational perspective. As such, this review has the potential to identify gaps in the current research and significantly impact future research in this field. Fourth, in contrast to biological (e.g., genetic) or demographic determinants such as age, ethnicity, or socioeconomic status, cognition and motivation variables represent potentially modifiable protective or risk factors. Fifth and finally, while interventions aimed at reducing sedentary behavior are urgently needed, research to identify effective behavior change strategies cannot advance without a more complete understanding of the cognitive and motivational factors underpinning behavior change.

2. Method

This review was conducted according to PRISMA guidelines for transparent reporting of systematic reviews and meta-analyses [59]. A review of the literature was first carried out by searching the following separate, specific electronic databases from their inception (dates included wherever available in the databases) until May 10, 2016: PsycINFO, PubMed, SPORTDiscus, Web of Science. The keywords used referred to the exposure (cognitive, social-cognitive and motivation) and outcome (sedentary behavior) variables of interest. Specifically, the search strategy was agreed upon by SR, AG and HP and involved entering the following search terms into abovementioned pertinent databases: (sedentary OR sitting) AND (correlate OR predictor OR psychosocial OR theory OR social cognitive OR intention OR motivation OR attitude OR self-efficacy OR barriers OR beliefs). Ethical approval was not required since this was a review and did not involve human subjects. Next to the search in electronic databases, the authors' personal databases, previous published reviews, and references of included publications were checked. As this was the first systematic review to focus exclusively on the relationship between cognitive and motivational factors and sedentary behavior, the search was not limited to specific populations. For the purpose of this specific review, studies that involved populations of any age (e.g., children/youth, adolescents, adults, older adults) were included. After identification of studies through database searching, duplicate publications were removed. The titles and abstracts of all citations derived from the search were screened independently by two of the authors. In case of uncertainty to either include or exclude the study, the full paper was read. For all relevant publications, full-text articles were then read and assessed further for eligibility.

In order to be included in this review, studies had to meet the following criteria: (a) include one or more assessments of sedentary behavior or sedentary time; (b) examine the relationship of at least one cognitive or motivation variable with sedentary behavior or sedentary time; (c) be one of the following types of study: randomized controlled trials, cross-sectional studies, case-control studies and cohort studies (i.e., reviews, editorials and opinion articles were excluded since they did not contain primary data); and (d) be published in English. Studies were excluded if they measured sedentary time but failed

to include possible correlates or if they did not measure predictors and behavior within the same individual (e.g., studies examining the relationship between parental beliefs and children's sedentary behavior were excluded). Studies examining mental health outcomes such as affect (e.g., depression, anxiety), quality of life, and physical self-perceptions were also excluded because these constructs are often viewed as consequences rather than antecedents of sedentary behavior. Finally studies that examined personality were excluded as they represent constructs that are considered stable and hence less modifiable.

All selected studies [21–45] were summarized in table format and data were extracted with regards to the author(s) and publication year, study population, sample size, sampling methods, study design, correlates/predictors examined, type and measurement of sedentary behavior or sedentary time, and the results pertaining to the relationship between behavior and significant correlates/predictors. In addition to summarizing the findings in table format and in text, we have visually represented the findings using what we have termed a pinwheel. The purpose of the pinwheel is to illustrate, at a glance, which constructs have been examined in the literature as well as whether a relationship emerged between the constructs. Within the health domain, sedentary behavior is considered a risk behavior. For this reason, the colour green was chosen to indicate a protective effect (i.e., lower sedentariness) due to its association with safety and the word "go-ahead" (e.g., its use in traffic lights). On the other hand, red is associated with a hazard and the word "stop". For this reason, we used the colour red to indicate an association between a factor and increased sedentary behavior. Yellow was chosen to indicate a null effect due to the fact that it is seen as in-between green and red (e.g., on a traffic light signal).

The methodological quality of individual studies was assessed using the Downs and Black checklist [60]. The Downs and Black instrument assessed study quality including strength of reporting, external validity, internal validity (bias), internal validity (confounding), and power. The checklist consists of 27 items with a maximum score of 32 points. A modified version of the checklist was employed with items that were not relevant to non-experimental studies removed (8, 13–15, 17, 19, and 21–24). The adapted checklist consisted of 20 items, including 14 items from the original list (1–3, 6–7, 9–12, 16, 18, 20, and 25–26); three items that were modified (4, 5, and 27); and three items created for purposes of this review. Reporting items 4 and 5 from the original list were reworded to align with non-intervention (i.e., cross-sectional and prospective) studies being examined in this review. Item 27, concerning power from the original list was modified to address the number of participants needed to detect a significant association between an exposure and sedentary behavior. Of the three items created, two were internal validity criteria and one was concerned with study power. We believe that changes made to the original checklist had merit and that modifications held value in assessing the methodological quality of studies included in this review. Each quality criterion was rated as positive (1), negative (0), or unknown/insufficiently described (0). A positive sign (+) was given if the publication provided a sufficient description of the item, per the predefined criteria, and met the quality criteria for

the item. A negative sign (-) was allotted if the publication did not provide an adequate description or did not address and/or perform the quality criteria for the item. Finally, if an insufficient or unclear description of the item was provided, a question mark (?) was given. The maximum possible score for the modified checklist was 20 points (higher scores indicate higher quality). The methodological quality of individual studies was independently scored by SR and verified by HP; if disagreements between assessors occurred, consensus was achieved through discussion with a third reviewer (AG). For each study, an overall methodological quality score was calculated. In addition, the percentage of studies meeting each quality criterion was calculated.

Data were not pooled for a number of reasons. First, there was little consistency among studies with respect to exposures and even when the same exposures were examined by multiple studies, they often used different scales. Second, studies used varying methodologies and reported statistics inconsistently. Therefore, to synthesize the evidence and allow conclusions to be drawn regarding the relationship between cognitive and motivational factors and sedentary behavior, a best-evidence synthesis that has been used in previous reviews [61] was implemented. The findings for each cognitive and motivational variable were interpreted on the following basis: there was no evidence of an association if more than 50% of the cross-sectional and prospective studies reported no association; there was inconclusive evidence for an association if 50% of the studies reported no association and 50% reported a positive or negative association; there was some evidence of an association if more than 50% of the studies reported a positive or negative association; and there was consistent evidence of an association if all of the studies reported a positive or negative association.

3. Results

The electronic search produced 4,866 articles (1298 from PsycINFO, 2595 from PubMed, 699 from SPORTDiscus, and 274 from Web of Science; Figure 1). After removing duplicates (n = 1121), a total of 3745 publications remained. After titles and abstracts were examined, 86 full-text articles were read and assessed further for eligibility. Of those, 21 articles were identified as suitable. The reference lists of studies included for full-text review were then checked for additional relevant references, resulting in four additional studies. A total of 25 studies published between the years 2003 and 2016 met the inclusion criteria and were included in the review [21–45]. The characteristics of these studies are presented in Supplementary (Table S1).
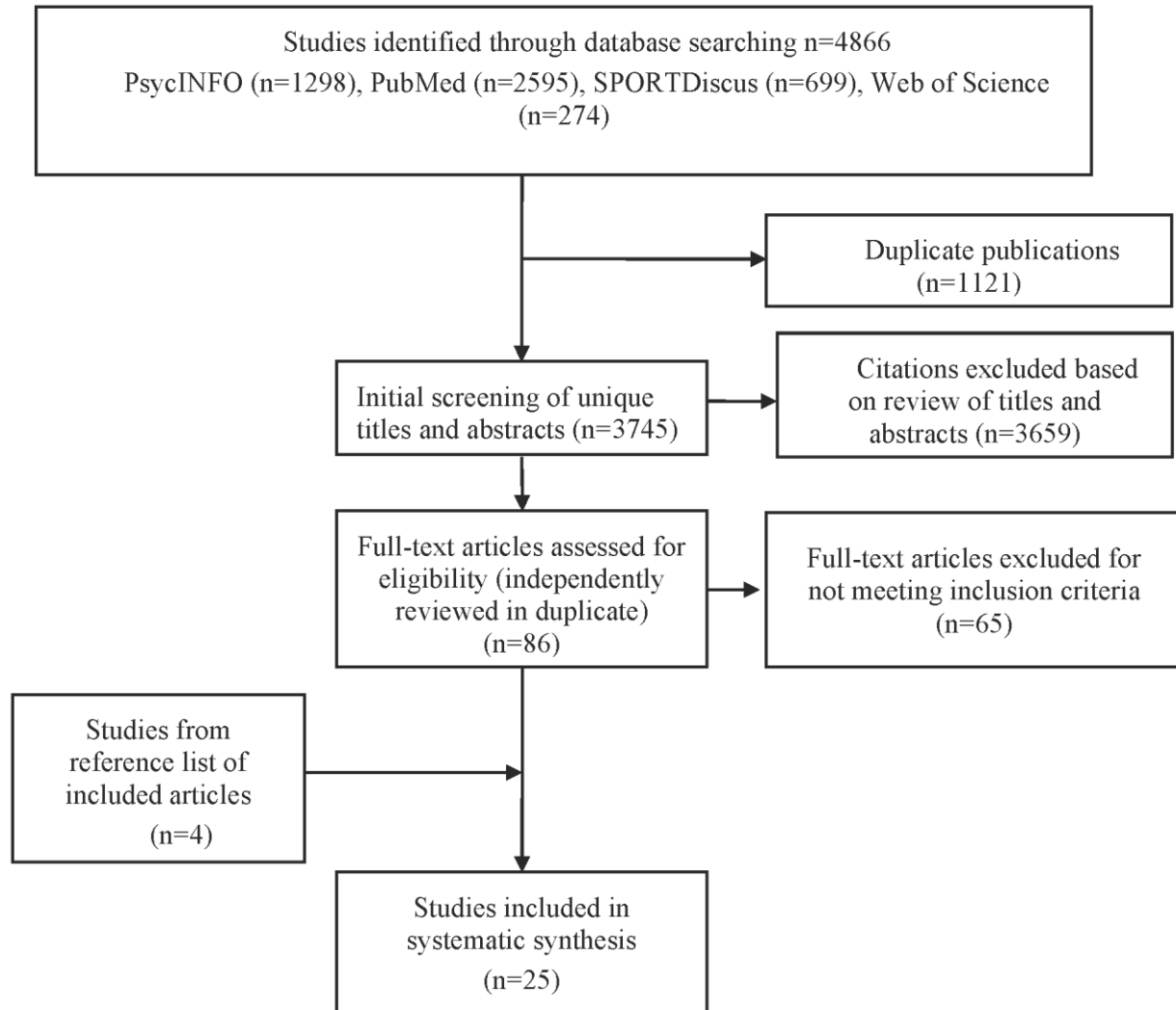
Figure 1. PRISMA flow diagram of study selection process in review of cognitive and motivational factors and sedentary behavior.

Eight [21,23,26,28,29,32,34,44] of the 25 reviewed studies did not specify a theoretical orientation in their study design and/or in the cognitive and motivational factors examined. Of these, only two [23,28] were longitudinal or prospective in nature while the remaining six [21,26,29,32,34,44] employed an observational, cross-sectional design. Researchers have emphasized the need for more longitudinal, prospective studies to be completed to fully understand temporal changes in sedentary time and corresponding psychological predictors [5,17]. Five studies [21,28,29,32,34] examined sedentary behavior in children and/or adolescent populations whereas only three studies [23,26,44] investigated cognitive and motivational determinants of sedentary behavior in adult populations. Four studies [21,28,29,34] employed convenience sampling methods and four studies [23,26,32,44] used random sampling methods. Sample sizes ranged from 188 to 1,515 participants (M = 671.88,

SD = 419.61). In terms of variables examined, six [23,26,28,29,32,44] of the eight studies investigated correlates across multiple levels of influence (i.e., socio-demographic, physical environmental, social environmental, social-cognitive, psychosocial, health-related, work-related, behavioral) and two [21,34] examined only cognitive variables. Furthermore, only four [23,26,34,44] of the eight studies assessed cognitive factors from a sedentary perspective or in a sedentary-specific manner. One study [21] examined cognitive factors from a general point of view, while three studies [28,29,32] assessed the associations between physical activity and/or exercise-specific cognitive factors and sedentary behavior.

Regarding measurement of sedentary behavior, all eight studies employed self-report measurement tools with only one study [21] capturing sedentary behavior both through self-report and objective measures. Despite the majority of studies measuring self-reported sedentary behavior, there was inconsistency between them in terms of specific sedentary pursuits assessed and the domains observed. One study [21] examined total time spent sedentary and time spent in specific leisure sedentary activities; one study [23] investigated determinants of context-specific sedentary time; four studies [28,29,32,34] measured screen time and/or screen-based behaviors; and two studies [26,44] looked at either occupational or work-related sitting time.

Primary associations of cognitive and motivational factors with sedentary behavior examined through non-theoretical studies are summarized in Table S1 and illustrated in Figure 2. Overall, the associations reported in Table S1 were small to medium in size. Five studies [23,26,29,34,44] investigated the relationship between attitudes and sedentary behavior. Of these, one study [29] found more positive attitudes towards exercise to be associated with lower sedentary behavior. Four studies [23,26,34,44] found more positive attitudes towards sedentary behavior to be associated with higher sedentary behavior. Contrary to expectations, one study [26] found more positive attitudes towards sedentary behavior to be associated with lower sedentary behavior. Five studies [21,23,26,28,32] examined the relationship between social support and/or norms and sedentary behavior. One study [21] found greater support in life to be associated with lower sedentary behavior, while one [32] study found greater support for physical activity to be associated with lower sedentary behavior. Three studies [26,28,32] found no association between sedentary behavior and greater support and/or norms for sedentary behavior. However, one study [26] found greater norms for sedentary behavior to be associated with lower sedentary behavior and one study [23] found greater support and/or norms to be associated with higher sedentary behavior. Five studies [23,26,28,29,32] investigated the relationship between self-efficacy and/or control beliefs and sedentary behavior. Two studies [28,29] found greater self-efficacy for physical activity to be associated with lower sedentary behavior, while one study [32] found this factor to be associated with lower sedentary behavior for boys but higher sedentary behavior for girls. One study [23] found greater self-efficacy for sedentary behavior to be associated with lower sedentary behavior and one study [26] found greater control for sedentary behavior to be associated with lower sedentary behavior. One study [26] showed no association between sedentary behavior and

self-efficacy for sedentary behavior. Two studies [23,34] examined the relationship between sedentary behavior habits and sedentary behavior, both of which found greater sedentary behavior habits to be associated with higher sedentary behavior. Two studies [26,34] investigated the relationship between intentions and sedentary behavior. One study [34] reported greater sedentary behavior intentions to be associated with higher sedentary behavior. Contrary to expectations, one study [26] found greater intentions to reduce sedentary behavior to be associated with higher sedentary behavior.

Figure 2. Pinwheel showing the association of cognitive and motivational factors with sedentary behavior.

Of the 25 studies included in this review, 17 were theoretically driven in their approach (see Table S1). Of these, 10 studies [22,24,27,30,31,38,39,40,42,43] employed an observational, cross-sectional design and six [25,33,35,36,37,45] were longitudinal, prospective in nature. One study [41] included samples from two separate populations, and employed both cross-sectional and prospective designs. Timelines for prospective studies ranged from seven days to three years. Five studies [22,30,31,33,38] examined sedentary behavior in children and/or adolescent populations, five studies [25,27,36,40,45] examined factors associated with sedentary behavior in college and/or university student populations, and six studies [24,35,37,39,42,43] investigated determinants of sedentary behavior in adult populations. One study [41] investigated sedentary behavior in two samples including an adult population and a university student population. Twelve studies [22,24,25,27,31,35–40,45] employed convenience sampling methods, four studies [30,33,42,43] used random sampling methods, and one study [41] employed both. Sample sizes ranged from 31 to 1,552 participants (M = 520, SD = 410.35). With regards to determinants examined, four studies [24,33,38,43] investigated factors across multiple levels of influence (i.e., socio-demographic, physical environmental, social environmental, social-cognitive, psychosocial, health-related, work-related, behavioral), seven studies [22,25,30,31,36,37,42] examined cognitive variables only, and six [27,35,39,40,41,45] were grounded in prominent social-cognitive and motivational theoretical models, such as Theory of Planned Behavior (TPB) [11], Protection Motivation Theory (PMT) [12], and Self-Determination Theory (SDT) [15]. Furthermore, 11 of the 17 studies [25,27,30,31,33,37–39,41,43,45] assessed cognitive and motivational factors from a sedentary perspective or in a sedentary-specific manner whereas four studies [22,24,35,40] assessed physical activity related factors and two studies [36,42] examined factors from both a sedentary and physical activity perspective.

In terms of sedentary behavior measurement, the majority of studies employed self-report measurement tools, however, two studies [33,35] measured sedentary behavior objectively and two studies [25,37] captured sedentary behavior both through self-report and objective measures. Nine studies [22,24,25,33,35,36,37,38,40] measured total sedentary time or overall sedentary behavior; five studies [27,39,41,42,45] investigated determinants of context-specific sedentary time; and three studies [30,31,43] measured screen time and/or screen-based behaviors.

Cognitive and motivational factors grounded in a theory-based framework and their respective associations to sedentary behavior are summarized in Table S1 and illustrated in Figure 2. Overall, the associations reported in Table S1 were small to medium in size. Eleven studies [22,30,33,35,37–39,41–43,45] examined the relationship between attitudes and sedentary behavior. Three studies [22,35,42] found more positive attitudes towards physical activity to be associated with lower sedentary behavior, however, one study [42] found no association between this factor and sedentary behavior. Seven studies [30,33,38,39,41–43] found more positive attitudes towards sedentary behavior to be associated with higher sedentary behavior, however, two studies [37,45] found no association.

Nine studies [24,30,31,35,38–41,43] investigated the relationship between social support and/or norms and sedentary behavior. One study [40] found greater support for physical activity to be associated with lower sedentary behavior; however, two studies [24, 38] failed to show an association. Five studies [30,31,39,41,43] found greater support and/or norms for sedentary behavior to be associated with higher sedentary behavior. Two studies [35,38] reported no association between this factor and behavior.

Twelve studies [22,24,31,35,37–43,45] examined the relationship between self-efficacy and/or control beliefs and sedentary behavior. One study [24] found that greater efficacy and control for life in general was associated with lower sedentary behavior. Four studies [22,24,40,42] found greater self-efficacy and/or control beliefs for physical activity to be associated with lower sedentary behavior, while one study [35] found no association. Five studies [31,38,39,43,45] reported that greater self-efficacy and/or control for sedentary behavior was associated with lower sedentary behavior; however, two studies [37,41] failed to show an association between this factor and sedentary behavior.

Three studies [25,36,37] investigated the relationship between habits, either towards sedentary behavior or physical activity, and sedentary behavior. Three studies [25,36,37] found greater sedentary behavior habits to be associated with higher sedentary behavior. One study [36] failed to show an association between greater physical activity habits and sedentary behavior.

Nine studies [25,30,35–39,41,45] examined the relationship between intentions and sedentary behavior. Two studies [37,38] found greater implementations intentions and/or planning to reduce sedentary behavior to be associated with lower sedentary behavior; however, one study [45] found no association. Two studies [25,36] found greater intentions to reduce sedentary behavior to be associated with lower sedentary behavior. One study [37] showed no association between this factor and behavior. Three studies [39,41,45] found greater sedentary behavior intentions to be associated with higher sedentary behavior. One study [30] found greater physical activity intentions to be associated with lower sedentary behavior; however, two studies [35,36] failed to show an association.

Two studies [27,40] investigated the relationship between motivational factors and sedentary behavior. One study [40] found higher intrinsic motivation and identified regulation towards physical activity to be associated with lower sedentary behavior. However, no associations were found between introjected regulation, external regulation, or amotivation and sedentary behavior. One study [27] found higher intrinsic motivation, introjected regulation, and external regulation towards sedentary behavior to be associated with higher sedentary behavior. In this study, no association was found between identified regulation towards sedentarism and behavior.

The modified Downs and Black checklist for assessment of the methodological quality of reviewed studies, including the percentage of studies meeting each item, is presented in Table 1. The overall scores of the quality assessment for each study are presented in Table 2. When the studies were evaluated, the methodological quality score of the publications ranged from 35% to 80%. The average

quality score for included studies was 69% (SD = 9.15). Out of the 25 publications (26 reported studies), one study [34] had a score of less than 50%. Three studies [22,31,36] had a score of 60%, eight studies [21,24,27,29,30,35,39,40] had a score of 65%, three studies [38,41b,45] had a score of 70%, eight studies [26,28,32,33,41a,42–44] had a score of 75%, and three studies [23,25,37] had a score of 80%. The average score of the included studies for the quality sub-scales of reporting, external validity, internal validity, and power were 88%, 31%, 71%, and 12%, respectively. Also highlighted through the assessment was the percentage of studies meeting each item on the checklist (Table 1). The majority of studies satisfied the reporting criteria (items 1–9) with >80% of studies meeting each of the items 1–8. However, only 42% of studies reported actual probability values for the main outcomes except where the probability value is less than 0.001 (item 9). In terms of the external validity criteria, items 10 and 11 attempt to address the representativeness of the findings of the study and whether they may be generalized to the population from which the study subjects were derived. Only 35% and 27% of studies met these items, respectively. The proportion of studies meeting the quality items with respect to internal validity (items 12–18) varied considerably per item, with only 35% of studies measuring the cognitive and/or motivation variables at a time prior to the assessment of sedentary behavior (item 13). Further, only 12% of studies scored positive on item 16 and included an objective assessment or some corroboration of the objective and subjective assessment in the measurement of sedentary behavior. For the power criteria (items 19–20), 88% of studies did not report a formal power calculation for determining the association between an exposure and sedentary behaviors (item 19). Because of this, it was unknown whether the sample size used for analysis was sufficiently powered for these studies (item 20).

Table 1. Checklist for Assessment of the Methodological Quality of Cross-sectional and Prospective Studies [based on modified Downs and Black checklist].

Criteria (rating of criteria: + = yes, − = no, ? = not or insufficiently described)	% studies meeting the item
Reporting	
1. Is the hypothesis/aim/objective of the study clearly described?	100
2. Are the main outcomes to be measured clearly described in the Introduction or Methods section?	100
3. Are the characteristics of the participants included in the study clearly described?	100
4. Is the study design clearly described (i.e., cross-sectional vs. prospective; if prospective, time of assessments)?	89
5. When appropriate, were principal covariates clearly described?	81
6. Are the main findings of the study clearly described?	100
7. Does the study provide estimates of the random variability in the data for the main outcomes?	92
8. Have the characteristics of participants lost to follow-up and/or with missing data been described?	89
9. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001?	42
External Validity	
10. Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	35
11. Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	27
Internal Validity—bias	
12. If any of the results of the study were based on "data dredging", was this made clear?	100
13. Were the exposure variables assessed at a time prior to the measurement of sedentary behavior?	35
14. Were the statistical tests used to assess the main outcomes appropriate?	100
15. Were the main outcome measures used accurate (valid and reliable)?	96
16. Did measurement of sedentary behavior (outcome) include an objective assessment or some corroboration of the objective and subjective assessment?	12
Internal validity—confounding (selection bias)	
17. When appropriate, was there adequate adjustment for confounding (i.e., covariates) in the analyses from which the main findings were drawn?	81
18. Were losses of participants to follow-up and/or with missing data taken into account?	73
Power	
19. Did the study report a formal power calculation for determining the association between an exposure and sedentary behaviors?	12
20. Was the sample size used for analyses reflective of the power calculation?	12

Table 2. Overall scores of the methodological quality assessment for the included studies.

Author/Criteria (1–20)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total/%
[21] Atkin, Corder, Goodyer, et al., 2015	+	+	+	+	+	+	+	+	−	−	?	+	−	+	+	−	+	+	−	?	13 65%
[22] Bai, Chen, Vazou, et al., 2015	+	+	+	−	+	+	+	+	−	−	−	+	−	+	+	−	+	+	−	?	12 60%
[23] Busschaert, De Bourdeaudhuij, Van Cauwenberg, et al., 2016	+	+	+	+	+	+	+	+	−	+	+	+	+	+	+	−	+	+	−	?	16 80%
[24] Chang & Sok, 2015	+	+	+	+	−	+	+	+	+	−	?	+	−	+	+	−	−	−	+	+	13 65%
[25] Conroy, Maher, Elavsky, et al., 2013	+	+	+	+	+	+	+	+	−	−	+	+	+	+	+	+	+	+	−	?	16 80%
[26] De Cocker, Duncan, Short, et al., 2014	+	+	+	−	+	+	+	+	+	+	+	+	−	+	+	−	+	+	−	?	15 75%
[27] Gaston, De Jesus, Markland, et al., 2016	+	+	+	+	+	+	+	+	−	−	?	+	−	+	+	−	+	+	−	?	13 65%
[28] Gebremariam, Totland, Andersen, et al., 2012	+	+	+	+	+	+	+	+	+	−	?	+	+	+	+	−	+	+	−	?	15 75%
[29] Ham, Sung, & Kim, 2013	+	+	+	+	−	+	+	+	+	−	?	+	−	+	+	−	−	−	+	+	13 65%
[30] He, Piché, Beynon, et al., 2010	+	+	+	+	+	+	−	+	−	+	+	+	−	+	+	−	+	−	−	?	13 65%
[31] Hoyos Cillero, Jago, & Sebire, 2011	+	+	+	+	+	+	+	−	+	−	?	+	−	+	+	−	+	−	−	?	12 60%
[32] Huang, Wong, & Salmon, 2013	+	+	+	+	+	+	+	+	−	+	+	+	−	+	+	−	+	+	−	?	15 75%
[33] Janssen, Basterfield, Parkinson, et al., 2015	+	+	+	+	−	+	+	+	−	+	?	+	+	+	+	−	−	+	+	+	15 75%

Study																					Score
[34] Kremers & Brug, 2008	+	+	+	+	−	+	−	−	−	−	−	+	−	+	−	−	−	−	−	?	7 35%
[35] Lowe, Danielson, Beaumont, et al., 2015	+	+	+	−	+	+	+	−	+	−	−	+	+	+	+	+	+	−	−	?	13 65%
[36] Maher & Conroy, 2015	+	+	+	+	−	+	+	+	−	−	−	+	+	+	+	−	−	+	−	?	12 60%
[37] Maher & Conroy, 2016	+	+	+	+	+	+	+	+	+	−	?	+	+	+	+	+	+	+	−	?	16 80%
[38] Norman, Schmid, Sallis, et al., 2005	+	+	+	+	+	+	+	+	+	−	?	+	−	+	+	−	+	+	−	?	14 70%
[39] Prapavessis, Gaston, & DeJesus, 2015	+	+	+	+	+	+	+	+	−	−	−	+	−	+	+	−	+	+	−	?	13 65%
[40] Quartiroli & Maeda, 2014	+	+	+	+	+	+	+	+	−	−	?	+	−	+	+	−	+	+	−	?	13 65%
[41] Rhodes & Dean, 2009 (A)	+	+	+	+	+	+	+	+	−	+	+	+	−	+	+	−	+	+	−	?	15 75%
[41] Rhodes & Dean, 2009 (B)	+	+	+	+	+	+	+	+	−	−	−	+	+	+	+	−	+	+	−	?	14 70%
[42] Salmon, Owen, Crawford, et al., 2003	+	+	+	+	+	+	+	+	−	+	+	+	−	+	+	−	+	+	−	?	15 75%
[43] Van Dyck, Cardon, Deforche, et al., 2011	+	+	+	+	+	+	+	+	+	+	−	+	−	+	+	−	+	+	−	?	15 75%
[44] Wallmann-Sperlich, Bucksch, Schneider, et al., 2014	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	−	+	−	−	?	15 75%
[45] Wong, Gaston, DeJesus, et al., 2016	+	+	+	+	+	+	+	+	−	−	−	+	+	+	+	−	+	+	−	?	14 70%

4. Discussion

The purpose of this paper was to systematically review and critique the current literature on the role that cognitive and motivational processes play in understanding sedentary behavior. While other reviews have been conducted on socio-demographic and behavioral correlates of sedentary behavior, to our knowledge this is the first to focus exclusively on cognitive and motivational factors.

Primary associations of cognitive and motivational factors with sedentary behavior examined through non-theoretical studies [21,23,26,28,29,32,34,44] showed that among children and adolescents, a more positive attitude towards watching TV and using a computer [34], a less positive attitude towards exercise [29], greater habit strength for watching TV and using a computer [34], and greater intentions for sedentary behavior [34] were associated with greater time spent in sedentary pursuits. Conversely, a more negative attitude towards screen time [34], a more positive attitude towards exercise [29], greater perceived family and peer support for physical activity [32], better friendship quality [21], greater perceived family functioning [21], and greater self-efficacy to engage in physical activity and overcome barriers [28,29,32] were associated with lower sedentary behavior. It is worth nothing that the majority of studies (4 out of 5) [28,29,32,34] with children and adolescents specifically examined screen-related sedentary behaviours. This is consistent with findings from past reviews, which found a less-developed research base on correlates of sedentary behavior among adults and highlighted the need to address this issue [5,17].

Among adults, one study [44] found, for men only, that a more positive attitude towards sitting, measured as indifference towards sitting for long periods of time, was associated with increasing work-related sitting durations. De Cocker and colleagues [26] sought to identity socio-demographic, health-related, work-related and psychosocial correlates of occupational sitting in Australian adult employees. It was found that adults who perceived greater control over how much they sat reported lower occupational sitting time, whereas those who believed that reducing their sitting time would be disadvantageous reported higher occupational sitting time. No associations emerged between self-efficacy or social support to sit less in the next month at work and occupational sitting time. Contrary to expectations, De Cocker and colleagues found that adults who perceived higher social norms towards sitting less at work, reported greater benefits of sitting less, and had greater intentions to sit less at work reported higher occupational sitting time compared to respective comparison counterparts. They also found that employment status and occupational classification had a moderating effect on the association between control to sit less at work and occupational sitting time such that lack of control to sit less at work was positively associated with occupational sitting time among full- and part-time workers and white-collar and professional workers only. These findings suggest that those who are full-time, white-collar and/or professional workers may have positive attitudes towards sitting less and

intentions to sit less; however, these individuals are also more likely to be employed in jobs that require prolonged sitting. Thus, in the absence of control, even attitudes and intentions are insufficient to lead to reduced sedentary behavior.

In a longitudinal study, Busschaert and colleagues [23] examined the relationship between changes in social-cognitive variables from baseline to one-year follow-up with changes in context-specific sitting times. They found that positive attitudes towards watching TV and computer use was associated with more sitting while watching TV and more sitting while using a computer, respectively. Higher perceived modeling of sedentary behavior (i.e., time partner spends watching TV) was associated with more sitting while watching TV and higher norms associated with computer use and motorized transport was associated with more sitting in those contexts. Self-efficacy to reduce computer use was associated with less sitting time while using a computer, whereas self-efficacy to use active transportation was associated with less sitting during motorized transport. In contrast to De Cocker and colleagues [26], Busschaert et al.'s [23] findings are in line with the expected relationships between cognitive variables and behavior. The most likely reason for this difference is De Cocker et al. [26] examined occupational sitting, a type of sedentary behavior less under an individual's control, while Busschaert et al. [23] examined leisure time sitting.

For the cognitive factors examined through non-theoretical studies, there is: consistent evidence of an unfavorable association between positive attitudes towards sedentary behavior, sedentary habits, sedentary intentions, and time spent in sedentary pursuits; consistent evidence of a favorable association between positive attitudes towards physical activity, general social support, support/norms for physical activity, and sedentary behavior; some evidence of a favorable association between self-efficacy/control beliefs for sedentary behavior and time spent in sedentary pursuits; and no evidence of an association between support/norms for sedentary behavior and levels of sedentary behavior (see Table S1 and Figure 2). While there was consistent evidence of an association between self-efficacy/control for physical activity and levels of sedentary behavior with majority of studies indicating a favorable association, one study demonstrated an unfavorable association between this factor and behavior. It is important to note that sedentary intentions, attitudes towards physical activity, general social support, and support/norms for physical activity and their relationship with sedentary behavior were only examined in one non-theoretical study each.

Health behavior change scientists from numerous fields, including physical activity, have underscored the superiority of using theory to guide their research [46]. Studies investigating cognitive and motivational factors grounded in a theory-based framework and their respective associations to sedentary behavior are summarized in Table S1 and Figure 2. Attitude, either towards sedentary behavior or physical activity, was one of the most often studied cognitions with 11 studies [22,30,33,35,37–39,41–43,45] including at least one measure of this construct. Seven studies [30,33,38,39,41–43] revealed that having more positive attitudes towards sedentary behavior was

associated with higher levels of sedentary behavior while two studies [37,45] showed no association between these constructs. Three studies [22,35,42] demonstrated having more positive attitudes towards physical activity to be associated with lower levels of sedentary behavior; whereas, one study [42] showed no association between these constructs. These findings are largely consistent with the bulk of the research on the relation between attitude and behavior, which shows that attitude can be a strong predictor of behavior [47]. A common strength of the included studies was the assessment of attitudes towards a single, specific, well-defined behavior. This may be one reason why the majority of studies demonstrated significant findings. Attitude can refer to affective attitudes (e.g., enjoyment of sitting) or instrumental attitudes (e.g., pros or cons associated with sedentary behavior). Among the studies included, three [30,33,42] assessed only affective attitudes, three [37,43,45] assessed only instrumental attitudes, and two [38,39] assessed both affective and instrumental attitudes. Among studies examining attitudes towards physical activity, two studies [22,42] examined affective and one study [35] examined both. For sedentary attitudes, all affective attitude measures and three out of the five instrumental attitude measures significantly predicted behavior. For physical activity attitudes, three out of four measures of affective attitudes and the only instrumental attitude measure were significant correlates of behavior. Taken together, these findings indicate that how individuals *feel* about sedentary behavior, and, to a lower extent physical activity, plays a strong role in affecting how sedentary they are. In summary, there is some evidence of an unfavorable association between positive attitudes towards sedentary behaviors and time spent in sedentary pursuits. There also is some evidence of a favorable association between positive attitudes towards physical activity and levels of sedentary behavior.

With regards to social support and norms as potential factors related to sedentary behavior, five studies [30,31,39,41,43] demonstrated that greater support/norms for sedentary behavior were associated with higher sedentary behavior. Two studies [35,38] failed to show an association between these factors and sedentary behavior. Five of these [31,35,39,41,43] specifically explored the influence of norms towards sedentary behavior as a potential risk factor. For the most part, the results highlight the importance of subjective norms in understanding levels of sedentary behavior. Prapavessis and colleagues [39] suggested that, as the majority of adults spend far more time being sedentary than being active, the role of others appears to be more important in encouraging sedentary than physical activity pursuits. Additionally, decisions to be sedentary are likely to be socially motivated, and socially motivated decisions enhance the recognition of normative perceptions, which in turn may influence behavior through intentions [48]. One study [40] found that greater support/norms for physical activity was associated with lower sedentary behavior; however, two studies [24,38] found no association between this factor and behavior. Among the studies, which failed to show an association, Chang and Sok [24] examined the relationship between social support for physical activity and sedentary behavior in elderly persons with hypertension and Norman and colleagues [38] examined parent-directed support for physical activity and sedentary behavior in a sample of adolescents. Chang and Sok [24] suggested,

from their findings, that predictors of sedentary behavior might be distinct from the well-known powerful predictors of physical activity. Quartiroli and Maeda [40], however, found that scoring higher with respect to the basic psychological need of relatedness in exercise was associated with lower levels of sedentary behavior. It is proposed then that perhaps, the perception of being close and connected to others through physical activity (i.e., relatedness) is a determinant of sedentarism to be explored further. In summary, there is some evidence of an unfavorable association between support/norms for sedentary behavior and time spent in sedentary pursuits. However, presently there is no clear evidence of an association between support/norms for physical activity and levels of sedentary behavior.

In terms of self-efficacy/control beliefs, outcomes assessed included self-efficacy to reduce sedentary behavior and/or screen time, scheduling self-efficacy, response self-efficacy, and perceived behavior control. Five studies [31,38,39,43,45] showed that greater self-efficacy/control for sedentary behavior was associated with lower sedentary behavior while two studies [37,41] showed no association. Maher and colleagues [37] failed to show an association between self-efficacy to limit sedentary behavior and sedentary time in older adults; however, task self-efficacy was associated with intentions to limit sedentary behavior. This indicates that efficacy beliefs may be an indirect determinant of sitting time in older adults. The authors also suggested that older adults might have particularly low levels of task self-efficacy to limit sedentary behavior due to pain or functional limitations, aging stereotypes, and previous failed attempts to engage in physical activity. Rhodes and Dean [41] showed no association between perceived behavioral control and sedentary leisure behaviors; this is contrary to findings by Prapavessis and colleagues [39] who found perceived behavioral control to be a protective factor for sedentarism. Rhodes and Dean [41] acknowledged that the absence of perceived behavioral control as a behavioral correlate or even an independent predictor of intention is markedly different from most health behaviors. However, they indicated that this could offer important information on the discriminant motivational structure of sedentary leisure behaviors compared to what is known about a behavior like physical activity, and suggest the difference may be due to high access and ease of use among people who wish to perform these behaviors. Additionally, four studies [22,24,40,42] showed that greater self-efficacy and control for physical activity was associated with lower sedentary behavior; however, one study [35] found no association between sedentary time and greater efficacy/control beliefs towards physical activity. This study was markedly different from the other studies in that it was examining TPB correlates of sedentary behavior in cancer patients with brain metastases. In this population, attitudes towards physical activity were most strongly correlated with sedentary behavior. The authors indicated that although not statistically significant, there were potentially meaningful differences in perceived behavioral control between those who sit or supine less than 20.7 hours per day and those who accumulate 20.7 hours or greater. One study [24] found that feeling more empowered overall (i.e., having greater feelings of efficacy and control for life in general) was associated with lower levels of sedentarism. In summary, there is some evidence of a favorable association between

self-efficacy/control for sedentary behavior and time spent in sedentary pursuits. Likewise, there is some evidence of a favorable association between self-efficacy/control for physical activity and levels of sedentary behavior. There is also consistent evidence of a favorable association between self-efficacy/control for life in general and levels of sedentary behavior; however, caution is warranted when interpreting this finding as only one study to date has examined this factor in relation to sedentary behavior.

Recently, due to the sporadic, varied, and unstructured nature of sedentary behavior, researchers have suggested that habit formation may play a role in understanding sedentary pursuits [36,37]. Dual process theories of motivation propose that both controlled and automatic motivational processes regulate behavior. Controlled processes are conscious, reflective, and volitional and include many of the constructs outlined in social-cognitive theories and this review. Automatic processes, on the other hand, are non-conscious, reflexive, and unintended, and can include constructs such as habits. It has been suggested that these two motivational processes may operate independently or interact to regulate health behaviors [37]. Habits develop through the repeated pairing of a contextual cue with behavior, over time, until the contextual cue automatically elicits the behavioral response [49]. Three studies [25,36,37] included in this review found greater sedentary behavior habits to be a risk factor for sedentarism. Maher and Conroy [37] recently showed that habit strength for sedentary behavior was the greatest of all the predictors of behavior, demonstrating that automatic processes, such as habits, represent a crucial component in understanding sedentarism. The findings of these studies demonstrated that the association between habit strength and sedentary behavior appears to be robust for both young and older adults. On the other hand, one study [36] failed to show an association between greater physical activity habits and sedentary behavior. The role of both controlled and automatic motivational processes in regulating sedentary behavior needs to be examined further. Dual-process models incorporating habit formation (i.e., automatic and unreasoned process) into prominent social-cognitive theoretical frameworks could explain a greater proportion of sedentary behavior and be effective in sedentary behavior reduction efforts. There has also been a call for improved measures of habit processes within the health domain, and specifically that of sedentarism [50,37]. Grove and Zillich [50] proposed a theoretical model of psychological processes associated with habitual exercise, in which they suggest that habitual health behaviours are characterized by several common features, including; strong stimulus response (S-R) bonds (i.e., driven by cues), automaticity, patterning of action, and negative consequences for nonperformance. It is possible that this model may hold value for assessing habits related to sedentary behavior. In summary, there is consistent evidence of an unfavorable association between sedentary behavior habits and time spent in sedentary pursuits, however, there is no evidence of an association between physical activity habits and levels of sedentary behavior.

In many behavior change models, intentions are seen as the principal, predisposing factor as to whether someone will engage in a particular health behavior (or not). With regards to intention as a

potential factor associated with sedentary behavior, one study [30] found greater physical activity intentions to be a protective factor for sedentarism; however, two studies [35,36] found no association. Two studies [25,36] demonstrated having greater intentions to reduce sedentary behavior to be associated with lower sedentary behavior. In one study [37], no association was found. In terms of intentions as risk factors for sedentarism, three studies [39,41,45] found greater sedentary behavior intentions to be associated with higher sedentary behavior. Finally, two studies [37,38] showed greater implementation intentions or planning to reduce sedentary behavior to be associated with less sedentary behavior, while one study [45] found no association. The abovementioned studies, taken together, provide evidence to support the theoretical construct of both goal and implementation intentions as correlates of sedentary behavior and suggest that engagement in sedentary pursuits may be a controlled motivational process similar to other health behaviours. Future studies examining the role of sedentary goal intentions need to be conducted to determine whether measuring goal intentions towards sedentary behavior itself, or goal intentions to change sedentary behavior is a more viable approach. In summary, there is no clear evidence of a favorable association between physical activity intentions and levels of sedentary behavior. However, there is consistent evidence of an unfavorable association between sedentary behavior intentions and time spent in sedentary pursuits. Additionally, there is some evidence of a favorable association between intentions to reduce sedentary behavior and levels of sedentary behavior. There is also some evidence of a favorable association between implementation intentions and/or planning to reduce sedentary behavior and levels of sedentary behavior.

Two studies [27,40] examined motivation type within a Self Determination Theory framework as a potential psychological determinant of sedentary behavior. Gaston, De Jesus, Markland, and Prapavessis [27] demonstrated higher external regulation, higher introjected regulation, and high intrinsic motivation towards sedentary behavior to be risk factors for sedentarism. Specifically, Gaston and colleagues found that intrinsic motivation was the strongest predictor of sedentary behavior, followed by external regulation and introjected regulation. These authors examined leisure and work/school activities separately, and found that autonomous motives (i.e., intrinsic motivation) underlied leisure/recreation sedentary pursuits whereas more controlled motives (i.e., external and introjected regulation) influenced work/school sedentary activities. Identified regulation, which occurs when an individual recognizes that a behavior is beneficial for achieving a personally valued goal and consequently adopts the behavior as their own [27], was not related to behavior. Since sitting is typically engaged in not for its own sake but as a means to an end, this finding was surprising. It should also be recognized that this study was the first to adapt the Behavioral Regulation in Exercise Questionnaire (BREQ) [51] for sedentary behavior. Quartiroli and Maeda [40] showed higher intrinsic motivation and higher identified regulation towards physical activity to be associated with lower levels of sedentary behavior. No association was found for introjected regulation, external regulation, and amotivation towards physical activity and sedentary behavior. The finding in both studies that intrinsic motivation is

related with sedentary behavior is consistent with the relation on attitudes and behavior. Similarly to measures of affective attitude, intrinsic motivation refers to performing a behavior for its own sake, in other words, for the enjoyment of it. More studies are required to validate the theoretical structure of SDT in explaining sedentary behavior and to identify sedentary-specific motivational factors related to sedentarism. In summary, there is convincing evidence from one study [40] of a favorable association between intrinsic motivation and identified regulation towards physical activity and levels of sedentary behavior. However, there is no evidence of an association between introjected regulation, external regulation, and amotivation towards physical activity and sedentary behavior. There is also convincing evidence from one study [27] of an unfavorable association between external regulation, introjected regulation, and intrinsic motivation towards sedentary behavior and time spent in sedentary pursuits. No evidence of an association between identified regulation towards sedentary behavior and levels of sedentary behavior has been shown.

Given that the associations between cognitive factors, motivational factors and sedentary behavior or sedentary time were small to medium in size, researchers interested in targeting these modifiable variables will need to take this into consideration when using these as agents of change for sedentary behavior interventions. Furthermore, these findings suggest that both physical activity related and sedentary-specific cognitive and motivational factors will play a role in understanding sedentarism. With respect to movement-related factors, research has shown a strong, inverse correlation between sedentary behavior and light-intensity physical activity [62], as well as a small to medium inverse correlation between sedentary behavior and leisure time physical activity [17,63]. If these behaviors are associated with one another, then it is highly likely that physical activity related cognitions could be associated with time spent sedentary. The findings, herein, serve to confirm this rationale and demonstrate that physical activity related cognitive and motivational factors are correlates of sedentary behavior. In order to maximize the contribution of studies examining physical activity related factors to our understanding of sedentary behavior determinants; researchers might need to measure these cognitions as they pertain to specific types of physical activity (i.e., total physical activity, light-intensity physical activity).

Based on the Downs and Black checklist [60] for assessment of the methodological quality, the findings from the included studies in this systematic review come from reasonably high quality studies (see Tables 1 and 2). For instance, 22 of the 26 reported studies had overall quality scores ≥65% and 11 of the 26 studies had overall quality scores ≥75%. We found no difference between the average quality scores (i.e., percentages) of theoretically-driven (M = 68.9%, SD = 6.4) versus non-theory based studies (M = 68.1%, SD = 13.5). Furthermore, studies that demonstrated an association between cognitive and/or motivational variables and sedentary behavior (M = 69%, SD = 9.2) were of similar quality to those studies that found no association between these constructs (M = 71%, SD = 5.8). The two major weaknesses with the included studies are that: only 35% of them measured the cognitive and/or motivational variables prior to the assessment of SB and only 12% of them included an objective

measure or some corroboration of the objective and subjective measure of SB.

A number of future recommendations should be considered with respect to the findings presented herein. There is a need for more longitudinal, prospective studies to be completed examining cognitive and motivational determinants of sedentary behavior. Only nine of the 25 reviewed studies were prospective in design and majority of these had relatively acute timelines (i.e., 7 to 14 day period). Studies that examine the association between cognitive and motivational factors and context-specific sedentary behavior over longer durations are required. The majority of the reviewed studies (i.e., 20 out of 25) employed solely self-reported estimates of sedentary behavior through a range of questionnaires, which differed in their outcomes assessed. Because of its high prevalence and habitual nature, sedentary behavior may be very difficult to recall accurately. It is recommended for future research in this field of inquiry to use accelerometers and/or inclinometers in conjunction with self-report methods. There was widespread variability between studies in the analytical methods used to identify correlates of sedentary behavior, as well as in the effect sizes reported. Consistent with the recommendations made by Rhodes et al. [17], researchers are encouraged to report standardized effect sizes along with the significance criterion when presenting their findings regarding cognitive and motivational factors related to sedentary behavior. This will allow for a meta-analysis to be conducted in this domain so the magnitude of cognitive and motivational constructs related to sedentary behavior can be evaluated and understood.

Replication of theory-based studies measuring sedentary-specific cognitive and motivational factors in high sedentary populations and contexts where sedentary behaviors are dominant is strongly recommended. These studies should also work on refining and validating instruments used to assess cognitions and conations (i.e., motivation) related to sedentarism. As noted in this review, a number of studies adapted physical activity scales or used non-validated tools to assess cognitive and motivational factors. The development of psychometrically validated tools and testing of theory is important for identifying and differentiating between protective and risk factors for sedentarism at varying life stages and across sedentary domains. This will allow researchers to identify the important cognitive and motivational correlates that should be targeted in interventions designed to reduce sedentary behavior. Owen and colleagues [5] suggested that the "primary strategic goal for research on sedentary behavior determinants and interventions is to integrate evidence to identify effective or promising strategies to reduce sitting time." Further, Rhodes et al. [17] proposed that cognitive, social, and environmental correlates seem better suited for intervention efforts to reduce sedentary behavior. Theoretical behavior change models have been useful in identifying cognitive and motivational factors that have been shown to be associated with sedentary behavior, however, the manipulation of these variables for purposes of behavior change interventions to reduce sedentary behavior has yet to be extensively examined. For instance, Carr and colleagues [52] conducted a randomized controlled trial and demonstrated that an intervention grounded in Social Cognitive theory led to reduced sedentary time among middle-aged, sedentary and overweight adults working in sedentary jobs. In another successful study, Gardiner and

colleagues [53] demonstrated that an intervention to reduce and break up sedentary time in older adults using Social Cognitive theory and behavior choice theory led to decreased sedentary time, increased breaks, and increased light-intensity physical activity and moderate-to-vigorous physical activity. While promising, further inquiry into the development of theory-based interventions targeting cognitive and motivational constructs with the goal of sedentary behavior reduction is needed.

Another potential theoretical model of interest for use in the sedentary behavior domain is the Health Action Process Approach [14] (HAPA). The HAPA model includes many variables that are similar to those shown in this review to be associated with sedentary behavior. This model holds several advantages over other models for intervention design and delivery in that it is a dynamic rather than static model. According to the HAPA model, successful behavior change involves both a pre-intentional motivational phase in which intention is formed and a post-intentional volitional phase in which intention is translated into action. To this end, the HAPA attempts to bridge the 'intention–behavior gap' inherent with other behavior change models (e.g., PMT, TPB) with action planning, coping planning, and action control components [54]. The HAPA model's effectiveness to explain the adoption and maintenance of numerous health behaviors has been demonstrated [14]. It is anticipated that the HAPA will also be of value in the sedentary behavior domain. It is recommended that the same line of inquiry be followed with HAPA as with previous behavior change models. First, valid and reliable HAPA sedentary constructs must be developed and then show an association to sedentary behavior. If relationships are found, the constructs must be targeted and modified through action and coping planning interventions with the goal of sedentary behavior reduction. Maher and Conroy [37], to our knowledge, are among the first to test a HAPA-based model of sedentary behavior and directly link planning, a key component of the HAPA model, with sedentary behavior. Maher and Conroy [37] highlighted that with other health behaviors, planning has been shown to be a crucial factor for bridging the goal intention-behavior gap. Their findings suggest that planning context-specific substitutes for sedentary behavior may be a promising approach for overcoming strong sedentary habits.

For purposes of this review, studies examining cognitive and motivational correlates of sedentary behavior from a qualitative approach were excluded. However, it is important to acknowledge that qualitative studies in this field of study exist and may potentially contribute to a deeper understanding of the role that cognitive and motivational factors play in sedentarism. For instance, Deliens, Deforche, De Bourdeaudhuij, and Clarys [55] used focus group discussions to examine a range of determinants of physical activity and sedentary behavior in university students, including perceived enjoyment, modeling, social support, and self-discipline. Similarly, this review was interested in the role of cognitive and motivational factors as determinants of sedentary behavior; as a result, studies examining affect (e.g., feelings, mood, stress, depression, coping behavior), physical self-perceptions (e.g., physical conditioning), health-related quality of life (e.g., physical function), and personality (e.g., traits, resilience) factors were excluded. It is recognized that these factors may also hold importance for a

complete understanding of sedentary behavior determinants. For example, Uijtdewilligen, Singh, Chinapaw, Twisk, and van Mechelen [56] investigated the role of problem-focused coping, emotion-focused coping, and personality traits (i.e., inadequacy, social inadequacy, rigidity, self-esteem, self-sufficiency/recalcitrance, dominance, hostility) as person-related determinants of TV viewing and computer time in a cohort of young Dutch adults. They found that higher rigidity and self-sufficiency/recalcitrance were positively associated with TV time, whereas higher scores on self-esteem were significantly associated with higher computer time. Further, Breland, Fox, and Horowitz [57] examined the relationship between daily screen time and depression in a cross-sectional sample of overweight or obese minority women. Independent of physical activity, findings showed that engaging in high levels of daily screen time was associated with increased depression risk. These types of studies are warranted if we are to gain a more comprehensive understanding of the role psychological factors play in sedentarism.

In conclusion, a number of cognitive and motivational factors were identified that were associated with sedentarism. Among sedentary behavior-related cognitions, risk factors for greater sedentary time included having a more positive attitude towards sedentary behavior, perceiving greater social support/norms for sedentary behavior, reporting greater sedentary behavior habits, having greater intentions to be sedentary, and having higher intrinsic, introjected, and external motivation towards sedentary behavior. Protective factors associated with lower sedentary time included having greater feelings of self-efficacy/control over sedentary behavior and greater intentions to reduce sedentary behavior. Among physical activity-related cognitions, protective factors for lower sedentary behavior included a more positive attitude towards physical activity, having greater social support/norms for physical activity, greater self-efficacy/control for physical activity, higher physical activity intentions, and higher intrinsic and identified motivation towards physical activity. In addition, feeling more supported and empowered in general was related with lower levels of sedentary behavior. To further extend our understanding of the relation between cognitive and motivational factors and sedentary behavior, more longitudinal, theory-driven studies examining cognitions and motivation from a sedentary perspective are required.

Conflict of Interest

The authors declare no conflict of interest.

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