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Review article

The effects of sedentary behaviour interventions on work-related productivity and performance outcomes in real and simulated office work: A systematic review

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ABSTRACT

This review examined the impact of environmental, behavioral, and combined interventions to reduce occupational sedentary behaviour on work performance and productivity outcomes. Productivity outcomes were defined as variables assessing work-related tasks (e.g., typing, mouse), whereas performance outcomes were categorized as any variables assessing cognition that did not mimic work-related tasks. Nine databases were searched for articles published up to January 2018. Sixty-three studies were identified that met the inclusion criteria: 45 examined a productivity outcome (i.e., typing, mouse, work-related tasks, and absenteeism), 38 examined a performance outcome (i.e., memory, reading comprehension, mathematics, executive function, creativity, psychomotor function, and psychobiological factors), and 30 examined a self-reported productivity/performance outcome (i.e., presenteeism or other self-reported outcome). Overall, standing interventions do not appear to impact productivity/performance outcomes, whereas walking and cycling interventions demonstrate mixed null/negative associations for productivity outcomes. Hence, standing interventions to reduce occupational sedentary behaviour could be implemented without negatively impacting productivity/performance outcomes.

1. Introduction

Sedentary behaviour (SB), has been defined as any waking behaviour characterized by an energy expenditure ≤1.5 metabolic equivalents (METs), while in a seated, lying, or reclining posture (Tremblay et al., 2017). Due to the dual postural and expenditure aspects to the definition, behaviors such as standing, sleeping, or sitting while cycling, are not considered SBs. It is important to note that SB (specifically non-SB) is unique from physical activity, in both definition and measurement. Physical activity refers to any bodily movement by skeletal muscles that results in energy expenditure (Caspersen et al., 1985); while some non-SB's are included in this definition (e.g., walking), behaviours like standing are not. Given the postural component of SB, measurement of SB must account for this through an inclinometer, whereas physical activity instruments (e.g., accelerometers) do not. Hence, the distinction between SB and physical activity is an important one to make when measuring and evaluating SB interventions.

Office workers and occupational environments are an area of interest for SB research. A study by Thorp et al. (2012) found that office workers spend up to 75% of their workday engaged in sedentary pursuits. In response, many workplaces have implemented interventions specific to reducing SB and promoting non-SB activities; these differ from physical activity interventions in that they seek to break up periods of prolonged sitting in multiple, frequent bouts, rather than a singular bout. Traditionally, these interventions have modified the built environment of the office (e.g., activity-permissive workstations: standing desks, cycling desks, etc.) as a means to improve SB outcomes through offering alternative work postures and/or being activity permissive. For instance, a meta-analysis by Neuhaus et al. (2014a), found a pooled reduction in sedentary time by 77 min per 8 h workday from the implementation of activity permissive workstations. These results are in line with more recent reviews which found > 60 min reductions in sitting per workday in the majority of studies utilizing sit-stand desks (Hutcheson et al., 2018), and moderate evidence for a reduction in SB at work from the use of sit-stand workstations (Commissaris et al., 2016).

Despite the effectiveness of these occupational SB interventions to reduce sedentary time in the office, the effect of these programs on

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work-related outcomes such as productivity and performance are questionable (Conn et al., 2009). Productivity and performance outcomes, and their relationship with SB, are of interest in an occupational population. Gilson, Straker, and Parry alluded to the importance of "making a case for business" with respect to SB, stating: "evidence of benefits using more objective indicators of work performance and sitting times are needed to convince decision makers to adopt and promote change at the organizational level" (Gilson et al., 2012).

Several systematic reviews have examined the relationship between productivity and/or work performance and SB in the workplace (Neuhaus et al., 2014a; Hutcheson et al., 2018; Commissaris et al., 2016; Cao et al., 2016; Karakolis and Callaghan, 2014; Karol and Robertson, 2015; MacEwen et al., 2015; Prince et al., 2014; Torbeyns et al., 2014; Tudor-Locke et al., 2014). Karakolis and Callaghan conducted one of the first reviews to examine the effect of SB on productivity through sit-stand desk use. They concluded that sit-stand desks resulted in little to no decrease in productivity, but attributed the weak evidence to only examining 3 studies, and all in a lab environment (Karakolis and Callaghan, 2014). These findings are in line with reviews by Neuhaus and colleagues and Torbeyns and colleagues which examined the use of activity permissive workstations on work-related outcomes as a secondary outcome, finding the majority of work-related outcomes unaffected; these reviews did note some conflicting evidence for cycle ergometers and treadmill desks, as they reported deleterious effects on work productivity (Neuhaus et al., 2014a; Torbeyns et al., 2014). More recent reviews examining environmental occupational SB interventions have shown general agreement with these findings (Hutcheson et al., 2018; Commissaris et al., 2016; Cao et al., 2016; Karol and Robertson, 2015; MacEwen et al., 2015; Prince et al., 2014; Tudor-Locke et al., 2014).

The effect of behavioral interventions for reducing workplace SB is less clear. One review found two of three studies targeting SB with a behavioral intervention showed a significant reduction in SB (Commissaris et al., 2016); however, the lack of research on behavioral and combined behavioral/environmental workplace interventions, as well as the limited use of behavioral models in these interventions (Hutcheson et al., 2018) restricts a definitive standpoint on their efficacy. Additionally, no review has yet examined the effect of occupational behavioral SB interventions on productivity/performance outcomes as a primary objective.

There are two key differences that separate the present systematic review from previous reviews. First, the current review examines performance and productivity as primary objectives. Focusing on productivity and performance potentially yields articles that may have been overlooked in previous work that only examined productivity and performance as secondary objectives. Concentrating on productivity and performance outcomes also allows for a more comprehensive and detailed analysis on the effect of these outcomes. To the authors' knowledge, only two other reviews have examined productivity and/or performance measures as a primary objective (Cao et al., 2016; Karakolis and Callaghan, 2014); however, these reviews did not differentiate between measures of productivity and performance. The current review builds upon these reviews by differentiating between productivity (i.e., work-related tasks or outcomes) and performance (i.e., cognition-related tasks or outcomes that do not mimic work-related tasks) outcomes.

The second way the current review differs from prior reviews is the inclusion criteria for studies. The majority of the aforementioned reviews examined environmental interventions (e.g., sit-stand and activity-permissive desks). To the authors' knowledge, only three other reviews have examined both environmental and behavioral intervention paradigms (Commissaris et al., 2016; Prince et al., 2014; Gardner et al., 2016), and two included studies in both occupational and adult populations (Prince et al., 2014; Gardner et al., 2016). The present review also builds upon these reviews by including both office-based and lab-based interventions. The work by Commissaris et al. examined the effectiveness of both behavioral and environmental interventions during productive work; however, they excluded lab-based work (Commissaris et al., 2016). Given the body of research examining productivity and performance outcomes in lab-based SB interventions, the authors feel the inclusion of these lab-based interventions is of value. Given the variability in inclusion criteria, recent reviews have differed in the number of studies included for analysis (e.g., 41 (Commissaris et al., 2016), 20 (Gardner et al., 2016), 15 (Hutcheson et al., 2018), 16 (Cao et al., 2016), 23 (MacEwen et al., 2015), or 32 (Torbeyns et al., 2014) studies).

Thus, the purpose of the present paper was to critically review and evaluate the impact of occupational SB interventions (i.e., environmental, behavioral, and combined) on productivity and work performance-related outcomes in office workers, or simulated office tasks. To the authors' knowledge, the present review is the first to incorporate all the aforementioned inclusion criteria to comprehensively investigate this purpose.

2. Methods

2.1. Study eligibility

Studies of interest were defined as any environmental and/or behavioral, active and/or standing workstation intervention. The included studies must have recruited a sample of office workers, or simulated office workers, and examined at least one measure of productivity and/or performance. The included studies were published articles and dissertations from thesis work, written in English. Additionally, there was no minimum number of participants required for eligibility. In order to comprehensively evaluate all relevant existing literature, all types of experimental study designs (e.g., pre-post, randomized controlled trial, within-subject designs) were included.

2.2. Literature search

This review was conducted in accordance with the PRISMA guidelines to ensure an appropriate process when conducting the systematic review (Moher et al., 2010). The search strategy was agreed upon by the authors and included entering (Posture OR (stand OR standing) OR (walk OR walking) OR "non-sitting" OR sedentary OR "non-sedentary" OR (sit OR sitting)) AND ("Workstation" OR desk OR behav* OR attitude OR intervention) AND (Productivity OR performance OR cognition OR task OR attention OR absenteeism OR efficiency OR effectiveness OR (type OR typing)) AND (Office OR (work OR worker OR working OR workplace) OR (employment or employee) OR job OR "work force") into the databases (Pubmed, psychINFO, SCOPUS, Web of Science, SportDISCUS, CBCA Business, ABI/INFORM, Physical Education Index, and Business Source Complete) for articles up to January 2018. Fig. 1 outlines the breakdown of obtained articles from the literature search to studies included in the review.

2.3. Study selection and quality assessment

Screening of all retrieved studies was done by WS, MF, and SS. Full-text articles that appeared to meet the inclusion criteria during initial screening were then examined to ensure they met the entirety of inclusion criteria. This process was conducted independently, followed by a review from one of the remaining two authors. When inconsistencies arose, discussion presumed, and a consensus was achieved.

Studies that met the inclusion criteria were assessed for risk of bias by using The Cochrane Risk of Bias Tool (Higgins et al., 2011). The Cochrane Risk of Bias Tool consists of 7 items within 6 domains (i.e., selection bias, performance bias, detection bias, attrition bias, reporting bias, and other bias) that assess the overall risk of bias of an experimental study. In total, this review utilized 10 items for assessing the included studies; an additional item for performance bias, detection