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Review

Too Much Workplace Sitting: A Brief Historical Perspective

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ABSTRACT

International Journal of Exercise Science 12(2): 777-785, 2019. Sedentary behavior is a risk factor for the development of chronic diseases, especially those of cardiovascular and metabolic origins. Prolonged sitting is one of the most common sedentary behaviors among adults. Individuals sit for hours every day for several reasons, including work and or physical limitations. Historical accounts regarding the negative health effects of prolonged sitting began with early epidemiological studies, which sparked a breakout of research examining this behavior in the workplace setting. Understanding the risks associated with prolonged workplace sitting is important when considering workplace interventions, such as sit-stand workstations. These interventions appear to be beneficial in reducing sedentary time in the workplace. Other methods of reducing prolonged sitting outside of the workplace have been studied and could, potentially, be implemented in the workplace. These methods include short bouts of physical activity and non-exercise related activity, such as fidgeting. Overall, implementing workplace interventions could potentially alleviate the cardio-metabolic health risks associated with occupational prolonged sitting.

KEY WORDS: Review, sedentary behavior, sit-stand workstations, diabetes, obesity, cardiovascular disease

INTRODUCTION

Sedentary behavior is a risk factor for the development of chronic disease, such as obesity, unhealthy blood lipid profiles, cardiovascular disease, and premature mortality (19). Traditionally, sedentary behavior has been defined as waking behavior where the energy expenditure ≤ 1.5 metabolic equivalents (METs), while reclining, lying, or sitting (31). Sitting, especially prolonged uninterrupted, is one of the most common sedentary behaviors in adults, and individuals sit for many hours every day for several reasons—occupation, commuting, entertainment, and or physical limitations (e.g., spinal cord injury) (3). Prolonged, uninterrupted sitting has been shown to negatively affect markers of central and peripheral vascular health (8), as well as decreases in cerebrovascular hemodynamics (6). Despite the risks of sedentary behavior, specifically prolonged sitting, individuals still spend a majority of their time seated—employees spend 62% of their workday sitting (1). This could be due to a combination of factors, such as lack of mechanistic scientific evidence, or dismissing the idea of sitting, independent of exercise, being an important risk factor for cardio-metabolic disease.

Physical inactivity is an ever-present issue. More than 80% of American adults do not meet the federal guidelines for aerobic and muscle-strengthening activity, which are at least 150 minutes to 300 minutes of moderate-intensity aerobic based activity or 75 minutes of vigorous-intensity physical activity per week, or a combination of these intensities to achieve the targeted volume with muscle-strengthening activity of at least moderate intensity on 2 or more days a week (32). Additionally, given the amount of time spent in the work place setting each day, and the transition from a physically-demanding job to a sedentary lifestyle, which is common among retirees, the workplace may be an important setting for health promotion, physical activity adoption, and behavior change (7). It is important to understand further the consequences associated with prolonged sitting, as well as potential interventions that could mitigate those risks. Thus, the purpose of this brief review paper is to use novel, landmark studies to trace the history of prolonged occupational sitting and review interventions that can be implemented to reduce workplace sitting and the burdens associated with this behavior. This paper will begin with a synopsis, describing a potential theory for why sitting has become our default, physiological anchor point.

PROLONGED SITTING

Individuals are biomechanically designed to engage in weight-bearing work with their legs and sit for rest. The body's default position is vertical and yearns for weight-bearing motion. As time progressed, however, the body's default position has shifted to sitting (19). For example, the first thing you are told upon entering an office for a meeting is "have a seat." Waiting rooms are filled with seats ready to be occupied, and even students are told to sit quietly for long periods in the classroom for instruction. This type of instruction and environment fosters sedentary behavior and, at times, allow for no other option but to sit (23). Many occupations are more conducive to spending extended amounts of time seated, which can lead to many negative health outcomes (4).

History of Occupational Sitting

Early epidemiologic studies focusing on occupational activity and sitting began as early as the late 1940s with a foundational study, conducted by Dr. Jerry Morris, a British epidemiologist, the famous London Double-Decker Bus Study (22). Researchers followed drivers and conductors on the double-decker bus system in London, and prospectively examined the incidence of coronary heart disease (CHD), under the premise that men with physically active jobs would have lower incidence of CHD than men in physically inactive jobs. The researchers observed men between the ages of 35 and 64 who were employed as bus, tram, and trolley drivers and conductors. Morris et al. (22) found that the drivers (those that spent the majority of their workday sitting at the wheel of the bus) were twice as likely to suffer from a myocardial infarction compared to the conductors (those constantly on their feet and climbing stairs to collect tickets and seat passengers). The results of this study led Morris to conclude that any sort of physical activity seemed to have a protective effect against CHD, a conclusion that was supported by a later study conducted on postal workers. Similar to double-decker bus workers, postal workers either walked or rode a bike on the delivery route compared to individuals in

more sedentary postal jobs. The postal workers with physically active jobs had lower CHD rates compared to their sedentary counterparts (22). In an effort to confirm the findings of Morris et al., Kahn (15) set out to determine the relationship between occupational physical activity and incidence of CHD in postal clerks and carriers. Kahn also found that CHD mortality risk was 40%-90% higher for those in sedentary jobs than those with more active jobs. In a later study by Paffenbarger et al. (1970), researchers followed longshoremen who performed strenuous, moderate, and light tasks and examined the incidence of CHD. After the 22 years of follow-up, the researchers found that longshoremen whose work required strenuous activity experienced fewer coronary events compared to those who completed moderated and light work (24). This study and the previously mentioned study by Kahn affirmed the work of Morris suggesting that repeated physical activity was protective of CHD. Importantly, the landmark research conducted by Morris and others placed the public health significance of physical inactivity in the limelight, in turn creating a breakout of physical inactivity research, which has progressed more recently to research examining the physiological ramifications of prolonged sitting.

Workplace Sitting

Individuals spend one-third of their adult life in the workplace. In a study examining full-time employees in the United States, researchers found that working adults employed in sedentary occupations spend approximately 7-8 hours sleeping and 11 hours of the waking day engaged in sedentary behaviors both during and outside of work, with 82% of sedentary time accounting for their work hours and 62% of their work hours spent sitting (1,12). With technological advancements and the increased use of computers, for most, sitting is a common behavior (4,17,18).

Most of the research, to date, regarding the consequences of prolonged sitting in the workplace has been focused on the biomechanical mechanisms, specifically consequences, such as musculoskeletal disorders, (e.g. lower back pain, knee and hip arthritis), resulting from improper posture that individuals adopt in the workplace (30). More recently, understanding the cardio-metabolic outcomes associated with prolonged workplace sedentary behavior has become increasingly relevant. Some evidence shows that occupational sitting is associated with health outcomes such as cardiovascular disease (CVD) (27), premature mortality (16), diabetes mellitus (10), cancer (16), and an unhealthy body mass index (BMI) (9). In a systematic review by van Uffelen et al. (33), these aforementioned negative health outcomes were identified in 43 studies examining the effect of occupational sitting. This leads to a simple, yet important question, of what can be done to alleviate the risks associated with too much sitting in the workplace.

INTERVENTIONS TO REDUCE SITTING

In an expert statement, commissioned by Public Health England and Active Working, there are 4 recommendations to reduce prolonged periods of sedentary working. These recommendations include: (a) at least 2 hours/day of standing and light activity during working hours and progress to 4 hours/day; (b) break up seated working with standing working; (c) avoid prolonged static sitting and static standing; and (d) employers should promote reducing

prolonged sitting and encourage healthy behaviors (5). To implement effective workplace interventions, it is important to understand the physiological mechanisms of sitting in order to alleviate the risks associated with that behavior. This allows for more targeted and individualized interventions to occur by providing researchers and providers with an understanding of the different responses that occur during sitting. Recent use of workstations, and light physical activity breaks have shown promise in tackling prolonged sitting-induced physiological changes. It was reported in the 2008 Physical Activity Guidelines that only 10-minute bouts of activity could count toward meeting the guidelines, but this was eliminated in the newer 2018 Physical Activity Guidelines to count all activity toward the requirements (32). Thus, implementing light-to-moderate physical activity into a work day may prove to be beneficial at reducing the sedentary behaviors associated with occupational sitting and lead to achievement of the necessary physical activity goals (25). However, incorporating workplace physical activity interventions may be challenging due to a lack of participation and adherence to the program (29). With the growing amount of evidence supporting the negative health effects of sitting, there is still inadequate evidence on workplace interventions to reduce sedentary time (28). Importantly, one such intervention examined in recent years is the sit-stand workstation. Highlighted below are several important landmark studies using this intervention which have paved the way for future research in this area.

Alkhajah et al. (2) was the first to objectively measure cardio-metabolic markers (e.g., fasting total cholesterol, high-density lipoprotein cholesterol, triglycerides, and glucose levels) and comparisons between groups after implementing a 3-month sit-stand workstation intervention. The intervention group had their offices outfitted with a sit-stand workstation (Ergotron WorkFit-S, Single LD Sit-Stand Workstation, Ergotron, Inc., Eagan, Minnesota), while the comparison group was instructed to maintain their daily activity. Individuals wore an accelerometer with an inclinometer (activPAL3, PALtechnologies, Glasgow, United Kingdom) to measure occupational sitting during the study period. In addition to the cardio-metabolic markers, measures of time spent sitting, standing, stepping, and transitions were gathered, along with anthropometrics and self-reported outcomes of health and work performance. Those individuals that received the sit-stand workstation reduced sitting time by 143 minutes on average per day in the office and increased their HDL cholesterol levels, relative to the comparison group, by an average of 0.26 mmol/L. There were no significance differences in the other biomarkers.

Following Alkhajah's 2012 study, Pronk et al. (26) conducted a community-based research study among individuals with sedentary jobs with the goal of reducing time spent sitting in the workplace. Over a 7-week period, sitting time, risk factors (e.g., cardiorespiratory fitness, physical activity levels, health status, role physical and emotional), and office behaviors (ratings of lower back and upper back pain, ratings of neck pain, informal face-to-face time with coworkers, time spent in physical activity breaks, and Profile of Mood States) were measured. This 7-week period was separated into a 1-week baseline period, 4-week intervention period, and 2-week post-intervention period. The intervention group received a sit-stand workstation (WorkFit-S or WorkFit-C, Ergotron, Inc., Eagan Minnesota) and was able to use it during the 4-week intervention period. To improve reliability and specificity of measurement, participants

received a pre-paid cellular phone in which they received 3 text messages at random points of the day saying: "Tell us what you are doing right now: sitting, standing, or walking?" The participants were to respond with 0, 1, or 2 denoting sitting, standing, or walking, respectively. Following the 7-week intervention, individuals that received the sit-stand workstation reduced their sitting by 224% (66 minutes per day) on average compared to those in the comparison group. The intervention group reported significantly less upper and lower back pain by 54% and improvements in their self-reported mood states. These landmark studies capture the general cardio-metabolic health response of reducing sitting time in a typical community-based setting. Research continues to optimize interventions for reducing sitting, especially given certain individual characteristics and pre-existing health conditions.

As such, a similar study by MacEwen, Saunders, MacDonald, and Burr (20) focused on the influence of a 3-month sit-stand workstation intervention on cardio-metabolic health markers and health behaviors in obese office workers. The researchers measured total cholesterol, high- and low-density lipoprotein, fasting blood glucose, and HbA1c using blood sticks of the finger at baseline and 12-weeks. Using tonometry, pulse wave reflection and augmentation index were measured. Lastly, the participants were outfitted with an activPAL accelerometer (PALtechnologies, Glasgow, United Kingdom). The intervention group was outfitted with a sit-stand workstation, while the control group remained at their seated workstation. Researchers found that the intervention group showed significant reductions in sitting time during the workday from pre- (344 minutes/day) to post-intervention (186 minutes/day) compared to the control group. There was also significant reduction in overall sitting time in the intervention group from pre- (645 minutes/day) to post-intervention (529 minutes/day). In addition, researchers found increases in standing time during the workday in the intervention group (364 minutes/day) when compared to the control group (271 minutes/day). However, the differences in sitting and standing times between the groups were not enough to improve any of the cardio-metabolic markers (e.g., blood pressure, fasting glucose, cholesterol, aortic augmentation index, and subendocardial variability) in the at-risk population office workers. Overall, sit-stand workstations appear to be beneficial for decreasing sedentary behavior among individuals with pre-existing health concerns in the workplace. These interventions have been shown to have positive impacts on blood profiles, mood states, and musculoskeletal pain.

Earlier research focused on the sitting-related health changes as it relates to changes in cardio-metabolic risk factors. More recently, other novel risk factor assessments and physiological outcomes have been addressed. Gibbs et al. (11) evaluated the use of a sit-stand workstation and improvements in traditional and other novel cardiovascular health markers, such as, blood pressure and arterial stiffness (i.e., pulse wave velocity), over a simulated workday in overweight/obese adults with hypertension. The participants completed two randomized, experimental sessions that lasted about 10 hours each with 5-14 days between each session, where one of the sessions involved the participant sitting continuously, and the other had the participants alternate between standing and sitting at 30-minute intervals. The participants also wore an activPAL accelerometer (PALtechnologies, Glasgow, United Kingdom) during the experimental visit. Time spent sitting, standing, and stepping were reported. Utilizing a sit-stand workstation, alternating between standing and sitting lowered diastolic blood pressure (-

1.0 ± 0.4 mmHg, $p = 0.020$), mean arterial pressure (-1.0 ± 0.4 mmHg, $p = 0.029$), and the carotid-ankle pulse wave velocity (-0.27 ± 0.13 m/s, $p = 0.047$). Overall, this study showed that sitting with standing breaks, using sit-stand workstations, during a workday was sufficient enough to decrease blood pressure and pulse-wave velocity in hypertensive, overweight and obese office workers.

Other methods of reducing prolonged sitting that have been studied outside of the workplace include short physical activity breaks (i.e. walking) and being active while sitting (i.e. fidgeting). One such modality used for breaking-up prolonged sitting was fidgeting. Morishima et al. (21) tested whether periodic leg movement or fidgeting could prevent a reduction in shear stress of the endothelium or frictional force of blood place on the blood vessel. Participants sat for 3 hours while one leg served as the experimental leg (1 minute on/4 minutes off of fidgeting) and the other served as the control. During the fidgeting intervention, the participants tapped the heel of their foot and bounced their knee at their own natural cadence. They were instructed to raise their heel about 3 centimeters (cm) from the ground. The number of taps were quantified during each bout for every participant with the average being around 250 taps/minute. Following the intervention, there was an increase in popliteal artery blood flow and shear rate in the limb that was subject to fidgeting. The authors concluded that endothelial dysfunction due to prolonged sitting could be preventable with intermittent leg movements. Similarly, the United Kingdom Women's Cohort Study examined if fidgeting modified the relationship between sitting time and mortality in 13,000 women. To measure their fidgeting behaviors, the women were asked to self-report the amount of time that they spent fidgeting on a scale from 1 to 10, where 1 indicated no fidgeting and 10 was constant fidgeting. From this information, the women were placed in a low-, middle-, or high-fidgeting group. It was found that women in the high fidgeting group who sat 5-6 hours/day reduced their risk of mortality by 37% compared to women in the low and medium fidgeting groups (13). While it is important to understand the physiology of fidgeting as it relates to changes observed during sitting, the potential, underlying mechanisms are unknown, thus it is important to understand what is mediating the response that is seen as a result of fidgeting. However, these few methods may be relatively simple to implement in a workplace setting.

CONCLUSION

In the last 5 decades, there has been an increase in individuals employed in sedentary occupations in the United States (7). The habitual behavior of sitting in the workplace may compromise cardiovascular health, even in physically active individuals. Thus, prior epidemiological research on occupational sitting hazards sparked a research movement on ways to reduce occupational sitting.

As prolonged sitting research progresses, the public health message continues to outline the need for effective workplace interventions to reduce the burden associated with prolonged occupational sitting. With this information, office workers are a vulnerable population due to the nature of their work. Thus, it is important to intervene and break-up sitting time in the workplace. Generally, the implementation of these interventions may be more reasonable than

strategies that promote physical activity (34). However, intervening in the workplace is not without limitations.

It is important that employers evaluate the needs of their employees and the best ways to achieve a healthy office environment. A few things should be considered prior to implementing an intervention into the workplace. Employers should consider employee adherence to the intervention program and how implementing breaks into the workplace can affect the productivity of the workers (14). In the meantime, advice should encourage less sitting for extended periods of time.

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