# Sedentary behaviour in the workplace: prevalence, health implications and interventions

Daniel P. Bailey[1,2]

[1]Sedentary Behaviour, Health and Disease Research Group, Brunel University London, Kingston Lane, Uxbridge, UB8 3PH.

[2]Division of Sport, Health and Exercise Sciences, Department of Life Sciences, Brunel University London, Kingston Lane, Uxbridge, UB8 3PH.

Phone: +44(0)1895 265363

Email: daniel.bailey@brunel.ac.uk

Short title: Sedentary behaviour in the workplace

*This is a pre-copyedited, author-produced version of an article accepted for publication in British Medical Bulletin following peer review. The version of record, Bailey, D.P. (2021) 'Sedentary behaviour in the workplace: prevalence, health implications and interventions', British medical bulletin, 137(1), pp. 42-50. doi: 10.1093/bmb/ldaa039, is available online at: https://academic.oup.com/bmb/article/137/1/42/6168546.*

**Abstract**

**Introduction:** This paper reviews the prevalence and health risks of excess sedentary behaviour in office workers, and the effectiveness of sedentary workplace interventions in a manner accessible to practitioners.

**Sources of data:** A narrative review of empirical studies obtained from PubMed and Web of Science.

**Areas of agreement:** Office workers are highly sedentary, increasing their risk of health problems. Interventions using individual, organisational and environmental level strategies can be effective for reducing workplace sitting.

**Areas of controversy:** The effects of sedentary workplace interventions on health is inconsistent. This may be due to a lack of randomised controlled trials powered to detect changes in health outcomes.

**Growing points:** Multicomponent interventions that use a combination of the strategies above may be the most effective for reducing sitting.

**Areas timely for developing research:** Determining the long-term health and cost-effectiveness of sedentary workplace interventions is a priority to encourage employer buy-in for their implementation.

**Keywords:** sitting, office workers, occupational health, sit-stand desks, sedentary behaviour, physical activity.

## Introduction

Society has developed into a modernised environment that is conducive to engagement in high volumes of sedentary behaviour i.e. any waking behaviour while in a sitting, reclining or lying posture with an energy expenditure of ≤1.5 metabolic equivalents (METs)[1]. People are now able to carry out nearly all of their daily activities whilst sat down. A growing body of evidence is emerging demonstrating adverse associations of excess sedentary time with physical and mental health[2-4]. Sedentary behaviour is now considered a unique hazard to health and only high volumes (60-75 minutes/day) of moderate-to-vigorous physical activity (MVPA) may offer protection against excess sedentary time[5]. Desk-based office workers are inevitably exposed to high amounts of sedentary time due to the requirement to be seated while working at a desk. This narrative review considers the prevalence of sedentary behaviour, the health risks of excess sedentary time, and the effects of interventions to reduce sedentary behaviour in office workplaces. It is anticipated that this review is easily accessible and of benefit to health practitioners, policy makers and employers seeking to promote the health of working adults. The review was informed by peer-reviewed journal articles obtained from a scoping search of PubMed and Web of Science databases using search strings pertaining to 'office workers', 'sedentary behaviour', 'health outcomes' and 'interventions'. There was no restriction placed on study design for the included literature but articles were required to be empirical research.

## Prevalence of sedentary behaviour in office workers

Many jobs that were traditionally labour-intensive are now carried out using computer-operated methods, while seated technical and desk-based office work has become increasingly prevalent[6]. This has led to a significant reduction in occupation-related energy expenditure from 1960 to 2008 of approximately 140 kcal per day for men and 124 kcal per day for women[7]. Office workers have become a popular group to study in the sedentary behaviour field given that this type of work is inherent of prolonged periods of sitting and lower amounts of physical activity.

The prevalence of sedentary behaviour in large samples of office workers has been explored using self-report methods. The Stormont study, which was a large cross-sectional analysis 4,436 employees in the Northern Ireland Civil Service, found that office workers self-reported sitting for 625±168 minutes on a workday[8]. This accounted for 60% (376±106 minutes) of total daily sitting

time[8]. Australian desk-based office workers (n=801) also reported that sitting at work accounted for 60% (median sitting time = 300 minutes/day) of their total daily sitting time[9]. Findings from the Stormont study suggest that office workers who were younger (18-29 years-old), obese, worked full-time and single/divorced/widowed engaged in the most amount of sitting time[8]. Higher total daily sitting time also appears to be negatively associated with age and positively associated with body mass index in office workers[9]. There may thus be specific office-based employee groups who could be targeted for health promotion purposes. However, the sensitive nature of targeting specific employee subgroups for intervention would require careful consideration.

Questionnaire-based methods for evaluating sitting time are important for collecting data from large samples in a time and cost-effective manner and provide important information regarding the context and domain of behaviour. However, self-report methods may lead to underestimations in sitting time due to social desirability bias or an inability to accurately recall this behaviour[10]. The activPAL device is a small activity monitor that attaches to the anterior of the thigh and can be worn continuously during the monitoring period (typically seven days) to provide a valid and reliable assessment of sitting, standing, stepping and postural transitions (i.e. moving from a sitting to standing posture and vice versa)[11,12]. This device, which is currently considered the gold-standard for measuring sitting time, has been used to evaluate the prevalence of sitting in relatively smaller samples of office workers. In a study of university office workers (n=78), participants spent 79% of their working day seated (6.4 hours/day) and engaged in an average of 9.8 hours of sitting across the total waking day[13]. Australian government office workers (n=231) also engaged in sitting for an average of 79% of their working hours and spent more time sitting on a workday (69%) compared with a non-workday (56%), when measured using this device[14]. The findings from these device-based studies show that sitting time is higher compared with self-report data. In addition to being able to assess total daily and workplace sitting, a key advantage of using such devices is the ability to assess the way in which sedentary time is accumulated. In addition to total daily sedentary time being detrimentally associated with health risks, engaging in prolonged bouts of sedentary time is also associated with poorer health status (e.g. elevated metabolic biomarkers), independent of physical activity levels and total daily sedentary time[15]. Data from device-based studies suggests that office workers could be at an increased risk of cardiometabolic disease as they spend a large proportion of time engaging in prolonged bouts of sitting (i.e. ≥30 minute bouts) during working hours and across

the whole working day[13,14]. For instance, in Australian government office workers, 42±19% and 36±13% of workplace and total working day time, respectively, was spent in prolonged sitting bouts[14].

The evidence reviewed suggests that office workers engage in high volumes of total and prolonged sedentary behaviour during working hours and across the whole day. It may thus be appropriate to focus occupational health promotion interventions on reducing and breaking up sedentary behaviour in office workers both in and outside of work.

**Health implications of sedentary behaviour**

There is a body of evidence supporting the notion that engaging in high amounts of sedentary time is associated with adverse health outcomes. A systematic review of 794,577 participants found that there was a 112%, 147% and 90% increased risk of diabetes, cardiovascular disease and cardiovascular disease mortality, respectively, in individuals who engaged in the most amount of sedentary time compared with those who engaged in the least[3]. Similar findings have been reported in other evidence reviews[2,16]. High volumes of sedentary time have also been associated with an increased incidence of cancers such as colon and breast cancer[17,18], although other studies have reported no association[19]. In addition to associations with physical health, high volumes of sedentary behaviour appear to be associated with an increased risk of poor mental health including more severe depression, anxiety and psychological distress[4,20]. In office workers specifically, higher occupational sitting time and time spent sitting while at a computer was detrimentally associated with mental health[20,21]. This evidence demonstrates that higher sedentary time is adversely associated with physical and mental health in office workers and the general population.

There appears to be a dose-response association between self-reported total daily sitting time and all-cause mortality risk; a 5% increased risk for each additional hour of sitting per day in adults who sit at least 7 hours/day[22]. This dose-response was not seen in adults who sat less than 7 hours/day. A meta-analysis of more than 1 million participants also found that 7 hours of self-reported daily sitting time was the cut-off at which mortality risk started to increase[23]. However, the cut-off was at 9 hours/day when sitting time was measured using device-based methods such as accelerometry[23]. This is in agreement with research showing that self-report measures underestimate total daily sitting time by a couple of hours compared to device-measured estimates[10]. Based on these findings, and the prevalence of sedentary behaviour in office workers discussed above, it would

appear that office workers are a high-risk population group that would benefit from intervention. However, a causal role of sedentary behaviour leading to adverse health outcomes cannot be assumed based on observational study designs. It is plausible, for instance, that poor physical or mental health could lead to increased sedentary behaviour. In the limited longitudinal research available that has evaluated the risk of health outcomes in response to changes in sedentary time, the change in depressive symptoms over five years was not related to changes in sedentary time in socioeconomically disadvantaged women[24]. Further studies of this nature are required to further elucidate the potential long-term causal effects of sedentary behaviour on physical and mental health outcomes.

There is evidence that the increased risk of cardiovascular disease, cancer and all-cause mortality from high amounts of sitting may be dependent on the physical activity levels of the participants. For instance, a dose-response association between sitting time with cardiovascular disease mortality was observed in people engaging in the least amount of physical activity, whereas this association was less consistent in more active groups[25]. There was also no association between daily sitting time and all-cause mortality in individuals who engaged in the greatest amount of physical activity[5]. However, this equated to around 60-75 minutes of moderate-intensity physical activity every day. Although this volume of moderate physical activity is unlikely to be achieved by the majority of office workers, interventions may need to be designed taking into consideration the physical activity levels of the target group.

In addition to considering the associations of total daily and occupational sitting time with health, the pattern in which sitting time is accumulated has emerged as an important area for research. Activity monitors that use inclinometry and accelerometry have made it possible to assess peoples' sedentary behaviour patterns, including sedentary bout durations, usual bout length, the number of breaks in sedentary time, the intensity of the physical activity during these breaks, and the number of postural transitions. Office workers accumulate a large proportion of their sitting time in prolonged bouts (e.g. bouts lasting at least 30 minutes)[14]. This may be of concern as greater amounts of prolonged sitting are adversely associated with body mass index, waist circumference, high-density lipoprotein cholesterol and triglycerides[26]. Furthermore, the detrimental association of sitting time with metabolic biomarkers appears to become stronger when sitting bouts are accumulated in longer durations[26]. It may thus be importance to avoid prolonged periods of sitting. Indeed, research

demonstrates that engaging in more breaks from sedentary time throughout the day is beneficially associated with a range of cardiometabolic disease biomarkers[15,27,28]. Carson, Wong, Winkler, Healy, Colley, Tremblay [27] found that each 10 additional breaks in sedentary time per day (a break being defined as a sedentary bout interrupted by ≥1 minute of light activity or MVPA) was associated with significant improvements in waist circumference, blood pressure, cholesterol, glucose and insulin. These associations were independent of MVPA and the total time spent in sedentary behaviour. However, as discussed previously, such observational study designs make it difficult to infer a causal effect of sedentary behaviour patterns on health.

The short-term (acute) causal effects of prolonged sitting and breaking up sitting on cardiometabolic and mental health have been documented in laboratory-based studies in which participants have followed strict protocols. These studies have consistently found that breaking up prolonged sitting with 2-5 minutes of light or moderate-intensity physical activity every 20-30 minutes leads to significant reductions in postprandial (post-meal) glucose levels over the course of a single day in participants who are healthy, overweight/obese, or have Type 2 diabetes[29-31]. Benefits have also been seen for a range of other cardiometabolic biomarkers such as triglycerides, insulin and blood pressure[31,32], although there is conflicting evidence[32]. Studies have reported improvements in cognitive function in response to breaking up prolonged sitting over a single day[33,34]. In a simulated office environment, alternating sitting and standing every 30 minutes for 8 hours/day led to reductions in postprandial glucose, fatigue and lower back musculoskeletal discomfort over a 5-day period[35,36]. Similarly, cardiometabolic health was improved when participants substituted several hours of sitting with standing and walking over a period of four days in free-living conditions[37,38]. These findings suggest that reducing and breaking up sedentary time, in the short-term, may benefit physical and mental health. Although the long-term effects of sedentary behaviour on health have been seldom researched, long-term interventions that have reduced workplace sitting have led to improvements in metabolic biomarkers, mental health and quality of life[39,40]. Sedentary behaviour interventions in the workplace should thus be considered as a health promotion strategy for office workers, although the long-term causal relationships between sedentary behaviour and health requires further study.

**Workplace sedentary behaviour interventions**

The development and implementation of interventions to reduce and break up sedentary behaviour in office workers could be an important strategy for public health promotion. Evidence regarding the effects of workplace interventions on sedentary behaviour and health has been growing in recent years[41]. These interventions have typically incorporated individual (e.g. self-monitoring of sitting time), organisational (e.g. walking and standing meetings) and environmental level strategies (e.g. providing sit-stand desks)[39,42,43]. The use of sit-stand desks offers an obvious opportunity for reducing sitting at work as it allows individuals to stand whilst continuing with their normal desk-based tasks. Provision of these desks alone or in combination with providing information around sitting and counselling reduces workplace sitting by an average of 57 minutes/day after 3 to 12 months[41]. A systematic review found that multicomponent interventions utilising a combination of individual, organisational and environmental level strategies may be most effective for reducing workplace sitting (mean reduction of 89 minutes/8-hour workday)[44]. Indeed, the Stand More AT (SMArT) Work and Stand Up Victoria multicomponent interventions that incorporated strategies such as education around sitting, health coaching, self-monitoring and feedback on sitting, and sit-stand desk provision, led to reductions in sitting by 45 to 83 minutes/workday after 12 months in two large randomised controlled trials[39,45]. There were also significant reductions in prolonged sitting time and increases in standing[39,45]. However, reductions in sedentary behaviour have not been consistently reported. Interventions focusing only on educational and behavioural strategies appear to be less effective than multicomponent and environmental strategies (i.e. sit-stand desks)[44]. These findings help to inform the implementation of future workplace interventions.

During the development of interventions, it is important to consider the meaning and function of sitting in the workplace and the associated barriers and facilitators to changing behaviour. Office workers view sitting less at work to be incompatible with the time pressure and demands of work as moving away from the desk is seen as wasting time and not being productive[46,47]. This could be particularly relevant for call centre workers who have restricted opportunity to move away from the desk. There is thus an organisational cultural expectation that work needs to be done while sitting at a desk. The use of sit-stand desks was identified by office workers as a strategy that could overcome this cultural barrier as it enables individuals to continue working at their desk while standing[46,47]. Organisational support, such as policy changes and senior management buy-in for sitting less, are also seen as important facilitators of behaviour change[46,47]. Using behaviour-change theory to

understand the barriers and facilitators to reducing sedentary behaviour in the workplace and informing intervention strategies is thus recommended. Indeed, this approach was used in the SMArT Work study that led to significant long-term reductions in workplace sitting and improvements in work engagement, occupational fatigue, sickness presenteeism, anxiety and quality of life[39].

Although there are a growing number of studies showing that interventions are effective for reducing workplace sitting[41], employers may be concerned with the cost and productivity implications associated with providing their staff with active workstations and accompanying intervention strategies. Although treadmill and cycling workstations may decrease work performance if the user is not familiar with them, there does not appear to be any detrimental effects on work performance when using sit-stand desks[48]. Furthermore, participants of the SMArT Work multicomponent intervention reported improvements in job performance, work engagement, occupational fatigue, sickness presenteeism, anxiety and quality of life[39]. This would suggest there is potential for productivity gains from such interventions. Many workplace interventions have also led to significant improvements in risk markers for cardiometabolic disease (e.g. blood pressure, glucose, and adiposity)[49]. However, as found in a systematic review of workplace sedentary behaviour interventions, these benefits have often been limited to a small selection of the health risk markers measured and some interventions did not improve any health markers[49]. Interventions with limited effects on health have, however, been conducted over relatively short timeframes (e.g. up to 12 weeks). Longer duration interventions may be needed for health improvements to occur. Studies have also not been sufficiently powered to detect changes in health parameters[49]. There may be specific behaviour change techniques that are more effective in sedentary workplace sedentary interventions, such as goal setting, habits and social influence, and others that are less promising e.g. self-reward and verbal persuasion about capability to reduce sitting[49]. Further intervention research that employs randomised controlled trial designs powered to detect changes in markers of health are thus needed. These interventions should be developed based on evidence-informed behaviour change strategies that may be optimal for changing behaviour and their cost-effectiveness evaluated. This will help to determine whether the health benefits of sedentary behaviour workplace interventions outweigh the costs of implementation, which would make them a more attractive proposition to businesses and employers.

**Considerations in the wake of COVID-19**

At the time of writing this review, the world was in the midst of the coronavirus disease 2019 (COVID-19) pandemic. COVID-19-related restrictions resulted in large increases in sitting time in the general population, which was associated with worse mental health[50]. The pandemic also affected the way in which many desk-based employees work. For instance, the UK government recommended that employees conduct their work at home wherever possible to reduce the risk of COVID-19 transmission. It is plausible that there may be a permanent shift towards more home working as employers may deem this to be a productive and cost-effective way of operating. Research is thus urgently needed to identify the short, medium and long-term effects of COVID-19 on workplace sedentary behaviour and the development and delivery of interventions to reduce sedentary behaviour in desk-based workers during and beyond the pandemic.

**Conclusions**

Sedentary behaviour is highly prevalent in office workers and is often accumulated in prolonged uninterrupted bouts. This places them at higher risk of adverse health outcomes, such as chronic disease and mental ill-health. The development and evaluation of interventions aimed at reducing and breaking up sedentary time in the workplace has thus received a great deal of attention from researchers in recent years. A large number of these interventions have achieved reductions in workplace sitting in the short (<3 months) and long-term (12 months). Although such interventions have led to improvements in health and job-related outcomes, further research is required to determine their long-term health and cost-effectiveness to further support their adoption in workplace policy and practice.

**References**

1. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act.* 2017;14(1):75.
2. Bailey DP, Hewson DJ, Champion RB, et al. Sitting Time and Risk of Cardiovascular Disease and Diabetes: A Systematic Review and Meta-Analysis. *Am J Prev Med.* 2019;57(3):408-416.
3. Wilmot EG, Edwardson CL, Achana FA, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. *Diabetologia.* 2012;55(11):2895-2905.

4. Hamer M, Coombs N, Stamatakis E. Associations between objectively assessed and self-reported sedentary time with mental health in adults: an analysis of data from the Health Survey for England. *BMJ Open.* 2014;4(3):e004580.
5. Ekelund U, Steene-Johannessen J, Brown WJ, et al. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet.* 2016;388(10051):1302-1310.
6. Church TS, Thomas DM, Tudor-Locke C, et al. Trends over 5 decades in U.S. occupation-related physical activity and their associations with obesity. *PLoS One.* 2011;6(5):e19657.
7. Church TS, Earnest CP, Skinner JS, et al. Effects of different doses of physical activity on cardiorespiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: a randomized controlled trial. *JAMA.* 2007;297(19):2081-2091.
8. Clemes SA, Houdmont J, Munir F, et al. Descriptive epidemiology of domain-specific sitting in working adults: the Stormont Study. *J Public Health (Oxf).* 2016;38(1):53-60.
9. Bennie JA, Pedisic Z, Timperio A, et al. Total and domain-specific sitting time among employees in desk-based work settings in Australia. *Aust N Z J Public Health.* 2015;39(3):237-242.
10. Chastin SF, Culhane B, Dall PM. Comparison of self-reported measure of sitting time (IPAQ) with objective measurement (activPAL). *Physiol Meas.* 2014;35(11):2319-2328.
11. Lyden K, Kozey Keadle SL, Staudenmayer JW, et al. Validity of two wearable monitors to estimate breaks from sedentary time. *Med Sci Sports Exerc.* 2012;44(11):2243-2252.
12. Grant PM, Ryan CG, Tigbe WW, et al. The validation of a novel activity monitor in the measurement of posture and motion during everyday activities. *Br J Sports Med.* 2006;40(12):992-997.
13. Keown MK, Skeaff CM, Perry TL, et al. Device-Measured Sedentary Behavior Patterns in Office-Based University Employees. *J Occup Environ Med.* 2018;60(12):1150-1157.
14. Hadgraft NT, Healy GN, Owen N, et al. Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep.* 2016;4:184-191.
15. Healy GN, Dunstan DW, Salmon J, et al. Breaks in sedentary time: beneficial associations with metabolic risk. *Diabetes Care.* 2008;31(4):661-666.

16. Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med.* 2015;162(2):123-132.
17. Howard RA, Freedman DM, Park Y, et al. Physical activity, sedentary behavior, and the risk of colon and rectal cancer in the NIH-AARP Diet and Health Study. *Cancer causes & control : CCC.* 2008;19(9):939-953.
18. George SM, Irwin ML, Matthews CE, et al. Beyond recreational physical activity: examining occupational and household activity, transportation activity, and sedentary behavior in relation to postmenopausal breast cancer risk. *American Journal of Public Health.* 2010;100(11):2288-2295.
19. Hildebrand JS, Gapstur SM, Campbell PT, et al. Recreational Physical Activity and Leisure-Time Sitting in Relation to Postmenopausal Breast Cancer Risk. *Cancer Epidemiology Biomarkers & Prevention.* 2013;22(10):1906-1912.
20. Rebar AL, Vandelanotte C, van Uffelen J, et al. Associations of overall sitting time and sitting time in different contexts with depression, anxiety, and stress symptoms. *Mental Health and Physical Activity.* 2014;7(2):105-110.
21. Puig-Ribera A, Martinez-Lemos I, Gine-Garriga M, et al. Self-reported sitting time and physical activity: interactive associations with mental well-being and productivity in office employees. *BMC Public Health.* 2015;15:72.
22. Chau JY, Grunseit AC, Chey T, et al. Daily sitting time and all-cause mortality: a meta-analysis. *PLoS One.* 2013;8(11):e80000.
23. Ku PW, Steptoe A, Liao Y, et al. A cut-off of daily sedentary time and all-cause mortality in adults: a meta-regression analysis involving more than 1 million participants. *BMC Med.* 2018;16(1):74.
24. Teychenne M, Abbott G, Lamb KE, et al. Is the link between movement and mental health a two-way street? Prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Preventive Medicine.* 2017;102:72-78.
25. Ekelund U, Brown WJ, Steene-Johannessen J, et al. Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med.* 2019;53(14):886-894.

26. Bellettiere J, Winkler EAH, Chastin SFM, et al. Associations of sitting accumulation patterns with cardio-metabolic risk biomarkers in Australian adults. *PLoS One.* 2017;12(6):e0180119.
27. Carson V, Wong SL, Winkler E, et al. Patterns of sedentary time and cardiometabolic risk among Canadian adults. *Prev Med.* 2014;65:23-27.
28. Healy GN, Matthews CE, Dunstan DW, et al. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. *Eur Heart J.* 2011;32(5):590-597.
29. Bailey DP, Locke CD. Breaking up prolonged sitting with light-intensity walking improves postprandial glycemia, but breaking up sitting with standing does not. *J Sci Med Sport.* 2015;18(3):294-298.
30. Dempsey PC, Larsen RN, Sethi P, et al. Benefits for Type 2 Diabetes of Interrupting Prolonged Sitting With Brief Bouts of Light Walking or Simple Resistance Activities. *Diabetes Care.* 2016;39(6):964-972.
31. Henson J, Davies MJ, Bodicoat DH, et al. Breaking Up Prolonged Sitting With Standing or Walking Attenuates the Postprandial Metabolic Response in Postmenopausal Women: A Randomized Acute Study. *Diabetes Care.* 2016;39(1):130-138.
32. Saunders TJ, Atkinson HF, Burr J, et al. The Acute Metabolic and Vascular Impact of Interrupting Prolonged Sitting: A Systematic Review and Meta-Analysis. *Sports Med.* 2018;48(10):2347-2366.
33. Chrismas BCR, Taylor L, Cherif A, et al. Breaking up prolonged sitting with moderate-intensity walking improves attention and executive function in Qatari females. *PLoS One.* 2019;14(7):e0219565.
34. Mullane SL, Buman MP, Zeigler ZS, et al. Acute effects on cognitive performance following bouts of standing and light-intensity physical activity in a simulated workplace environment. *J Sci Med Sport.* 2017;20(5):489-493.
35. Thorp AA, Kingwell BA, Owen N, et al. Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/obese office workers. *Occup Environ Med.* 2014;71(11):765-771.
36. Thorp AA, Kingwell BA, Sethi P, et al. Alternating bouts of sitting and standing attenuate postprandial glucose responses. *Med Sci Sports Exerc.* 2014;46(11):2053-2061.

345 37. Duvivier B, Schaper NC, Koster A, et al. Benefits of Substituting Sitting with Standing and Walking
346 in Free-Living Conditions for Cardiometabolic Risk Markers, Cognition and Mood in Overweight
347 Adults. *Front Physiol.* 2017;8(353).
348 38. Duvivier BM, Schaper NC, Hesselink MK, et al. Breaking sitting with light activities vs structured
349 exercise: a randomised crossover study demonstrating benefits for glycaemic control and insulin
350 sensitivity in type 2 diabetes. *Diabetologia.* 2017;60(3):490-498.
351 39. Edwardson CL, Yates T, Biddle SJH, et al. Effectiveness of the Stand More AT (SMArT) Work
352 intervention: cluster randomised controlled trial. *BMJ.* 2018;363:k3870.
353 40. Healy GN, Winkler EAH, Eakin EG, et al. A Cluster RCT to Reduce Workers' Sitting Time: Impact
354 on Cardiometabolic Biomarkers. *Med Sci Sports Exerc.* 2017;49(10):2032-2039.
355 41. Shrestha N, Kukkonen-Harjula KT, Verbeek JH, et al. Workplace interventions for reducing sitting
356 at work. *Cochrane Database Syst Rev.* 2018;6:CD010912.
357 42. Maylor BD, Edwardson CL, Zakrzewski-Fruer JK, et al. Efficacy of a Multicomponent Intervention
358 to Reduce Workplace Sitting Time in Office Workers: A Cluster Randomized Controlled Trial. *J*
359 *Occup Environ Med.* 2018;60(9):787-795.
360 43. Chau JY, Daley M, Dunn S, et al. The effectiveness of sit-stand workstations for changing office
361 workers' sitting time: results from the Stand@Work randomized controlled trial pilot. *Int J Behav*
362 *Nutr Phys Act.* 2014;11:127.
363 44. Chu AH, Ng SH, Tan CS, et al. A systematic review and meta-analysis of workplace intervention
364 strategies to reduce sedentary time in white-collar workers. *Obes Rev.* 2016;17(5):467-481.
365 45. Healy GN, Eakin EG, Owen N, et al. A Cluster Randomized Controlled Trial to Reduce Office
366 Workers' Sitting Time: Effect on Activity Outcomes. *Med Sci Sports Exerc.* 2016;48(9):1787-1797.
367 46. Such E, Mutrie N. Using organisational cultural theory to understand workplace interventions to
368 reduce sedentary time. *International Journal of Health Promotion and Education.* 2017;55(1):18-
369 29.
370 47. Ojo SO, Bailey DP, Hewson DJ, et al. Perceived Barriers and Facilitators to Breaking Up Sitting
371 Time among Desk-Based Office Workers: A Qualitative Investigation Using the TDF and COM-B.
372 *International Journal of Environmental Research and Public Health.* 2019;16(16):2903.
373 48. Ojo SO, Bailey DP, Chater AM, et al. The Impact of Active Workstations on Workplace Productivity
374 and Performance: A Systematic Review. *Int J Environ Res Public Health.* 2018;15(3):417.

49. Brierley ML, Chater AM, Smith LR, et al. The Effectiveness of Sedentary Behaviour Reduction Workplace Interventions on Cardiometabolic Risk Markers: A Systematic Review. *Sports Med.* 2019;49(11):1739-1767.

50. Meyer J, McDowell C, Lansing J, et al. Changes in Physical Activity and Sedentary Behavior in Response to COVID-19 and Their Associations with Mental Health in 3052 US Adults. *Int J Environ Res Public Health.* 2020;17(18).

**Data availability statement:** No new data were generated or analysed in support of this research..