Understanding the role of breaks from sitting on musculoskeletal symptoms in desk-based workers

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THE UNIVERSITY *of* EDINBURGH

Thesis submitted for the degree of Doctor of Philosophy

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June 2023

Acknowledgements

I have many acknowledgements to make in relation to completing my PhD. I would like first to express my deepest gratitude to my supervisors Professor Ailsa Niven, Dr Samantha Fawkner and Dr Graham Baker. You have given me more of your time than I hoped for, from planning my PhD proposal until the end of my PhD journey. Your constant support and patience throughout my PhD were invaluable to continuing my PhD work after various challenges that I came across during this journey. I thank you all for always giving me a push when I needed it and for inspiring me to be an independent researcher.

Special thanks to all the members of the Physical Activity for Health Research Centre (PAHRC), past and present. Your constant advice, academic guidance, and encouragement to me and other students have proven to be priceless for my growth as a researcher. The weekly PAHRC sessions have been so valuable and such an important learning experience during my PhD. Special thanks to Chloë and Niamh for proofreading my thesis and for giving me PhD advice.

I would also like to thank my wonderful friends in Mexico (to Isaac✝ who always believed in me), and to my friends in other parts of the world who have been part of this journey. Although you are far away, you are my greatest support. To Mark and friends in Scotland, thank you for the fun times and so much needed distraction. To my sisters Jemima and Abi, I will always be thankful for your support, advice and company during the difficult times that happened during my PhD.

Finally, I would like to dedicate this thesis to the most important influences in my life, my parents. To my mum Sylvia, you taught me to be perseverant, always encouraged me to continue with my studies, and motivated and supported me to finish this PhD. To my dad Victor, although you are not here anymore, you always motivated me and my sisters to follow our dreams. I love you both, this PhD could have never been completed (or started) without your influence.

Abstract

Musculoskeletal disorders are conditions that affect musculoskeletal (MSK) tissues (e.g., muscles, bones) and are characterised by an inflammatory process that leads to pain and discomfort in the affected area. According to the Global Burden of Diseases (2019) study, musculoskeletal disorders are amongst the top twenty causes of years lived with disability at all ages. These disorders also contribute to a high economic burden on health systems worldwide and lead to job absenteeism due to incapacity to work.

Sedentary behaviour (SB) has been associated with a high risk for all-cause mortality, type 2 diabetes, cancer, and the development of MSK symptoms. Office workers are particularly at risk to develop these health problems due to the high prevalence of SB. Thus, strategies to reduce SB are necessary to decrease health problems in this population. Breaks from sitting are non-sedentary activities that take place between sedentary bouts. Research evidence has suggested that reducing SB with breaks from sitting provides benefits on cardio-metabolic, vascular, and cognitive health. However, evidence of the effects of breaks from sitting on MSK outcomes has been limited to mainly self-reported evidence.

Due to the COVID-19 pandemic, there was a sudden shift for many workers from working in the office to work from home (WFH). There is limited understanding of SB when WFH, including evidence of the impact of breaks from sitting on MSK symptoms. The overall aim of this thesis was to expand knowledge of the role of breaks from sitting as a strategy to reduce MSK symptoms and occupational SB in office workers. Three studies were conducted to address this aim.

The first study was a systematic review planned to address the limited evidence of the effects of breaks from sitting on device assessed MSK outcomes. Two objectives were followed. First, synthesise evidence of the effectiveness of breaks

from sitting on device assessed MSK spinal outcomes. Second, compare those findings with self-reported MSK spinal outcomes if available. Twelve studies (n=12) were included in this review. Studies were divided into acute-single session interventions and medium to long-term interventions (2 weeks to 3 months). Three main types of breaks were identified: stretching, standing, and walking breaks. When divided by break type, it was evident that stretching breaks were the most effective break to improve device assessed and self-reported MSK spinal outcomes in acute single session and medium to long-term settings. Breaks from sitting seemed to be a useful strategy to reduce MSK symptoms in sedentary workers in office settings. With workers increasingly WFH, it was important to understand what the role of breaks from sitting was in the home environment.

The second study was a cross-sectional quantitative study planned considering the shift for workers to increased WFH, and the favourable effects of breaks from sitting from the first study. The study aimed to explore differences in MSK symptom prevalence between groups defined by occupational sitting, breaks from sitting, and chair settings. Objectives were to describe occupational sitting, breaks from sitting, chair settings and MSK symptoms in University of Edinburgh staff WFH. Participants (n=332, age range 18-61; female 73%) sat for most of their working day (89% of the workday) and took 1.3±1.4 breaks per hour, duration 5.3±7.0 minutes. A high prevalence (93%) of MSK symptoms was indicated in staff. Chair mean scores (3.5±1.2) indicated that staff chair settings while WFH represented a low risk of pain development. In relation to MSK symptoms, it was found that staff with the longest occupational sitting (over 8 hours per day) had a significantly higher prevalence of MSK symptoms, but there were no significant effects of the number and duration of breaks and chair settings on MSK symptoms prevalence in staff WFH. Understanding why staff engaged in prolonged SB was key to reducing this behaviour, and subsequently reducing MSK symptoms prevalence.

The third study was a qualitative study planned considering the elevated prevalence of SB and MSK symptoms in University of Edinburgh staff from the second study. This study aimed to understand the factors influencing SB and breaks from sitting in University of Edinburgh staff with MSK symptoms WFH. The study was built using two theoretical models, the COM-B model, and the Theoretical Domains Framework. University of Edinburgh staff (n=17; age 47.1±9.4; female 82%) were interviewed on MS Teams. The Framework method was chosen to analyse data from the interviews. The main findings indicated that participants had the psychological and physical capability to reduce their sitting. Unexpectedly, the presence of MSK symptoms appeared to not be a barrier for staff to break up their sitting while WFH. Barriers to reducing sitting at home were mapped to the physical and social opportunity, automatic and reflective motivation constructs. Additionally, the most important barrier for participants to reduce their sitting was their current workload and the various barriers associated with this. There are various challenges to reducing SB while WFH, but is essential to target workload management for this population to reduce their SB.

This thesis has advanced knowledge on the role of breaks from sitting as a strategy to reduce MSK symptoms and SB prevalence in two work environments (office and home). Thesis findings suggest that breaks from sitting, specifically stretching breaks, are a useful strategy to reduce MSK spinal symptoms at the office. However, it appears the number and duration of breaks do not affect MSK symptoms prevalence in workers WFH. On the other hand, engaging in occupational SB of over eight hours does affect this prevalence. Nevertheless, MSK symptom prevalence did not seem to affect SB at home, whereas workload was the most influential factor to remain sedentary. Changes around workload are necessary for desk-based workers with MSK symptoms to reduce their SB while WFH, and subsequently reduce their MSK symptoms. Future research should focus on exploring the direct effects of breaks on MSK symptoms during working hours at the office and the home environment.

Lay summary

Musculoskeletal disorders are conditions that affect the musculoskeletal structures of the body (e.g., joints, bones, muscles, tendons), and have symptoms such as pain and discomfort of the affected areas. These conditions are very common, and they can affect a person's quality of life and attendance at work.

Desk-based workers are workers who generally spend many hours at a desk and often work in front of a screen. These workers have elevated levels of sedentarism, which refers to activities undertaken when awake and do not require too much physical effort. These activities can be done while reclining, sitting, or lying. Having high levels of sedentarism has been linked to many negative health problems such as all-cause mortality, type 2 diabetes, cancer, and musculoskeletal disorders. Desk-based workers are at a high risk of developing these negative health problems due to their sedentarism. It is necessary to support desk-based workers and provide them with strategies to reduce their desk time and consequently help them reduce the risk of negative health problems.

Current research suggests that taking breaks from sitting is useful to reduce both desk time and the health problems that come with being sedentary. However, this previous research focuses mainly on exploring the effects of breaks from sitting on chronic health problems (e.g., all-cause mortality, cancer, diabetes). There is very little evidence about how breaking up sitting can affect pain and discomfort and other symptoms that come with musculoskeletal disorders.

Since the COVID-19 pandemic, office workers have started and continued to work from home for some or most of their working week. Due to this, further research is still necessary to explore various aspects of the home as a workplace. Moreover, to understand what the effect of breaks from sitting is on musculoskeletal symptoms at home. The thesis aimed to understand more about how breaks from sitting can reduce musculoskeletal symptoms and sedentarism in desk-based workers, at both the office and at home. Three studies were created to research this in more detail.

For the first study, 12 studies were identified using a systematic process and summarised to understand how musculoskeletal symptoms in the spine (e.g., lower back pain) are affected by taking breaks from sitting at work. The study had two objectives. The first objective was to summarise findings from studies that used research tools to measure changes in musculoskeletal structures (e.g., using a stadiometer to measure height). The second objective was to understand how the changes in these structures were related to pain and discomfort. The findings indicated that stretching breaks were the most effective form of break to reduce changes in musculoskeletal structures. Additionally, stretching breaks were also helpful to reduce pain and discomfort in sedentary workers.

The second study was created to explore changes in the workplace caused by the COVID-19 pandemic (people working from home or hybrid working). This study aimed to explore sedentarism and musculoskeletal disorders in University of Edinburgh staff working from home. To explore this, first, it was necessary to describe the staff desk time, the number and duration of breaks from sitting, their chair settings and their bodily pain and/or discomfort while working from home. Results showed that participants were at their desks for 89% of their working day, and most of them had bodily pain/discomfort (93%). Also, staff took breaks from sitting (1.3) per hour and these breaks lasted around 5.3 minutes. A main finding was that staff sitting for over eight hours per day had a higher presence of bodily pain/discomfort. However, it was noticed that bodily pain was not different in participants taking breaks (regardless of the number and duration). Lastly, the staff’s chair settings did not seem to affect bodily pain.

Building on these results, the purpose of the third study was to understand what factors influenced the elevated sedentarism in University of Edinburgh staff working from home with bodily pain/discomfort. For this, 17 staff members with pain/discomfort were interviewed online in MS Teams, and their interviews were recorded, transcribed, and analysed. Results showed that staff were aware of their elevated desk time, they knew how they could reduce it, and their pain/discomfort was not affecting their desk time. On the other hand, and contrary to the office, they had noticed obstacles linked to not having the space or the social interaction at home to reduce their desk time. Other influential factors were not being reinforced to take breaks from sitting (e.g., not feeling supported by the university), and feelings of guilt when absent from their desks. The most influential factor for staff to reduce their desk time at home was their current workload and many barriers related to this.

To conclude, this thesis has advanced the understanding of how breaks from sitting can reduce musculoskeletal disorders and sedentarism in two work settings. From the thesis findings, it appears that taking breaks from sitting (especially stretching breaks) is useful to reduce musculoskeletal symptoms in the spine at the office. However, the number and duration of breaks seemed to not bring benefits to people working from home. At home, sitting for over 8 hours per day for work seemed to be related to a higher presence of bodily pain/discomfort. Still, having pain did not seem to affect staff desk time at home. On the other hand, staff workload did influence how long staff were at their desks. Strategies to reduce sedentarism and musculoskeletal disorders symptoms are still necessary in this population. Targeting workload management is needed to reduce both outcomes in this population, and future research should continue exploring the direct effects of breaks from sitting at the office and the home environment.

PhD overview

Funding

My PhD was partially funded by the Consejo Nacional of Ciencia y Tecnologia (CONACYT) from the Mexican government. This included tuition fees and a monthly stipend. The funding concluded in December 2021.

Supervisory arrangement

The supervisory team for my PhD are members of the Physical Activity for Health Research Centre (PAHRC). The team is formed by Professor Ailsa Niven, Dr Samantha Fawkner and Dr Graham Baker.

Thesis outline

This thesis is formed by five chapters. Chapter 1 introduces the background for the thesis, and provides an overview of the thesis aims, objectives and methodology. Chapters 2 to 4 contain individual studies that were carried out to address the thesis objectives. Specifically, chapter 2 (study 1) is a systematic review synthesising the effects of breaks from sitting on musculoskeletal spinal outcomes. Chapter 3 (study 2) addresses the shift from office workers to work from home after the COVID-19 pandemic. Chapter 4 (study 3) focuses on understanding what factors influence sedentary behaviour in the home environment in people with musculoskeletal symptoms. Finally, chapter 5 discusses and summarises the thesis findings, discusses the implications for practice and recommendations for future research, and provides the strengths and limitations of the thesis.

PhD timeline

The PhD was undertaken from March 2018 until December 2022. The individual studies, specifically Study 2 (chapter 3) and Study 3 (chapter 4), were designed and carried out during the COVID-19 pandemic declared by the World Health Organization (WHO) on the 11th of March 2020 (World Health Organization, 2020a).

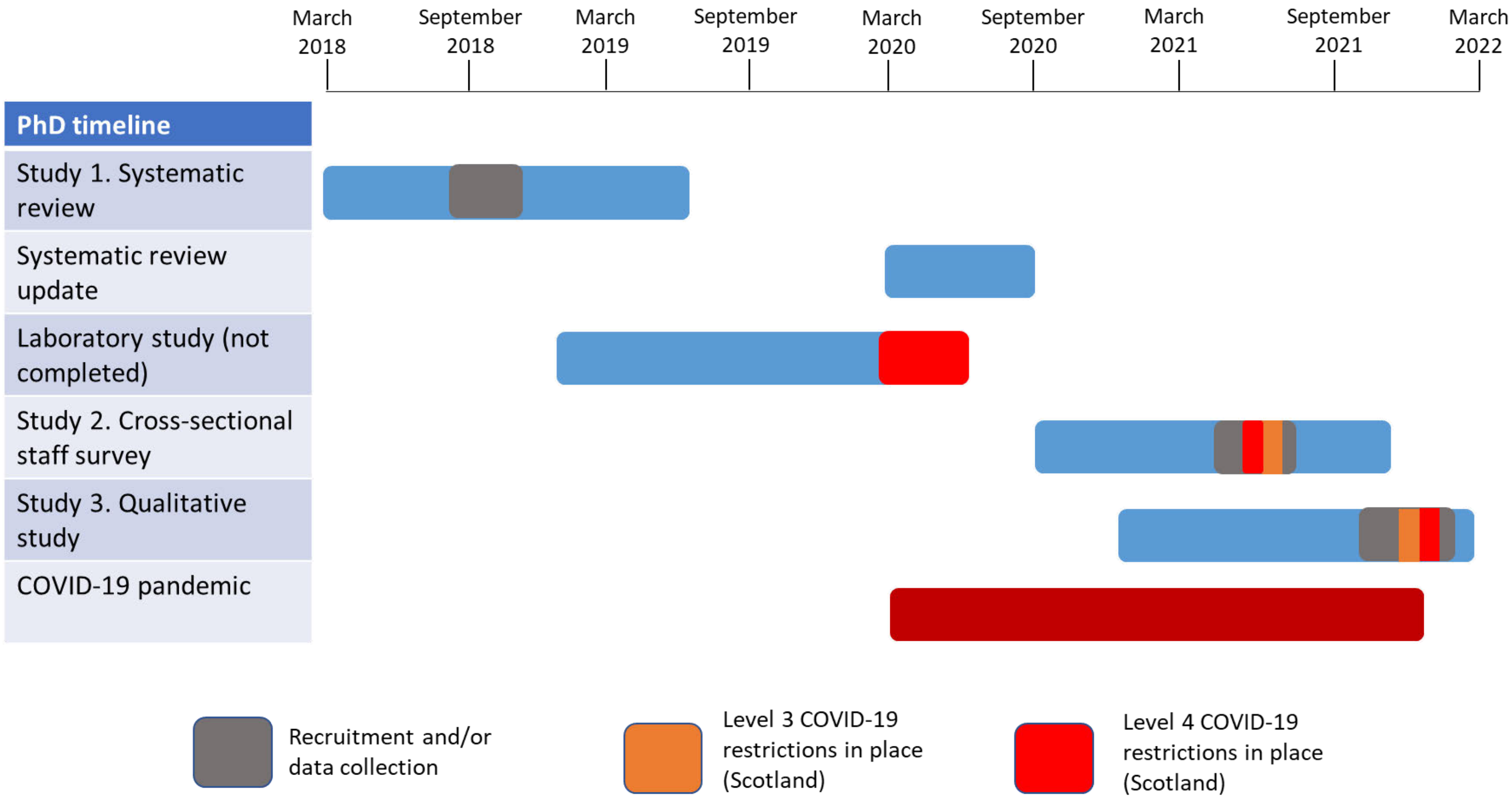
A laboratory study, which was intended to be the second study of this PhD was not completed due to the pandemic restrictions involving the closure of educational, leisure and work centres. This is explained further in the first chapter of this thesis. Figure A illustrates the timeline for the individual studies in the context of the COVID-19 pandemic restrictions up to March 2022.

The design of Study 2 (chapter 3) began six months after the pandemic was declared (September 2020). The recruitment and data collection for the study was done for four weeks from the 13th of April 2021 to the 11th of May 2021. During this period, Scotland moved from protection level 4 (office workers to work from home exclusively) to level 3 (office workers work from home where possible) on the 26th of April 2021 (The Scottish Parliament, 2023).

The recruitment and data collection for study 3 (chapter 4) were carried out from the 17th of November 2021 to the 24th of January 2022. During this period, a new variant of the COVID-19 virus was detected in Scotland on the 10th of December 2021. Due to this, Scotland moved from protection level 3 (work from home where possible) to level 4 (work from home exclusively). These restrictions were eased on the 31st of January 2022. All the restrictions in Scotland were eased by the 9th of May 2022 (The Scottish Parliament, 2023).

Figure A.

Timeline of individual studies in relation to the COVID-19 pandemic restrictions.



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List of abbreviations

BCTs: Behaviour Change Techniques

BCW: Behaviour Change Wheel

CI: Confidence interval

CMO: Chief Medical Officer

CMDQ: Cornell Musculoskeletal Discomfort Questionnaire

CVD: Cardiovascular disease

DALYS: Disability Adjusted Life Years

EMG: Electromyography

GBD: Global Burden of Diseases

HR: Hazard ratios

LBP: Low back pain

LPA: Light physical activity

MET: Metabolic equivalent of task

MSDs: Musculoskeletal Disorders

MSK: Musculoskeletal

MVPA: Moderate to Vigorous Physical Activity

NHS: National Health Service

OSPAQ: Occupational Sitting and Physical Activity Questionnaire

PA: Physical activity

RCT: Randomised controlled trial

ROSA: Rapid Office Strain Assessment

RR: Relative risk

SB: Sedentary behaviour

SBRN: Sedentary Behaviour Research Network

SWiM: Synthesis Without Meta-analysis

UK: United Kingdom

UoE: University of Edinburgh

USA: United States of America

YLD: Years Lived with Disability

WFH: Working from home

WHO: World Health Organization

Chapter 1. Thesis introduction

The purpose of this chapter is to provide the thesis background and the most relevant concepts related with this research. The chapter starts with an overview of sedentary behaviour concepts and its effects on health, particularly in the occupational setting. The chapter also discusses the prevalence and burden of musculoskeletal disorders and summarises the literature around strategies to reduce sedentary behaviour in the workplace. To conclude, the chapter points out gaps in literature, formulates the thesis aims and objectives, and describes in detail the methodology of the thesis.

Sedentary behaviour concepts and health research

Sedentary behaviour (SB) has been defined by the Sedentary Behaviour Research Network (SBRN) as any waking activity with a low energy expenditure of ≤1.5 metabolic equivalent of task (MET), whilst sitting, reclining, or lying (Tremblay et al., 2017). SB does not include sleeping as the energy expenditure (-1 MET) is lower than the SB energy expenditure (Tremblay et al., 2017). SB involves activities in more than one setting such as sitting while commuting, eating, screen time (e.g., use of computer, smartphone or watching TV while sitting). Sedentary time is defined by the SBRN as time spent in SB for any duration or context (Tremblay et al., 2017). People engaging in SB usually engage in prolonged sedentary bouts, which are periods of uninterrupted sedentary time (Tremblay et al., 2017).

The use of terms such as ‘prolonged sitting’ have been used previously in SB literature to refer to prolonged sedentary time (Hadgraft et al., 2016; Peddie et al., 2021; Saunders et al., 2018). To avoid the use of ableist language (Smith et al., 2021), this thesis will avoid using the term ‘prolonged sitting’ to refer to prolonged periods of SB in any context or domain. Instead, the terms ‘prolonged sedentary time’ or ‘prolonged SB’ will be used. The term ‘sitting’ is still used through the thesis, as many studies provide data from either self-report or device assessed sitting as an assessed outcome of their studies (e.g., Occupational Sitting and Physical Activity Questionnaire).

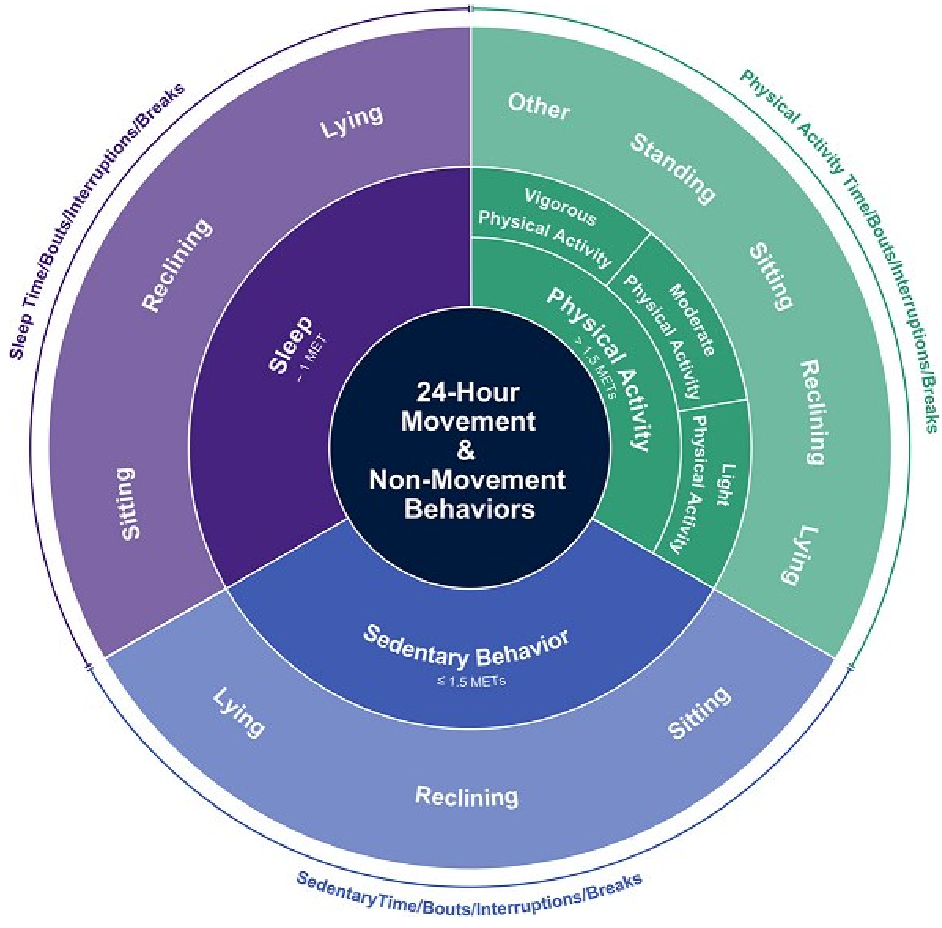
SB can often be confused with physical inactivity. However, while they are similar in principle, both concepts present many differences and cannot be considered the same. Sedentary individuals are frequently engaged in continuous sedentary bouts for any duration in any type of setting. Whereas physical inactivity refers to an individual that do not meet the physical activity (PA) recommendations (Tremblay et al., 2017). While this thesis does not focus on PA, it is important to understand the difference between SB and physical inactivity.

The PA recommendations are based on the next notions. PA was initially defined by Caspersen et al. (1985) as “any bodily movement produced by skeletal muscles that results in energy expenditure”. Later, other provisions were incorporated, and for behaviour to be considered as PA the activities needed to result in an energy expenditure of over 1.5 MET (Ainsworth et al., 2011). PA is also categorised in relation to the activity energy expenditure, such as light intensity PA (1.6 to 2.9 METS), moderate intensity PA (3.0 to 5.9 METS) and vigorous intensity PA (over 6 METS).

Throughout the 24-hour day, individuals engage in either movement or non-movement behaviours which are described above. Figure 1 illustrates SB terminology recognised by the most recent expert consensus from the SBRN. In addition, this figure is organised around a 24-hour day, the inner part shows existing movement and non-movement behaviours, with the outer part showing the existing postures within these behaviours.

Figure 1

Conceptual map for movement behaviours.



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Recommendations for PA from the UK Chief Medical Officer (CMO) suggest that adults should engage in accumulated bouts of at least 150 minutes per week on moderate intensity PA or 75 minutes per week on vigorous intensity PA and engaging in muscle strengthening activities at least twice a week (Department of Health and Social Care, 2019). An individual spending time in frequent sedentary activities might be meeting the physical activity recommendations established for each age group and still be considered sedentary. An example of this was provided by a cross-sectional study (8471 participants) from Bakker, Hopman, et al. (2020). Findings from this study signalled that 86% of adults met the PA guidelines but still engaged in SB for 9.1 hours per weekday and 7.4 hours during the weekend. Thus, indicating that sedentary individuals are not necessarily physically inactive, and thereby illustrates the differences between both concepts. These findings are pertinent to understand how individuals can accumulate SB through the day regardless their PA. It should be noted, the authors used solely self-reported measurements which can be subjected to recall bias and social desirability (Althubaiti, 2016). Nevertheless, contrary to these findings, there is substantial evidence pointing out that sedentary individuals are generally sedentary through the whole day, which will be discussed later in this chapter.

When split throughout the day, SB can be divided into different contexts or domains. Three main SB domains are identified in the literature: occupational (e.g., SB for work), leisure (e.g., SB while watching TV) and transportation (e.g., SB while commuting) (Bakker, Hopman, et al., 2020; Dunstan et al., 2012). The leisure SB domain includes activities such as watching TV or playing video games while sedentary at home. The transportation SB domain entails activities carried out while in transit such as sedentary time while commuting. The occupational SB domain encompasses sedentary time spent at work. This thesis focused on SB in the occupational domain.

Sedentary behaviour prevalence

The prevalence of SB is high in various populations. A cross-sectional study by Loyen et al. (2019) indicated a prevalence of non-occupational SB of 61% (equivalent to 8 hours a day) of in 1624 Dutch households. Additional cross-sectional evidence from Loyen et al. (2018) explored trends of SB in Australian adults including data from the Australian Health Surveys (21,000 responses) from three different survey years (2007-2008, 2011-2012 and 2014-2015). Throughout the three surveys timeframe (8-year period), respondents reported low variations of occupational and leisure SB, both averaging a 55% of their day (over 7 hours). Supplementary primary cross-sectional evidence reported SB prevalence changes across 15 years (2002-2017) in 28 European countries. The data came from the Sport and Physical Activity EU Special Eurobarometer which collects SB and PA data (López-Valenciano et al., 2020). Authors reported significantly higher SB prevalence across the years which increased from 49.3% to 54.5% for all adults in all the included countries.

To summarise, it is evident that SB is recurrent throughout the day in these populations (Loyen et al., 2019; Loyen et al., 2018). The individuals from these studies appeared to engage in SB not only for work, but also for leisure and transportation. Thus, resulting in individuals spending a high number of waking hours in SBs which is detrimental for health. The prevalence of SB seems to remain and, in some cases, increase across the years in European countries, indicating that sedentary individuals are more sedentary over time. This evidence comes from self-report assessment which is subjected to recall bias (Althubaiti, 2016). Nevertheless, the evidence accumulated from three large representative samples (up to 96,004 adults) from various countries and various socio-economic backgrounds, providing a clear outline of SB prevalence.

Occupational SB prevalence

As presented earlier in this chapter, the occupational SB domain entails sedentary time while at work (Bakker, Hopman, et al., 2020; Dunstan et al., 2012). Some occupations may involve higher occupational SB than others. Office workers are sedentary workers that spend most of their working hours in front of a desk (e.g., educational, administrative, managerial, secretarial work) (Yang et al., 2017). Although there is no published record of how many workers are desk-based in the UK, published data from the United States of America (USA) indicated that office workers were the main taskforce in 2018 with 21.8 million people employed in various office jobs (Bureau of Labor Statistics. U.S. Department of Labor, 2018).

Nowadays, office work has become more frequent with workers tending to remain sedentary for long periods in comparison to other occupations (e.g., construction workers) (de Rezende et al., 2014; Katzmarzyk et al., 2019; Ku et al., 2018; Saunders et al., 2020). There is a large body of cross-sectional studies presenting evidence in relation to this. Yang et al. (2017) signalled that blue collar workers (e.g., construction workers) had a self-reported occupational desk-time of 30 minutes per day, whereas desk-based workers had a desk-time of 330 minutes per day.

Combined evidence from other authors provided device assessed occupational SB data. This signalled that sedentary time in office workers was undeniably longer (64 - 80% of working day) than blue-collar workers (44% of working day) (Ellingson et al., 2018; Jiang et al., 2020; Rosenkranz et al., 2020). This evidence is indicative of desk-based jobs being characterised by prolonged SB. Additional evidence of office workers also indicated that these workers not only have high levels of occupational SB but also engage in sedentary bouts regularly. Ryan et al. (2011) was one of the first studies to report quantified accelerometer data from an observational study in office workers. These workers had extended sedentary bouts, with some workers spending up to 98 minutes (SD 34 minutes) without leaving their desks. Further evidence from Parry and Straker (2013a) found that sedentary bouts of over 30 minutes per day accounted for 56.7% (18.2 hours) of the total working week in office workers. Evidence from both studies was taken from small samples (less than 100 participants) so results might not be generalizable. Yet, the evidence provides an idea of the prevalence of SB at the workplace.

SB prevalence during and after the COVID-19 pandemic

The novel coronavirus SARS-CoV-2 (COVID-19) spread rapidly during the first months of the year 2020, and a global pandemic was declared by the WHO in March 2020 (World Health Organization, 2020a). Due to the mandatory quarantines, the pandemic initially 'forced' office workers to stay at home and carry out their work activities. The pandemic also changed the work landscape forever and at present, workers tend to work from home either for some (hybrid working) or all of their working week (Office for National Statistics, 2022).

The Office of National Statistics in the UK reported in 2022 that 38% of interviewed employees worked from home during the working week. Also, 42% of office workers had planned to continue engaging in hybrid working which was an increase from only 12% in 2021 (Office for National Statistics, 2022). It has been reported that SB prevalence is higher at the home environment, when compared to the office (Javad Koohsari et al., 2021; Ráthonyi et al., 2021). Thus, adding health concerns for office workers at both the workplace and at the home environment. Chapter 3 (study 2) discusses in detail working from home and the SB prevalence in this work setting.

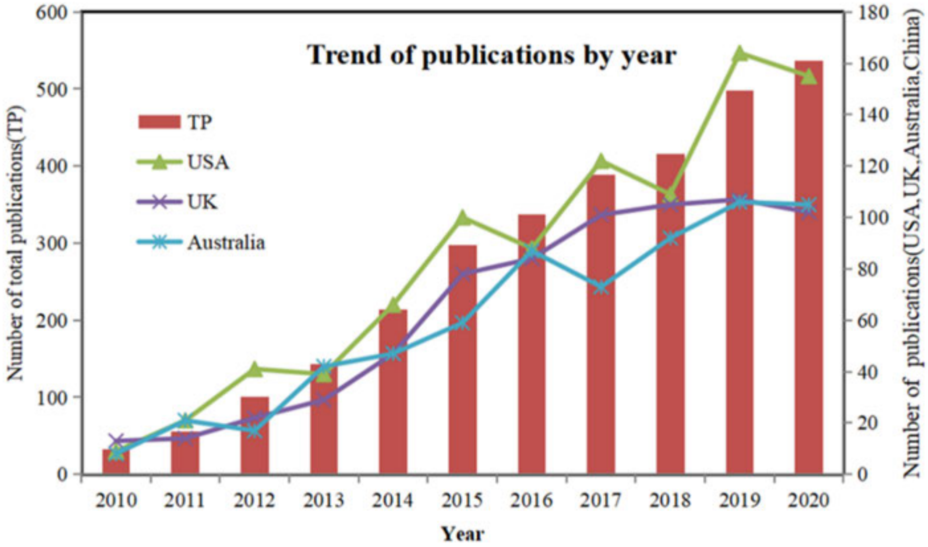
Collectively, it seems apparent that office workers have high levels of occupational SB regardless of their workplace. It has been indicated that SB is linked to several detrimental health outcomes. Accumulating SB during the day might increase these health problems. The following section focuses on these aspects.

SB and health

In relation to the health effects of SB, the field is still considered novel in research, with publications increasing since the early 2000s and an upward trend since 2010 (Biddle et al., 2019; Fang et al., 2021). Figure 2 illustrates the yearly trend of SB publications since the year 2010 which has rapidly increased per year.

Figure 2

Yearly trends for SB publications.



Note: Reprinted from "Recent Trends in Sedentary Time: A Systematic Literature Review" by Fang et al. (2021). Healthcare, 9(8), 969. Open Access under the terms of the Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0/).

Due to the novelty of the field, evidence of the exact effects of SB on health outcomes are still emerging. Nevertheless, research in the field has grown a considerable amount in the past years providing researchers with a clearer idea of what these health effects are.

SB, all-cause mortality and chronic physical illness

The health-related costs of illnesses related to SB for National Health Services (NHS) in the UK are estimated for £0.8 billion during 2016-2017, with specific costs assigned to cardiovascular disease (CVD) (£424 million), type 2 diabetes (£281 million), and various types of cancer (£56 million) (Heron et al., 2019). The data is conservative though and it is important to understand that there might be further influencing factors for these costs (e.g., age, socio-economic factors, gender).

There is a large body of evidence indicating the association of SB with the development of health problems. A comprehensive systematic review and meta-analysis (47 prospective studies) from Biswas et al. (2015), presented relevant information for associations between health problems, and all-day SB. The largest statistical effect was in relation to type 2 diabetes with a pooled HR of 1.910 (95% CI [1.642, 2.222]). Other significant associations were found with all-cause mortality (HR 1.220, 95% CI [1.090, 1.410), CVD mortality and incidence (HR 1.150 95% CI [1.107, 1.195], HR 1.143 95% CI [1.002, 1.213] respectively), and cancer mortality and incidence (HR 1.130 95% CI [1.053, 1.213] for both). In addition, authors suggested that although PA attenuated these health risks, they were still present, especially in individuals with lower levels of PA.

Additional systematic review evidence by Patterson et al. (2018) (34 studies) examined the associations between SB with all-cause, CVD and cancer mortality, and type 2 diabetes incidence. The authors differentiated between total SB and TV viewing and informed the number of hours that individuals need to engage in SB to increase these health risks. In relation to total SB, findings signalled increased risk for all-cause mortality in SB above 8 hours per day. CVD mortality also appeared to be associated with total SB over 6 hours per day. No associations were found with type 2 diabetes incidence due to a low number of studies. In relation to TV viewing, increases in risk for all-cause, CVD, and cancer mortality were associated with SB higher than 3 to 4 hours per day. Also, TV viewing seemed to be strongly associated with increased risk to develop type 2 diabetes. Similar to Biswas et al. (2015), findings suggested that PA attenuated but not eliminated mortality and incidence risks for all outcomes.

Lastly, an unique systematic review and meta-regression analysis from Ku et al. (2018) summarised data from 19 longitudinal studies with more than 1 million participants through follow-up times ranging from 2.8 to 15.7 years. In contrast to the other reviews, this review made a distinction between self-reported, and device assessed SB data. Findings from this review showed a linear correlation between daily SB and all-cause mortality risk. Evidence pointed out that increased all-cause mortality risk was significantly higher when sedentary time exceeded 7.5 hours a day. The increased risk for all-cause mortality and SB seemed to differ depending on the measurement tool (self-report and device assessed). From device assessed data this link was apparent when individuals engage in SB of 7 hours. Whereas the cut-off point for self-reported SB was 9 hours. This information is key to differentiate device assessed SB data from self-reported SB data. However, other variables, such as follow-up periods and loss of participants (over 86 thousand deaths) may have also affected these outcomes.

To summarise, it is apparent that higher levels of SB are associated with increases in risk for all-cause, CVD and cancer mortality, and type 2 diabetes incidence. Some of these health risks seem to be attenuated when individuals engage in PA, but do not eliminate the risk of mortality or incidence. Furthermore, total SB and TV viewing seem to contribute differently to health risks. For example, SB of over 6 and 8 hours increases the risk for all these outcomes, whereas TV viewing requires less time (3 to 4 hours) to increase these outcomes. However, it is possible that this is influenced by having a generally sedentary lifestyle or food intake during TV viewing (Andrade-Gómez et al., 2017).

Several limitations are noted from this evidence. Although some authors mention that PA can act as an attenuating factor for these health problems, there is no specific PA threshold stated to counteract these health problems. Nevertheless, this has been reported by other authors (Ekelund et al., 2019; Ekelund et al., 2020) and the evidence is presented in a later section. Overall, many studies included in these reviews rely mainly on self-reported data which as mentioned earlier is subject to recall bias. Explicitly, only Ku et al. (2018) provided evidence of different cut-off points for self-reported SB and device assessed SB data in relation to all-cause mortality. However, these variations might be attributed to recall bias from self-report assessment.

SB and mental wellbeing

SB also seems to have effects on mental wellbeing, although the evidence for this link is still emerging. An overview of systematic reviews (44 studies) from Saunders et al. (2020) signalled negative associations between high levels of SB with cognitive function and depression. These associations were consistent during total SB and TV viewing, but not for internet and computer use which seemed to have a positive effect on both outcomes. However, this evidence is taken cautiously as it is obtained from mainly self-report measures and very low to low quality systematic reviews.

Supplementary evidence from a meta-analysis (12 prospective studies) found evidence of significant associations between SB and risk of clinical depression in adults (Huang et al., 2020). Like Saunders et al. (2020), subgroup analyses indicated that the positive associations were mainly linked to TV watching, but not to computer use. Thus, reflecting that 'mentally passive' SB might be associated with lower levels of mental wellbeing.

Primary evidence from Jiang et al. (2020) (29,298 participants) showed positive associations between SB of 7 hours per day with anxiety, depression, and suicide ideation, regardless of participants' PA. This meaning that highest sedentary time increased negative mental health outcomes.

Ellingson et al. (2018) reported associations between SB (using accelerometers) and mental health in individuals across a one-year period. Findings from the authors suggested that decreasing SB time by 90 minutes per day, was associated with an improvement on moodiness, sleep, and stress levels. Furthermore, an improvement on mood and stress levels was observed when prolonged sedentary bouts (over 30 minutes) were reduced.

Limitations from literature of associations between SB and health outcomes are noteworthy. Overall, it seems that the most apparent shortcoming of SB literature and health is the use of self-report tools to assess SB. A lack of standardisation in tools to measure SB is also notable from this evidence. Studies included in these systematic reviews and meta-analyses are quite heterogeneous in design (e.g., observational versus randomised controlled trials), measurement (e.g., self-reported questionnaires versus device assessed data), and quality assessment (e.g., low versus high-quality evidence). There is still a scarcity of research in relation to SB and mental health with evidence mainly based on observational research. Additionally, samples might not be representative with many studies focused on specific populations (e.g., younger adults, >31, high educational level). It is relevant to point out that despite these limitations, agreement on the negative health effects of SB on various health outcomes is still attained from this evidence.

SB appears to be associated with various chronic physical illnesses and mental health detrimental outcomes. There is also evidence indicating that SB is a contributor for musculoskeletal disorders (MSDs) development. The next section encompasses the global problem of musculoskeletal disorders and how SB influences this prevalence. The section also aims to explain the underlying factors between SB and MSDs prevalence.

Musculoskeletal disorders prevalence and global burden

Musculoskeletal disorders (MSDs) are non-communicable conditions that affect various bodily tissues such as muscle, bones, soft tissue and joints (Ingram & Symmons, 2018). MSDs are characterised by an inflammatory process leading to pain and discomfort of the affected area which ultimately leads to mobility problems (Ingram & Symmons, 2018). The cost of treating MSDs is also high for health providers, in England approximately £171.2 million was reported to cover costs related to MSDs in 2020 (Versus Arthritis, 2021). In large countries, such as the USA, the costs related to MSDs have been reported as the highest in relation to other ailments (e.g., diabetes, ischemic heart disease) (Dieleman et al., 2020). Moreover, MSDs accounted as the second highest spending in health with approximately of $129.8 billion dollars (Dieleman et al., 2020). MSDs also lead to job absenteeism and early retirement due to mobility reduction caused by pain (Ingram & Symmons, 2018). In the UK, MSDs were the second most common cause for job absenteeism in 2020 (Office for National Statistics, 2021).

The burden of MSDs in global health is high. Reports from The Global Burden of Diseases (GBD) provide relevant data in relation to various diseases that affect the Disability Adjusted Life Years (DALYs) worldwide since 1993 (Mathers, 2020). The DALYs consist of measuring the years of life lost (YLL) from premature deaths and adding the years lived with disability (YLD). Both, DALYs and YLDs are used to report the total population health burden (Mathers, 2020). It is also important to mention that data taken from the GBD is dependent of data availability (e.g., national health reports) and data may be under or overestimated, which does not fully reflect the entire burden of diseases. Regardless, the GBD reports contain critical data to understand how the burden of various diseases (369 diseases and injuries) affect the DALYs and YLDs globally. From the latest report of the GBD (Abrams et al., 2020) it was indicated that 1.71 billion people suffer from MSDs globally. MSDs were also amongst the top 20 leading causes for the increase of YLD across all ages.

The prevalence of MSDs seems to increase across the years. An example of this was provided by de Luca et al. (2022). Authors used metadata from the latest GBD report to produce a unique systematic analysis and report the national prevalence of MSDs across the years in Australian adults. Findings from this analysis signalled that MSDs contributed to a 75% increase of YLD, from 1990 to 2019. MSDs were also identified as the leading cause for disability in Australia with the highest peak in older adults (over 65 years old). Additionally, the prevalence of MSDs affected people in their peak labouring years and numbers increased with age (de Luca et al., 2022).

Considering the global burden of MSDs, the development of strategies and policies to tackle these conditions should be a global priority. The only known global strategy was created by the United Nations and the WHO, which comprises of a rehabilitation initiative to include rehabilitation of MSDs in global health systems by 2030 (Gimigliano & Negrini, 2017). However, this health initiative is generalised to all types of conditions (e.g., osteoarthritis, gout), and not specific conditions that might be developed from occupational risks. For instance, individuals engaging in SBs are at risk of developing painful MSDs (e.g., low back pain, neck pain).

SB and MSDs

There is growing evidence of the relationship between SB and its effects on the musculoskeletal (MSK) system which eventually leads to MSDs development. A novel systematic review and meta-analysis of 79 studies by Dzakpasu et al. (2021) synthesised evidence of the associations of MSDs with various SB domains in adults. From the meta-analysis, findings showed that non-occupational all-day SB was associated with low back pain (LBP) (pooled effect size OR=1.19, 95% CI [1.03, 1.38]). Self-reported occupational SB found positive associations between SB and LBP (OR=1.47, 95% CI [1.12, 1.92]), neck pain (OR=1.90 9% CI [1.35, 2.68]), shoulder pain (OR=1.71 95% CI [1.31, 2.22]), but no association with extremities pain (OR=1.17 95% CI [0.65, 2.11). Findings from the narrative synthesis also indicated associations between non-occupational SB and knee pain, arthritis, and other unspecified MSDs, with inconclusive evidence on neck, shoulder pain, hip pain and extremities pain. Evidence on the association between leisure SB and MSDs was inconclusive for LBP, upper back pain, neck, shoulder, knee, and general MSDs pain. Specific to the occupational SB domain, authors found inconsistent evidence for association of LBP, neck and shoulder pain and device assessed occupational SB. On the other hand, computer time seemed to be associated with neck and shoulder pain, but not with LBP or other MSDs. Nevertheless, the evidence for many of these associations were taken from cross-sectional evidence where the causality of the outcomes is undetermined (e.g., people with MSK might have higher levels of SB). Findings from experimental designs (RCTs and non RCTs) also signalled positive correlations of workplace sitting reduction with LBP, neck, shoulder, and other MSDs pain reduction, with no evidence of pain decreases on limbs. This reduction might be attributed to reduced computer use (e.g., use of mouse and keyboard) which is inherent to desk-based work. On the other hand, reducing workplace sitting might not be sufficient to decrease pain in limbs, which could be attributable to circulation issues caused by prolonged SB.

Further systematic review evidence (20 studies) from Jun et al. (2017), focused on workplace settings, indicated various individual risk factors influencing neck pain development in office workers. These work factors were keyboard position (pooled RR 1.46), static postures with low task variation (RR 1.27), and muscular tension (RR 2.75), suggesting that static postures in combination to computer use are risk factors for office workers to develop neck pain.

Literature focused strictly on the physio-pathological development of MSDs has suggested prolonged sedentary time as a contributing factor to this development. Restaino et al. (2015) indicated a link between prolonged sedentary time (static postures) and loss of bone mass and muscle strength, as well as lower limb circulation problems. Chan et al. (2011) signalled increases on spinal load, reduction of joint lubrication and intervertebral discs fluid, and increased stiffness on spinal MSK tissues. Harris-Adamson et al. (2017) indicated that because of continuous static positions (e.g., sitting) and absence of rest periods, an increase in intramuscular pressure and blood flow impairment led to muscular fatigue and muscle discomfort. In addition, repetitive movements such as use of a keyboard or mouse exceeded the capability of hand and forearm muscles, and led to the development of work-related MSDs, along with deteriorating physio-pathological outcomes (Harris-Adamson et al., 2017).

Combined evidence from individual cross-sectional studies has also indicated associations between prolonged sedentary time and computer use with MSDs development in adults with sedentary occupations (Basakci Calik et al., 2022; Caromano et al., 2015; Okezue et al., 2020; van Vledder & Louw, 2015). Findings from these authors suggest associations between the increase of pain on neck, upper back, and shoulders and daily computer use of over six hours.

To summarise, collective evidence of systematic reviews and individual primary studies suggests that prolonged SB is a relevant factor to develop MSDs. However, the shortage of research in the relation of SB and MSDs is evident, with various shortcomings similar to SB literature. The lack of standardisation in measurement tools, and the predominant use of self-report tools to measure both SB and MSK symptoms are identified within these limitations. The lack of RCTs or experimental designs are also missing from most of this research with only Dzakpasu et al. (2021) including experimental designs in their review. However, this evidence accounted only for 15% of all the included studies. It seems clear that to reduce these negative outcomes, SB should be reduced in all populations. The next section addresses the existing literature on strategies to reduce SB.

Reducing the negative health effects caused by SB

The limited evidence on how to counteract the negative health effects of SB is reflected in the shortcomings of the existing guidelines to reduce SB. Contrary to PA, SB guidelines for adults are still in progress. Various recommendations to reduce SB have been made by governments or organisations. For example, the WHO has recommended to limit SB during the day, without specifying how often individuals should break up their SB (World Health Organization, 2020b). In the UK, there are also no SB guidelines stating how often adults (19 to 64 years old) should break up their SB. The latest recommendation from the CMO is to limit the amount of SB throughout the day (Department of Health and Social Care, 2019). Similar guidelines are found in Australia where the recommendation is to reduce SB throughout the day (Australian Government Department of Health, 2021). The most comprehensive recommendations available are from the Canadian 24-hour movement guidelines (Canadian Society for Exercise Physiology, 2020). These guidelines advise limiting the amount of SB to 8 hours or less through the day and limiting leisure SB to 3 hours per day. These guidelines also suggest breaking up long periods of sedentary time through the day. Nevertheless, further evidence is still needed to complement these guidelines, and to understand how reducing SB can help to improve health.

There is growing evidence around the reduction of the negative effects of SB on health by engaging on high levels of PA. As mentioned earlier in this chapter, the CMO PA recommendations for adults suggest performing at least 150 of moderate intensity PA or 75 minutes per week on vigorous intensity PA and carry out muscle strengthening activities at least twice per week to obtain various health benefits (Department of Health and Social Care, 2019). Some of these health benefits are reduced all-cause mortality risk, increased quality of life and benefits on cognitive, mood and mental health (Nakagawa et al., 2020; Posadzki et al., 2020). Despite these health benefits, literature suggests that to be able to reduce the health problems that come from prolonged SB is necessary to perform higher levels of PA than the recommended by the PA guidelines.

Three systematic reviews have signalled those individuals performing higher levels of PA (than suggested by the PA guidelines) might be able to counteract negative health effects of SB. Specifically, eliminating the risk of all-cause, CVD and cancer mortality (Ekelund et al., 2019; Ekelund et al., 2020). A systematic review evidence from Blond et al. (2020) also indicated that individuals with high levels of

PA (5 – 7 times above the guidelines) showed lower CVD and all-cause mortality which are detrimental problems derived from prolonged SB.

Ekelund et al. (2019) systematic review and meta-analysis suggested that having high levels of MVPA (50 – 65 minutes per day/week) can attenuate the negative health associations between SB with CVD and cancer mortality. However, this attenuation was weaker in individuals who sat for over 8-hour periods per day and had low levels of PA during the day (from 5 minutes to 35 minutes per day/week). These findings do come mainly from self-reported data which is subjected to recall bias and social desirability (Althubaiti, 2016).

Another systematic review by Ekelund et al. (2020) (over 44 000 adults) addressed the shortcomings from the previous systematic review and summarised data from studies measuring device assessed PA and SB (using accelerometers). Findings from this review suggested that individuals sitting for over 8 hours per day but performing 30 to 40 minutes of MVPA during the day, could attenuate the adverse consequences of elevated SB including lower all-cause mortality risk. However, this attenuation was less noticeable in people sitting for over 8-hour periods and performing the lowest levels of PA during the day (10.6 – 27.0 minutes of MVPA per day), thus increasing their all-cause mortality risk.

To summarise these findings, the negative associations between SB, PA and health are primarily attenuated in people who meet or exceed the PA recommendations. However, this attenuation is lower for people who do not meet the PA recommendations and engage in sedentary bouts of over 8-hour per day. This meaning that mortality, CVD and cancer risks increases when people are less physically active and more sedentary.

Achieving the PA guidelines and surpassing them is challenging for many adults worldwide. Guthold et al. (2018) indicated that over a quarter of adults were physically inactive in 2016 with a global prevalence of 27.5%. In Scotland, the latest report of the Scottish Health Survey (The Scottish Government, 2020) indicated that less than half (46%) of Scottish adults (over 16 years) were meeting these guidelines in 2020. The number of adults reporting meeting the PA guidelines also decreased by age. It is also suggested that office workers who work for long hours (e.g., over 7 hours per day) were less likely to engage in PA in their free time (Clemes et al., 2014). Furthermore, these workers accumulated high levels of SB after work on leisure SB (e.g., reading, watch TV).

A main concern is then that sedentary workers might not be able to meet and exceed the PA recommendations in their free time. Hence, not being able to counteract the detrimental health outcomes from prolonged SB. Further evidence exploring the reduction of health-related problems derived from SB is still needed. This evidence should also consider the high global inactivity levels. A proposed alternative is displacing SB with other movement behaviours to reduce SB and achieve optimal health. This is discussed in the next sub-section.

Displacing SB health effects with PA

Recent research exploring the 24-hour jointly associations between SB and PA has indicated that displacing SB with PA has positive effects on health (Farrahi et al., 2021; Grgic et al., 2018). An example of this is provided by Grgic et al. (2018) systematic review which explored an iso-temporal substitution model to analyse replacing SB with PA for health benefits. Findings from this review suggested that reallocating SB to light PA (LPA) or MVPA are significantly associated with a reduction in mortality risk, adiposity and cardiometabolic markers adults in adults. Specifically, reallocating one-hour of SB to one-hour of MVPA or LPA was indicated to reduce mortality risk in adults (42% for MVPA, 18% for LPA,). These findings also suggest that higher PA intensity provides further health benefits when compared to lighter PA intensity. These findings come from mainly device assessed data, and studies had moderate to high methodological quality. However, considering all the movement behaviours that occur during 24-hour day it was noticeable that sleep duration was unaccounted for. This limitation could have influenced the results due to the low energy expenditure of sleeping (-1 MET). Nevertheless, other studies have addressed this shortcoming and they are discussed below.

Supplementary evidence from a longitudinal study (over 10 000 and a follow-up 46-year period) by Farrahi et al. (2021) identified associations between SB, PA with cardiometabolic markers. This study also accounted for other movement behaviours such as sleep duration and their reallocation into PA, to reduce health problems. Findings from this study indicated that groups of people with the lowest SB and the highest PA per day had higher benefits on cardiometabolic markers when compared to the group with the highest SB and lowest PA. Moreover, reallocating 30 minutes of SB, sleep and LPA to MVPA per day significantly favoured cardiometabolic markers. These favourable effects were also observed when reallocating 60 minutes from SB and sleep time to LPA. On the contrary, reallocating further time to SB and sleeping (and reducing daily MVPA and LPA) were significantly associated with adverse cardiometabolic markers.

In summary, reallocating SB to LPA and MVPA appears to be useful to decrease health problems linked to SB. However, higher levels of LPA (when compared to MVPA) are needed to reduce SB health problems. The reallocation of SB to LPA during the day might be a useful form that could provide many benefits for sedentary workers health. Moreover, LPA activities could be added during working hours. Other factors to reduce SB should also be considered, for example, what strategies are the most effective to reduce SB at work. These are considered in the next section.

Reducing SB in the workplace

When considering the high prevalence of SB in office workers, it is useful to acknowledge different strategies that might be helpful to reduce SB in the workplace. A systematic review and meta-analysis (34 studies) by Shrestha et al. (2018a) suggested effective strategies to reduce SB in the workplace. Findings indicated that there was significant evidence of sit-stand desks contributing to an average reduction of 100 minutes of sitting per 8-hour workday (95% CI [116, -84]), when compared to seated desks. This reduction was observed up to a 3-month follow-up period. No significant effects were found for workplace policy changes and walking strategies implementation (MD -15 minutes per day). Short breaks (e.g., 5-minute breaks) significantly reduce sitting time for 40 minutes per day at short or medium-term follow-up (up to 3 months, and up to 12 months respectively).

An additional systematic review and meta-analysis (26 studies) by Chu et al. (2016) showed a reduction in sitting of 39.6 minutes per 8-hour workday (95% CI, [-51.7, -27.5]). The highest reduction was observed in studies using multicomponent interventions, specifically using sit-stand workstations combined with behavioural and educational changes. This showed a reduction of 88.8 minutes per 8-hour workday (95% CI, [-132.7, -44.9) in multi-component, environmental changes and educational-behavioural interventions also reduced sitting per 8-hour workday (-72.8 minutes, 95% CI [-104.9, -40.6]; -15.5 minutes, 95% CI [-22.9, -8.2] respectively). Both reviews suggest that sit-stand desks are useful to reduce SB at the workplace. However, literature suggests that standing for prolonged periods might not be sufficient to reduce negative health outcomes.

A systematic review (9 studies) from Saeidifard et al. (2020), indicated that replacing sitting with standing bouts of 30 minutes had slightly significant positive effects on cardiovascular risk factors (low levels of fasting blood glucose and body fat) in intervention groups (standing) versus control groups (sitting). These findings were from relatively small samples (10 to 65, and 15 to 68 participants for control and intervention groups, respectively) with only two studies with over a hundred participants (95 to 144, and 136 to 173 participants for control and in intervention groups, respectively). Additionally, only two studies had follow-up periods of over 6 months (one study reported 6-month, one study reported 12-month follow-up), with the rest of the evidence having short follow-up periods (5 days to 3 months).

Supplementary primary evidence from Peddie et al. (2021) made a comparison between the acute effects of prolonged sedentary time (6 hours), prolonged standing (6 hours) and activity breaks (2 minutes walking every 30 minutes of sitting) on vascular function and postprandial glucose. In relation to vascular function, blood flow increased during the activity breaks condition and the standing conditions. However, the effects on this outcome only remained for 60 minutes in the standing condition, whereas the blood flow increase remained for the 6-hour period in the activity breaks group. Similarly, postprandial glucose was reduced only during the activity breaks conditions, but not during the prolonged sedentary time and prolonged standing conditions.

There is also evidence that prolonged standing causes negative effects in the musculoskeletal (MSK) system, contributing to MSDs development. A large sample (32,970) cross-sectional study from Jo et al. (2021) signalled that adults engaging in prolonged standing (for some or most of their working day) suffered from presence of MSK symptoms in lower limbs, LBP, and general body fatigue. A proportional correlation was also found between standing hours and MSK symptoms. Findings indicated that when standing hours increased MSK symptoms did accordingly. These findings were taken from different work backgrounds and not just sedentary workers. Therefore, the working conditions might differ from desk-based work.

Individual primary evidence from an observational study (Smith et al., 2022) signalled that 84% of participants experienced MSK symptoms after standing for a two-hour period. It was also reported the onset of MSK symptoms (lumbar area, lower extremity, and ankles and feet) began after 30 minutes of standing, and further increases were observed at the end of the 2-hour period. Findings were taken from a relatively small sample (69 participants) in single-session acute settings. Thus, limiting the understanding of the development of MSK symptoms over longer term interventions.

From both primary evidence studies, it can be implied that prolonged standing can also contribute to MSDs development, and in observational settings the pain onset can start from standing for 30 minutes.

Further evidence from an expert panel in SB provided relevant considerations for SB reduction (Biddle et al., 2019). Concluding remarks from the authors signalled that both prolonged sedentary time and prolonged standing were negative for health. Even though standing provided health benefits, these were attributed mainly to the change of posture, and not the standing posture itself. Another main finding indicated that breaking up sitting with movement breaks, involving postural change, were key to reducing the negative health outcomes derived from prolonged sedentary time. This evidence however comes from an expert panel opinion which according to the evidence-based practice in health hierarchy of 'best evidence', this is at the bottom of the hierarchy due to its lack of rigour methodology, and needs to be taken cautiously (University of Canberra, 2022). Nevertheless, these knowledge is useful to provide insights of the current directions of the SB research.

The use of sit-stand desks seems to be an important form to reduce SB in the workplace. However, there are also other considerations in relation to this, such as the cost of these workstations for organisations, and the recognition that some people might not be able to stand for prolonged periods (e.g., individuals with mobility problems). In addition, evidence suggests that replacing sitting with standing might not be sufficient to reduce the health problems associated with prolonged SB (e.g., cardiovascular markers, vascular function, and postprandial glucose), including MSDs.

From the evidence presented above, it seems that activity breaks provide further benefits in various markers, especially when compared to only sitting and only standing conditions. Current literature, including the expert consensus study (Biddle et al., 2019) and the 24-hour Canadian movement guidelines for adults 18-64 (Canadian Society for Exercise Physiology, 2020) have suggested that breaks from sitting might be helpful to reduce detrimental health outcomes of prolonged sedentary time.

Breaks from sitting

Breaks from sitting, or sedentary breaks, are defined by the Sedentary Behaviour Research Network (SBRN) as "non-sedentary activities taking place between sedentary bouts" (Tremblay et al., 2017). For the purpose of this thesis, breaks from sitting, or 'active breaks' (Waongenngarm et al., 2018), refers to breaks involving postural change (e.g., standing, standing and stretching, walking).

There is evidence suggesting LPA is to be useful to protect against the negative health effects of SB (Ekelund et al., 2020; Farrahi et al., 2021). A systematic review (44 studies) from Saunders et al. (2018) indicated that breaking up sitting time every 20 to 30 minutes with bouts of LPA and MVPA significantly reduced acute glucose (ES=-0.36) and insulin levels (ES=-0.37). Both results were indicated when compared to only sitting conditions, and regardless the breaks intensity. A main limitation of this evidence is that studies were quite diverse with a large range of break frequency (e.g., every 10 – 30 minutes), break intensity (LPA to MVPA), and break type (e.g., standing, walking on a treadmill). There were also large differences on testing periods ranging from 1 hour and up to 24 hours. These longer testing periods might not apply to the occupational SB domain.

Further evidence from Farrahi et al. (2022) has observed that individuals that are able to engage in any type of PA intensity bout, from LPA to MVPA, might obtain benefits on cardio-metabolic health by reallocating SB to PA. From this evidence, it also seems apparent that active breaks from sitting might be promising to reduce metabolic conditions.

In relation to break frequency, an unique 3-year period longitudinal study has presented evidence of the association between the length of sedentary bouts, and metabolic syndrome risk in office workers (Honda et al., 2016). After a 3-year annual follow up, positive associations were found between sedentary bouts of over 30 minutes and risk of metabolic syndrome. On the other hand, no association between risk of metabolic syndrome and time spent in non-prolonged sedentary bouts (less than 30 minutes) was found. Thus, suggesting that breaking up sitting every 30 minutes might benefit these outcomes.

To summarise it can be suggested from this evidence that frequent breaks from sitting (e.g., every 20 – 30 minutes) are promising to reduce risk of metabolic syndrome, and cardio-metabolic markers in adults. Also, it is suggested these breaks need to include some postural change to achieve these benefits.

Breaks from sitting and MSDs

Publications in relation to breaking up prolonged SB and its effects on MSDs have increased in the past years. Four systematic reviews have sought to synthesise evidence of the effects of breaks from sitting on MSK outcomes, though findings are contradictory (Agarwal et al., 2018; Luger et al., 2019; Parry et al., 2019; Waongenngarm et al., 2018).

A systematic review (6 studies) from Luger et al. (2019) found no significant effects for active breaks (e.g., walking, high intensity exercises) on self-reported pain, discomfort or fatigue when compared to passive breaks (e.g., breaks with no postural change). A systematic review (10 studies) from Parry et al. (2019) indicated that interventions using sit-stand desks and treadmills did not have a considerable effect on LBP, upper back, neck, pain, shoulder, elbow, hand or knee pain intensity, in comparison to no intervention.

Two other systematic reviews found positive effects of active breaks from sitting on LBP. Waongenngarm et al. (2018) systematic review (11 studies) found evidence of four types of breaks, active breaks with postural change (e.g., standing and move around), active breaks without postural change (e.g., sitting and stretching), passive breaks (e.g., sitting while relaxing), and standing breaks (e.g., sit-stand schedules) while performing computer tasks. From these breaks, the most effective break to reduce LBP while maintaining productivity was active breaks with postural change while seated. However, there was also evidence that standing breaks, and breaks without postural change were helpful for discomfort prevention. On the other hand, passive breaks were indicated to be ineffective for both discomfort reduction and prevention.

Additional review evidence (12 studies) from Agarwal et al. (2018) aimed to explore the effects of using sit-stand breaks on LBP in adults with and without MSK symptoms. Findings from this review indicated that sit-stand schedules were useful to slightly reduce LBP in participants catalogued as pain-free.

It is clear that the available published evidence exploring MSK symptoms reduction by using breaks from sitting is mixed. Findings from these reviews do come from low-quality studies and a low number of studies have highly heterogeneous break protocols. This makes it difficult to draw further conclusions to understand the effects of breaks from sitting on MSK symptoms. These reviews are also limited to self-reported data, which seems to be predominant in both SB and MSK literature.

In summary, breaks from sitting appear to provide positive health effects and reduce SB. However, additional research is still needed to understand this association.

Behaviour change to reduce SB

Recapitulating the evidence presented in previous sections, it can be noticed that SB entails various aspects (e.g., domain, lifestyle). It appears that individuals engaging in occupational SB, also engage in further SB during their leisure time (Clemes et al., 2014). Considering this, it seems essential to understand the factors influencing SB to be able to reduce this behaviour. Behaviour change theories have been employed in occupational research, and its use appears to be effective to identify factors influencing SB. Thus, this element would be essential to target occupational SB reduction.

Systematic review evidence suggests that understanding these factors might be helpful to inform interventions to reduce SB and yield positive reductions. For example, a systematic review from Chu et al. (2016), found that behavioural interventions achieved a reduction in sitting of 15.5 minutes per workday in the workplace. Additional evidence from a systematic review from Peachey et al. (2020) also indicated that interventions targeting behavioural change in the workplace achieved reductions in sitting of 23 minutes per workday.

Primary evidence has also provided information on what factors are the most relevant to reduce SB at the workplace. A study by Munir et al. (2018) which undertook interviews to office workers reported the most relevant factors influencing occupational SB in the workplace. Findings suggested that interventions targeting education, training, environmental restructuring, incentivisation, and goal-setting would be necessary for this population to reduce their SB.

These examples provide information about specific factors needed for office workers to change their SB. However, these factors are likely to vary in accordance with each population. With recent changes in the work landscape, it is necessary to understand the factors influencing SB in the home environment. Behaviour change appears to be indispensable for SB reduction and can only be achieved by understanding the factors influencing SB. Chapter 4 (study 3) presents the most relevant aspects in literature related to behaviour change theories, and SB reduction at the workplace and home.

Summary and knowledge gap

The global burden of MSDs is considerably high and has increased in the past years, with billions of people suffering from a painful MSD worldwide (Abrams et al., 2020). Painful MSDs can lead to early retirement due to mobility reduction (Ingram & Symmons, 2018). In addition, MSDs are the second most common cause for job absenteeism in the UK (Office for National Statistics, 2021). The accounted cost of treating MSDs is also burdensome for global health systems (Dieleman et al., 2020; Versus Arthritis, 2021).

SB has been identified as a risk factor for MSD development (Dzakpasu et al., 2021). Also, SB has been found to be detrimental for various physical and mental health outcomes, adding burden to health systems (Ellingson et al., 2018; Saunders et al., 2020).

It seems evident that office workers engage in high levels of prolonged occupational SB during work, and they are likely to engage in further SB after working hours (Clemes et al., 2014). Consequently, this population is likely to be at risk to develop various health problems (e.g., cardiovascular conditions, metabolic disorders, cancer), and painful MSDs.

Research evidence has pointed out that the health problems associated with prolonged SB might be decreased by carrying out higher levels of PA (over 50 minutes per day) than the recommended PA guidelines (Ekelund et al., 2019; Ekelund et al., 2020). Moreover, the high levels of PA seem to be only protective when individuals have a SB lower than 8 hours per day and perform over 30 minutes of MVPA per day (Farrahi et al., 2021). Many adults might not have the opportunity to reduce their SB through the day, nor meet and surpass these guidelines as levels of physical inactivity worldwide are high (Guthold et al., 2018). Therefore, the negative health risks in office workers are likely to linger.

Various strategies to reduce SB in the workplace have been explored by research. Some research has considered sit-stand workstations to reduce SB in the workplace (Chu et al., 2016; Shrestha et al., 2018a). However, the acquisition of sit-stand workstations might result in high costs for organisations. In addition, evidence suggests that prolonged standing is also associated with the development of MSK symptoms in office workers (Jo et al., 2021; Smith et al., 2022). Standing also appears to be insufficient to reduce cardiovascular and metabolic markers (Saeidifard et al., 2020).

A possible alternative to reduce SB and the negative health outcomes are taking breaks from sitting. Specifically, breaks involving postural change including some form of LPA. These breaks are suggested to benefit cardiometabolic markers, cancer and mortality risk (Ekelund et al., 2019; Ekelund et al., 2020; Grgic et al., 2018). In addition, the reallocation of SB to LPA activities (by 60 minutes per day) could be beneficial to sedentary workers and these activities can be easily spread throughout the day.

Breaks from sitting seem to not require additional costs for organisations and can be added to a work schedule without taking a high amount of worker's time. Systematic review evidence has indicated positive effects of breaks from sitting with postural change on LBP reduction and prevention (Waongenngarm et al., 2018). Nevertheless, evidence on the use of breaks from sitting to reduce MSDs development in office workers is limited and mainly based on self-report measures.

Additional considerations also need to take place for office workers to reduce their occupational SB. For example, it seems evident that interventions need to target various aspects of SB such as understanding the underlying factors of this behaviour. Understanding these factors is essential to target behaviour change in sedentary individuals and achieve SB reduction. The next section details the thesis aims, objectives and methodology.

Thesis aim, objectives and methodology

A mixed-method approach was used for this PhD thesis. The methodology of the thesis encompassed three studies and each study addressed a research objective of the thesis.

The overall aim of this thesis was to expand knowledge of the role of breaks from sitting as a strategy to reduce MSKs symptoms and occupational SB in office workers. The thesis objectives were:

1. To systematically review the literature of the effects of breaks from sitting on spinal MSK symptoms in sedentary workers.
2. Explore SB and MSK symptoms prevalence in University of Edinburgh desk-based staff working from home.
3. Identify factors influencing SB and breaks from sitting in University of Edinburgh desk-based staff with MSK symptoms while working from home.

Thesis methodology

The first study was planned to explore evidence in relation to the effects of breaks from sitting on MSK symptoms. In view of the identified prevalence of spinal pain (e.g., LBP, neck pain, upper back pain), this review aimed to synthesise primary evidence of the effects of breaks from sitting on spinal outcomes in sedentary workers. As most of the available published evidence came from self-report, two objectives were established for this systematic review. The first objective was to review literature of the effects of the breaks from sitting from device assessed spinal musculoskeletal outcomes in sedentary workers. The second objective was to compare the effects of breaks from sitting between device assessed spinal outcomes and self-reported spinal outcomes in this population, when available. Results from this systematic review were used to inform and plan the second study for this thesis. The methodology for the second study was revised due to the COVID-19 pandemic, more information is presented at the end of this chapter.

The confinement periods due to the COVID-19 pandemic forbid office workers to access to their regular workplaces. With new COVID-19 variants emerging regularly, the end of the confinement periods was uncertain. Prior to the pandemic, some desk-based workers had the opportunity to carry out some of their work activities while staying at home. However, this change had been gradual. Conversely, during the pandemic confinement periods, office workers were required to carry out their work activities at home.

Considering these changes in the work landscape, the purpose of the second study of this PhD was to increase knowledge on various outcomes related to the working from home environment, including SB and MSK symptoms prevalence. This was a cross-sectional and quantitative study focused on University of Edinburgh staff. The study aim was to explore differences in MSK symptoms prevalence between groups defined by occupational sitting time, breaks from sitting and ergonomic chair settings in staff from the University of Edinburgh. Research objectives were to describe occupational sitting time, breaks from sitting, ergonomic chair settings and musculoskeletal symptoms prevalence in University of Edinburgh staff while working from home (WFH). The findings from the second study (high prevalence of MSK symptoms in University of Edinburgh staff and an elevated time engaging in prolonged sedentary time while WFH) were used to develop the third and final study of this PhD thesis.

The purpose of the third study of this thesis was to explore factors influencing SB and breaks from sitting in desk-based University of Edinburgh staff with MSK symptoms while WFH. The study was a qualitative study and aimed to identify the most common barriers and facilitators to reduce SB at the home environment, by undertaking a behavioural diagnosis. The behavioural diagnosis was carried out using the COM-B model which is a theory-based model formed by three constructs (Capability, Opportunity and Motivation). This model was used in combination with the Theoretical Domains Framework (TDF). Both models were used to identify barriers and facilitators to reduce SB in office workers with MSK symptoms while WFH. Findings from this study were valuable to support staff with MSK symptoms to reduce their SB while WFH.

The impact of the COVID-19 pandemic on the methodology of this thesis

As mentioned earlier in this chapter, a global pandemic was declared by the WHO in March 2020 (World Health Organization, 2020a). Confinement periods were established worldwide to slow down the spread of the virus and the saturations of hospitals. Schools, recreation centres, non-essential shops and workplaces were closed to the public to prevent further contagion (Cucinotta & Vanelli, 2020). Due to the confinement periods, office workers were forced to start and continue working from home. These rapid changes also brought many challenges surrounding the methodology of this PhD thesis, and the focus had to realign accordingly. On the other hand, these changes also created an opportunity to undertake novel research at a different work environment, the home environment. Additional information on the methodology changes is presented at the end of chapter 2.

The following three chapters describe exhaustively each individual study undertaken to address the aim and objectives of this thesis.

Chapter 2. A systematic review of the effectiveness of breaks from sitting on device assessed musculoskeletal spinal outcomes in adults with sedentary occupations.

This chapter contains the first study of this PhD. The purpose of this study was to address the lack of literature around the device assessed effects of breaks from sitting on spinal MSK outcomes. The study was also planned with the view of the high prevalence of spinal symptoms in workers with high levels of occupational SB.

Background

MSDs are non-communicable diseases that affect various bodily tissues such as muscles, bones, soft tissues and joints (Ingram & Symmons, 2018). MSDs are characterised by inflammation, which leads to pain and discomfort of the affected area(s), and ultimately to mobility problems (Ingram & Symmons, 2018). The global prevalence of MSDs has increased by 17% from 2007 to 2017, raising the YLDs prevalence accordingly (Stanaway et al., 2018). MSDs also lead to job absenteeism and early retirement due to mobility reduction caused by pain and discomfort (Ingram & Symmons, 2018). In the UK, MSDs were the second most common cause for job absenteeism in 2020 (Office for National Statistics, 2021). In England approximately £171.2 million were spent on costs related to MSDs in 2020 (Versus Arthritis, 2021).

From all the conditions considered MSDs, low back pain (LBP) is in the top 10 of leading causes for disability worldwide in adults at a working age (18-65) (Abrams et al., 2020). LBP has also been identified to contribute to morbidity levels of overall DALYs burden in UK, having higher levels than heart disease and lung cancer (Steel et al., 2018). Cost-wise, LBP accounts for an average of 400 million pounds per year in costs to the NHS in the UK (Versus Arthritis, 2021).

If untreated, MSDs can lead to additional health concerns such as neuropathic pain (e.g., sciatica), radiculopathies, decreased mobility and increased disability in individuals, causing high costs for the global population (Gore et al., 2012; Hartvigsen et al., 2018). Between 2019 and 2022, it was reported that UK adults in labouring years (18 – 64) had a 31% increase for job absenteeism due to long-term sickness related to back and neck pain (Office for National Statistics, 2022). Thus, indicating that spinal MSDs are a health concern that need to be addressed to avoid further health issues.

SBs are low expenditure waking activities of ≤1.5 METs carried out while sitting, reclining or lying (Tremblay et al., 2017). SB has been associated with various negative health outcomes including all-cause mortality, risk of various types of cancer (e.g., colon, endometrial), CVD and type 2 diabetes (Biswas et al., 2015; Ku et al., 2018; Patterson et al., 2018). There is also evidence suggesting that SB has effects on depression, anxiety and mood (Ellingson et al., 2018; Huang et al., 2020; Saunders et al., 2020). Systematic review evidence has found associations between SB and the onset of MSDs such as LBP, neck, upper back pain, shoulder pain in leisure and occupational SB (Dzakpasu et al., 2021).

Prolonged sedentary time and spinal MSDs

LBP, upper back pain, and neck pain are common MSDs that affect various spinal structures (Ingram & Symmons, 2018). Evidence from a systematic review by Dzakpasu et al. (2021) signalled that non-occupational all-day SB was associated with LBP. From the evidence it was also found that self-reported occupational SB had positive associations with LBP, neck pain and shoulder pain. Systematic review evidence from Jun et al. (2017) also found an association between neck pain, prolonged SB and computer use in sedentary adults. Authors identified various factors that could influence this association. It was suggested that combined risk factors, such as muscular tension, static postures and repetitive movements, along with inadequate work-rest periods, might yield neck pain in office workers.

Primary evidence has also found associations between prolonged sedentary time and MSK discomfort. An observational study from Heneghan et al. (2018) indicated reductions of thoracic mobility for individuals sitting >7 hours per day. In addition, the reductions on thoracic mobility appeared to be higher in individuals engaging in fewer hours of PA.

Further evidence in university students found that those who spent an average of 13.4 hours per day in SBs (studying, leisure, transportation), had a large incidence of moderate self-reported pain in neck (38.01%), trapezius muscle (34.87%), and thoracolumbar area (40%), which was exacerbated by afternoon time (Caromano et al., 2015). Moreover, students engaging in more than 2 hours of sedentary activities per day had spinal MSK symptoms which were intensified due to their prolonged computer use (Dockrell et al., 2015). Prolonged computer use has also been associated with an increase in neck and LBP in office workers (Daneshmandi et al., 2017; van Vledder & Louw, 2015). Moreover, the upper back has been found to be particularly predisposed to develop MSDs, with 65-75% prevalence rates reported in computer users (van Vledder & Louw, 2015).

Combined evidence provides us with an insight of the development of MSK pain and prolonged sedentary time in combination to computer use. However, this evidence comes mainly from self-reported MSK symptoms. This type of assessment is subject to recall bias and social desirability (Althubaiti, 2016), thus needs to be taken with caution. Nevertheless, this evidence is useful to further understand this association.

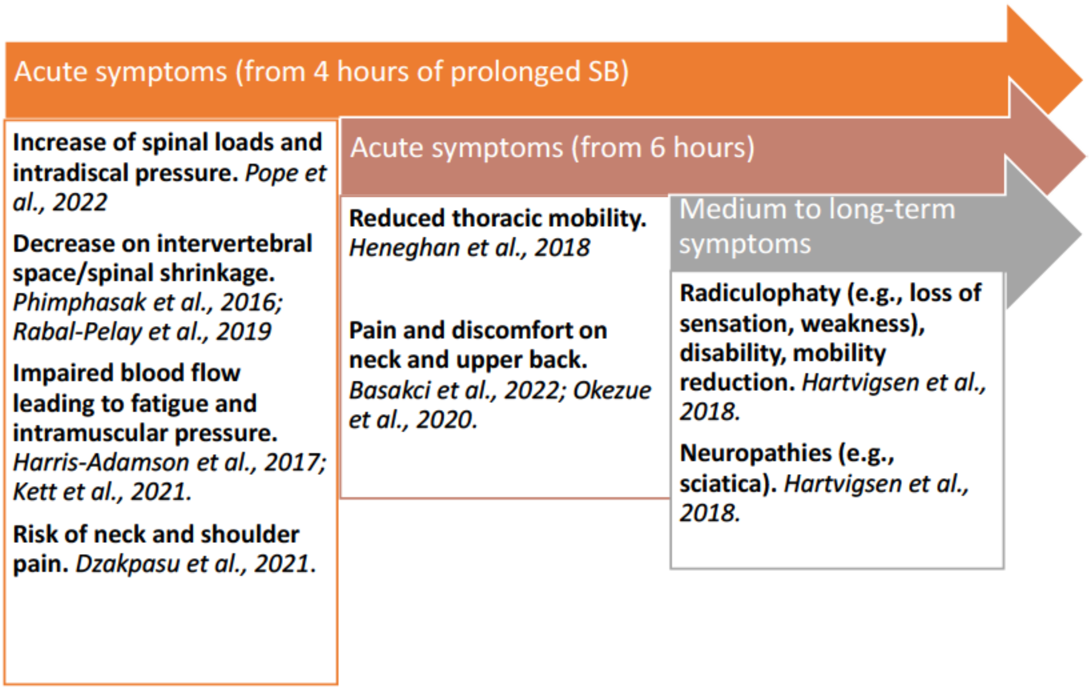
Physio-pathological MSK changes are also evident in primary individual research. Combined evidence suggests that prolonged sedentary postures (static postures) might not provide an adequate muscular load stimulation in the back muscles throughout the day, which contributes to the development of LBP

(Phimphasak et al., 2016). Seated postures are monotonous and inflict mechanical loads to the spine when performed for long periods (Pope et al., 2002). Evidence from a controlled experiment by Kett et al. (2021) also indicated that prolonged SB caused stiffness in the lower back when individuals had a 4.5-hour sitting period.

Another negative effect suggested by literature is the spinal flattening which involves a reduction of intervertebral space or discs height, known as spinal shrinkage (Pope et al., 2002; Rabal-Pelay et al., 2019). Associations between prolonged sedentary time, back and neck pain, and spinal shrinkage have been found previously in office workers (Rabal-Pelay et al., 2019). It was indicated that asymptomatic office workers, assessed after an 8-hour sitting period, had significant spinal shrinkage (Rabal-Pelay et al., 2019). Moreover, 19.5% of the participants indicated having LBP, 22% neck pain and 31% in the upper back at the end of the 8-hour workday (Rabal-Pelay et al., 2019). Figure 3 synthesises the acute and medium to long-term physio-pathological changes in MSK structures occurring during prolonged sedentary time.

Figure 3

Acute and medium to long-term MSK physio pathological changes derived from prolonged SB.



To summarise this section, an increase on spinal MSDs has been found in sedentary populations, especially in occupations with high levels of SB. It is suggested that prolonged sedentary time is a risk factor for the development of negative spinal outcomes, including pain, discomfort, spinal shrinkage. Accordingly, strategies to break up sedentary time are necessary to reduce negative health outcomes.

Breaks from sitting and spinal MSDs

The use of breaks from sitting has been suggested as a helpful strategy to reduce MSK spinal symptoms in sedentary workers ((Agarwal et al., 2018; Waongenngarm et al., 2018). Systematic review evidence from Waongenngarm et al. (2018) synthesised evidence of the impact of breaks from sitting on LBP, discomfort, and work productivity in office workers. From the four types of breaks identified (active breaks with postural changes, active breaks without postural changes, seated passive breaks, and standing breaks), active breaks with postural change was the most effective type of break to reduce LBP (Waongenngarm et al., 2018). Similarly, authors suggested that active breaks with postural changes and standing breaks were effective to prevent discomfort in office workers (Waongenngarm et al., 2018).

Additional systematic review evidence from Agarwal et al. (2018), indicated that using sit-stand schedules as a form of breaking up sitting time decreased low back and neck pain in healthy office workers engaging in prolonged sedentary time (Agarwal et al., 2018). Together, these findings suggest that breaking up sitting is beneficial to reduce MSK pain and discomfort on the spine in office workers. Nonetheless, findings from both reviews come from a small number of low-quality studies with high heterogeneity, which were based solely on self-reported data.

Self-reported and device assessed measurement of MSK symptoms

Device assessed measurement is frequently used in the PA and SB field. This type of measurement is useful to quantify both behaviours directly. This type of measurement can also provide further understanding of the assessed outcomes, while avoiding several biases that come from self-report assessment (Aunger & Wagnild, 2022). There are various tools in both fields (PA and SB) that are recommended for device assessed measurement. For example, the accelerometer has been considered as the 'gold standard' to measure SB and PA (Bakker, Hartman, et al., 2020). Differently to SB and PA literature, MSK literature does not postulate a 'gold standard' to measure MSK symptoms. Hence, self-report tools are frequently adopted when measuring these symptoms.

MSK literature has signalled the use of various scales (e.g., Visual Analogue Scale, Nordic Musculoskeletal Discomfort Questionnaire, Cornell Musculoskeletal Discomfort Questionnaire) to assess pain and discomfort (Dzakpasu et al., 2021). There is evidence that the use of self-reported pain questionnaires in health are subjected to social desirability (Althubaiti, 2016). Also, evidence suggests that people tend to either over- or under-report self-report pain intensity for various reasons (e.g., obtain rapid medical attention) (Boring et al., 2021).

Self-reported tools to assess MSK symptoms still provide valuable information to detect pain and discomfort which are MSDs symptoms. However, it would be useful to understand what the underlying factors triggering pain and discomfort are. In addition, pain is a key marker that signposts the existence of MSK tissue problems, and normally needs to be complemented with further clinical assessment to identify unseen damage to bodily tissues (Hawker, 2017). This further assessment is helpful to identify tissue inflammation, tenderness or joint stability (Hawker, 2017). The assessment of the structural changes of MSK tissues is still necessary to understand the physio-pathological changes derived from MSDs (e.g., increase on spinal loads, spinal shrinkage, reduced mobility), and how these changes are related to pain and discomfort.

The measurement of device assessed MSK outcomes seems useful to provide supplementary data for MSK assessment. For example, Candotti et al. (2008) provided relevant data in relation to this. Authors assessed muscle activity using electromyography (EMG) in individuals with and without LBP. In addition, authors distinguished between asymptomatic and symptomatic individuals by comparing self-reported pain with EMG data. From the testing it was observed that individuals with back pain showed low muscle activity which was indicative of muscle fatigue. These findings suggested that symptomatic individuals have low levels of muscle activity compared to asymptomatic individuals. Additionally, by using both types of assessment, authors were able to distinguish between symptomatic and asymptomatic participants in 89.5% of the cases.

Further evidence from Rabal-Pelay et al. (2019) signalled reductions on device assessed spinal height (using a digital stadiometer) of 0.65 cm (SD 0.4) measured while standing, and 0.60 cm (SD 0.4) measured while sitting, after an 8-hour sitting period. An increase in upper back pain was also reported by participants, and neck pain was statistical significantly correlated with spinal shrinkage in male participants. This indicates that physio-pathological changes in the spine are also accompanied by pain and discomfort.

Lastly, Cini et al. (2017) observed changes in device assessed range of motion (using a goniometer) following a stretching intervention. Findings indicated that stretching had provided beneficial increases on range of motion and flexibility of the hamstrings, and lower back muscles, translating into pain reduction.

These findings are from a relatively small samples (46 – 60 participants), and only one study was in a work setting. However, these studies allow us to acknowledge device assessed changes on MSK outcomes that accompany pain and discomfort. In addition, these studies demonstrate changes in MSK structures that cannot be assessed solely by self-report measurement.

Summary and knowledge gap

Sedentary workers are at high risk to develop spinal MSK symptoms due to a high prevalence of SB and combined with computer use (Caromano et al., 2015; Dockrell et al., 2015; Jun et al., 2017; van Vledder & Louw, 2015). Studies assessing MSK symptoms in sedentary workers have mainly employed self-report measurements to evaluate these outcomes (Jun et al., 2017). The use of self-report measurements to assess pain or discomfort caused by MSDs is highly accepted in research. Also, self-report measures are useful to classify pain severity. However, in addition to pain, MSDs are characterised by inflammation and changes on internal MSK structures (e.g., spinal discs, muscles, ligaments) (Kett et al., 2021; Pope et al., 2002; Rabal-Pelay et al., 2019). The device assessed measurement of MSK outcomes seems to provide valuable information about what structures are affected when pain and discomfort is present.

In relation to breaks from sitting, systematic reviews synthesising their effects on spinal MSK symptoms have focused solely on self-reported MSK symptoms (Agarwal et al., 2018; Waongenngarm et al., 2018). It is of interest for this study to understand the effectiveness of breaks from sitting on device assessed MSK outcomes. Moreover, there is a need to understand if the effectiveness of breaks from sitting on spinal MSK outcomes is consistent between device assessed and self-report measurement. No published systematic reviews exploring the effects of breaks from sitting on device assessed spinal outcomes were found during the design of this study. Therefore, the purpose of this study was to address this gap in literature.

Aim and objectives

This study aimed to systematically review primary evidence of the effects of breaks from sitting on spinal MSK outcomes in sedentary workers. The first objective was to review literature on the effects of sitting breaks on device assessed spinal MSK outcomes in sedentary workers. The second objective was to compare the effects of breaks from sitting on device assessed spinal outcomes with its effects on self-reported spinal outcomes in this population.

Methods

PROSPERO Protocol

A protocol for the systematic review was developed and published in the International prospective register of systematic reviews (PROSPERO, www.crd.york.ac.uk), registration number: CRD42018104105. This study followed the steps described in this protocol, which are outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021).

Search strategy and data sources

The PICO(S) guidelines (Population, Intervention, Comparisons, Outcomes, Study design) were used to develop the search string or syntax by using various keywords related to the research aim (Higgins et al., 2022).

‘Reverse snowballing’ (Livoreil et al., 2017) was used to identify relevant studies. This process consisted of using relevant sources of the topic of interest and identifying subsequent publications that have cited these sources. Using this process was useful to build a ‘test-list’ (Livoreil et al., 2017). The ‘test-list’ consisted in five studies identified as relevant sources for the review aim and objectives (Balci & Aghazadeh, 2003; Bao & Lin, 2018; Chaikumarn et al., 2018; Sheahan et al., 2016; Thorp et al., 2014). Afterwards, the final search strings were used to make repeated searches into one database (Scopus) to check if the 'test-list' studies appeared in the results. If any 'test-list' studies did not appear in the results, modifications to the search string were made until all 'test-list' studies appeared in the results. Table 1 illustrates terms used in the final syntax, and possible variants expected to be found in the final searches.

Table 1.

Keywords used in the final search string and possible variants expected to be found.

Term	Variant	Term	Variant
Sit*	Sitting Sit-stand Sit	Spin*	Spine Spinal
Seat*	Seated Seating	Neck	Neck
Sedent*	Sedentary Sedentarism	Work*	Workers Work Working
Break*	Break (s)	VDU	Visual display unit operators/users
Musc*	Muscle Musculoskeletal	VDT	Visual display terminal operators/users
Tissue*	Tissue (s)	Student*	Student(s)
Back	Back/upper back		

A final search syntax was used to carry out searches in the selected databases. Seven databases (Scopus, MEDLINE, EMBASE, Web of Science, PubMed, CINAHL Plus, and PEDro) were selected to carry out systematic searches, due to their relevance to the research topic. Final records were imported to COVIDENCE (www.covidence.org) and after duplicates were removed, a total of 9309 records were identified. An update of this review was carried out 18 months after the first searches, the update took place in March 2020. Systematic searches were carried out in the same databases used for the first systematic searches (Scopus, MEDLINE, EMBASE, Web of Science, PubMed, CINAHL Plus, and PEDro). A total of 4356 additional records were imported to COVIDENCE, and after duplicate removal, 2193 records were included for title and abstract screening. Figure 4 illustrates the process through a PRISMA diagram, this figure is presented in the results section.

Study selection and eligibility criteria

PICO(S) guidelines from the Cochrane Collaboration (Higgins et al., 2022) were used to establish inclusion and exclusion criteria for study selection. During the design of the study, it was evident that office workers are at a high risk to develop MSK spinal symptoms. However, it was also identified that other sedentary populations, such as students (Caromano et al., 2015; Dockrell et al., 2015), might be also at risk of developing spinal symptoms due to their prolonged SB. Therefore, the inclusion criteria for the population were expanded to sedentary populations and not solely focused on office workers. Widening the inclusion criteria for studies still addressed the research question which aimed to understand the effects of breaks from sitting on MSK spinal symptoms. Table 2 illustrates the inclusion and exclusion criteria for studies included in this review following the PICO(S) guidelines.

***Table* 2.**

Inclusion and Exclusion Criteria based on PICO(S) guidelines.

Category	Inclusion	Exclusion
Population	Participants were adults from 18 – 65 years old engaging in prolonged sedentary time either for work or education; with or without the presence of spinal pain or discomfort	Studies where the participants have pre-existing conditions: neurological diseases (e.g., cerebral palsy, Guillain-Barre, motor neuron disease), any type of arthritis (e.g., degenerative, gout), autoimmune conditions (e.g., lupus, rheumatoid arthritis), whiplash, herniated disc, fibromyalgia, etc. Studies with non-sedentary population (e.g., nurses)
Intervention	Studies using breaks from sitting with postural changes	Studies not using ‘active’ breaks from sitting (breaks without postural change), studies evaluating the effects of long

Category	Inclusion	Exclusion
		exercise programmes in the office (e.g., 1-hour programme)
Comparison	Studies comparing any type of break versus each other, or with sitting conditions	None
Outcome	Studies with at least one musculoskeletal spinal outcome assessed, using device assessment	Studies assessing only self-reported changes on spinal outcomes
Study design	RCTs, non-RCTs, quasi-experimental studies, cluster randomised trials, cross-over trials, within-subjects, repeated measures	Systematic, scoping or narrative reviews or any study synthesising primary research findings, qualitative studies, cross-sectional studies

Title and abstract screening

The screening tool was piloted by two reviewers when screening the first hundred articles. Inter-rater reliability was calculated using Cohen's kappa coefficient (McHugh, 2012), and results from the pilot screening kappa coefficient were: 1.00 (perfect agreement). Following pilot screening, 10% of the total records were screened by the second reviewer with an inter-rater reliability of: 0.85 kappa coefficient (strong agreement). All records were screened twice by the first reviewer, and intra-rater reliability was strong agreement (kappa 0.80). During the review update, one reviewer carried out 100% of title and abstract screening (2,193 records), and a second reviewer carried out 10% of the total records (224 records), with almost perfect agreement (kappa 0.97). Disagreements (three records) were examined by both reviewers, and after discussion it was agreed to exclude those three records.

Full-text screening

Four reviewers were involved at the full-text screening stage during the first searches, and three reviewers during the review update. Studies included for first stage screening (n=63) were screened by the main reviewer and divided in three sets to allocate to the other three reviewers (21 records per reviewer). Disagreements were solved with the involvement of either one of the three secondary reviewers not involved in the allocated study (kappa 0.43, moderate agreement). During the review update, nine records (n=9) were identified. Three reviewers carried out 100% of full-text screening at this stage (3 studies each), with a 100% agreement and a kappa value of 1.0 (perfect agreement). None of the new records fulfilled the inclusion criteria of the review and did not continue to the data extraction stage. Figure 4 (presented in the results section) illustrates the systematic review process using a PRISMA flow diagram. This figure illustrates separately the results for the first and review update searches (first searches/update searches).

Data extraction

Three reviewers were involved in the data extraction stage. From the 12 studies, the main reviewer extracted data for all the records, and the other two reviewers were independently allocated half of the studies each (n=6). Afterwards, comparisons were made between two reviewers for coherence and agreement using Excel spreadsheets. The Cochrane guidance for collecting data (Li et al., 2019) was followed and the subsequent data were extracted: type of study, participants, types of interventions, types of comparisons, types of outcome measures, and results.

Quality assessment

Three reviewers were involved in the process, and the main reviewer carried out 100% of the quality assessment, while the other two reviewers assessed half of the included studies each (n=6). The Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018) was used to carry out quality assessment of the included studies due to its broad usefulness to appraise different designs of empirical studies.

Two categories (categories 2 and 3) from the MMAT guidance were selected to report quality appraisal of the studies. Category 2, named 'quantitative randomised controlled trials' comprised five questions (*2.1. Is randomization appropriately performed?, 2.2. Are the groups comparable at baseline?, 2.3. Are there complete outcome data?, 2.4. Are outcome assessors blinded to the intervention provided?, 2.5. Did the participants adhere to the assigned intervention?).* Category 3, named 'quantitative non-randomised' also comprised five questions (*3.1 Are the participants representative of the target population?, 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?, 3.3. Are there complete outcome data?, 3.4. Are the confounders accounted for in the design and analysis?, 3.5. During the study period, is the intervention administered (or exposure occurred) as intended?*). Each individual questions from the categories included three types of answers for each question ('Yes', 'No', 'Can´t tell').

As MMAT guidance suggests to not assign a quality score to the included studies, the quality of the included studies included were reported taking account the percentage of the MMAT criteria they met. As each MMAT assessment category contains five items, each 'Yes' response was assigned a 20% value (100/5=20), whilst 'No' and 'Can't tell' were assigned a 0% value as MMAT guidance suggests that these values indicate poor reporting.

Data synthesis

Studies included in this review were found to be heterogeneous in a variety of aspects, clinically (participants, interventions, outcomes), methodologically (study design, quality assessment) and statistically (findings) (Higgins et al., 2022). Furthermore, as the conditions assessed by the included studies were diverse (break type, frequency, duration), and study findings were heterogeneous, it was decided to not carry out a meta-analysis. The synthesis without meta-analysis (SWiM) guidance was used to inform the methodology used for the data synthesis process (Campbell et al., 2020)

Synthesis without meta-analysis (SWiM)

In order to improve transparency and clarity, the approach to analysis was reported in line with Synthesis Without Meta-analysis (SWiM) guidance (Campbell et al., 2020). The SWiM guidance comprises seven components of value to guide the reporting of quantitative data in systematic reviews when it is not appropriate to conduct a meta-analysis. These seven components of this guidance are: 1. Grouping studies for synthesis, 2. Describe the standardised metric and transformation methods, 3. Describe the synthesis methods, 4. Criteria used to prioritise results for summary and synthesis, 5. Investigation of heterogeneity in reported effects, 6. Certainty of evidence, 7. Data presentation methods.

Heterogeneity (related to SWiM item 5)

As studies were clinically and statistically different (Higgins et al., 2022), findings were considered heterogeneous. Hence, a meta-analysis was not carried out. Tables were created to examine the heterogeneity of the findings for the studies included in this review. Tables 5a, 5b, 6, 7a, 7b and 8 (presented in the results section) illustrate the heterogeneity of study findings.

Data synthesis of intervention effects (related to SWiM 1-4, 6, 7)

Results were organised by describing patterns across the studies and reporting significant direction of effects and effect sizes (Popay et al., 2006). The direction of intervention effects with statistical significance (favoured or not favoured) was emphasised to identify patterns of intervention effectiveness following Popay's guidance (Popay et al., 2006).

Studies were grouped by design and intervention duration, resulting in three groups: i) single intervention session study (within-subject design); ii) single intervention session study (randomised controlled trials); and iii) studies >1 intervention session (weekly and monthly, between study designs). All between study designs were RCTs, although participants from Blasche et al. (2013) chose which group they wanted to be randomized into. Statistical significance was illustrated by indicating the direction of the intervention effects (when available) and representing the number of comparisons that were significantly favoured in contrast to all the comparisons (e.g., 1/10 meaning that only one comparison of 10 was significantly favoured).

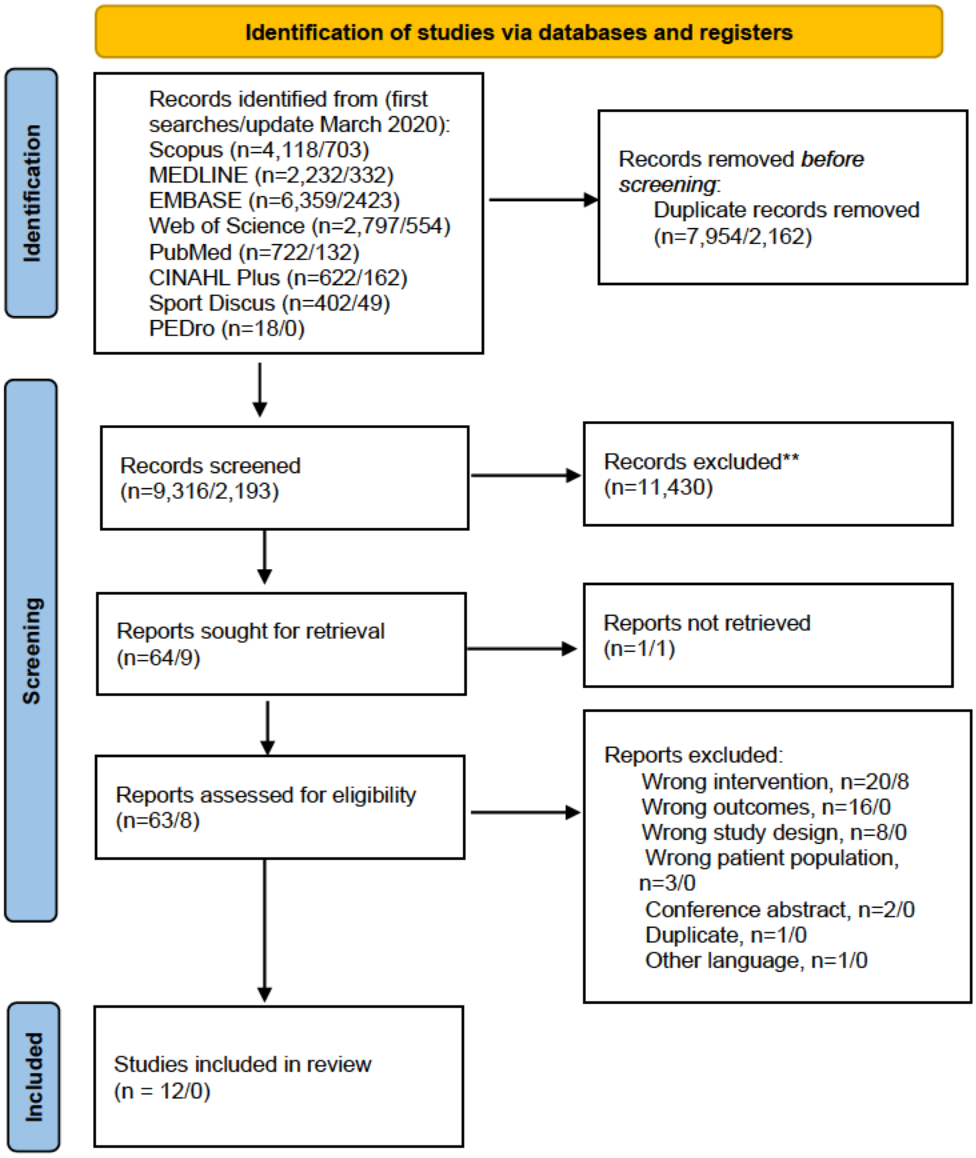
Effect sizes were calculated using Cohen’s D standardised mean difference (Cohen, 2013) where possible (if pre to post intervention data were provided). These were represented as trivial (under 0.2), small (0.2), moderate (0.5), and large (0.8). If pre to post data were not presented, change scores were calculated using mean change from pre to post intervention data, from both control and intervention group (Linn & Slinde, 1977). Missing data were handled by contacting authors to obtain access to raw data. If authors did not reply (after two emails) data were represented as Not available (NAvail). For studies where pre to post data were not presented, authors reports (e.g., in text synthesis) were used to demonstrate intervention effects. In addition, when data were not presented in text synthesis the software WebPlotDigitazer (Version 4.6; Rohatgi, 2022) was used to extract data from figures presented in the paper (Li et al., 2019).

Results

There were 11,502 records found in the systematic searches, 71 full text studies were reviewed, and 12 studies met inclusion criteria. Figure 4 illustrates the number of records (first searches/review update) retrieved from systematic searches in different databases.

Figure 4

PRISMA flow diagram illustrating the systematic review process of study selection during first search/update search.



Note: Based on Higgins et al. (2022).

Description of studies

Study characteristics

Table 3 details the study characteristics from the twelve included studies. Studies were conducted in the USA (n=3), Canada (n=3), an Austria (n=1), Sweden (n=1), Saudi Arabia (n=1), Malaysia (n=1), China (n=1), and Thailand (n=1). A large range of publication dates were included, the most dated being from 1996 and the most recent from 2018. Two types of study designs were utilized in these studies, half (n=6) were within-subjects designs, and the other half (n=6) were between subject with a RCT study design. Seven studies were conducted in workplace settings (Bao & Lin, 2018; Billy et al., 2014; Blasche et al., 2013; McLean et al., 2000, 2001; Shariat et al., 2017; Tsauo et al., 2004), four were conducted in university laboratories (Mathiassen & Winkel, 1996; Mohamed & Radwan, 2017; Nakphet et al., 2014; Sheahan et al., 2016), and one did not report the intervention setting (Babski-Reeves & Calhoun, 2016).

Table 3.

Study characteristics of the studies included in the review.

Author, year of publication	Country	Design	Setting	Sample (n), occupation, gender	Intervention description	Length of intervention (n) sessions	Device assessed outcomes	Self-report outcomes
Babski-Reeves & Calhoun, 2016	USA	Within subjects, 3 arms	NM	24 NM F: 12 M: 12	I1: Desktop sit 20 /stand 5 I2: Docked laptop sit 20 /stand 5 I3: Laptop sit 20- stand 5	1 hr, 3 sessions	MVC of bilateral: upper trapezius and lower trapezius, lumbar erector spinae - EMG	Head, neck and low back discomfort - VAS tool
Bao & Lin, 2018	USA	Within subjects, 4 arms	Work	12 office workers F: 8 M: 4	I1: 60 sit / 60 stand (1:1) I2: 80 sit / 40 stand (2:1) I3: 60 sit / 30 stand (3:1) I4: 105 sit / 15 stand (7:1)	8 hrs, 4 sessions	Muscle fatigue upper trapezius - EMG Spinal shrinkage - stadiometer	Self-reported discomfort - Borg CR10 scale
Billy et al., 2014	USA	Within subjects, 2 arms	Work	12 computer-based workers F: 11 M: 1	I1: Stand and stretch lumbar area every 15 min during 4 hrs RG: Sitting 4 hours	4 hrs, 2 sessions	Disc height and disc diameter (L1-S1) – MRI scan	NA
Blasche et al., 2013	Austria	RCT, 4 arms	Work	93 computer-based workers I1: 25, I2: 21, I3: 25, RG: 22 F: 56	I1: BFB biofeedback assisted relaxation program, relaxation and stretching for 5-8 min, whilst providing biofeedback to the participants, 2 per day I2: BAL Balance training on unstable platform, various	8 weeks (2nd stage), 3 months (3rd stage)	Neuromuscular muscle activity upper trapezius - Biofeedback	MSK discomfort – FBL-R questionnaire

				M: 37	balance and strengthening exercises for arm, leg and abdominal muscles while standing on a board 5-7 min, 2 per day I3: NW: Nordic walk after work RG: follow best practice without recommendations			
Mathiassen & Winkel, 1996	Sweden	Within subjects, 2 arms	Laboratory	8 female workers with no assembly work	I1: Twenty min active break with 3-4 min lifting and carrying boxes (8-15 kg), and 6-7 of furnishing workstation, 10 min of VDU standing work RG: Twenty min passive seated break	6 hrs, 2 sessions	MVC bilateral upper trapezius - EMG	Shoulder-neck pain region - Borg CR10 scale
McLean et al., 00'	Canada	Within subjects, 2 arms	Work	18 computer-based workers F: 15 M: 3	I1: Standing and walking 30 secs every 20 min RG: Seated 20 min break	80 mins, 2 sessions	MES of upper trapezius, cervical extensors and lumbar paraspinal – Surface MES	NA
McLean et al., 01'	Canada	RCT, 3 arms	Work	45 female office workers I1: 15, I2: 15, RG:15	I1: Standing and walking 30 secs every 20 min I2: Standing and walking 30 secs every 40 min RG: Breaks taken as desired	3 hrs, 4 weeks	MNF cycling in MES - Portable electro physiological data-loggers	Discomfort of examined areas - VAS scale

Mohamed & Radwan, 2017	Saudi Arabia	RCT, 3 arms	Laboratory	45 female university employees I1: 15, I2:15, RG: 15	I1: Stretching 5 min every 30 min (Mid-rest) I2: Stretching 5 min every 15 min (Multiple rest) RG: No stretching 10 min passive break (No rest break)	1 hr, 1 session	Electrical muscle activity bilateral upper trapezius - EMG	NA
Nakphet et al., 2014	Thailand	RCT, 3 arms	Laboratory	30 female VDU operators I1: 10, I2: 10, RG: 10	I1: Perform static stretching exercises (twice) for 3 min every 20 min (Stretching Group) I2: Perform 3 sets of dynamic exercises for 3 min every 20 min (Dynamic Contraction Group) RG: Seated break	1 hr, 1 session	Muscle electric activity of right: upper and lower trapezius, cervical erector spinae - EMG	Muscle discomfort - Borg's CR-10
Shariat et al., 2017	Malaysia	RCT, 2 arms	Work	40 office workers (gender NM) I1: 20, RG: 20	I1: Seated and standing stretching exercises, during 10-15 min, 10 repetitions, 3 times per day RG: Not alter daily activities	3 sessions per week, 11 weeks	Neck flexors ROM - Goniometer	Musculoskeletal discomfort of neck and lower back – Cornell Musculoskeletal Discomfort Questionnaire
Sheahan et al., 2016	Canada	Within subjects, 4 arms	Laboratory	20 university population F: 10 M:10	I1: Sit 30 min / stand 5 min I2: Sit 15 min / stand 2.5 min I3: Sit 5 min / stand 50 secs RG: No break (sit 60 min)	1 hr, 4 sessions	Muscle activity of bilateral lumbar erector spinae – EMG	Self-reported pain – VAS tool

Tsauo et al., 2004	China	RCT, 4 arms	Work	178 airline office employees I1: 56, I2: 69, I3: 14, RG: 39 F: 100 M: 78	I1: Stretching neck during office breaks (15-20 min) 10 repetitions holding 5 secs, with access to a physiotherapist (PT) if had queries (SEG) I2: Same as SEG program, performing once a day under PT supervision (TEG I) I3: Same as TEG I, but performing twice a day (TEG II) RG: lecture about exercises	2 weeks (2nd stage), 3 months (3rs stage)	Cervical ROM – Inclinometer	General pain - modified Nordic Questionnaire

Note: Abbreviations: I: Intervention, RG: Reference Group, MSK: Musculoskeletal, NA: Not Applicable, F: Female, M: Male, MVC: Maximal Voluntary Contraction, MRI: Magnetic Resonance Imaging, MES: Myoelectric signal, NM: Not Mentioned, MNF: Median Frequency, VDU: Visual Display Unit, ROM: Range of Motion, BAL: Balance exercising, BFB: Biofeedback relaxation and stretching, SEG: Self Exercise Group, TEG: Team Exercise Group

First and second review objectives

The MSK outcomes assessed in the twelve studies were varied. Seven of the included studies examined muscle activity of neck and/or lower back, with various markers (e.g., maximal voluntary contraction, myoelectric signal) (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Blasche et al., 2013; Mathiassen & Winkel, 1996; Mohamed & Radwan, 2017; Nakphet et al., 2014; Sheahan et al., 2016). Likewise, different tools were used to assess these outcomes including EMG, physiological data loggers, and biofeedback. Two studies examined changes on spinal shrinkage, one using a digital stadiometer (Bao & Lin, 2018), and another used MRI scan (Magnetic resonance imaging) (Billy et al., 2014). From the remaining studies two assessed muscle myoelectrical signal (McLean et al., 2000, 2001), two assessed cervical range of motion (Shariat et al., 2017; Tsauo et al., 2004), and one study assessed disc height and diameter (Billy et al., 2014).

Self-reported MSK symptoms were explored in nine of twelve studies included in the review. Neck pain/discomfort were the most common assessed outcome in eight studies (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Blasche et al., 2013; Mathiassen & Winkel, 1996; McLean et al., 2001; Nakphet et al., 2014; Tsauo et al., 2004), followed by low back pain/discomfort assessed in six studies (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Blasche et al., 2013; McLean et al., 2001; Shariat et al., 2017; Sheahan et al., 2016), and two studies evaluated upper back pain/discomfort (Bao & Lin, 2018; Tsauo et al., 2004). Various self-reported tools were used, the most frequent being the Visual Analogue Scale (Wewers & Lowe, 1990)(n=3) and Borg CR10 scale (Borg, 1982)(n=3). Also, one study used the Freiburg complaint list (FBL-R) (Fahrenberg, 1995), one study used the Cornell Musculoskeletal Discomfort questionnaire (CMDQ) (Hedge et al., 1999), and another study used the Nordic Musculoskeletal questionnaire (NMQ) (Kuorinka et al., 1987).

Participant characteristics

Studies recruited a wide range of participants, ranging from eight participants (Mathiassen & Winkel, 1996) to 178 participants (Tsauo et al., 2004). The total number of participants was 525. In nine studies all participants were office workers engaging in computer use. One study targeted university students (Sheahan et al., 2016), one in-experienced assembly workers (Mathiassen & Winkel, 1996), and one did not report participant occupation (though participants were frequent computer users) (Babski-Reeves & Calhoun, 2016).

From the 12 studies only seven provided information on age, ranging from 16 to 66 years old. Across all the studies, only eight reported mean participant age, with a combined mean age of 32.12 (SD 6.55). Participants were mainly female (70.1%), and four studies focused solely on female participants (Mathiassen & Winkel, 1996; McLean et al., 2001; Mohamed & Radwan, 2017; Nakphet et al., 2014). One study did not report gender (Shariat et al., 2017).

Intervention characteristics

Different lengths of interventions were used in the 12 studies. All six within-subjects studies consisted of single-session (from 1 to 8 hrs duration) conditions. These conditions were assessed on several days ranging from one to four sessions depending on the number of conditions (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Billy et al., 2014; Mathiassen & Winkel, 1996; McLean et al., 2000; Sheahan et al., 2016). All six RCTs had medium to long-term interventions ranging from 2 weeks (McLean et al., 2001; Tsauo et al., 2004) to 3 months (Tsauo et al., 2004).

Interventions included in this review used different types of breaks from sitting. Three within-subject studies used sit to stand schedules as a form of break (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Sheahan et al., 2016). Two within-subjects (Mathiassen & Winkel, 1996; McLean et al., 2000) and one between study RCT used walking breaks (McLean et al., 2001). Stretching breaks were used in one within-subject study (Billy et al., 2014), four between study RCTs (Mohamed & Radwan, 2017; Nakphet et al., 2014; Shariat et al., 2017; Tsauo et al., 2004), also one between study RCT combined stretching with other activities (balance exercises, and biofeedback relaxation) (Blasche et al., 2013).

Quality assessment

Table 4 summarises the quality assessment of studies included by using the two relevant categories (quantitative RCTs and quantitative non-randomised) of the MMAT checklist (Hong et al., 2018). From the 12 studies, the majority were consistent in poor reporting and low methodological quality. Two studies met 0% of MMAT criteria (McLean et al., 2000; Tsauo et al., 2004), four studies met 20% (Babski-Reeves & Calhoun, 2016; Blasche et al., 2013; Mathiassen & Winkel, 1996; Shariat et al., 2017), two studies met 40% (McLean et al., 2001; Mohamed & Radwan, 2017), and four met 60% (Bao & Lin, 2018; Billy et al., 2014; Nakphet et al., 2014; Sheahan et al., 2016).

Table 4

MMAT Quality assessment

			2. Quantitative randomised controlled trials			
Studies included	**2.1**	**2.2.**	**2.3**	**2.4**	**2.5**	**Meets MMAT criteria (%)**
Blasche et al., 2013	No	Yes	No	Can't tell	No	20%
Mathiassen & Winkel, 1996	Can't tell	Can't tell	Yes	Can't tell	Can't tell	20%
McLean et al., 2000	Can't tell	Can't tell	No	Can't tell	Can't tell	0%
McLean et al., 2001	Can't tell	Yes	Yes	Can't tell	Can't tell	40%
Mohamed & Radwan, 2017	Can't tell	Yes	Yes	Can't tell	Can't tell	40%
Nakphet et al., 2014	Can't tell	Yes	Yes	Can't tell	Yes	60%
Shariat et al., 2017	Can't tell	Yes	No	Can't tell	Can't tell	20%
Sheahan et al., 2016	Yes	Can't tell	Yes	Can't tell	Yes	60%
Tsauo et al., 2004	Can't tell	No	No	Can't tell	No	0%
			3. Quantitative Non-randomised studies			
	3.1	**3.2**	**3.3**	**3.4**	**3.5**	**Meets MMAT criteria (%)**
Babski-Reeves & Calhoun, 2016	Can't tell	Yes	Can't tell	Can't tell	Can't tell	20%
Bao & Lin, 2018	Yes	Yes	Yes	Can't tell	Can't tell	60%
Billy et al., 2014	Can't tell	Yes	Yes	Yes	Can't tell	60%

Table 5a

Acute one-session within subjects' studies reporting device assessed spinal musculoskeletal outcomes

Author	Duration of session, number of session(s)	Break type, frequency, duration	Outcomes, comparisons	Direction of statistically significant effects between conditions	Number of statistically significant comparisons for which each condition is favoured, out of total number of comparisons	Intervention effect size between conditions	Direction of statistically significant pre to post intervention effects
				Standing breaks			
Babski-Reeves & Calhoun, 2016	1 hr, 3 sessions	Sit 20 mins / stand 5 mins (Pooled results: C1. Desktop, C2. Laptop, C3. Docked laptop)	Muscle activity 1. UT 2. LT 3. LES	Decrease of UT muscle activity during standing, compared to sitting	**Sit vs Stand UT: 1/1** Sit vs Stand LT 0/1 Sit vs Stand: LES 0/1	NAvail	NAvail
Bao & Lin, 2018	8 hrs, 4 sessions	C1. Sit 90 / Stand 30 (3:1) C2. Sit 80 / stand 40 (2:1) C3. Sit 105 / stand 15 (7:1) (RC) C4. Sit 60 / stand 60 (1:1)	Muscle activity 1. LUT 2. RUT 3. LES 4. RES	C4 schedule favoured a decrease of LES muscle activity when compared to longest sitting schedule C3	C1 vs C3 LUT, RUT, LES, RES: 0/4 C2 vs C3 LUT, RUT, LES, RES: 0/4 C4 vs C3 LUT, RUT, **LES**, RES: 1/4	NAvail	NAvail
			Spinal shrinkage	No significant main effect per condition	-	NAvail	NAvail
Sheahan et al., 2016	1 hr, 4 sessions	C1. Sit 30 min / stand 5 min C2. Sit 15 min / stand 2.5 min C3. Sit 5 min / stand 30 sec RC. Sit 60 min / No break	Muscle activity 1.RES 2.LES	No significant main effect per condition	-	NAvail	NAvail

			Stretching breaks				
Billy et al., 2014	4 hrs, 2 sessions	C1. Stretching 20 seconds, every 15 mins RC. Sit 4 hrs	Lumbar disc height 1. L1-L2 2. L2-L3 3. L3-L4 4. L4-L5 5. L5-S1	NAvail	-	C1 vs RC L1-L2: Large L2-L3: Small L3-L4: Triv L4-L5: Triv L5-S1: Triv	L4-L5 disc height decreased on RC
			Lumbar disc diameter 1. L1-L2 2. L2-L3 3. L3-L4 4. L4-L5 5. L5-S1	NAvail	-	C1 vs RC L1-L2: Small L2-L3: Triv L3-L4: Triv L4-L5: Small L5-S1: Triv	No significant pre to post intervention effects
			Walking breaks				
Mathiassen & Winkel, 1996	6 hrs, 2 sessions	C1. Walking with box lifting during 10 mins RC. Sit 20 mins	Muscle activity 1. UT	No significant main effect per condition	-	NAvail	NA
McLean et al., 00'	80 mins, 2 sessions	C1. Walking 30 secs every 20 min RC. Sit 20 mins	MEDFREQ MES cycles 1. Neck 2. Back	NAvail	-	C1 vs RC: Neck: Moderate Back: Small	C1 favoured a reduction on neck MEDFREQ MES cycles

Note: Statistically significant in bold. Effect sizes: Triv (lower than small). Abbreviations. C: Condition, RC: Reference condition, UT: Upper trapezius, LT: Lower trapezius, LUT: Left upper trapezius, RUT: Right upper trapezius, LES: Left erector spinae, RES: Right erector spinae, NA: Not applicable, NAvail: Not Available CES: Cervical erector spinae, MEDFREQ: Median frequency, MES: Myoelectric signal.

Table 5b

Acute one-session RCTs reporting muscle activity and using stretching breaks

	Number of statistically significant comparisons for which each	**Direction of statistically**

Author	Duration of session, number of session(s)	Break type, frequency, duration	Outcome, comparisons	Direction of statistically significant effects between groups	condition is favoured compared with total number of comparisons			Intervention effect size between groups	significant pre to post intervention effects
					RG	EG1	EG2		
Mohamed & Radwan	1 hr, 1 session	Sit – Stretch EG1. Mid-rest break 30 mins - 5 mins EG2. Multiple rest break 15 mins – 2.5 mins RG: No break for 60 mins	1. LUT	EG1 and EG2 favoured a decrease on muscle activity compared to RG	0/2	1/2	1/2	RG vs EG1: Large RG vs EG2: Large	NA
			2. RUT	EG1 and EG2 favoured a decrease on muscle activity compared to RG	0/2	1/2	1/2	RG vs EG1: Large RG vs EG2: Large	NA
Nakphet et al.	1 hr, 1 session	EG1. Stretching every 20 mins x 3 mins EG2. Dynamic contraction every 20 mins x 3 mins RG: No break, sit for 60 mins	NRMS 1. LUT 2. RUT 3. CES	No significant main effects per group	-	-	-	NAvail	NA
			MF 1. LUT 2. RUT 3. CES	No significant main effects per group	-	-	-	NAvail	NA

Abbreviations: EG: Experimental group, RG: Reference group, LUT: Left upper trapezius, RUT: Right upper trapezius Upper trapezius, CES: Cervical erector spinae, NMRS: Normalised Root mean square, MF: Median Frequency, NA: Not Applicable, NAvail: Not available

Table 6

RCTs using medium and long-term interventions and reporting device assessed spinal musculoskeletal outcomes

Author	Length of intervention, follow up time	Break type, frequency, and duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with control out of total number of comparisons				Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
					RG	EG1	EG2	EG3		
				Stretching breaks						
Blasche et al., 2013	8 weeks (2nd stage), 3 months (3rd stage)	EG1. BAL, 5-7 mins, twice per day EG2. BFB, 5-8 mins, twice per day EG3 Nordic walk, after work RG: Follow best practice	Muscle activity†	No significant main effects per group at 2nd or 3rd stage					2nd stage	
			1. UT rest		-	-	-	NA	RG vs EG1: Triv RG vs EG2: Moderate	NA
			2. UT work	No significant main effects per group at 2nd or 3rd stage					3rd stage	
					-	-	-	NA	RG vs EG1: Triv RG vs EG2: Large	NA
Shariat et al., 2017	3 sessions per week, 11 weeks	EG1. Stretching 10-15 mins RG: No alteration to daily activities	ROM 1. Right Neck bending	EG1 favoured increase on right neck bending	0/1	1/1	-	NA	EG1 vs RG: Large	NA
			2. Left neck bending	EG1 favoured increase on left neck bending	0/1	1/1	-	NA	EG1 vs RG: Large	

Author	Length of intervention, follow up time	Break type, frequency, and duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with control out of total number of comparisons	Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
Tsauo et al., 2004	2 weeks (2^{nd} stage), 3 months (3rs stage)	Stretching EG1. SEG: 15-20 mins, once a day, unsupervised 2 weeks EG2. TEG I: 15-20 mins, once a day under supervision EG3. TEG II: 15-20 mins, twice a day (once supervised) RG: Lecture about exercises	1. CROM	NAvail	2^{nd} stage		
					- - - -	EG1 vs RG: Triv EG2 vs RG: Small EG3 vs RG: Triv	No significant pre to post intervention effects per group
				NAvail	3^{rd} stage		
					- - - -	EG1 vs RG: Triv EG2 vs RG: Small EG3 vs RG: Small	No significant pre to post intervention effects per group
			2. Head protrusion	NAvail	2^{nd} stage		
					- - - -	EG1 vs RG: Small EG2 vs RG: Triv EG3 vs RG: Large	No significant pre to post intervention effects per group
				NAvail	3^{rd} stage		
					- - - -	EG1 vs RG: Triv EG2 vs RG: Moderate	No significant pre to post intervention effects per group

Author	Length of intervention, follow up time	Break type, frequency, and duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with control out of total number of comparisons			Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
								EG3 vs RG: Large	
				Unspecified type of breaks					
McLean et al. , 01’	3 hrs, 4 weeks	EG1. 20 mins work/30 secs of break walking away from workstation	MNF MES cycles 1. Neck	RG and EG2 favoured an increase of neck MNF cycles	1/2	1/2	0/2	NAvail	NA
		EG2. 40 mins work/30 secs break walking away from workstation RG: Breaks taken as desired	2. Back	EG1 and EG2 favoured the increase of back MNF cycles	0/2	1/2	1/2	NAvail	NA

Note: † Logged data used to calculate effect sizes, Effect sizes: Triv, lower than small

Abbreviations: EG: Experimental group, RG: Reference group, BAL: Balance training, BFB: Biofeedback assisted relaxation, UT: Upper trapezius, MNF: Median frequency, ROM: Range of motion, CROM: Cervical range of motion, NA: Not Applicable, NAvail: Not Available

Summary of intervention effects

First objective: Device assessed MSK spinal outcomes

The majority (n=8) of the included studies, were acute single-session interventions, and the remaining four had interventions with diverse lengths ranging from two weeks to three months. If pre to post intervention data were available, effect sizes were calculated. Five of twelve studies did not present sufficient data to calculate effect sizes (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Mathiassen & Winkel, 1996; Nakphet et al., 2014; Sheahan et al., 2016).

Acute single-session intervention effects on device assessed spinal MSK outcomes.

Table 5a summarises findings of eight single-session intervention effects, using a within-subject study. Table 5b summarises four studies using single-session studies using a RCT design. Various types of breaks were used in the single-session studies, including standing breaks (n=3), stretching breaks (n=3), walking breaks (n=1), and unspecified active break (n=1).

Effects of acute single-session standing breaks.

Three studies examined the effects of acute single-session standing breaks (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018; Sheahan et al., 2016), and data to calculate effect sizes were not provided (nor accessible from authors). Hence, intervention effect sizes were not calculated. However, intervention effects were summarised using in-text information (e.g., synthesis of results). Significant and favourable effects were found by Babski-Reeves and Calhoun (2016) when using standing breaks compared to a 20-minute sitting period, for one of three muscle activity comparisons. Statistical significance was indicated for muscle activity reduction on upper trapezius (one of three assessed muscles), after a 5-minute standing break, in comparison to 20-minute sitting period, regardless of type of workstation (desktop, laptop, docked laptop). On the other hand, no significant effects were found on muscle activity of lower trapezius and left erector spinae.

From Bao and Lin (2018) study, only one of seven sit-stand schedules (60 min sit – 60 min stand) showed favourable effects on muscle fatigue reduction. This was when compared to the longest sitting schedule (105 min sit – 15 min stand), though changes were found solely on the left erector spinae muscle (one of four assessed muscles). Furthermore, standing breaks did not produce significant main changes (either positive or negative) on spinal shrinkage in any of the seven conditions.

Sheahan et al. (2016) reported no significant main effects between groups (nor pre to post significant effects) on any of three sit-stand intervention conditions, on muscle activity of erector spinae (right and left).

Effects of single-session stretching breaks. Billy et al. (2014) found a significant decrease in disc height in the reference group (sitting for 4-hour period), from pre to post assessment, when compared to the stretching intervention. No comparisons between conditions were reported for intervention main effects (reference vs intervention), but effect sizes were calculated with the data provided in the reported tables. Effects from the stretching condition indicated favourable effects on disc height preservation of two intervertebral lumbar discs, with small and large effect sizes (L2-L3, L1-L2 respectively). Disc diameter assessment showed no changes from pre- to post- intervention for any condition. However, intervention effect size indicated changes on disc diameter with small effect sizes on L1-L2 and L4-L5. Also, trivial effect sizes (inferior to small) were found on L3-S1 (lumbar and sacrum) disc height, as well as in L2-L4 and L5-S1.

With an RCT study design (table 5b), Mohamed and Radwan (2017) reported favourable and significant effects on the decrease of upper trapezius (left and right) muscle activity. This was after carrying out stretching breaks every 30 and 15 minutes, in comparison to a reference condition (60-minute period). In addition, both stretching conditions (30 and 15 minutes) had large intervention effects, benefiting a reduction on upper trapezius muscle activity, when compared to the reference condition. Another RCT from Nakphet et al. (2014) found no significant main effects on normalised EMG root mean square (NRMS) or median frequency (MF) for either of the intervention groups (dynamic stretching versus static stretching) when compared to reference group. Additionally, effect sizes were not calculated as pre- to post- data were not available.

Effects of single-session walking breaks. Two studies (within-subjects design) examined the use of walking breaks (Mathiassen & Winkel, 1996; McLean et al., 2000), one in combination with box lifting (Mathiassen & Winkel, 1996). At Mathiassen and Winkel (1996) no significant main intervention effects were found on upper trapezius muscle activity, when compared to the reference condition (four hours sitting, and 20-minute seated break). Moreover, as data were not presented in the study report, or available from authors, effect sizes were not available for calculation.

At McLean et al. (2000) a favourable and significant pre to post reduction was found on neck median frequency (MEDFREQ) myoelectrical signal (MES), but not in the back. This was after a 30-second walking break, in comparison to a 20-minute sitting condition. Furthermore, intervention effect sizes indicated a moderate effect for neck MES, and a small effect for back MES.

Medium and long-term intervention effects on spinal MSK outcomes.

Table 6 summarises main study findings from interventions using breaks from sitting at medium and long-term, alongside effect sizes when available. From four of the twelve studies, one study was identified for this review as medium-term (2 – 4 weeks), and three long-term (over 4 weeks to 3 months) interventions, all with an RCT study design. Two types of breaks with postural change were used in these interventions (Blasche et al., 2013; Shariat et al., 2017; Tsauo et al., 2004). One study used a stretching intervention combined with biofeedback relaxation and balance training (Blasche et al., 2013). The other study employed unspecified breaks from sitting which included stepping away from the workstation (McLean et al., 2001).

Effects of long-term interventions using stretching breaks. Blasche et al. (2013) found no significant intervention group effects on upper trapezius muscle activity (during rest and work), at either 2nd stage (8 weeks) or 3rd stage (three months). Effect sizes showed a moderate effect size on muscle activity of upper trapezius, during rest assessment, when compared to the reference group (followed best practice during breaks). A moderate effect was found in the balance training group (BAL), and a trivial effect (lower than small) was found in the biofeedback and stretching group (BFB) when compared to the reference group. On the other hand, upper trapezius muscle activity during work indicated a large effect for BFB when compared to reference group, and BAL showed a trivial effect compared to reference group. The stretching group was significantly favoured with an increase in right and left neck bending range of motion (ROM) in comparison to the reference group (that kept their daily activities with no stretching). In addition, a large effect size was identified for both left and right neck bending ROM after the 11-week programme completion.

Tsauo et al. (2004) found no pre to post significant changes for cervical range of motion (CROM) nor head protrusion in the intervention groups after 2 weeks (2nd stage) or 3-month time (3rd stage) in comparison to the reference group (lecture about exercises). Small effect sizes were found for CROM for the team-exercise group I (TEG I: breaks every 15 – 20 minutes once a day, supervised) at 2nd and 3rd stages, and for the team-exercise group II (TEGII: breaks every 15 – 20 minutes twice a day, unsupervised) at 3rd stage. Small effect sizes were found for head protrusion in the self-exercise group (SEG) at 2nd stage. In addition, a moderate intervention effect size was found on head protrusion for the TEG I at 3rd stage, and large effect sizes for the TEG II at both 2nd and 3rd stages (Tsauo et al., 2004). Trivial effect sizes were also found in the SEG (2nd and 3rd stage), TEG II (3rd stage) on CROM, and on head protrusion for the TEG I (2nd stage) and the SEG (3rd stage).

Effects of medium-term interventions using unspecified active breaks. In the study by McLean et al. (2001), participants carried out a 'micro-break' protocol (30 seconds break every 20 and 40 minutes) for a 2-week period. Results from this study indicated a significant increase on median frequency (MNF) myoelectric signal (MES) cycles for the neck and back. This was found in both intervention groups (30 seconds breaks every 20 and 40 minutes), when compared to the reference group (breaks taken as desired). Moreover, neck MNF MES cycles were positively favoured on the 20-minute break group, and similarly favoured on the control group. Back MNF MES cycles were also favoured on both intervention groups (every 20 and 40 minutes). Effect sizes were not calculated for this study as data were not available.

Table 7a

Acute one-session within subjects' studies reporting spinal self-reported MSK outcomes.

Author	Duration of session, number of session(s)	Break type, frequency, duration	Outcomes, comparisons	Direction of statistically significant effects between conditions	Number of statistically significant comparisons for which each condition is favoured, out of total number of comparisons	Intervention effect size between conditions	Direction of statistically significant pre to post intervention effects
				Standing breaks			
Babski-Reeves & Calhoun, 2016	1 hr, 3 sessions	Sit 20 mins – stand 5 mins (Pooled results: C1. Desktop, C2. Laptop, C3. Docked laptop)	1. Neck 2. Lower back	Favoured a decrease of neck and low back pain during standing, when compared to sitting	Sit vs Stand: **Neck: 1/1** **Lower back: 1/1**	NAvail	NA
Bao & Lin, 2018	8 hrs, 4 sessions	C1. Sit 90-Stand 30 (3:1) C2. Sit 80- stand 40 (2:1) C3. Sit 105- stand 15 (7:1) (RC) C4. Sit 60- stand 60 (1:1)	1. Neck 2. Upper back 3. Low back	No significant main effect per condition	-	NAvail	NA
Sheahan et al., 2016	1 hr, 4 sessions	C1. Sit 30 min/stand 5 min C2. Sit 15 min/stand 2.5 min C3. Sit 5 min/stand 30 sec RC. Sit 60 min/No break	Lower back	NAvail	-	NAvail	NAvail
				Walking breaks			
Mathiassen & Winkel, 1996	4 hrs, 2 sessions	C1. Walking with box lifting during 10 mins RC. Twenty min passive seated break	Neck perceived fatigue	No significant main effect per condition	-	NAvail	NA

Note. Statistically significant in bold. *Abbreviations*. C: Condition, RC: Reference condition, NAvail: Not Available, NA: Not Applicable

Table 7b

Acute one-session within subjects' studies reporting spinal self-reported MSK outcomes.

Author	Duration of session, number of session(s)	Break type, frequency, duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with total number of comparisons			Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
					RG	EG1	EG2		
Nakphet et al., 2014	1 hr, 1 session	EG1. Stretching every 20 mins x 3 mins EG2. Dynamic contraction every 20 mins x 3 mins RG: No break, sit for 60 mins	Neck discomfort	No significant main effect per group	-	-	-	NAvail	NA

Abbreviations: EG: Experimental group, RG: Reference group, LT: Left trapezius, RT: Right trapezius, NAvail: Not available, NA: Not Applicable

Table 8

RCTs using medium and long-term interventions and reporting spinal self-reported MSK outcomes

Study	Length of intervention - follow up time	Break type, frequency, and duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with control out of total number of comparisons				Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
					RG	EG1	EG2	EG3		
				Stretching breaks						
				2nd stage						
Blasche et al., 2013	8 weeks (2nd stage), 3 months (3rd stage)	EG1. BAL, 5-7 mins, twice per day EG2. BFB, 5-8 mins, twice per day EG3 Nordic walk, after work RG: Follow best practice	Pooled MSK complaints (neck, shoulder, lower back, arms, legs)	EG2 favoured decrease of MSK complaints when compared to RG	0/2	0/1	1/1	NA	RG vs EG1: Triv RG vs EG2: Large	NA
				3rd stage						
				No significant main effect per group	0/2	0/1	0/1	NA	RG vs EG1: Triv RG vs EG2: Small	NA
Shariat et al., 2016	3 sessions per week, 11 weeks	EG1. Stretching 10-15 mins RG: No alteration to daily activities	1. Neck	EG1 favoured a decrease on neck pain when compared to RG	0/1	1/1	NA	NA	NAvail	NA
			2. Lower back	EG1 favoured a decrease on LBP when compared to RG	0/1	1/1	NA	NA	NAvail	NA
Tsauo et al., 2004	2 weeks (2nd stage), 3 months (3rd stage)	Stretching EG1. Self-Exercise: 15-20 mins, once a day, unsupervised 2 weeks	Soreness	2nd stage						
			1. Neck	NAvail	0/1	0/1	0/1	0/3	NAvail	NA

Study	Length of intervention - follow up time	Break type, frequency, and duration	Outcome, comparisons	Direction of statistically significant effects between groups	Number of statistically significant comparisons for which each condition is favoured compared with control out of total number of comparisons				Intervention effect size between groups	Direction of statistically significant pre to post intervention effects
		EG2. Team Exercise I: 15-20 mins, once a day under supervision		3rd stage						
				NAvail	0/1	0/1	0/1	0/3	NAvail	NA
	2 weeks (2nd stage), 3 months (3rd stage)	EG3. Team Exercise II: 15-20 mins, twice a day (once supervised) (RG)		2nd stage						
			2. Upper back	NAvail	0/3	0/1	0/1	0/1	NAvail	NA
		CG: Lecture about exercises		3rd stage						
				NAvail	0/1	0/1	1/1	0/3	NAvail	NA
Unspecified active breaks										
McLean et al., 01'	3 hrs, 4 weeks	EG1. 20 mins work/30 secs of break walking away from workstation	Discomfort 1. Neck	No significant main effect per group	-	-	-	-	NAvail	NAvail
		EG2. 40 mins work/30 secs break walking away from workstation RG: Breaks taken as desired	2. Back	Significant group x time interaction (direction of effect unknow)	-	-	-	-	NAvail	NAvail

Note. Effect sizes: Triv lower than small. *Abbreviations:* EG: Experimental group, RG: Reference group, BAL: Balance training, BFB: Biofeedback assisted relaxation, NAvail: Not Available, NA: Not Applicable, MSK: Musculoskeletal, LBP: Low back pain

Second objective: Self-reported MSK spinal outcomes

From the 12 studies included in this review, nine studies explored self-reported MSK spinal outcomes. These outcomes were commonly reported as pain and/or discomfort. Only one of nine studies presented pre to post data to calculate effect sizes (Blasche et al., 2013). Five studies were acute single-session interventions (four within-subjects, one RCT), and the remaining were medium to long-term interventions (2 weeks to 3 months).

Acute single-session intervention effects on self-reported pain/discomfort. Table 7a summarises findings of three single-session intervention effects, using a within-subject study and table 7b summarises two single-session studies using an RCT design. Three types of breaks were used, standing breaks (n=3), walking breaks with box lifting (n=1) and stretching breaks (n=1). Results data were not presented in any of the acute single-session studies included in the review, therefore no effect sizes could be calculated.

Effects of single-session standing breaks. Babski-Reeves and Calhoun (2016) found a significant decrease in self-reported discomfort on neck and lower back during standing breaks when compared to sitting conditions by pooling data from all the conditions (desktop, laptop and docked laptop). Bao and Lin (2018) indicated no main effect on neck, upper and lower back for any of the four sit-stand schedules tested. Sheahan et al. (2016) did not present data of main effects on lower back discomfort scores for any of the tested conditions nor pre to post significant changes. As mentioned previously, none of the acute single-session studies using standing breaks reported results data. Therefore, effect sizes could not be calculated.

Effects of single-session walking and stretching breaks. Mathiassen and Winkel (1996), employed the use of walking breaks combined with box lifting. Results showed no main effects on neck perceived fatigue for the break condition when compared to reference condition. Nakphet et al. (2014), an RCT study design, indicated no main effects for none of the stretching break groups (dynamic and static stretching groups) in comparison to the reference group. Similar to other acute single-session studies included in this review, neither of these studies presented data to calculate intervention effect sizes.

Medium and long-term intervention effects on spinal MSK outcomes. Table 8 summarises findings for self-reported MSK outcomes from four interventions using breaks from sitting at medium and long-term. Two types of breaks with postural changes were used in these interventions: stretching (n=3), with one stretching intervention combined with biofeedback relaxation, and balance training (Blasche et al., 2013), and one study used unspecified breaks from sitting (McLean et al., 2001). From the four studies, only one study reported data to calculate effect sizes (Blasche et al., 2013).

Effects of medium-term interventions using stretching breaks. In the study by Blasche et al. (2013), the BFB intervention significantly favoured a decrease on MSK complaints (pooled data of neck, shoulder, lower back, arms, and legs), when compared to the reference group, at the 2nd stage (8 weeks). Although, non-significant main effects were found at the 3rd stage (3 months). The BAL intervention group showed no significant main effects when compared to the reference group, at either 2nd or 3rd stages. Nevertheless, trivial intervention effect sizes were found for the BAL group at both 2nd and 3rd stages, in comparison to the reference group. A large intervention effect size for was found the BFB group at the 2nd stage, whereas a small effect size was showed at the 3rd stage.

At Shariat et al. (2017), the stretching intervention favoured a significant decrease on neck and lower back discomfort, when compared to the reference group. As pre to post data were not reported, effect sizes were not calculated.

Tsauo et al. (2004) did not report main effects for any of the intervention groups, or control group on bodily soreness. However, a Chi-square test was used to calculate and report between group soreness prevalence. Results indicated that upper back soreness was significantly reduced on the TEG I group at the 3rd stage of the intervention, this when compared to the reference group (TEG II). As data were not available for any of the groups, effect sizes were not calculated.

Effects of medium-term interventions using unspecified active breaks. McLean et al. (2001) found no significant main intervention effects on neck discomfort, for any of the intervention groups (breaks at 20 or 40 minutes). Significant effects were shown on back discomfort when considering group per time interaction. However, the direction of the interventions effects was unknown. Data to calculate effect sizes were not available for this study (McLean et al., 2001).

Discussion

The aim of this study was to systematically review the literature exploring the effects of breaks from sitting on MSK spinal outcomes in sedentary workers. The first objective was to synthesise evidence of the effects of breaks from sitting on device assessed spinal MSK outcomes in sedentary workers. The second review objective was to compare the effects of breaks from sitting on device assessed MSK spinal outcomes with its effects on self-reported MSK spinal outcomes in this population (when available).

To the author's knowledge, this was the first review (during the design of the study) exploring the effects of breaks from sitting on device assessed MSK spinal outcomes. Also, the study was the first review to compare device assessed MSK spinal outcomes with self-reported MSK spinal outcomes. From the 12 studies included in this review, four types of break interventions were found: standing, stretching, walking, and one unspecified type of break (break with postural change). Diverse methodological considerations were identified in this study, including a high heterogeneity for all the included studies, and the unavailability of data. It is relevant to mention the low percentages scores in the quality assessment (MMAT), as authors reported incomplete data. Consequently, concluding remarks from this review findings are made cautiously.

Study characteristics

Publication date

The scarcity of studies assessing breaks from sitting on device assessed spinal outcomes was noticeable. Only twelve studies meeting the review inclusion criteria were published before our search dates. A predominance of publications in the past decade was observed, with eight studies being published after 2010. Similar to this review findings, most of the studies included in other systematic reviews on the field, were also published after 2010 (Agarwal et al., 2018; Luger et al., 2019; Parry et al., 2019; Shrestha et al., 2018b; Waongenngarm et al., 2018). A possible reason for this shortage may be the increase in research on the SB field and its effects on health, which start expanding after the year 2000, and peaked after the year 2010 (Biddle et al., 2019; Fang et al., 2021). Thus, indicating that the SB field is still in its infancy. Consequently, research exploring breaks from sitting and its effects on health is still emerging.

Participants

From 525 participants the majority were female (70.1% female against 29.9% male). This could be indicative that female are more likely to volunteer for research participation than male. It is also likely that additional factors (e.g., motivation, free time) influenced female participation to be higher than male participation in our included studies. Future research should aim to have more even gender split to ensure the generalisability of findings.

Countries of publication

Participants were mainly from high-income countries (three from USA, three from Canada, one from Austria, one from Sweden). These findings may indicate that occupational sitting has become more frequent (though not exclusive), in high-income countries, in comparison to developing countries (Bauman et al., 2011). Hence, this limits the generalizability of the results to lower-income countries, where workers might engage in less sedentary occupations.

First review objective. Device assessed MSK spinal outcomes

The first objective for this review was to synthesise literature of the effects of breaks from sitting on device assessed MSK spinal outcomes. Three main categories of breaks from sitting were identified: standing, stretching, and walking. One study did not specify the type of break, and this added a fourth category of unspecified break. The findings are discussed by break type.

Standing breaks effects

Acute single-session interventions using standing breaks indicated mixed findings of the effects of these breaks on muscle activity in relation to right, or left erector spinae. From the three studies exploring type of break, only two studies indicated a positive reduction on muscle activity (Babski-Reeves & Calhoun, 2016; Bao & Lin, 2018), and the other study did not find main effects on muscle activity (Sheahan et al., 2016). Findings indicated that standing breaks were effective to decrease muscle activity in the upper trapezius after a five-minute standing break (Babski-Reeves & Calhoun, 2016), but not after a 60-minute standing break (Bao & Lin, 2018). On the other hand, a positive decrease on the left erector spinae muscle activity were indicated after a 60-minute standing break (Bao & Lin, 2018), though not after a five-minute break (Babski-Reeves & Calhoun, 2016).

Acute single-session studies exploring the effects of standing breaks on spinal muscle activity are limited. One individual study, published after this review initial searches and update, explored the effects of standing versus sitting typing tasks on upper trapezius muscle activity (Cui et al., 2020). Although the break protocols were not equal to the ones from the studies included in this review. The study from Cui et al. (2020) did observe a reduction of upper trapezius muscle activity after a 90-minute standing typing task, when compared to a 90-minute sitting typing task. Discrepancies are also noted between this review and these authors' findings. This review findings indicated that upper trapezius muscle activity was reduced by employing a 5-minute standing break. Whereas at Cui et al. (2020) the reduction in upper trapezius muscle activity was found after a 90-minute period.

Another difference between Cui et al. (2020) and this review findings are identified when considering evidence from Bao and Lin (2018), where authors did not observe main changes on upper trapezius muscle activity after a 60-minute standing break. Therefore, it is evident that the effectivity of standing breaks on upper trapezius muscle activity by using different break frequencies needs further assessment.

Collectively, this review findings suggest that standing breaks are beneficial to reduce muscle activity on upper trapezius when taken for 5 minutes, and on left erector spinae when taken for at least 60 minutes. This might be indicative that perhaps larger muscles (as erector spinae) need longer break durations to obtain positive benefits on muscle activity.

Bao and Lin (2018) also assessed changes on spinal shrinkage after using different types of sit-stand schedules during an 8-hour period. A statistically significant decrease on spinal shrinkage was observed in all participants, at the end of the 8-hour day. However, these changes were not significant between conditions. Also, authors did not differentiate what type of sit-stand schedule was the most optimal to reduce spinal shrinkage, nor in which condition (sitting or standing) spinal shrinkage occurred. Comparable to these findings Gao et al. (2016), showed no significant differences on spinal shrinkage, from baseline to post intervention assessment, after emulating a full workday in participants using sit-stand workstations. Authors also reported that spinal shrinkage was present in both standing and sitting. This suggests that the use of standing breaks may not be sufficient to reduce spinal shrinkage in acute settings. However, as findings are only from one study, they should be taken cautiously.

Considering this evidence, it is suggested that standing breaks are useful to reduce muscle activity in the neck muscles but not in the lower back muscles. Standing breaks seem also insufficient to avoid spinal shrinkage after an 8-hour working day. As evidence is not conclusive, these findings should be taken carefully.

Stretching breaks effects

Acute single-session interventions using stretching breaks. Three studies explored the acute single-session effects of stretching breaks on various types of device assessed spinal MSK outcomes (disc height and diameter, and muscle activity). Only one study (Billy et al., 2014) examined the acute single-session effects of stretching breaks on spinal outcomes and considered them as beneficial. Findings indicated that lumbar disc height and disc diameter were maintained after a 20-second stretching break every 15 minutes (during a 4-hour period). These findings were compared to an only sitting condition (4-hour sitting), where both disc height and diameter were reduced during the 4-hour period. With only one study exploring the effects of stretching breaks on lumbar disc height and diameter, it is challenging to draw conclusions. To interpret these findings, it is useful to consider that to my knowledge there are no other published studies that have explored the effects of stretching breaks on spinal shrinkage in sedentary workers. However, literature on spinal height assessment during prolonged sedentary time can be useful to interpret these findings. Research undertaken by Rabal-Pelay et al. (2019), has indicated that sitting during an 8-hour period is sufficient to reduce spinal height of 6.5 mm in office workers (Rabal-Pelay et al., 2019). Evidence from these authors suggests that sitting for prolonged periods produces reductions on spinal height, also known as spinal shrinkage. Taking Billy et al. (2014) findings, we could suggest that stretching breaks are beneficial to maintain spinal height and avoid spinal shrinkage during a 4-hour period. However, we need to consider that Billy et al. (2014) intervention sitting period was shorter (4 hours) than Rabal-Pelay et al. (2019) research (8 hours). Collectively, this evidence suggests that stretching breaks are useful to maintain spinal height during a 4-hour period in office workers. However, this evidence is taken from only one study. Therefore, further research of the effectivity of stretching breaks is needed, with interventions emulating time frames of a full working day.

Two studies (RCT design) assessed the effects of acute single session stretching breaks on muscle activity, and findings were mixed. In Mohamed and Radwan (2017), stretching breaks were deemed to carry benefits, when compared to one-hour sitting conditions. Furthermore, different break durations (5 and 2.5 minutes) and frequencies (every 30 or 15 minutes) significantly decreased muscle activity on upper trapezius. On the other hand, in Nakphet et al. (2014) study, no significant main effects on upper trapezius or cervical erector spinae were found for two types of stretching breaks (dynamic and static stretching) when performed for 3 minutes. From Nakphet et al. (2014) findings we could suggest that neither type of stretching were adequate to decrease muscle activity one from another. Also, it could be suggested that both dynamic and static stretching breaks have similar effects on the cervical muscles. Similar findings to Mohamed and Radwan (2017) were observed in a study published after our research dates (Ding et al., 2020). After a single-session intervention, Ding et al. (2020) found a significant and positive decrease on upper trapezius muscle activity by using 5-minute stretching breaks and after 40 minutes of sitting time. This suggests that 5-minute stretching breaks are effective to decrease muscle activity in the upper trapezius. Collectively, findings from the two studies employing stretching breaks (included in this review), do not inform us what is the most optimal duration or frequency to break up sitting time. By collating evidence from Mohamed and Radwan (2017) with evidence from Ding et al. (2020) , it could be indicated that 5-minute stretching breaks are sufficient to decrease muscle activity on upper trapezius when compared to seated conditions. Whereas, 3-minute stretching does not seem to provide changes on cervical muscle activity.

Long-term interventions using stretching breaks. With respect to longer-term interventions, three studies explored the effects of stretching breaks. All signalling positive effects on diverse spinal MSK outcomes. In one study, a positive decrease on upper trapezius muscle activity was found after using stretching breaks combined with biofeedback relaxation, for 5 – 7 minutes and twice a week (Blasche et al., 2013). The other two studies (Shariat et al., 2017; Tsauo et al., 2004), assessed changes on cervical range of motion (CROM). Both studies found positive increases on neck bending, neck protrusion after using stretching breaks ranging from 10 – 15 (Shariat et al., 2017), and 15 – 20 minutes (Tsauo et al., 2004). Although both interventions explored the effects of stretching breaks on CROM, Tsauo et al. (2004) explored mainly the ability of workers to follow a stretching breaks programme with supervised, and unsupervised sessions, either once or twice a day. Even though results from this study indicated positive outcomes, it is possible that other factors (e.g., daily repetitions, exercise supervision) might have affected these outcomes. Therefore, these results are taken with caution.

Comparable to this review's findings for medium to long-term interventions, a 7-week intervention employing a 45-minute exercise stretching session also indicated positive increases on neck ROM when applied twice a week for 7 weeks in office workers (Caputo et al., 2017). Discrepancies are also noted between this review findings and these authors. At this review, inclusion criteria specified that interventions employed solely breaks from sitting, excluding exercise programmes. In addition, the longest stretching break duration from our included studies was 20 minutes, whilst Caputo et al. (2017) employed a 45-minute programme. Another important difference is that participants in this study had pain and discomfort at baseline (at least 2 of 10 of the Numeric Rating Scale [NRS]), contrary to included studies where participants had no pain or discomfort at baseline.

Collectively, findings from long-term interventions indicated that stretching breaks can be helpful to decrease negative spinal outcomes, especially in the neck region. It also appears that stretching breaks ranging from 10 – 20 minutes are adequate to increase neck ROM long-term. Although findings indicate benefits from stretching breaks, heterogeneity of the studies make impractical to fully compare all the studies directly. Consequently, findings should be taken cautiously.

Overall, research indicates stretching is important to increase joint flexibility, muscle strength and power, postural balance and stability, but also to decrease muscle tightness and stiffness (Arntz et al., 2023; Garber et al., 2011; Liguori et al., 2021). These effects are observed due to changes in length of musculotendinous units which are present in the muscles and help to maintain bodily flexibility. Static stretching (holding a position until the end of the ROM for a certain amount of time) has been linked to an increase on joints ROM reducing the risk of MSDs in adults. The American College of Sports Medicine (ACSM) suggests in their latest guidelines that adults should carry out static stretching holding 10 – 20 seconds, 2 - 3 times per week (with larger effects when performed daily) to improve their joints flexibility and increase mobility. A recent systematic review by Arntz et al. (2023) indicated that long-term static stretching provides further benefits in sedentary populations (as their flexibility tends to be impaired by prolonged sedentary time periods), when compared with physically active individuals. Considering that stretching was collectively the most useful form of break to reduce spinal MSK outcomes in this review, and the known effects of stretching, it is key that future research focus on exploring these benefits in sedentary workers.

Walking breaks and unspecified active breaks effects

Acute single-session interventions using walking breaks. Two studies considered the benefits of acute single-session walking breaks. Findings from one study did not show main effects on muscle activity, specifically on upper trapezius, when walking breaks were combined with box lifting (Mathiassen & Winkel, 1996). The other study, used brief 30-second walking breaks (every 20 minutes) (McLean et al., 2000). This study appeared to benefit a decrease on median frequency myoelectric muscle signal (MNF MES) on neck muscles (but not in the back muscles) when compared to a seated condition. Together, these two studies cannot be compared, especially since they explored different outcomes.

Referring to McLean et al. (2000), findings suggest that breaking up sitting time with brief walking breaks can positively benefit MNF MES in the neck. Resembling McLean et al. (2000), Ding et al. (2020) observed that 5-minute walking breaks were effective to decrease significantly upper trapezius muscle activity, when compared to a sitting condition. Differently to Ding et al. (2020), Mathiassen and Winkel (1996) walking breaks had no effects on upper trapezius muscle activity. It is fair to suggest that the ineffectiveness of combining walking breaks with box lifting (on reducing upper trapezius muscle activity) might be attributable to the tension used to carry the box weight (8-15 kg). Collectively, it is suggested that short walking breaks (30 seconds) may provide benefits on MNF MES. However, when combined with carrying heavy loads these breaks do not provide benefits to spinal outcomes.

Medium-term interventions using walking breaks. One study (McLean et al., 2001) employed an unspecified type of break at a medium-term (4 weeks). This break from sitting involved standing and walking away from a workstation for 30 seconds. Positive effects on neck and back median frequency myoelectric signal (MNF MES) were found, after breaking up sitting time at 20 and 40 minutes (and when compared with control group). Though positive effects were found by the authors, it was observed that the control group took unmonitored breaks. The absence of monitoring the control group breaks may have affected the effectivity of the break protocol. Therefore, these findings are taken with caution. Findings from this study are important to understand how breaking up sitting time with postural change is useful to reduce spinal outcomes (MNF MES). However, it is important to mention that there is only another study exploring the effects of breaks from sitting and MNF MES. This study is from the same author (McLean et al., 2000), and examines the use of walking breaks with positive effects on MNF MES. Consequently, direct comparisons with further literature on the topic, and McLean et al. study is not possible. Nevertheless, it is suggested from these findings that breaks with postural change (sitting to standing, and walking away from one point to another), are beneficial to increase MNF MES at neck and back muscles. Future research to understand the effects of postural change on spinal muscles, and specifically having monitored control groups is needed.

Table 9

Summary of the effectiveness of breaks from sitting on device assessed and self-reported MSK spinal outcomes

Study	Type of break	Device assessed outcome(s)	Body part	Overall effects	Self-reported outcome(s)	Overall effects
Babski-Reeves &Calhoun, 2016	Standing	Muscle activity	UT	*Positive effect*	Neck	*Decreased pain*
			LT	*No effect*	Lower back	*Decreased pain*
			LES	*No effect*		
Bao & Lin, 2018	Standing	Muscle activity	RUT	*No effect*	Neck	*No effect*
			LUT	*No effect*	Upper back	
			LES	*Positive effect*	Lower back	
		Spinal shrinkage	-	*No effect*		
Sheahan et al., 2016	Standing	Muscle activity	RES	*No effect*	Lower back	*NAvail*
			LES	*No effect*		
Billy et al., 2014	Stretching	Lumbar disc	Height	*Positive effect*	Unexplored	*Unexplored*
			Diameter	*Positive effect*		
Mathiassen & Winkel, 1996	Walking	Muscle activity	UT	*No effect*	Perceived neck fatigue	*No effect*
McLean et al., 2000	Walking	MNF MES	Neck	*Positive effect*	Unexplored	Unexplored
			Back	*No effect*		
Mohamed & Radwan, 2017	Stretching	Muscle activity	LUT	*Positive effect*	Unexplored	Unexplored
			RUT	*Positive effect*		
Nakphet et al., 2014	Stretching	Muscle activity	LUT	*No effect*	Neck	*No effect*
			RUT	*No effect*		
			CES	*No effect*		
	Stretching	Muscle activity	UT work	*Positive effect*		*Decreased pain*

Study	Type of break	Device assessed outcome(s)	Body part	Overall effects	Self-reported outcome(s)	Overall effects
Blasche et al., 2013			UT rest	*Positive effect*	Pooled MSK complaints	
Shariat et al., 2017	Stretching	ROM	Right neck bending	*Positive effect*	Neck	*Decreased pain*
			Left neck bending	*Positive effect*	Lower back	*Decreased pain*
Tsauo et al., 2004	Stretching	ROM	CROM	*Positive effect*	Neck	*No effect*
			Neck protrusion	*Positive effect*	Upper back	*Decreased pain*
McLean et al., 2001	Unspecified/Postural effect	MNF MES	Neck	*Positive effect*	Neck	*No effect*
			Back	*Positive effect*	Back	*No effect*

Abbreviations: UT: Upper trapezius, LT: Lower trapezius, LUT: Left upper trapezius, RUT: Right upper trapezius, LES: Left erector spinae, RES: Right erector spinae, NAvail: Not Available, CES: Cervical erector spinae, MES: Myoelectric signal, MNF: Median Frequency, ROM: Range of Motion, CROM: Cervical range of motion.

Second review objective: Self-reported MSK compared to device assessed outcomes

The second objective of this review was to compare evidence of the effectiveness of breaks from sitting on device assessed spinal outcomes, with self-reported MSK outcomes. Findings for both review objectives are contrasted in this section. Nine studies reported self-reported MSK spinal outcomes and outcomes were reported as pain and/or discomfort. Most of the studies did not present a complete report of the findings (e.g., unreported findings, missing data). Table 9 summarises main findings on the effectiveness of breaks from sitting of both device assessed and self-reported MSK spinal outcomes. Main findings are summarised on acute single-session interventions, and medium to long-term interventions.

Acute single-session interventions

Five studies employed acute single-session break interventions, which included three studies using standing breaks, one study using walking breaks combined with box lifting, and one study using stretching breaks.

Standing breaks. From the three studies using standing breaks, one found no main intervention effects on neck, upper back and lower back discomfort (Bao & Lin, 2018), and the second study did not report main effects of standing breaks on LBP (Sheahan et al., 2016). Only one acute one-session intervention indicated to have effects on decreasing neck and LBP, when compared to a seated condition (Babski-Reeves & Calhoun, 2016). Babski-Reeves and Calhoun (2016) results suggested that 5-minute standing breaks are beneficial to reduce neck discomfort (compared to a 20-minute sitting condition). Furthermore, this study also revealed a positive reduction on neck muscle activity (review primary outcome). On the other hand, 5-minute standing breaks seemed sufficient to reduce low back discomfort, but not to reduce muscle activity on the left erector spinae. It appears that a reduction on neck muscle activity led to a simultaneous reduction of neck discomfort. Thus, indicating that 5-minute standing breaks are beneficial to reduce spinal MSK outcomes (muscle activity, and neck and lower back discomfort).

The second study (Bao & Lin, 2018), used various sit-stand schedules (Sit/Stand: 30 /5 minutes; 15/2.5 minutes; 5 minutes/30 seconds). These sit-stand schedules appeared to be insufficient to change (negatively or positively) neck, upper or low back pain. This study also indicated no main changes on upper trapezius and left erector spinae muscle activity, nor spinal shrinkage. Hence, indicating that possibly their break protocols were not sufficiently effective to reduce spinal outcomes.

A possible reason for Bao and Lin (2018) results could be due two factors. One factor is the length of the standing break, as the shortest standing break was 15 minutes, and the longest 60 minutes. This shows agreement Smith et al. (2022) where participants indicated MSK discomfort after standing for 30 minutes. Therefore, it is possible that shorter standing breaks (such as 5-minute breaks in Babski-Reeves and Calhoun (2016)) are more beneficial for pain and discomfort, whereas longer standing breaks exacerbate MSK pain. A second factor might be attributed to the sitting length. Sitting periods were quite varied, ranging from 60 to 105 minutes. This is different from Babski-Reeves and Calhoun (2016), where positive effects on discomfort were found when sitting lasted only 20 minutes. This might be indicative of prolonged sedentary bouts been harmful to MSK tissues when sitting for over 20 minutes. However, further evidence is needed to confirm this finding.

While results from interventions using standing breaks are mixed, findings from one study (Babski-Reeves & Calhoun, 2016) were consistent with a recent systematic review exploring the self-reported pain/discomfort effects of sit-stand schedules (Agarwal et al., 2018). Authors also observed that interventions using sit-stand schedules tend to produce a positive reduction on LBP when compared to sitting (Agarwal et al., 2018). Nonetheless, similar to our review, authors did not find conclusive evidence on the optimal break frequency or duration to achieve these benefits.

Collectively, findings from studies using standing breaks are mixed, and conclusive remarks of their effectivity on spinal pain cannot be draw. There is evidence from one study suggesting that 5-minute breaks are beneficial to reduce self-reported neck and low back discomfort. However, this evidence comes only from one study. It was suggested from the evidence that breaks from sitting do not alleviate pain after a 20-minute sedentary bouts. Nevertheless, this evidence comes from only two studies with highly heterogeneous protocols. Recommendations on what is the most optimal length, or frequency of standing breaks to reduce MSK spinal pain/discomfort remain unclear.

Walking breaks. Only one study employed walking breaks (Mathiassen & Winkel, 1996). The authors explored the effects of walking breaks whilst carrying out assembly work, on perceived muscle fatigue, and no main effects were found. It is indicated from these findings that standing breaks, combined with box lifting, are inadequate to decrease muscle activity in the upper trapezius, and to reduce neck fatigue in acute one-session settings. In addition, it is suggested that walking breaks might not be effective in counteracting assembly work activities, such as carrying heavy loads.

Primary research in female workers (Jansen et al., 2013) has indicated high prevalence of neck pain (44%) in assembly workers due to repetitive work. Consequently, it is observed that assembly work activities are a risk factor for developing spinal pain/discomfort. Systematic review evidence of the effects of walking breaks to reduce MSK symptoms in sedentary workers (non-assembly workers) has also been signalled to be unconvincing (Parry et al., 2019). Parry et al. indicated that walking breaks were effective to reduce baseline MSK pain/discomfort in office workers. However, this evidence was taken from only one study with low-quality evidence for the effects of walking breaks.

Considering this evidence, it is advised that walking breaks are an ineffective strategy to decrease self-reported MSK symptoms in sedentary workers. Especially if they are combined with carrying heavy loads. The effectivity of walking breaks on MSK self-reported symptoms in sedentary occupations are still unknown. These findings are taken cautiously.

Stretching breaks. Only one study (Nakphet et al., 2014) explored the effects of two types of stretching breaks: dynamic and static (against a 60-minute seated condition). No significant main effects were found on neck discomfort after a 3-minute stretching protocol. It was also observed that the authors did not find main effects for neither muscle activity (device assessed), or discomfort (self-reported) in any of their groups (static and dynamic stretching). Current evidence of the acute one-session effects of stretching breaks on self-reported MSK spinal symptoms are limited to LBP. Consequently, the effects of breaks from sitting on neck are only drawn from this study.

It can be suggested that both dynamic and static stretching breaks seem to be ineffective to reduce MSK spinal outcomes in acute one-session interventions. However, it is of importance to point out that the absence of data in the study report forbids us to draw further conclusions. Therefore, further research on these outcomes is needed to understand the acute effects of stretching breaks on neck pain.

Medium to long-term effects

Four studies considered the medium to long-term effects of breaks from sitting, and its effects on self-reported spinal pain/discomfort. Three interventions employed stretching breaks, and one used an unspecified break from sitting. Only one study (McLean et al., 2001) used unspecified active breaks from sitting (walking away from workstation for 30 seconds), but these involved postural change. Conflicting findings between device assessed and self-reported MSK spinal outcomes were observed. The authors indicated no main effects for the reduction of neck and back self-reported pain/discomfort. On the other hand, a positive effect on neck and back median frequency myoelectric muscle signal was observed (MNF MES). Studies using the same type of breaks as McLean et al. (2001) are unavailable. However, though McLean et al. (2001) did not specify the type of break they used, postural change was present, as participants left their sits and walk away from their workstations. Waongenngarm et al. (2018) review explored the effects of breaks with and without postural change on LBP. Unlike this review's findings, results from Waongenngarm et al. (2018) indicated a positive reduction on LBP when using postural change from sitting. Whereas McLean et al. (2001) showed no effects on either neck pain or LBP. It can be proposed that a positive reduction on MNF MES can be achieved during short breaks (30 seconds) with postural change, but these breaks might not be sufficient to reduce neck and back pain/discomfort.

Three studies employed stretching breaks, and all displayed a decrease of MSK self-reported complaints on neck and/or lower back (Blasche et al., 2013; Shariat et al., 2017; Tsauo et al., 2004). In one study (Blasche et al., 2013), the use of stretching breaks (mixed with biofeedback relaxation - BFB), suggested a simultaneous reduction on both upper trapezius muscle activity (device assessed), and MSK neck complaints (self-reported) at all intervention stages. The authors also evaluated self-reported pain/discomfort on lower back, and positive effects were found. Nevertheless, device assessed MSK outcomes in the lower back were not assessed. Another two studies in this review employed stretching breaks and evaluated its effects on CROM (Shariat et al., 2017; Tsauo et al., 2004). Both studies indicated positive intervention effects on CROM, a statistically significant decrease on neck discomfort decrease (Shariat et al., 2017), and a decrease on upper back soreness (at 3rd intervention stage, 3 months) (Tsauo et al., 2004).

A significant reduction of LBP was also found at Shariat et al. (2017). Nonetheless, we cannot make a direct comparison between both review objectives from Shariat et al. (2017), as the device assessed effects of stretching breaks on low back were not measured. Together, findings from these three studies showed positive effects of stretching breaks on neck, upper and low back pain/discomfort. Thus, proposing that stretching breaks are effective on reducing spinal self-reported MSK outcomes in medium to long-term intervention settings.

Although current literature of the effects of breaks on self-reported discomfort is not conclusive, some agreement with this review's findings were found by another systematic review (Waongenngarm et al., 2018). Authors signalled that interventions where breaks with postural change were used had lower rates of LBP, at medium and long-term (up to 4 months). Stretching breaks are considered as a form of break where postural change is required. Consequently, taking in consideration Waongenngarm et al. (2018) findings, and this review findings where LBP was reduced (Blasche et al., 2013; Shariat et al., 2017) we could suggest that stretching breaks (as a form of break with postural change) are beneficial to reduce self-reported LBP. Nevertheless, Waongenngarm et al. (2018) review explore only self-reported LBP, and no other spinal areas. Therefore, we cannot make direct comparisons from this review findings of the effectiveness of stretching breaks on the reduction of self-reported neck and upper back discomfort.

Heterogeneity of studies

Considerable heterogeneity was present in the 12 studies included in this review. These had a wide range of break types, break durations, and break frequencies. The twelve studies also examined diverse spinal MSK outcomes (e.g., muscle activity, spinal ROM, spinal shrinkage). Hence, comparing the study's findings was challenging. The heterogeneity of research protocols, measurements, and explored outcomes suggests that research exploring breaks from sitting is undeveloped. Consequently, is not feasible to conclude what is the most beneficial type, duration or frequency of breaks from sitting from this review findings.

Methodological considerations of the included studies

Various methodological issues were identified in the included studies. Study quality was low, with none of the studies fulfilling 100% of MMAT criteria (Hong et al., 2018). The MMAT quality assessment identified low quality on reporting, more specifically a need for clarification on randomisation, confounders accounting, blinding of researchers, and intervention adherence. It is recommended that future research improves their description of study methods and protocols, improving clarity and transparency (e.g., CONSORT guidelines).

A main concern found in the studies was the absence of data reported, causing difficulties to summarise study findings. Intervention effects between conditions, or group comparisons, were not reported in various studies causing difficulties to identify the effects of breaks from sitting on MSK spinal outcomes. Although authors were contacted, the response rates were low (only 2/12 authors responded), which made unfeasible to obtain the missing data.

Review strengths and limitations

A key strength of this review is the systematic process thoroughly followed, including a wide literature search (studies published until March 2020). Two reviewers were involved in all the review stages (title and abstract screening, full-text screening, data extraction, and quality assessment) to minimise bias and errors in the review process, in accordance with the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2022). Another strength is the inclusion in searches of studies not only in English but also in Spanish language, having a larger pool of studies, though none of the studies in Spanish fulfilled the review inclusion criteria.

Another strength was improving reporting transparency, and clarity for the review process, by following the SWiM guidelines (Campbell et al., 2020). In addition, the Guidance on the conduct of Narrative Synthesis in Systematic review was used to summarise the review findings into a narrative synthesis (Popay et al., 2006).

In relation to limitations, the Cochrane guidance for systematic reviews (Higgins et al., 2022) indicates that a meta-analysis can be carried out with results of two or more studies. Nonetheless, as interventions and outcomes of the studies included in this review were highly heterogeneous (clinically, statistically, and methodologically) (Higgins et al., 2022), it was decided that a meta-analysis should not being conducted as this could misrepresent the findings.

Another limitation of this review is that through the title and abstract screening stage, only 10% of the abstracts were screened by two reviewers. The use of two reviewers, during title and abstract screening has been demonstrated to increase study selection by 6.6% to 11.9%, decreasing random and selection error (Stoll et al., 2019). Although full-text screening, data extraction and quality assessment were double screened, only the main reviewer screened 100% of all the studies in the full-text screening stage. Whilst other reviewers involved carried out one third of full-text screening studies (separately), and half of studies during data extraction and quality assessment, this could create misinformation bias during the review process.

Implications for future research

As previously mentioned, deficient study reporting has made it difficult to generalise the main findings of this review. Future research should aim to address the methodological considerations pointed out above. Authors should aim to report using guidelines (e.g., CONSORT guidelines) and submit full reports with complete data. Furthermore, authors should thoroughly report primary and secondary outcomes (if applicable) for all examined groups, as well as report subgroup analysis, and intervention effect sizes (Schulz et al., 2010).

It is also key to improve the transparency while reporting methods, so future research can replicate their methodology. Further research is needed to investigate what break frequency, and duration, are optimal to decrease spinal MSK symptoms on sedentary populations. It is crucial to understand the clinical significance of various types of breaks from sitting on MSK symptoms, as well as test their adaptability to different workplaces to be able to develop future workplace policies.

Conclusion

Twelve studies were included in this review. Findings from this review propose that in acute single-session interventions (setting), stretching breaks were the most effective form to reduce MSK spinal outcomes. Stretching breaks were indicated to benefit three different device assessed spinal outcomes (decrease muscle activity, maintain disc height and disc diameter). However, the effects of single-session stretching breaks on self-reported MSK spinal outcomes are taken cautiously. Primarily, because the only study exploring together both variables reported no main findings on the reduction of spinal discomfort. Acute single-session standing breaks seemed to be the most effective form to benefit the reduction of neck and low back pain in an acute setting. Nevertheless, these findings are obtained from one study, and they should be taken cautiously.

In medium and long-term interventions (2 weeks up to 3 months), stretching breaks were also the most beneficial intervention to reduce MSK spinal outcomes. Interventions using stretching breaks were useful to reduce various spinal objective outcomes at the neck (muscle activity, and cervical ROM). Stretching breaks were also effective to reduce pain and discomfort in neck, upper and lower back. Yet, these findings were taken from only three studies, and further research is needed to corroborate this evidence.

To conclude, results from this review indicate that breaks from sitting, especially stretching breaks, are effective in reducing device assessed and self-reported MSK spinal outcomes. Nevertheless, due to limitations from the available literature we are unable to make conclusive recommendations of what type of break from sitting, frequency and duration is the most adequate to decrease spinal MSDs in sedentary occupations. Further research with higher quality methodology, reporting and sample diversity (most participants were female) is warranted to generalise study findings.

Chapter summary and transition from study 1 to study 2

This chapter aimed to identify what the effectiveness of breaks from sitting on device assessed MSK spinal outcomes were. Additionally, to compare these effects with self-reported MSK spinal outcomes. This review's findings suggest that stretching breaks are the most useful form to reduce both device assessed and self-reported MSK outcomes in the spine. This review findings also suggest the need for further research to increase knowledge and expand the evidence of the effects of breaks from sitting on MSK outcomes. It is also essential for research to consider what is the most 'ideal' break schedule (e.g., frequency, duration) to achieve health benefits from this strategy.

The impact of the COVID-19 pandemic on the methodology of this thesis.

The findings of the first study indicated a lack of high-quality research of the effectiveness of breaks from sitting on device assessed and self-reported spinal MSK outcomes in sedentary workers. These findings led to plan a laboratory study to understand the acute effects of breaks from sitting on both device assessed (spinal height and range of motion) and self-reported MSK spinal outcomes (self-reported pain/discomfort). The study rationale, laboratory protocol and risk assessment were carried out before the pandemic. Additionally, an Ethics application was submitted for approval to Moray House Ethics Committee in April 2020.

Study 2 consisted of a within-subjects study design, where participants would have tested three conditions (Condition 1: Standing break, Condition 2: Standing and static stretching, Condition 3: Sitting only). The testing period would have been a 4-hour period where participants would be able to carry out their own desk work. Device assessed and self-reported MSK spinal outcomes assessment would have been carried out at baseline and at the end of the intervention day. Nevertheless, undertake this study was not possible as all research facilities were closed due to the outbreak of the COVID-19 pandemic. This study would have also required close contact measurements between participants and researchers, which would have been unfeasible due to the COVID-19 no close-contact guidelines. Therefore, a new study had to be planned to address the thesis aim.

The COVID-19 pandemic changed the work landscape, with people working for some or all their working week at home. The change in the work landscape created new research questions for the SB field, as there were many unknown aspects of working from home. Exploring SB and MSK symptoms prevalence in desk-based workers while working from home became essential to be able to expand the understanding of this new work landscape. The next chapter contributes to explore and understand the recent changes in the work environment due to a global pandemic. Furthermore, the next chapter contributes as novel research in MSK prevalence in desk-based workers while WFH.

Chapter 3. Sedentary behaviour and musculoskeletal symptoms in University of Edinburgh desk-based staff working from home

This chapter contains the second study of this PhD. The chapter focuses on the changes that took place in the working environment during and after the global pandemic of COVID-19 in early 2020. This study aimed to expand knowledge on SB, and MSK symptoms while working from home. Before the pandemic, the term office workers was used mainly to describe desk-based workers. From this chapter on, the term 'office worker', is now referred as 'desk-based worker' to reflect these changes.

Background

Sedentary occupations, such as desk-based workers, are particularly at risk of developing a variety of negative health outcomes, including MSDs (Dzakpasu et al., 2021; Jun et al., 2017; Patterson et al., 2018). Combined research results have signalled high levels of occupational SB in these workers, indicating that they sit for most of their working day (up to 82%) (Clemes et al., 2014; Hadgraft et al., 2016; Parry & Straker, 2013b; Ryan et al., 2011; van Dommelen et al., 2016). Review evidence has linked the onset of spinal MSDs in sedentary adults engaging in prolonged sedentary time, especially when combined with computer use of more than 4 hours per day (Ardahan & Simsek, 2016; Jun et al., 2017). Consequently, strategies to reduce prolonged sedentary time are necessary to also reduce MSDs development.

Review evidence suggests that breaking up sedentary time intermittently is beneficial to reduce self-reported MSK pain and discomfort in desk-based workers (Agarwal et al., 2018; Waongenngarm et al., 2018). In addition, findings from study 1 (chapter 2) also suggested that breaks from sitting were effective to reduce various spinal outcomes in sedentary workers. Together, these findings suggest the importance of breaks from sitting to benefit various health outcomes in sedentary workers. While these findings are important, recent changes in the work landscape have made remote work more frequent in desk-based workers. Expanding knowledge of the prevalence of occupational SB and MSK symptoms in the home setting is still necessary.

WFH and the COVID-19 pandemic

The coronavirus pandemic (COVID-19) took place worldwide during early 2020, affecting the normality of various activities (e.g., work, school, leisure) (Cucinotta & Vanelli, 2020; World Health Organization, 2020a). Meanwhile, desk-based workers were enforced to work from home (WFH).

Prior to COVID-19, some organisations already permitted WFH and hybrid working (Hassan et al., 2013). This was possible due to the growth of mobile technologies, and continuous connectivity, which facilitated remote work (Hassan et al., 2013; Messenger, 2017). Although working from home (WFH) gained popularity in the past years, changes took place gradually for workers. Conversely, due to the confinement periods during COVID-19, an upsurge of people WFH was observed. In the UK, 30% of people with administrative, educational, and secretarial workers were WFH at least once a week in 2019 (Watson, 2020). During the COVID-19 pandemic these numbers increased up to 46.6% (Cameron, 2020). Survey findings conducted with desk-based workers from various countries (United States, Italy, Spain, France, UK and Germany), also showed that the number of people WFH almost doubled (from 33 to 60%) since the COVID-19 pandemic began (Nagel, 2020). The most recent figures from the Office of National Statistics (early 2022) reported that 38% of workers in the UK still WFH during the working week (Office for National Statistics, 2022).

Primary evidence exploring SB in adults during the COVID-19 pandemic, signalled increases in sedentary time during the pandemic (Moretti et al., 2020;

Šagát et al., 2020; Sañudo et al., 2020; Zheng et al., 2020). Compared to pre-COVID-19, SB during COVID-19 was indicated to be higher in adults staying at home (either for work or study), with an average increase on self-reported sitting ranging from 2.2 to 3.3 hours per day (Sañudo et al., 2020; Zheng et al., 2020). Thus, indicating that the home environment is conducive of higher SB in adults. However, this evidence was taken during the confinement periods, when people were required to remain at home, which might have influenced this prevalence.

In relation to MSK symptoms, a relationship between SB increase and an upsurge on self-reported low back (41.2%), and neck pain (23.5%) was observed in adults staying at home during the COVID-19 pandemic (Moretti et al., 2020; Šagát et al., 2020). These findings support pre-COVID evidence signalling that SB is linked to MSDs development. Nevertheless, participants from Šagát et al. (2020) were not desk-based workers solely, which could have affected MSK prevalence as their work activities might have been different.

Prior to the pandemic, WFH had been defined as an "office environment where paid work is carried out from home, and linked with a traditional office for administrative support" (Hassan et al., 2013). Even though some of these points are still pertinent, the nature of WFH has evolved since the pandemic. For example, nowadays, many workers can often choose when to WFH and when to work at the office (hybrid working) without needing administrative/managerial support, offering these workers greater flexibility.

In the UK, the number of desk-based workers planning to continue engaging in hybrid working increased since 2021, from 31% (2021) to 42% in 2022 (Office for National Statistics, 2022). Additional evidence also reinforced this notion, with workers from various high-income countries intending to continue engaging in hybrid working after the pandemic (Nagel, 2020; Williamson et al., 2020). Thus, highlighting that desk-based workers will continue WFH, or engaging in hybrid work, instead of returning to a full office environment.

WFH brings many advantages to desk-based workers. Amongst the most common are a decrease in commuting time, a better life-work balance, greater schedule flexibility, improved wellbeing and an increase in job satisfaction (Bloom et al., 2015; Office for National Statistics, 2022; Olsen et al., 2018a). However, WFH also seem to have disadvantages to these workers such as increased SB, which is linked to various health problems, including MSDs.

After the pandemic, many individuals have engaged in hybrid working instead of solely WFH. During the creation of this study, only two studies (from the same research group) had explored SB while engaging in hybrid working (Olsen et al., 2018b, 2018c). In one study, desk-based workers perceived and recognised increases of sitting while WFH when compared to the office, accrediting these problems to online communication such as email communication, and online meetings becoming more frequent, in opposition to the workplace where they must stand up from their desks, and walk to a meeting location (Olsen et al., 2018c).

The second study from Olsen et al. (2018b) was an intervention targeting sitting reduction at both home and office settings. The study also quantified occupational sitting with the use of accelerometers. Following a 6-week intervention (while working at home once a week), it was found that participants' sitting time increased by 20.5 minutes per day while WFH, when compared to the office (rest of the week) (Olsen et al., 2018b). Differently, when participants carried out their work at an office, sitting time was decreased by 40% (56 minutes per day). Nevertheless, these workers only worked one day at home, whereas nowadays many people might spend most of their week WFH.

From both studies (Olsen et al., 2018b, 2018c), it is evident that the home environment exacerbates the prevalence of SB. The increase in SB might be related to various aspects of WFH. For example, at home, most of the work activities (e.g., meetings) are carried out in front of a screen, whereas at the office these involve moving to a different location. The absence or reduction of commuting time and incidental movement (e.g., walking for a toilet break, walk outside the building during lunch or teatime), might also contribute to SB increases while WFH. Thus, creating further challenges for desk-based workers to reduce their occupational SB.

To summarise this section, WFH became the norm during the COVID-19 pandemic and has continued to be common post-pandemic. WFH appears to exacerbate the already high prevalence of SB in desk-based workers. Also, it is evident that during hybrid work, the prevalence of SB is higher at home when compared to the office. Considering this, it is expected that desk-based workers increase various health problems related to prolonged SB. For example, higher levels of SB while WFH appear to be associated with a high prevalence of MSK symptoms. Nevertheless, other factors might be also influencing the prevalence of MSK symptoms. These are discussed in the next section.

WFH and ergonomic guidelines

Desk-based work has become more dependant of visual display units (e.g., desktop computer or laptop), at the office or when WFH. Poor ergonomic postures related to the use of new and portable technologies and electronic devices (e.g., laptops, tablets, phone) have been suggested to be a risk factor for the development of spinal, arm and leg MSK symptoms (González-Menéndez et al., 2019; Honan, 2015).

Appropriate ergonomic settings are essential to avoid MSK problems in desk-based workers. However, setting up workstations at home can be challenging and might not be straightforward for many desk-based workers. Due to the COVID-19 pandemic, improvised working spaces were arranged at home creating work settings where ergonomic guidelines could not be followed correctly.

Davis et al. (2020) explored the ergonomic design of home workstations and the most frequently used electronic devices in university staff WFH during COVID-19. From 46 participants, three quarters of participants used laptops as monitors, with a high percentage (65%) of laptop monitors set lower than recommended by ergonomic guidelines (Davis et al., 2020). Other ergonomic problems found were lack of back support, no lumbar support, chairs at incorrect height, and external monitors set lower than indicated ergonomically (Davis et al., 2020). In relation to this, evidence from various studies has indicated that incorrect ergonomic settings can cause MSK pain and discomfort.

Combined evidence has signalled that using non-adjustable chairs is an influencing factor for developing MSK pain and discomfort in desk-based workers (Galof & Šuc, 2021; Rodrigues et al., 2017; Yorulmaz et al., 2022). Further evidence from Radulović et al. (2021) indicated that not having an ergonomic chair at home or an adequate office desk increased MSK symptoms in desk-based workers during the COVID-19 pandemic. In addition, Rodrigues et al. (2017) found that incorrect chair height and armrests seemed to be contributors to MSK pain development in desk-based workers.

Laptop use is more frequent while WFH and various problems are present from using these display units (Davis et al., 2020). One challenge would be the difficulty to follow ergonomic guidelines while using laptops, as laptop screens are positioned lower than desktop screens (Davis et al., 2020). Additional research of laptop users has indicated increases of neck, upper and lower back discomfort after engaging in laptop use for over one hour (Heidari et al., 2019). Both studies suggested that there are challenges present when using portable technologies such as laptops. Moreover, if the laptop is set up incorrectly it can contribute to an increase of MSK symptoms. Nonetheless, current evidence is limited, and needs to be expanded to understand if ergonomic settings contribute to the MSK prevalence at the home environment.

Summary and knowledge gap

Along with the unprecedented growth of desk-based workers leaving their offices to WFH due to the COVID-19 pandemic, it was expected that these work settings would affect desk-based workers' health. Nowadays, hybrid work has become more predominant among desk-based workers (Office for National Statistics, 2022).

Desk-based workers are likely to be more sedentary at home due to various factors (e.g., the absence of daily commuting, online meetings whilst sitting) (Bloom et al., 2015; Olsen et al., 2018a, 2018b, 2018c). An increase of SB at the home environment, when compared to the office, has been identified in desk-based workers (Olsen et al., 2018a, 2018b). This increase was also observed in adults WFH during the quarantine period, which seems to intensify MSK symptoms such as pain and discomfort (Moretti et al., 2020; Šagát et al., 2020; Sañudo et al., 2020; Zheng et al., 2020).

Breaking up sitting has been signalled to prevent and aid detrimental health outcomes, including MSK pain and discomfort (Agarwal et al., 2018; Waongenngarm et al., 2018). Nevertheless, there is limited research of the effects of breaks from sitting in the home environment.

In addition to prolonged SB, inadequate ergonomic work settings (e.g., chair, laptop use) and poor working postures may increase MSDs amongst adults while WFH (Davis et al., 2020; González-Menéndez et al., 2019; Honan, 2015). Although some studies have explored MSK symptoms in desk-based workers, there is limited evidence of these outcomes when WFH. Contemplating the limited evidence in relation to the home environment as a workplace, this study focused on addressing these shortcomings.

Study aims and objectives

This study focused on increasing knowledge on various outcomes related to the WFH environment. The study aimed to explore differences in MSK symptoms prevalence between groups defined by occupational sitting, breaks from sitting and ergonomic chair settings. In addition, it was hypothesised that highest occupational sitting time would be reflected in higher MSK symptoms prevalence.

The research objectives were:

1. Describe self-reported occupational sitting, self-reported breaks from sitting (number and duration), and ergonomic settings while WFH.
2. Describe self-reported MSK symptoms prevalence while WFH.
3. Explore differences in MSK symptoms between groups defined by their total occupational sitting time.
4. Explore differences in MSK symptoms between groups defined by number and duration of breaks from sitting.
5. Explore differences in MSK symptoms between groups defined by ergonomic chair settings score.

Methods

Ethics

Ethical standards followed the British Psychological Society (BPS). Approval for the study was given by the Moray House of Education and Sport Research Ethics Committee (Reference: AN17022021-1). The Participants Information Sheet (detailing the study) and consent form were embedded as a section of the online questionnaire (Appendix 1 respectively).

Study design

A cross-sectional study design was used to collect participants' data. This study was part of a larger project (Niven et al., 2022) with specific sections included to address the research questions of the thesis. The project was presented to participants as an online survey (Appendix 1) and contained the participants information sheet, consent form and it consisted of eight sections: 1. Demographic information; 2. How much do we sit whilst working from home; 3. What influences our ability to reduce our sitting time?; 4. Pain and discomfort. Cornell Musculoskeletal Discomfort Questionnaire; 5. The Warwick and Edinburgh Mental Well-Being Scale; 6. Work and Wellbeing survey; 7. Working from home facilities; 8. Anything else.

The data collected for this study was taken from sections 1, 2, 4 and 7 which are highlighted in Appendix 1.

Study population

Considering that desk-based workers such as academics, professionals and secretarial staff have been classified as the largest group (57%) WFH in the UK (Watson, 2020, March 24), this study focused on university staff. There were thirteen thousand office staff at the University of Edinburgh (UoE) (including colleges staff and secretaries, and excluding corporate services), and nine thousands of these workers had a full time equivalent contract (during the creation of the study) (The University of Edinburgh, 2021a). Many of the staff were WFH since the office closures caused by the COVID-19 pandemic.

Inclusion criteria were UoE staff over 18 years old, WFH with frequent computer use. No specific exclusion criteria were used for this study.

Measures and outcomes

Demographic information.

Demographic data were collected from participants: age, gender, ethnicity, height, weight, job type, type of work contract (e.g., full-time), length of work for UoE.

WFH ergonomic workstations.

A description of the home workstations was provided through general questions. Based on two recent studies during COVID-19 (Davis et al., 2020; Moretti et al., 2020), key information related to home workstations were collected. This included data related to their WFH space (home space), input device (laptop, desktop), number of monitors, and type of desk (sitting, standing, other).

Self-reported musculoskeletal symptoms

The Cornell Musculoskeletal discomfort questionnaire (CMDQ) (Hedge et al., 1999) was used to assess self-reported musculoskeletal discomfort or pain at eighteen body areas (neck, left and right shoulders, upper back, left and right upper arms, lower back, left and right forearms, left and right wrists, hip/buttocks, left and right thigh, left and right knees, and left and right lower legs). CMDQ has been indicated to have high content and face validity, moderate concurrent validity, and test-retest reliability for all components when tested in desk-based workers with MSDs (Shariat et al., 2016).

The CMDQ was used as a descriptive tool to determine last 7-days participant's pain or discomfort. The CMDQ consists of three main questions asked in relation to each examined body area. One question related to pain frequency *(1. During the last work week how often did you experience ache, pain, discomfort in? Five possible answers [Never, 1-2 times last week, 3-4 times last week, once every day, several times every day])*, one related to pain intensity *(2. If you experienced ache, pain,* *discomfort, how uncomfortable was this? Three possible answers [Slightly, moderate, and very uncomfortable])*, and one related to work interference due to pain/discomfort *(3. If you experienced ache, pain, discomfort, did this interfere with your ability to work? Three possible answers [Not at all, slightly interfered and substantially interfered]).* Scoring guidelines for the CMDQ were followed for each question (frequency score [0, 1.5, 3.5, 5, 10], discomfort score [1,2,3] and interference score [1,2,3]) by summing the rating scores (Hedge et al., 1999).

Results from the three questions were summed individually per body area (eighteen areas). MSK final values were used to create a dependent continuous variable. This variable was used to examine group differences with independent variables (occupational sitting, breaks from sitting, and ROSA score).

Self-reported occupational sitting time and breaks from sitting

Two tools were used to capture relevant aspects of sitting patterns while WFH, including breaks from sitting. Although some similarities were present in the questions included in these tools (e.g., During the last 7 days, how many days were you at work?), repetitiveness was avoided by applying recurring questions only once. These tools are described below.

Occupational Sitting and Physical Activity Questionnaire (OSPAQ).

The Occupational Sitting and Physical Activity Questionnaire (OSPAQ) (Chau et al., 2012) is a self-reported questionnaire used to collect data on self-reported occupational sitting and occupational physical activity. This tool has been indicated to have good test-retest intra-class reliability for its domains (Bakker, Hartman, et al., 2020).

The OSPAQ has three questions, one explores total working hours *("How many hours did you work in the last 7 days?" # of hours*), one related to the working days (*"During the last 7 days, how many days were you at work?" # of days*), and the third question explores various domains of activities performed at work that are answered in percentages to summarise a 100% of the working day (*"How would you describe your typical workday in the last 7 days?" Four domains: a) sitting (including driving), b) standing, c) walking, d) heavy labour or physically demanding tasks*).

Results from the OSPAQ were converted into minutes per day by using the OSPAQ scoring guidelines (total working hours/days of work per week * sitting, standing, walking, heavy labour) (Chau et al., 2012). The OSPAQ score was used to create the independent variable 'groups of sitting'.

Workforce Sitting Questionnaire (WSQ). The Workforce Sitting Questionnaire (WSQ) (Chau et al., 2011) was used to complement the OSPAQ tool. This tool is used to capture sedentary behaviour during working and non-working days. The tool has been indicated to have fair to excellent test-retest reliability for all its domains (Chau et al., 2011).

The WSQ has two questions. The first question explores the time spent sitting during the week ("*During the last 7 days, please estimate how much time you usually spend SITTING in each of the following activities on a WORKING day and a NON-WORKING day"*) and entail five domains ("*a) Transport; b) At work; c) Watching TV; d) Using a computer at home; e) Other leisure activities [not including TV or computer use]*"). The responses are open ended in hours and minutes. The second question (which is similar to the OSPAQ) explores working days during a seven-day week (*"During the last 7 days, how many days were you at work?"*), and the responses are open ended.

The data obtained from this tool was not used for the data analyses as participants overreported (e.g., sitting for 28 hours in a day spread across domains) their total SB during the week. Therefore, only the data from the OSPAQ was used for the data analyses.

Breaks from sitting

The Sudholz et al. (2018) questionnaire assessed breaks from sitting while WFH. The two components of this tool have showed fair construct validity, and good test-retest reliability when compared to ActivPAL3 inclinometer and ActiGraph accelerometer in sedentary adults.

Participants' breaks from sitting per hour (during work) were explored using the second question of this tool (*"In the last 7 days, how many breaks from sitting did you take per hour, while at work? This could include standing, stretching, taking a short walk. Do not count lunch or tea breaks", with 7 possible answers [0, 1, 2, 3, 4, 5, 6 or more]*). The Sudholz et al. (2018) limits the number of breaks to 6 breaks per hour. Data from the first question on occupational time was not used to inform the sitting time data in this study ("*During the last 7 days, how much time did you usually spend sitting at work on a weekday?" open answer with hours and minutes box*). Data of numbers of breaks from sitting were used to create the independent variable 'number of breaks from sitting'.

Two additional questions (1. "*How long were these breaks from sitting?" Open response in minutes", 2. "In the last 7 days, how many workdays did you work at home?", 7 answers [1,2,3,4,5,6,7]*) were added to the online questionnaire to explore participants working days while WFH. These data were used to create groups for the independent variable 'breaks from sitting duration'.

The Sudholz tool states that tea and lunch breaks are not considered as a break from sitting. The question was included verbatim from the text to explore solely short breaks from sitting which can be carried out while working. Contemplating that lunch and tea breaks might be carried out during established break times (e.g., one-hour lunch break), while seated and their duration might be lengthier than a short break these breaks were not considered for this question.

Rapid Office Strain Assessment (ROSA)

An adapted version of the Rapid Office Strain Assessment (ROSA) (Sonne et al., 2012) was used to collect data of the participants chair settings. ROSA tool is used to "quickly quantify risks associated with computer work" and it has displayed high inter and intra-observer reliability (Sonne et al., 2012).

Data collected were from ROSA section A: chair height, seat depth, armrests, and back support. These data was converted using the ROSA scoring guidelines (Sonne et al., 2012). A scoring table was used to get the chair score (chair seat pan/height compared to arms/back rest). As stated in the ROSA scoring guidelines, to produce the total chair score, total sitting hours were added to this sum considering participants sitting time per day (e.g., chair score of 4 + hours of sitting time). Afterwards, this score was used to create groups individuals with high risk of MSK symptoms (scores above 5) and low risk (scores below 5).

Procedure

An online questionnaire was created through Qualtrics (Qualtrics, Provo, UT, https://www.qualtrics.com). This online software is compliant to the General Data Protection Regulation (GDPR). All self-reported tools, assessing outcomes of interest to this research, were uploaded to the online questionnaire.

Invitations to participate in the study were shared to UoE staff as a link through email (e.g., staff bulletins), and in social media posts (Twitter and Facebook). The online survey was active for four weeks (13^{th} of April 2021 to 11^{th} of May 2021). During the recruitment and data collection stage Scotland moved from protection level 4 (office workers to work from home exclusively) to level 3 (office workers work from home where possible) on the 26^{th} of April 2021. Completing the eight sections of the survey took an average of 15 to 20 minutes.

All responses were anonymous and untraceable. After completing the survey, participants were given the opportunity to participate in a £50 voucher prize draw by providing their email. In addition, participants were given the option to give their email to be contacted for future research. The data for the voucher prize and participation in future research were kept separately from the survey data.

Data analyses

Missing data and outliers

All the questions in the online survey were optional to responders, with no force response option activated. This might have cause various missing values were found. Values were considered as missing when a response was shown as not recorded in the survey, and they were omitted from the main analyses, but still represented as 'missing' in the system outputs.

Outliers were identified during the data analysis for all the independent variables (breaks, sitting, ergonomic chair score). The outliers were explored using the dataset and checked individually per variable to identify their source (e.g., underlying health conditions of participants). The exploration of the outliers did not suggest any evidence of underlying conditions that affected the data. The data were reanalysed, and two separate Kruskal-Wallis tests were carried out to examine if the results were influenced by the outliers' data. One analysis was done by keeping the outliers' data in the dataset. The second analysis consisted of removing outliers from the data and then repeat the statistical test. Both analysis were consistent in results (not significant group differences on MSK symptoms for any variable). Considering the results were not significantly altered it was decided to keep the outliers' data and report these results.

Data analysis

All data were processed using SPSS IBM version 25 software. Descriptive statistics were used to present participant characteristics (mean, standard deviation, median, range and frequencies). Data normalities were analysed carrying out the Kolmogorov-Smirnov test for all variables. The Kolmogorov-Smirnov tests indicated that data distribution for MSK symptoms $D(332)=0.167, p<0.000$ were not normally distributed. Equivalent results for data distribution were found for sitting $D(327)=0.154, p<0.000,$ number of breaks from sitting $D(324)=0.301, p<0.000$, duration of breaks $D(329)=0.303, p<0.000,$ and chair score $D(309)=0.212, p<0.000.$

As data did not follow a normal distribution, non-parametric tests were used. MSK symptoms were considered as a dependent continuous variable, and sitting, breaks from sitting and chair scores were considered as categorical ordinal variables and groups were created (transforming the variables into categories) to analyse the data.

The Kruskal-Wallis test was used to explore differences between groups of variables with MSK symptoms. Post-hoc analysis using pairwise comparisons with Bonferroni corrections (three comparisons, [0.05/3], significance level $p< 0.0166$) were carried out where there was a significant main effect to understand group differences. Effect sizes were calculated for all comparisons using the formula $r=z/\sqrt{N}$ (z-score/square root of number of observations). Results were interpreted using Cohen's guidance (Cohen, 2013) and described as small (0.2), medium (0.5) and large (0.8) effect sizes.

Groups of variables of interest. The groups for each variable of interest were created considering various aspects. For groups of sitting, variables were grouped contemplating current literature suggesting the onset of MSK symptoms starts at 4 hours of prolonged SB (Kett et al., 2021), with the onset of additional MSK concerns at 6 hours (Basakci Calik et al., 2022; Heneghan et al., 2018) and 8 hours (Rabal-Pelay et al., 2019). Therefore, staff were divided in four groups, sitting for less than 4 hours (group 1), over 4 to 6 hours (group 2), over 6 to 8 hours (group 3), and over 8 hours (group 4).

Current literature exploring breaks from sitting do not provide information about the 'ideal' frequency or duration of breaks from sitting to reduce MSK symptoms yet. Consequently, for groups of breaks from sitting, it was decided to create the variables to test if the MSK symptoms prevalence was different in people taking breaks from sitting (group 1) against people not taking breaks from sitting (group 2). Similarly, for duration of breaks, groups were created to differentiate between the prevalence of MSK symptoms in various breaks lengths. The groups were breaks duration of 0 to 4 minutes (group 1), 5 to 10 minutes (group 2), and over 10 minutes (group 3).

Lastly, for chair scores, groups were formed using the guidance from ROSA (Sonne et al., 2012), where scores of below 5 (group 1) or above 5 (group 2) identify people with low or high risk for MSDs development (respectively).

Results

Sample characteristics

A total of n=332 desk-based UoE staff completed the online survey. Participants mean height were 169.2 (SD 8.8) cm, weight 74.2 (SD 18.8) Kg, with a BMI of 25.7 (SD 6.1) kg/m^2. From the total sample, most staff were female (72.9%) of white ethnicity (92.8%). Age range was varied with the highest percentage (33.4%) being workers of 41 - 50-years. Most of the workers were fulfilling professional services roles (71.7%). A high number of workers had a full-time contract (82.2%), and more than half (59.9%) had worked for the University for 1 - 10 years. Participants reported working 4.7 (SD 1.0) days from a 7-day working week. Participants worked an average of 35 hours per week (SD 9.3). Table 10 summarises the general characteristics for participants.

Table 10

General characteristics of participants (n=332).

Variable	Mean (SD)	Median (Range)
Height (cm)	169.2 (8.8)	168.0 (46.0)
Weight (Kg)	74.2 (18.8)	70.0 (154.0)
BMI	25.7 (6.1)	24.2 (59.3)
Age range	**Total N (%)**	
18 – 30	36 (10.8%)	
31 – 40	97 (29.2%)	
41 – 50	111 (33.4%)	
51 – 60	70 (21.1%)	
61+	18 (5.4%)	
Gender		
Male	85 (25.6%)	
Female	242 (72.9%)	
Non-binary/ third gender/ Prefer not to say	5 (1.5%)	
Ethnicity		
White	308 (92.8%)	
Mixed ethnicity	6 (1.8%)	
Asian, Scottish Asian, British Asian	6 (1.8%)	
Other ethnic groups	6 (1.8%)	
African, Scottish African, British African/Caribbean or Black	3 (0.9%)	
Work characteristics		
Job type		
Professional services	238 (71.7%)	
Academic	77 (23.2%)	
Technician	5 (1.5%)	
Other	11 (3.3%)	
Contract type		
Full-time (1.0 FTE)	273 (82.2%)	
Part-time (≥ 0.6 FTE)	48 (14.5%)	
Part-time (< 0.6 FTE)	11 (3.3%)	
Length of work at the University		
Less than 1 year	26 (7.8%)	
1 – 10 years	199 (59.9%)	
11 – 20 years	66 (19.9%)	
20+ years	41 (12.3%)	

Ergonomic settings at home

UoE staff used different types of workstation and input devices while WFH. Most staff (84.6%) used a laptop device either on its own or connected to an external monitor and a peripheral mouse (56.3%). The second most used workstation (22.6%) was desktop computer including monitor, keyboard and mouse. Participants also reported using 1 monitor (44.5%) or 2 monitors (43.6%). Lastly, the most popular type of desk amongst the participants was a sitting desk (59.4%). The second highest percentage (27.6%) indicated to use 'Other' type of working desk. Among these other arrangements, were reported the use of various house furniture as a desk (e.g., coffee table, kitchen table, sofa). Table 11 illustrates the main findings regarding the participants working settings while WFH.

Table 11

Ergonomic settings while working from home.

Type of workstation	Total number (percentage %)
Desktop including monitor, keyboard and mouse	75 (22.6%)
Laptop connected to an external monitor, including mouse	187 (56.3%)
Laptop (no external mouse or keyboard)	50 (15.1%)
Laptop with mouse	56 (16.9%)
Laptop with external keyboard	56 (16.9%)
Other	18 (5.4%)
Number of monitors	
1	145 (44.5%)
2	142 (43.6%)
Other	39 (12.0%)
Desk type	
Sitting desk	196 (59.4%)
Standing desk	13 (3.9%)
Sitting table	30 (9.1%)
Various house surfaces (e.g., kitchen table, sofa, coffee table)	93 (27.6%)

Self-reported pain and discomfort – CMDQ

Eighteen bodily areas were assessed using the CMDQ. From n=332 participants, 93% showed at least one MSK symptom (7% were asymptomatic). Highest prevalence of self-reported pain were found on neck (65.4%), lower back (64.8%), and right shoulder (48.5%). MSK prevalence was 25.7 (SD 7.4, *Mdn*=24.0, range=45.0). Table 12 illustrates pain and discomfort prevalence for all the CMDQ assessed areas.

Table 12

Prevalence of bodily pain and discomfort using the Cornell Musculoskeletal Discomfort Questionnaire.

Body area	Total number, Musculoskeletal symptoms prevalence (%)
Neck	217 (65.4%)
Right shoulder	161 (48.5%)
Left shoulder	130 (39.2%)
Upper back	140 (42.2%)
Right upper arm	77 (23.2%)
Left upper arm	58 (17.5%)
Lower back	215 (64.8%)
Right forearm	91 (27.4%)
Left forearm	49 (14.8%)
Right wrist	112 (33.7%)
Left wrist	59 (17.8%)
Hip/buttocks	148 (44.6%)
Right thigh	60 (18.1%)
Left thigh	59 (17.8%)
Right knee	95 (28.6%)
Left knee	80 (24.1%)
Right lower leg	62 (18.7%)
Left lower leg	60 (18.1%)

Occupational sitting - OSPAQ

Participants WFH showed high percentage of occupational sitting, with staff sitting for 89.5% of their working day. Participants' working day varied depending on their type of contract (e.g., FTE, 0.5 FTE) and the average of time spent in each OSPAQ domain was calculated for working days only. Average sitting was 395.7 (SD 99.2) minutes per day, or 6.5 (SD 1.6) hours per day. Table 13 illustrates the OSPAQ results reported per domain.

Table 13

Results from the Occupational Sitting and Physical Activity Questionnaire per domain.

Activity	Percentage per day	Minutes Mean (SD)	Minutes Median (Range)
Sitting	89.5 %	395.7 (99.2)	411.6 (690.9)
Standing	6.5%	29.0 (62.2)	8.4 (432.0)
Walking	3.7%	16.7 (27.5)	1.5 (201.6)
Heavy labour	0.3%	1.3 (6.8)	0.0 (50.4)

Group differences for occupational sitting in relation to MSK symptoms

Sitting time data were split in four groups. Group 1: Sitting less than 4 hours, group 2: sitting over 4 to 6 hours, group 3: sitting over 6 to 8 hours, group 4: sitting over 8 hours. Table 14 illustrates descriptive data for MSK symptoms in relation to groups of sitting time, and descriptive data for each sitting time group.

Table 14

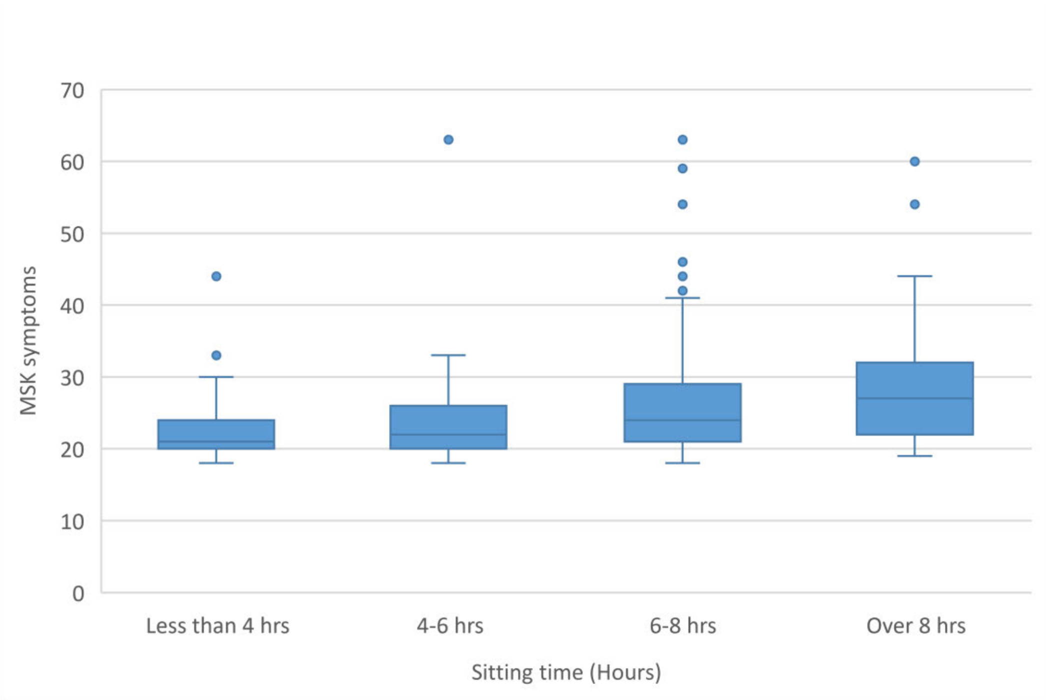
Sitting time descriptive data organised in quartiles in relation to MSK symptoms.

Sitting time per day	N	Sitting Mean (SD)	Sitting Median (Range)	MSK symptoms Mean (SD)	MSK symptoms Median (Range)
Group 1	23	133.7 (77.9)	144.0 (236.2)	23.1 (6.1)	21.0 (26.0)
Group 2	61	326.7 (27.2)	336.0 (110.0)	23.4 (6.3)	22.0 (45.0)
Group 3	202	418.5 (30.7)	420.0 (115.7)	26.0 (7.2)	24.0 (45.0)
Group 4	41	535.8 (50.0)	516.0 (204.9)	28.5 (9.1)	27.0 (41.0)

A Kruskal-Wallis test was used to explore differences in MSK symptoms between groups of sitting. There was significant strong evidence for differences between the groups; *H(3)=21.1, p=0.000*. Bonferroni corrections (p=0.0166 level) revealed differences were found only between group 1 and group 4 (*p=0.006, r=0.39)*. However, no differences were found between group 1 and group 2 (*p=1.000, r=0.06)*, or group 1 vs group 3 *(p=0.054, r=0.17).* This indicated that longest sitting time (over 8 hours) had significantly higher MSK symptoms scores when compared to lowest sitting time (less than 4 hours). Figure 5 illustrates sitting group differences in relation to MSK symptoms.

Figure 5

Boxplots illustrating group differences for sitting time groups in relation to MSK symptoms.



Breaks from sitting – Sudholz tool

Most of the participants took breaks every hour (68.4%). Furthermore, results from the Sudholz tool signalled participants took 1.3 (SD 1.4) breaks from sitting per hour of work. Additionally, breaks durations showed to be 5.38 (SD 7.0) minutes.

Descriptive data were split into two groups (group 1: no breaks, group 2: 1-6 breaks per hour) to explore breaks from sitting and three groups for breaks duration (group 1: 0-4 min, group 2: 5-10 min, group 3: over 10 min). Table 15 illustrates descriptive data for both break variables (number and duration), and in relation to MSK symptoms prevalence.

Table 15

Breaks from sitting descriptive data in relation to MSK symptoms.

Number of breaks per hour	N	Breaks Mean (SD)	Breaks Median (Range)	MSK symptoms Mean (SD)	MSK symptoms Median (Range)
No breaks	105	0.1 (0.2)	0.0 (0.7)	25.3 (6.8)	23.0 (41.0)
1-6 breaks	219	1.9 (1.3)	1.0 (5.0)	25.8 (7.7)	24.0 (45.0)
Breaks duration					
Group 1 (0-4 min)	257	1.3 (1.3)	2.0 (5.0)	25.4 (7.3)	23.0 (42.0)
Group 2 (5-10 min)	52	6.4 (2.2)	5.0 (5.0)	25.8 (7.5)	24.0 (45.0)
Group 3 (>10 min)	23	24.6 (16.3)	16.0 (48.0)	25.2 (5.0)	25.0 (19.0)

Group differences for breaks from sitting in relation to MSK symptoms

Kruskal-Wallis tests were carried out to examine differences between groups for number and duration of breaks from sitting. No significant differences were found for groups of number of breaks from sitting, $H(1)=0.39, p=0.52$. Likewise, no significant group differences were found for groups of breaks duration, $H(2)=0.66, p=0.71$. Figure 6 and 7 illustrates group comparisons for number of breaks from sitting and breaks duration respectively, in relation to MSK symptoms scores.

Figure 6

Boxplots illustrating group differences for number of breaks from sitting in relation to MSK symptoms scores.

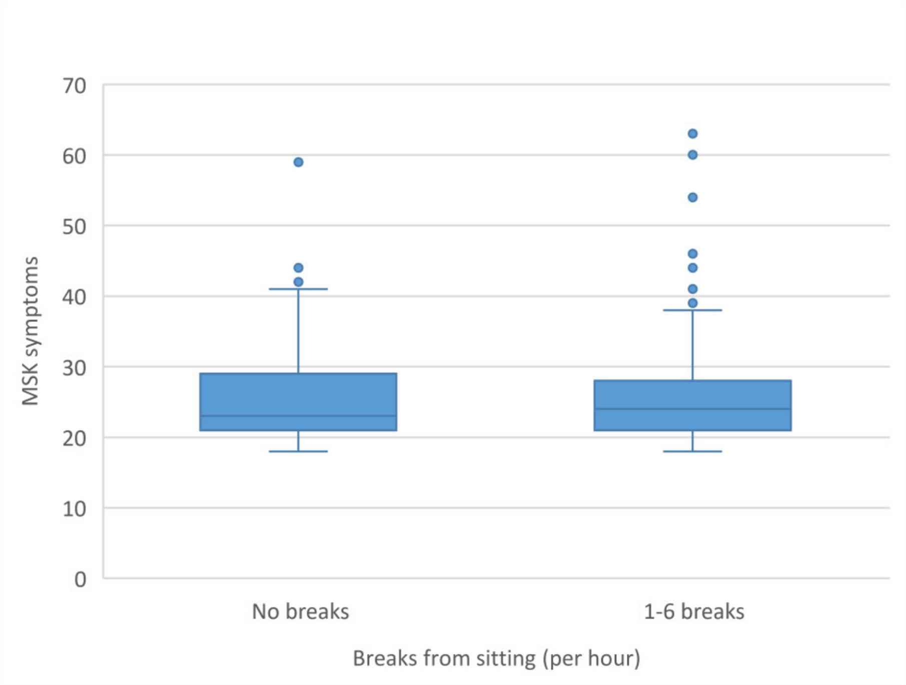
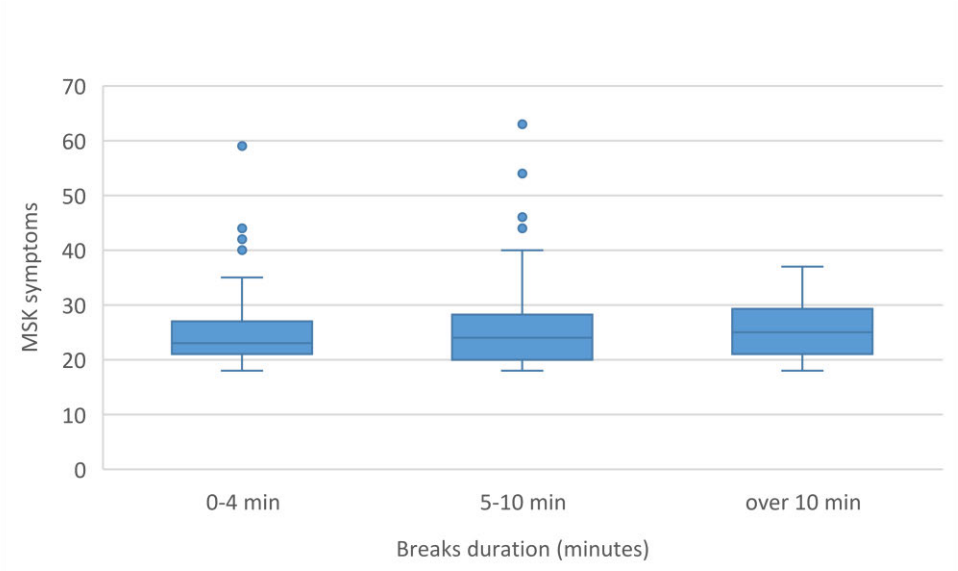


Figure 7

Boxplots illustrating group differences for breaks duration in relation to MSK symptoms scores.



Ergonomic chair settings - ROSA

From the total sample, n=331 participants (of 332) responded the questions related to the Rapid Office Strain Assessment (ROSA) (Sonne et al., 2012) chair assessment. Chair assessment involved selecting the relevant options for the primary used chair (height, seat depth, armrests and back support). Score was calculated following the section A from the ROSA guidance for chair assessment (Sonne et al., 2012). A sum of total chair score and total sitting duration (sitting for less than 1 hour per day: score -1, 1-4 hours per day: score 0, over 4 hours: score +1) were used to calculate chair score. According to the guidance, scores of five or over indicates 'high risk' of musculoskeletal development. Total chair assessment indicated an M=3.5 (SD 1.2), with most participants having scores of less than five (80.6%). Table 16 illustrates descriptive data for ROSA scores grouped in low and high risk of musculoskeletal development.

Table 16

ROSA descriptive data split into low and high risk of musculoskeletal development.

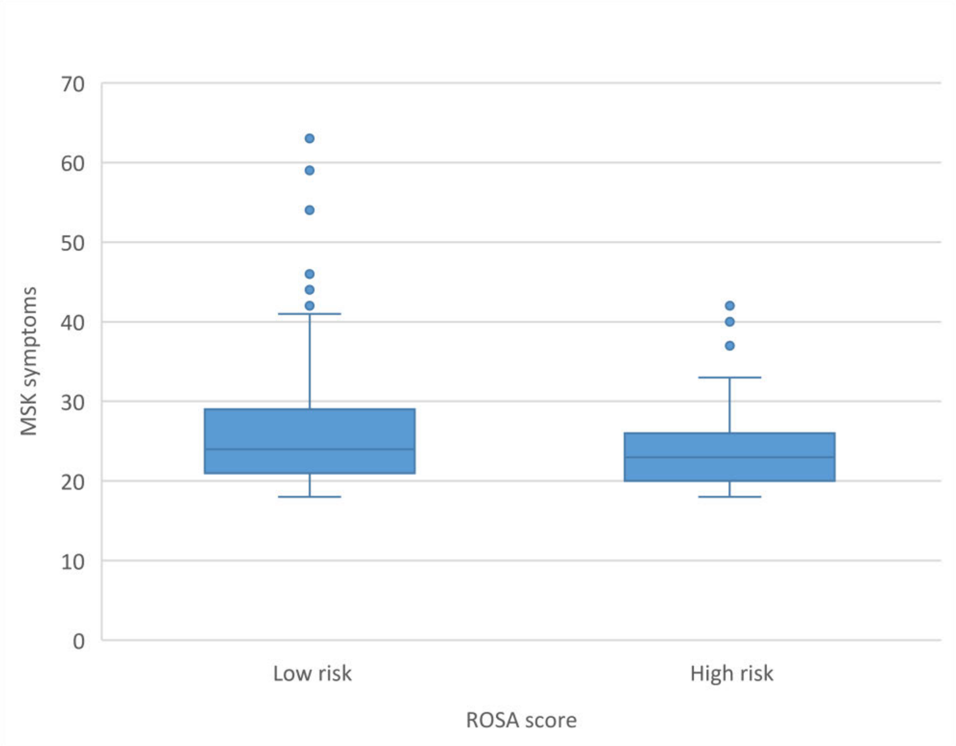
ROSA chair scores	N	ROSA Mean (SD)	ROSA Median (Range)	MSK symptoms Mean (SD)	MSK symptoms Median (Range)
Low risk (Score <5)	249	3.3 (0.9)	3.0 (4.0)	26.0 (7.6)	24.0 (45.0)
High risk (Score >5)	82	6.1 (0.5)	6.0 (2.0)	25.2 (7.0)	23 (24.0)

Group differences for ROSA score in relation to MSK symptoms

Kruskal-Wallis tests indicated that there were no significant differences between ergonomic chair settings for both groups (low and high risk), *H(1)=0.62, p=0.43,* on MSK symptoms prevalence. Figure 8 illustrates group comparisons for ROSA scores in relation to MSK symptoms.

Figure 8

Boxplots illustrating group differences for ROSA scores in relation to MSK symptoms scores.



Discussion

Confinement due to the COVID-19 pandemic forced desk-based workers to WFH. After two years, desk-based workers continue WFH, for some (hybrid work) or all their working week. Previous literature of desk-based workers WFH indicated that these workers engage in longer occupational SB periods when compared to the office (Olsen et al., 2018a, 2018b). The increase of SB at home has been linked to increased prevalence of MSK symptoms in these workers.

This study focused on expanding knowledge of a novel work setting, the home environment. The aim of the study was to explore differences between groups defined by occupational sitting time, breaks from sitting and chair settings in relation to MSK symptoms prevalence in UoE staff WFH. Research objectives were to describe occupational sitting time, breaks from sitting, ergonomic chair settings and musculoskeletal symptoms prevalence in UoE staff while working from home (WFH). It was also hypothesised that the highest occupational sitting time would be reflected in higher MSK symptoms prevalence.

There main findings in this study are. Firstly, UoE staff sat for most of their working day (89% of their day) while WFH. Secondly, participants showed a high prevalence of MSK symptoms while WFH (93%). Thirdly, staff with the longest sitting time (over 8 hours per day) showed a significantly higher prevalence of MSK symptoms than those with the lowest sitting time. Thus, supporting the study hypothesis. Lastly, a large number of participants (68.4%) reported taking a high number of breaks from sitting (1.3 breaks per hour) which differs from current SB literature. The main findings are discussed in the following sub-sections.

MSK symptoms while WFH

Increases in sitting time have been associated with a higher prevalence of MSK symptoms in desk-based workers (Ardahan & Simsek, 2016; Dockrell et al., 2015; Jun et al., 2017). In this study, a high prevalence of MSK symptoms (93%) was found in UoE staff WFH. Most staff had at least one MSK symptom, and the most prevalent body areas were neck (65.4%), lower back (64.8%), and right shoulder (48.5%). These findings are consistent with current literature of MSK symptoms prevalence in desk-based workers during and after the pandemic (Argus & Pääsuke, 2021; Gerding et al., 2021; Matsugaki et al., 2021; Moretti et al., 2020; Prieto-González et al., 2021; Radulović et al., 2021; Šagát et al., 2020; Yorulmaz et al., 2022).

High prevalence of 81% for MSK symptoms was indicated by Argus and Pääsuke (2021), with the most prevalent areas being neck (50%), upper (31%) and lower back (45-50%). Increases on moderate to severe discomfort was also signalled by Gerding et al. (2021), from 21.5% (pre-COVID) to over 40% during periods of quarantine, with the highest prevalence on upper back-shoulders (49.7%), neck (46.8%) and lower back (42.8%). At Prieto-González et al. (2021), 61.3% of participants had spinal pain and discomfort with neck (74.8%) and lower back (67.6%) being the most prevalent areas. From Matsugaki et al. (2021) it was signalled that desk-based workers WFH had 49% prevalence of low back pain. Yorulmaz et al. (2022) also signalled a small increase of 6.6% prevalence of MSK symptoms in academics comparing findings from the office to the WFH environment. Additional evidence from Radulović et al. (2021) signalled increases on LBP (39.1%), upper back/neck (45.7%) and hand pain (27.2%) in people WFH, when compared to the office. Nevertheless, many of these studies were carried out during the quarantine periods. Thus, this might have an effect increasing MSK symptoms prevalence as individuals had less movement because they were restricted to be at home.

It seems evident that MSK symptoms prevalence is frequent in desk-based workers while WFH. Various factors might be contributing to MSK prevalence in these population. In some studies, this prevalence was linked to SB. However, literature from office settings has identified additional factors that might influence MSK prevalence. These factors were explored in this study (sitting time, breaks from sitting and ergonomic chair settings).

Occupational sitting time while WFH

UoE staff WFH sat for work for 89% of their working day (equivalent to 395.7 minutes, approximately 6.6 hours per day). These findings are comparable to research in desk-based workers where it was signalled that desk-based workers sat 68% to 82% of their entire working day (Clemes et al., 2014; Hadgraft et al., 2016; Parry & Straker, 2013b; Ryan et al., 2011; van Dommelen et al., 2016).

Systematic review evidence (Ráthonyi et al., 2021) signalled that workers reported higher occupational sitting time (18 of 24 studies) while WFH during the

COVID-19 pandemic, when compared to the office. Further primary research during confinement also suggested that sitting time for desk-based workers while WFH was longer when compared to the office (Aegerter et al., 2021; Fukushima et al., 2021; Guler et al., 2021; Javad Koohsari et al., 2021). The longest increase of sitting time while WFH was reported by Fukushima et al. (2021), where desk-based workers WFH sat 1.85 hours longer than workers not WFH. Additionally, Javad Koohsari et al. (2021) signalled that WFH for additional days a week was significantly associated to higher occupational sitting (when compared to the office).

It seems evident that desk-based workers have higher levels of occupational SB while WFH, in comparison to the office environment. However, many studies exploring WFH explored this outcome during the confinement periods which might have affected this prevalence. Nevertheless, previous literature has linked prolonged SB with many negative health outcomes, including MSDs.

Occupational sitting while WFH and MSK symptoms

This study found that UoE staff with the longest sitting time (over 8 hours) had a high prevalence of MSK symptoms. However, the prevalence of MSK symptoms in groups of staff sitting for less than 8 hours was unaffected. Contrary to this, review findings from Ardahan and Simsek (2016) indicated that prolonged sedentary time with computer use for over 4 hours was a risk factor for MSK symptoms incidence. Systematic review evidence from Dzakpasu et al. (2021) signposted that occupational sitting time with computer use for over 4 hours a day was associated with an increase of neck and shoulder MSK symptoms.

Further cross-sectional research (Prieto-González et al., 2021) also suggested that desk-based workers sitting for most of their day reported back and neck pain. However, the authors did not mention the length that these workers sat per day. This evidence strongly suggests that occupational sitting is a risk factor for MSK symptoms prevalence especially in the spine. Prolonged SB has various adverse health consequences (e.g., cardio-metabolic, cognitive, mental, musculoskeletal (Boscolo & Zhu, 2017; Dockrell et al., 2015; Ingram & Symmons, 2018; Jun et al., 2017; Saunders et al., 2020). Considering this, it is necessary to understand the underlying factors for this behaviour. However, the current study did not explore influencing factors for occupational sitting time. Therefore, further research is still needed to explore these factors in desk-based workers WFH.

Breaks from sitting

A study aim was to explore differences between groups for number and duration of breaks from sitting in relation to MSK symptoms. UoE staff reported having 1.3 breaks from sitting per hour of work, and their duration was approximately 5.38 minutes. Most participants took at least one break per hour (68.4%). Evidence for the duration of breaks while WFH is very limited in current literature, and to the author’s knowledge there is only one study presenting this information. The only study reporting breaks duration is Gerding et al. (2021), where participants reported taking a walking break of more than five minutes one to four times a day. Nevertheless, the author provided no further data about breaks duration. Therefore, a direct comparison of breaks duration cannot be made with the results of the current study.

Further literature exploring number of breaks from sitting while WFH showed similarities to this study findings. Although various authors Aegerter et al. (2021) reported participants’ breaks from sitting while WFH, the reporting of the outcomes were rather mixed. Guler et al. (2021) indicated that less than half of participants (34.5%) took one break every hour. Whereas more than half of the participants took one break every 2 to 4 hours. Comparably Gerding et al. (2021) study reported that the majority of university employees (71%) spent more than one hour without taking a break. From current literature, only Aegerter et al. (2021) reported number of breaks, where participants indicated taking 2.5 breaks per day. These results are rather different from these study findings where participants took 1.3 breaks per hour.

Current evidence appears to point out how a large number of desk-based workers WFH do not take breaks from sitting every hour while WFH. It is not possible to confirm why UoE staff reported taking more breaks when WFH than other individuals in current studies. A possible reason for this could be that staff had access to an online health and safety training (Cardinus – Online health and safety training) released by the Health and Safety department from the UoE. This training program contained information about healthy work at home (e.g., wellbeing, setting up ergonomic workstations), which could have been useful to create awareness for UoE staff while WFH. However, only 55% of participants reported taking this online training. Further examination of this topic would be useful to understand these findings.

Another finding from the study was that the prevalence of MSK symptoms was not different in the groups of breaks from sitting. Results indicated no significant differences between groups of participants who did and did not take breaks from sitting. The prevalence of MSK symptoms did not differ in groups taking breaks versus the groups who did not take breaks from sitting. Current literature of breaks from sitting and MSK symptoms in desk-based workers indicated mixed findings (Aegerter et al., 2021; Celik et al., 2018; Gerding et al., 2021; Guler et al., 2021; Nunes et al., 2021). Nunes et al. (2021) signalled that not interrupting sitting for 2-3 hours were significant risk factors for neck pain development in desk-based workers. Celik et al. (2018) found that desk-based workers taking less breaks at work had a higher incidence on neck pain. However, authors did not indicate how many breaks per hour these participants took. Aegerter et al. (2021) indicated that neck pain disability was reduced by having more breaks from sitting per day (2.4 breaks per day), but that number of breaks did not reduce significantly neck pain intensity. Comparably to this study findings, Gerding et al. (2021) and Guler et al.

(2021) also found no association between breaks from sitting and MSK symptoms prevalence.

It may be inferred from current literature that breaks from sitting have mixed effects on the prevalence of MSK symptoms. It seems apparent that not taking breaks often increases the risk of MSK symptoms. However, there is no agreement from current literature about this outcome. A possible explanation for this can be due to the problem that breaks from sitting research is still considered a novel research field. The limited standardisation regarding assessment of breaks from sitting creates challenges for current research to explore this outcome in the same manner.

Another factor influencing this study results may be accredited to the measurement tools. Existing literature (including this study) have used solely self-reported tools to measure breaks from sitting, which are subject to recall bias. While the Sudholz et al. (2018) tool has showed to measure breaks from sitting adequately having fair construct validity and good test-retest reliability, the device assessed measurement would be useful to complement self-reported measurement. Moreover, it would be valuable to collect specific data about the number and duration of breaks in desk-based workers, specially while WFH. Other unexplored influencing factors may have also influenced the prevalence of MSK symptoms. Study 1 (chapter 2) indicated that the most effective type of break to reduce MSK symptoms in desk-based workers was breaks from sitting combined with stretching. However, breaks type in desk-based workers WFH were not investigated in this study.

Further experimental research is necessary to understand what types of breaks from sitting desk-based workers can carry out while WFH. Research exploring if breaks from sitting are sufficient to counteract health issues associated with prolonged sedentary time, such as MSK symptoms prevalence, is still necessary.

Ergonomic settings

Additional factors that could have had an impact on the high prevalence of MSK symptoms in university staff, could be attributed to the workstations used while WFH. In relation to workstation type, this study found some similarities to other two studies of university staff during the COVID-19 pandemic (Davis et al., 2020; Gerding et al., 2021).

The majority of UoE staff used a laptop device (84%) either alone or combined with an external monitor. In the Gerding et al. (2021) study it was indicated that a large percentage (70%) of desk-based workers used only a laptop device. Davis et al. (2020) reported that less than half (39%) of workers used both laptop and external monitor. However, other participants also used a laptop on its own as a working device (but without a second monitor).

Considering these findings, it can be said that a large number of participants WFH use a laptop device. There is good evidence to suggest that the use of laptops are a risk factor for developing MSDs in desk-based workers (Heidari et al., 2019; Yu et al., 2018). Laptops provide challenges that prevent this device type to be adapted ergonomically. Laptop use has also been associated with an increase on neck and elbow flexion, as well as shoulder elevation (Heidari et al., 2019; Yu et al., 2018). Likewise, computer use of over 4 hours in general has also been identified as a risk factor of MSK symptoms development in desk-based workers (Ardahan & Simsek, 2016). A combination of both laptop use, and prolonged sedentary time might have contributed to MSK symptoms prevalence in UoE staff. However, as most staff did not use laptop devices solely (56.3% used laptops with an external monitor), this study did not explore the use of laptop in relation to MSK symptoms.

Other ergonomic factors such as chair settings (e.g., lumbar support, armrests) are signalled to be contributors to MSK symptoms development. This study explored chair settings using the ROSA score (Sonne et al., 2012). In this study, no group differences on MSK symptoms prevalence were found in participants from either 'low risk group' or the 'high risk group'. Thus, indicating that the MSK symptoms prevalence did not differ between groups of chair settings while WFH. A study from Rodrigues et al. (2017) employing the ROSA scale, signalled that individuals with higher ROSA scores had a higher prevalence of MSK symptoms. Additionally, these workers had also higher scores in the chair section from ROSA. This in contrast to these study findings, where ROSA groups (regardless their score) had no effect on MSK prevalence.

Additional literature contradicted also the results from this study. Prieto-González et al. (2021) and Gerding et al. (2021) signalled that inadequate ergonomic settings (e.g., not following ergonomic guidelines) increased pain and discomfort in desk-based workers. Galof and Šuc (2021) found a significant correlation with adjustable chair settings and back pain. Yorulmaz et al. (2022) indicated that individuals without an ergonomic chair had higher levels of MSK symptoms. Lastly, Radulović et al. (2021) signalled strong correlations between not having an ergonomic chair at home with LBP, upper/neck and hand pain.

It is important to point out that although ROSA tool is a reliable method to assess ergonomic risk factors, this study only explored ROSA chair settings excluding other categories from the assessment (monitor, keyboard, peripherals). This score was adapted from the scoring guidance, which might have affected the results of this study. Therefore, the ergonomic assessment of chair settings in this study might have been inadequate to assess fully ergonomic risks in staff.

Strengths and limitations

To the author's knowledge this is the first study exploring occupational sitting, breaks from sitting, ergonomic chair settings and MSK symptoms in desk-based workers while WFH. This study contributes to expand knowledge of these outcomes. In addition, this is the first study that explores differences between groups of sitting, breaks from sitting (number and duration) and ergonomic chair settings all in relation to MSK symptoms.

One of this study strengths is the use of tools with acceptable reliability and validity to assess dependent and independent variables. The adequacy and consistency of tools selected to measure the outcomes of interest of this study were key to understand fully SB at home. The study used a specific tool to measure breaks from sitting (Sudholz et al., 2018) whereas similar literature measuring breaks from sitting did not use specific tools to measure breaks from sitting (e.g. use of open answer questionnaire) (Aegerter et al., 2021; Celik et al., 2018; Gerding et al., 2021). The OSPAQ (Chau et al., 2012) has been showed to have good test-retest intra-class reliability in office settings. Additionally, the OSPAQ has showed fair levels of validity for sitting and standing in desk-based workers WFH (Dillon et al., 2021).

Study limitations are also present in this study. The exploration of ergonomic settings while WFH provided insightful information from University of Edinburgh staff workstations. However, the adapted version of the ROSA tool did not provide full information of other important ergonomic risk factors (monitor position, telephone, mouse and keyboard). It has been indicated that ROSA scores are useful to identify ergonomic risk factors and its relation to bodily discomfort in desk-based workers (Sonne et al., 2012). Further comprehensive research assessing ergonomic settings and their impact on MSK symptoms while WFH is still needed.

Another limitation of the study is not exploring other influencing factors to MSK symptoms development. Current literature has indicated that desk-based workers WFH not engaging in PA during lockdown had a higher prevalence in bodily pain and discomfort (Argus & Pääsuke, 2021; Prieto-González et al., 2021). Also, evidence from Rodríguez-Nogueira et al. (2020) found that desk-based staff who increased their PA during the confinement periods showed MSK symptoms reduction. This factor was unaccounted in this study. Other contributing factors to MSK pain and discomfort should be explored to gain understanding about what are the most relevant contributors.

The sample could have been more representative as most of the respondents were female (73%) and from white ethnicity (93%). For example, research staff from UoE has accounted for a 50/50 gender split and less than half (54%) are international staff (The University of Edinburgh, 2021b). Nevertheless, no data were found for professional services, which were the largest group of participants in this study (73%). It is also acknowledged that the total number of participants from this study might not be representative of the total amount of workers from the UoE (total 13,000) (The University of Edinburgh, 2021a). Research involving a larger and diverse sample of participants would be of interest to generalise study findings.

Another limitation is the cross-sectional nature of the study, which does not allow to fully infer the causality of MSK symptoms. Experimental research is necessary still to understand the relation of prolonged sedentary time and MSK symptoms at the home environment.

Lastly, the combination of various self-reported tools (e.g., OSPAQ, WSQ, Sudholz) might have influenced the results of the survey as some of the participants' responses might have been influenced by previous questions due to the social desirability effect (e.g., people reporting sitting for 80% of their day might have also thought they needed to report a higher or lower number of breaks).

Implication for research and practice

Although this study employed validated self-reported tools for data collection, the use of device assessed tools would be useful to complement these findings. Further research including device assessed methods is needed. Likewise, exploring other outcomes such as the nature and type of breaks would be useful to understand other desk-based workers behaviours while WFH (including workers engaging in hybrid working). The inclusion of PA outcomes may be useful as well to explore its effects on MSK symptoms while WFH. As current literature has indicated, desk-based workers WFH, not carrying out PA during lockdown, showed higher prevalence in bodily pain and discomfort (Argus & Pääsuke, 2021; Prieto-González et al., 2021). Therefore, assessing other influencing factors would be useful to understand the high prevalence of MSK symptoms in desk-based workers WFH.

The exploration of breaks from sitting is still needed to advance the understanding of their role to decrease SB at the home environment. Within this topic, the standardisation of breaks measurement is still needed to increase consistency and reliability. In addition, understanding the optimal break frequency and duration would be key to both reduce SB and MSK symptoms while WFH.

Given that incorrect ergonomic settings are a risk factor for MSK symptoms development (González-Menéndez et al., 2019; Honan, 2015) a thorough evaluation of these settings is needed in desk-based workers WFH. In addition, individualised ergonomic recommendations are necessary to decrease risk factors in the home working environment. Lastly, further research should focus on targeting sitting time reduction in desk-based workers WFH, especially in workers with MSK symptoms.

Conclusion

The COVID-19 pandemic accelerated changes in the work landscape. This study focused on expanding knowledge of occupational SB and MSK symptoms in a novel work setting. Main study findings are that UoE staff had high levels of occupational sitting time while WFH. High prevalence of MSK symptoms in staff WFH was also found in these workers. In addition, the highest prevalence of MSK symptoms was found in the group of participants with the highest sitting time (over 8 hours). On the other hand, no group differences for number and duration of breaks from sitting, and chair settings were found in relation to MSK symptoms prevalence, signalling that these outcomes were not significantly different between groups. Still, a large percentage of participants took more than one break from sitting per hour while WFH.

Further research is necessary to complement these findings. Particularly, research focusing on exploring additional influencing factors (e.g., PA) relevant to MSK symptoms development is needed. To decrease ergonomic risk factors, comprehensive evaluations of workstations at home are necessary. Additionally, personalised recommendations to adapt ergonomically adequate workstations while WFH are needed. Finally, interventions aiming to reduce occupational sitting in desk-based workers WFH, or engaging in hybrid working, are necessary. This would help to attenuate the negative health consequences of prolonged SB, and the prevalence of MSK symptoms while WFH.

Chapter summary

This chapter provided novel evidence in relation to the home environment in desk-based workers. This chapter also presented relevant evidence regarding MSK symptoms prevalence, occupational sitting time, breaks from sitting and ergonomic chair settings all while WFH. From the findings of this study, it was evident that desk-based UoE staff sat for a long time during their working days. Moreover, prolonged sedentary time was linked to MSK symptoms prevalence in groups of workers that sat for longer periods.

Considering these findings, it is important to understand the factors influencing SB and breaks from sitting in the home environment in UoE staff with MSK symptoms. Understanding such factors will allows us to support these workers to reduce their sitting while WFH. The next chapter focuses on exploring the factors influencing SB in UoE staff with MSK symptoms while WFH.

Chapter 4. Factors influencing SB in University of Edinburgh desk-based staff with musculoskeletal symptoms working from home

This chapter contains the third and final study of this PhD. This chapter considers the findings from study 2 (chapter 3) and aims to explore factors influencing SB in desk-based workers WFH by using behaviour change theory. Specifically, this study focused on University of Edinburgh staff experiencing MSK symptoms while WFH.

Background

Prolonged SB and computer use are risk factors to develop MSK pain and discomfort in desk-based workers (Dockrell et al., 2015; Jun et al., 2017). Primary research evidence suggests that desk-based workers with pain and discomfort have higher occupational SB than workers with no MSK symptoms (Bontrup et al., 2019; Zemp et al., 2016). WFH has gained popularity in the past years with desk-based workers carrying out remote work without stepping into an office (Bloom et al., 2015; Hassan et al., 2013; Messenger, 2017). Also, the accelerated growth of portable technologies has made remote work more frequent (Hassan et al., 2013).

In the UK, the COVID-19 pandemic accelerated the shift from working at an office to working remotely (Watson, 2020, March 24). After the COVID-19 pandemic, many workers expressed their desire to continue working at home or engaging in hybrid work (Nagel, 2020; Office for National Statistics, 2022). Pre-COVID-19 research has indicated increases of SB (20.5 minutes per day) in desk-based workers at the home environment when compared to the office (Olsen et al., 2018a). Also, when these workers were at the office, their SB was reduced by 56 minutes per day (Olsen et al., 2018a).

Increases of SB were also signalled during the COVID-19 lockdown period, ranging from additional 2.2 to 3.3 hours of sitting time per day (Sañudo et al., 2020; Zheng et al., 2020). Findings from study 2 (chapter 3) indicated that desk-based workers from the UoE had high levels of SB and reported sitting for most of their working day (89%).

In view of occupational SB being higher in desk-based workers while WFH, it is likely that this population shows an increase of MSK symptoms. Adults staying at home (either for work or study) during the COVID-19 pandemic showed MSK prevalence on neck (30.3%) and low back (43.8%) (Moretti et al., 2020; Šagát et al., 2020). Increases in MSK symptoms prevalence were also found in individuals WFH, when compared to the office (Radulović et al., 2021; Yorulmaz et al., 2022). Findings from study 2 (chapter 3) also indicated a high prevalence of MSK symptoms (93%) in staff WFH, with the most prevalent areas being neck (65.4%), lower back (64.8%), and right shoulder (48.5%).

A main finding from study 2 (chapter 3) was that groups of workers with longer occupational sitting (over 8 hours per day) had significantly higher prevalence of MSK symptoms. Desk-based workers with acute back pain and chronic low back pain appear to remain sedentary for longer periods than workers without back pain symptoms (Bontrup et al., 2019; Zemp et al., 2016). Additionally, symptomatic workers seem to have reduced movement during working hours, and did not break up their sitting frequently, in comparison to their asymptomatic co-workers (Bontrup et al., 2019).

To summarise, evidence from these studies indicates that desk-based workers have high levels of occupational SB while WFH. Correspondingly, these increases in SB appear to be related with a higher MSK symptoms prevalence. It is important for this population to reduce their SB, specially while WFH.

Breaking up sitting has shown benefits to reduce pain and discomfort at the workplace. Systematic review evidence indicates that breaking up sitting is helpful to reduce spinal pain and discomfort in the workplace (Agarwal et al., 2018; Waongenngarm et al., 2018). Study 1 (chapter 2) findings indicated that breaks from sitting, combined with stretching, were effective to reduce pain and discomfort in medium to long-term (2 weeks – 3 months) in neck, upper and lower back. However, this evidence came solely from individuals with no pre-existing MSK symptoms, and typically working in office settings. Therefore, these effects might differ in desk-based workers WFH.

In summary, it seems that desk-based workers with MSK symptoms are likely to be more sedentary and have less breaks from sitting than workers with no MSK symptoms. Hence, indicating that pain and discomfort might influence occupational SB behaviour in desk-based workers. It is still necessary to understand what factors influence SB at home. This is necessary to support desk-based workers with MSK symptoms to reduce their SB while WFH.

Interventions targeting sedentary time reduction in desk-based workers

The upsurge of people WFH has led to an increase in occupational SB, and a subsequent increase in MSK symptoms (Moretti et al., 2020; Šagát et al., 2020). Considering this, it is important to target SB reduction in desk-based workers with MSK symptoms WFH and identify what factors influence their SB while WFH. Research directed at sedentary time reduction while WFH is limited. In the dearth of research focusing on reducing SB whilst WFH, it is useful to consider evidence from interventions aiming to reduce sitting time reduction in office settings.

Systematic review evidence provided information of various types of interventions that have been employed to target SB reduction in desk-based workers (Chu et al., 2016; Peachey et al., 2020). Evidence from Chu et al. (2016)

signalled the most effective interventions to reduce SB were educational and behavioural (e.g., counselling), environmental changes (e.g., sit-stand), and multi-component interventions (e.g., sit-stand and goal setting). Statistically significant pooled intervention effects showed a reduction in sitting of 39.6 minutes per 8 hours workday in the intervention groups. The highest sitting reduction was observed in studies using multicomponent interventions, specifically the use of sit-stand workstations combined with behavioural and educational changes. This showed a reduction of 88.8 minutes per 8-hour workday in multi-component interventions. Environmental changes, and educational/behavioural interventions also reduced sitting per 8-hour workday (72.8 minutes, 15.5 minutes, respectively).

Peachey et al. (2020) suggested that multicomponent interventions (e.g., use of prompts with self-monitoring behaviour) reduced sitting for 35 minutes per day. Behavioural interventions reduced sitting by 24 minutes per day (Peachey et al., 2020). Still, this evidence come from low-quality studies and only from self-reported studies, which are subject to social desirability and recall bias.

As this evidence was taken from the office environment, adaptations need to take place to deliver these strategies in desk-based workers WFH. A recent rapid review from Morton et al. (2022) identified the most effective intervention strategies to reduce SB in the office, and to appraise their transferability to the home environment. Findings signalled educational materials, use of role models, incentives, and regular prompts as the most easily transferable strategies, with the most potential to reduce SB at home. Still, these interventions are yet to be explored at the home environment. Moreover, there is still the need to fully understand what factors influence SB at the home environment, with current evidence limited to the office environment.

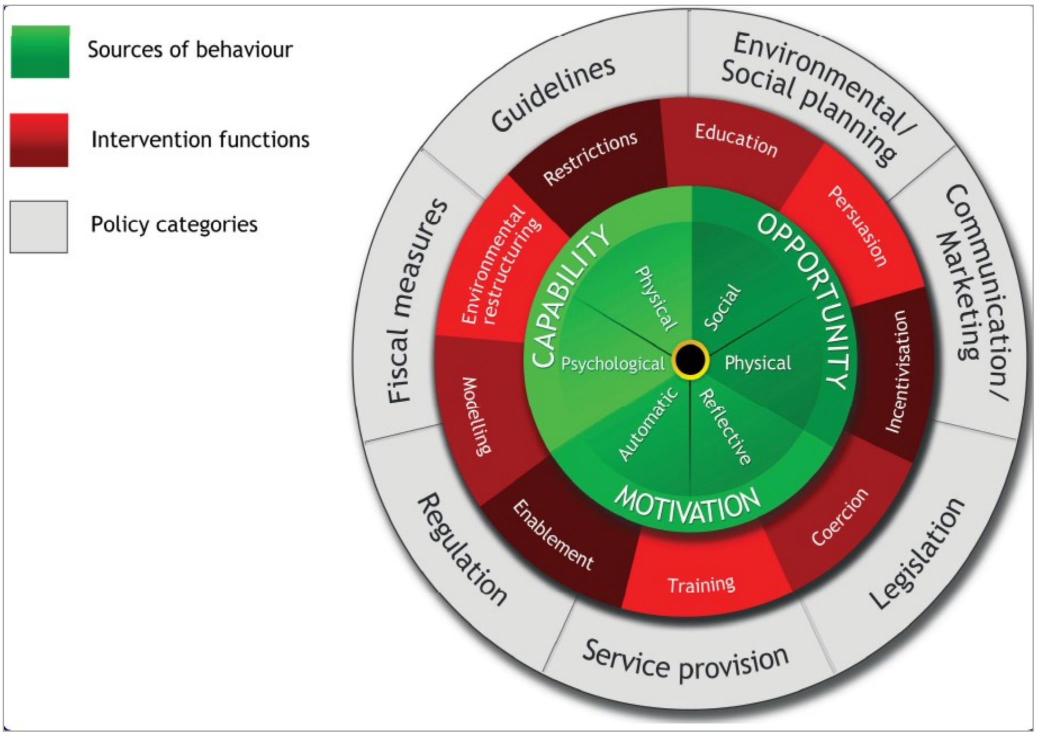
Behaviour change theories have been used to identify relevant factors for sedentary workers to reduce their SB. The following section focuses on these theories.

The Behavioural Change Wheel

The Behaviour Change Wheel (BCW) provides guidance to design and implement behaviour change interventions. The BCW components are useful to inform and tailor interventions that will target the identified behaviours to achieve behaviour change (Michie et al., 2014). The BCW was developed from considering nineteen different behaviour change intervention frameworks (Michie et al., 2011). Figure 9 illustrates the BCW layers and its components.

Figure 9

The Behaviour Change Wheel components



Note: Reprinted from "The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Sci 6, 42" by Michie et al. (2011). Open Access under the terms of the Creative Commons Attribution International License *(http://creativecommons.org/licenses/by/2.0/).*

To achieve behaviour change, an interaction of the BCW components is necessary. The BCW inner layer or 'sources of behaviour' forms the COM-B model. The COM-B model is a key element to carry out a behavioural diagnosis in individuals. This model comprises three main constructs (Capability, Opportunity and Motivation) that are responsible for individuals' behaviours. The next section expands thoroughly on this model.

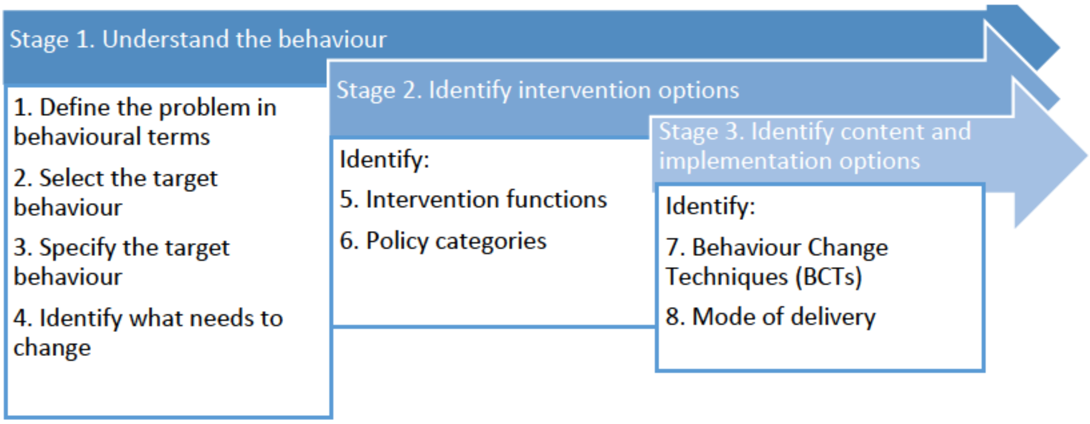
The next layer, 'intervention functions' is made up of nine components. Intervention functions are comprehensive categories useful to understand what intervention type may be more useful to achieve behaviour change. Intervention functions categories can be used either solely (e.g., intervention based in education) or combined (e.g., intervention based in education and modelling). After identifying and understanding the underlying factors for these behaviours, these are mapped to the intervention functions. This action helps to select what would be the most appropriate intervention approach to achieve behaviour change (based on the identified behaviours).

Lastly, the outer layer, 'policy categories', identifies seven types of policies that are used to support the intervention functions. These policies embody the decisions from authorities or organisations (e.g., government, guidelines) to help support the intervention delivery (e.g., the dissemination of guidelines to achieve sitting time reduction). The next step is to identify the behaviour change techniques (BCTs) which are active components of behaviour change interventions. The BCTs are used to deliver the intervention functions.

To design and implement an intervention, the BCW provides an intervention design process consisting in three stages, and eight steps within the stages. Figure 10 illustrates the intervention design process stages and the steps within each stage.

Figure 10

Behaviour change intervention design process. Based on Michie et al. (2014).



The first stage is set to understand the behaviour we want to target to achieve behaviour change. The second stage identifies the intervention functions (to select the intervention type) and policy categories (select the best form for organisations to deliver the intervention). Lastly, the third stage identifies what is the intervention content (BCTs) and what is the intervention delivery mode (select the best for intervention to be delivered to the target population).

To summarise this section, using the BCW components systematically is essential to target specific behaviours that require behaviour change as well as intervention design and implementation. The COM-B model and the Theoretical Domains Framework are two separate models that are useful to carry out a behavioural diagnosis (COM-B) and to identify what is necessary for behaviour to change (TDFs). These two models are described in detail in the next sections.

The COM-B model

The COM-B model of behaviour intends to explain what behavioural factors may affect individuals' behaviour change. This behavioural (B) model consists of three constructs: Capability (C), Opportunity (O), and Motivation (M) (Michie et al., 2014). 'Capability' refers to behaviours that the individual is able of performing, and it can be physical (e.g., ability to stand up or move around) and psychological (e.g., health knowledge or health beliefs about SB). The 'Opportunity' construct relates to the behaviour execution. Moreover, this opportunity can be physical (e.g., workplace settings or work environment) or social (e.g., workplace pressure to be sitting at a desk). Finally, the last construct, 'Motivation' is associated with either reflective (e.g., deciding to take a break from sitting) or automatic (e.g., taking a break as a habit) behaviours influencing the individuals' motivation to perform a behaviour.

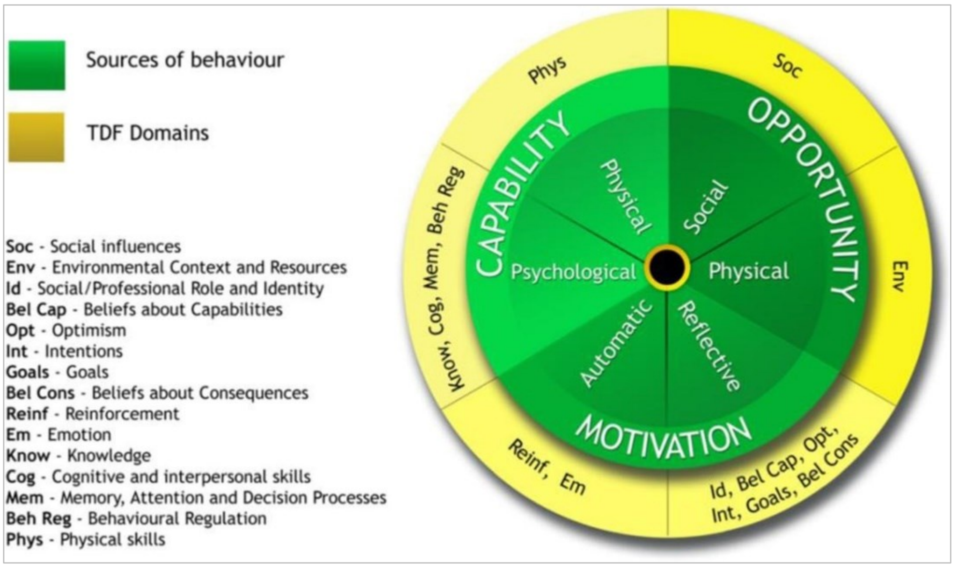
To understand an individual's behaviours, and how this can change, it is necessary to reflect on the interaction of the COM-B model constructs. This interaction is based on the principle that for a behaviour to happen, an individual must have the physical and psychological capability to carry out the behaviour (e.g., physically able to take breaks, have sufficient knowledge to carry out the behaviour). Likewise, the individual must have the physical and social opportunity for the behaviour to happen in any environment (e.g., physical space to take breaks at home, feel supported by peers to take breaks). Finally, individuals must be strongly motivated to carry out the behaviour, either automatically or reflectively (e.g., being prompted to take a break, have the habit of taking breaks). Therefore, to achieve behaviour change, one or more of the COM-B constructs needs to be targeted.

The Theoretical Domains Framework (TDF)

The Theoretical Domains Framework (TDF) is an additional framework often used in combination to the BCW (Cane, O'Connor, & Michie, 2012) to support implementation. Figure 11 displays the TDF domains and how they are mapped to each COM-B model construct.

Figure 11

Theoretical Domains Framework (TDFs) mapped to COM-B model constructs.



Note: Reprinted from "A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. Implementation Sci 12, 77" by Atkins et al. (2017). Open Access under the terms of the Creative Commons Attribution 4.0 International License *(http://creativecommons.org/licenses/by/4.0/).*

The TDF was developed from 128 theoretical constructs from 33 theories (Atkins et al., 2017). Furthermore, TDF is an "integrative theoretical framework" and was created to inform the behavioural diagnosis and intervention development in health professionals (Atkins et al., 2017; Michie et al., 2014). The TDF has 14 domains related to both barriers and facilitators that are necessary for behaviour change. All the TDF domains relate to the COM-B constructs (portrayed in figure 11). The TDF 14 domains are: knowledge; skills; memory; attention and decision processes; behavioural regulation (associated to Capability); social/professional role and identity; beliefs about capabilities; optimism; beliefs about consequences;

intentions; goals; reinforcement; emotion (associated to Motivation); environmental context and resources; social influences (associated to Opportunity).

Interventions using the COM-B model and TDF

Systematic review evidence has identified literature using the BCW components to achieve SB reduction in adults (Gardner, Smith, Lorencatto, Hamer, & Biddle, 2016). This evidence (based on 26 studies) identified strategies to reduce SB in adults and classified them using the BCW 'intervention functions' (Gardner et al., 2016). From the included studies, four intervention functions were identified as relevant (educational, environmental restructuring, persuasion and training) for SB reduction. Moreover, amongst these intervention functions two were indicated to be the most promising to reduce sitting time. These functions were educational (e.g., increasing health knowledge) and environmental restructuring (e.g., changing workstations). Although these findings are useful, the population occupation was varied and only 54% of the studies had desk-based workers as their population of interest. Thus, targeted behaviours might be different considering the total sample were not solely desk-based workers. Also, the quality of evidence was pointed out as low for the several of the included studies. Therefore, results are taken cautiously.

Primary research evidence has also focused on the reduction of occupational SB in desk-based workers using the BCW components for intervention design (Munir et al., 2018; Ojo, Bailey, Brierley, Hewson, & Chater, 2019a, 2019b).

Two studies from the same research group (Ojo et al., 2019a, 2019b) identified relevant COM-B and TDF components that are necessary for SB reduction (Ojo et al., 2019a, 2019b). Authors used identified semi-structured interviews (based on the COM-B and TDF) and identified seven main themes amongst these workers. These themes were 'knowledge-deficit sitting (psychological capability; knowledge)', 'willingness to change (reflective motivation; belief about capabilities, belief about consequences, intentions)', 'tied to the desk (physical opportunity; environmental context and resources)', 'organisational support and interpersonal influences (social opportunity; social influences)', 'competing motivations (automatic motivation; reinforcement, social/professional role and identity)', 'emotional influences (automatic motivation; emotion, reinforcement)', and 'inadequate cognitive resources for action (psychological capability; memory, attention and decision processes, behavioural regulation). From the findings, it was evident that to achieve behaviour change associated to SB, an interaction of factors related to the COM-B components is necessary. Still, findings from both studies have not been used to carry out an intervention. Therefore, the effectiveness is yet to be determined.

On the other hand, findings from the Munir et al. (2018) study were used to develop an intervention to reduce SB in desk-based workers. The Stand More At Work (SMArT) study employed the BCW to develop an intervention to reduce sitting in desk-based workers from health services working at hospital facilities (NHS, United Kingdom). Considering both COM-B and TDF components, authors identified and targeted the most relevant influences on behaviour to reduce occupational SB. Authors employed focus groups to collect data on these outcomes. The most relevant COM-B constructs and TDF domains were identified as self-regulation of behaviour, knowledge (psychological capability), social – professional identity, intentions, belief about capabilities (reflective motivation). Following this preliminary work, a tailored intervention based on these findings was delivered at a workplace and tested using a cluster randomised controlled trial (RCT) (Edwardson et al., 2018). The main intervention consisted of providing organisational (e.g., management encouragement), environmental (e.g., adjustable desks), individual (e.g., goal-setting plan) and group strategies (e.g., health seminar) for 12 months. Results from this RCT signalled important and statistically significant changes in SB at short, medium and long-term (3, 6 and 12 months respectively) in the intervention group, compared to the control group.

Additional primary research from Niven et al. (2022), provided evidence of the factors influencing SB in UoE staff WFH. Both quantitative and qualitative data were reported in this study. Combined findings indicated high levels of capability (physical 8.7 SD 1.9, psychological 6.9 SD 2.5), and knowledge (7.0 SD 2.5) in participants. On the other hand, opportunity (physical 5. SD 3.1, social 5.16 SD 3.1) and motivation (reflective 6.4 SD 2.6, automatic 3.17 SD 2.8) had lower levels. Related to the opportunity construct, participants identified influential factors such as the lack of space to reduce SB at home (physical opportunity) and feel been watched/monitored by others to be at their desk (social opportunity). In relation to motivation, participants mentioned feeling that reducing their SB at home would affect their productivity (reflective motivation). Both findings suggest that lower levels of opportunity and motivation are present at the home environment. In addition, it seems that participants were not in the habit of breaking up their sitting (automatic motivation) which might have translated in automatic motivation having the lowest score from all the constructs. This study is key to understanding what factors in relation to the COM-B model influence SB at the home environment. However, it is important to note that people with MSK symptoms might be influenced by other factors, such as pain and discomfort.

Collectively, these studies indicate that the COM-B and the TDFs are useful models to understand the factors influencing SB in both office and home settings. Moreover, evidence from all the studies indicate these factors are influenced by the interacting components of the COM-B model.

Summary and knowledge gap

The upsurge of desk-based workers WFH due to COVID-19 influenced an increase of SB and MSK symptoms prevalence in this population (Sañudo et al., 2020; Zheng et al., 2020). To reduce the health problems related to SB, including MSDs, is necessary to target SB reduction to support these workers. This need is reinforced by the evidence that desk-based workers with MSK symptoms engage in longer sedentary bouts than workers with no MSK symptoms (Bontrup et al., 2019; Zemp et al., 2016). Hence, it is important to understand what factors are influencing SB and breaks from sitting while WFH in this population. This exploration would be useful to identify what changes are necessary for desk-based workers with MSK symptoms to break up their SB in the home environment, and to inform future interventions.

Evidence from literature employing the BCW, COM-B and TDF has indicated that these models are useful to inform, design and implement interventions to target the reduction of occupational SB at the workplace (Edwardson et al., 2018; Gardner et al., 2016; Munir et al., 2018; Ojo et al., 2019a, 2019b). However, all these findings are focused on behaviour change at the office, and not at the home environment.

There is evidence from UoE staff suggesting that SB at home is influenced by various factors, and these can be mapped to the COM-B constructs (Niven et al., 2022). However, this evidence comes from people with no MSK symptoms. The second study of this PhD (chapter 3) showed a high prevalence of both SB (89%) and MSK symptoms (93%) in UoE staff WFH. These workers might be influenced by pain and discomfort to not reduce their SB at home. Therefore, understanding the factors motivating symptomatic staff to reduce their SB at home, is key to help them reduce both SB and MSK symptoms prevalence while WFH.

Study aim

This study aimed to understand what factors influenced occupational SB and breaks from sitting in desk-based workers with MSK symptoms while WFH by undertaking a behavioural diagnosis using the COM-B model. In combination with the TDF, both models were used to identify what needs to change to reduce SB in desk-based workers with MSK symptoms while WFH.

Methods

Ethics

A level 2 ethics application (following the British Psychological Society [BPS] and the Internet Mediated Research [IMR] guidelines), was approved by the Moray House of Education and Sports Ethics Committee in November 2021 (Appendix 2, Reference: ECOR09092021). Data collection was carried out between November 2021 and January 2022.

Study design

The study design was a qualitative study, and employed semi-structured interviews based on the COM-B model and the TDFs to collect the data.

Participants sampling and recruitment

Inclusion and exclusion criteria

Participants were desk-based University of Edinburgh staff working from home (over 50% of their working week). This was planned with the intention of understanding further WFH and hybrid work, and these workers could provide this information as they worked at home half or most of their working week. Additional criteria were working part-time or full-time, having a desk-based role, aged 18 to 65 years old, and having at least one MSK symptom.

The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) (Hedge et al., 1999) was used to determine the participants' number and severity of symptoms. The items used to determine if participants had MSK symptoms were: 1. Participants selecting having at least one MSK symptom and selecting frequency of symptoms 1-2 times a week or more; 2. Participants selecting any discomfort score (slightly, moderately, or very uncomfortable). 3. Participants selecting any work interference due to MSK symptoms (not at all, slightly interfered, substantially interfered). Exclusion criteria were participants with no MSK symptoms, not working at home for most of the week and not desk-based workers.

Sample size and information power

The 'information power' model for sample size consideration was used for this study (Malterud et al., 2016). Table 17 illustrates the use of the five information power factors considered to determine the sample size in this study. This model suggests "the larger information power the sample holds, the number of needed participants is lower, and vice versa" (p. 1754). In this model, five main factors are influential to guide sample size selection in qualitative research: study aim, sample specificity, use of established theory, quality of dialogue, analysis strategy. The information power model is valuable to understand sample considerations for qualitative research. Nevertheless, the model does not suggest a specific number of participants to recruit, as the information provided by participants is more relevant than a specific number of participants.

As suggested by the 'information power' model an initial appraisal was carried out to determine the sample size for the study. This initial appraisal determined the number of participants to be set at 20 interviews. After 15 interviews a second appraisal was done, and it was determined that the sample was adequate to conclude with the recruitment and data collection. Nevertheless, before this appraisal, two participants had been scheduled to be interviewed for the study and it was decided to move forward with both interviews, concluding the data collection with 17 participants.

Table 17

Sample size considerations considering the information power model (Malterud, Siersma, & Guassora, 2016).

Factors	Information Power model	Current study considerations
1. Study aim (narrow or broad)	"A broad study aim requires a larger sample than a narrow aim to offer sufficient information power, because the phenomenon under study is more comprehensive".	Narrow aim. As the study explored factors influencing solely participants with MSK symptoms working from home.
2. Sample specificity (dense or sparse)	"To offer sufficient information power, a less extensive sample is needed with participants holding characteristics that are highly specific for the study aim compared with a sample containing participants of sparse specificity".	Dense specificity. A less extensive sample was needed as participants hold highly specific characteristics for the study aim.
3. Established theory (applied or not)	"A study supported by limited theoretical perspectives would usually require a larger sample to offer sufficient information power than a study that applies specific theories for planning and analysis".	Applied established theory. An established framework was used in this study to formulate the research question. The COM-B model and the TDF framework were used to draft the interview schedule.
4. Quality of dialogue (strong or weak)	"A study with strong and clear communication between researcher and participants requires fewer participants to offer sufficient information power than a study with ambiguous or unfocused dialogues".	Strong. The lead researcher had carried out qualitative research in the past. Also had experience interviewing physiotherapy patients.
5. Analysis strategy (case or cross-case)	"An exploratory cross-case analysis requires more participants to offer	Framework analysis would provide an in-depth analysis of the participants. This by using

	sufficient information power compared with a project heading for in-depth analysis of narratives or discourse details from a few, selected participants”.	a combined analysis approach based deductively from theory (COM-B and TDFs), and inductively from the information provided by participants.

Procedure and instruments

Recruitment procedure

Considering guidance for qualitative research (Clarke & Braun, 2013), and the study research question, purposive sampling was used to recruit participants. Purposive sampling involves selecting participants on the assumption that they will have certain characteristics or experience (Clarke & Braun, 2013, p. 56). Participants were recruited using a flyer (Appendix 3) distributed through Moray House of Education and Sport communications (staff bulletins and Twitter), relevant Twitter channels, and flyers were posted in a physiotherapy clinic (FASIC) from the University of Edinburgh. The flyer contained information about the study and contact details for the main researcher.

In addition, invitation emails were sent to participants who provided their email during the study 2 survey giving permission to be contacted for further research. These invitation emails contained one participants information sheet (Appendix 4) with all the information about inclusion and exclusion criteria, consent form including permission to be recorded (Appendix 5), and a research flyer (Appendix 3). Similarly, participants who contacted the main researcher after seeing the research flyer, were sent an invitation email containing the same information as the research invitation emails (information sheet, consent form and flyer).

Participants who agreed to take part in the study were asked to return their signed consent form through email. The consent forms were uploaded to OneDrive in a password protected folder. Afterwards, an email containing a link to the screening questionnaire (CMDQ) was sent to the possible participants. Data for MSK symptoms data were collected using the Qualtrics platform (https://www.qualtrics.com). Participants fulfilling the inclusion criteria were sent a follow-up email informing them about their suitability for the study, and online interviews were scheduled in the Microsoft Teams calendar.

Screening questionnaire

The CMDQ was used as a screening questionnaire and to assess self-reported musculoskeletal discomfort in possible participants. The CMDQ was used as a descriptive tool to determine the participants' bodily pain or discomfort over the last 7-days in various body areas (neck, shoulders, upper back, upper arm, lower back, forearms, wrists, hip/buttocks, thigh, knees, and lower legs). The CMDQ consists of three main questions asked in relation to each examined body area. One question related to pain frequency (*1. During the last work week how often did you experience ache, pain, discomfort in? Five possible answers [Never, 1-2 times last week, 3-4 times last week, once every day, several times every day]*), one related to pain intensity (*2. If you experienced ache, pain, discomfort, how uncomfortable was this? Three possible answers [Slightly, moderate, and very uncomfortable]*), and one related to interference to work due to pain/discomfort (*3. If you experienced ache, pain, discomfort, did this interfere with your ability to work? Three possible answers [Not at all, slightly interfered and substantially interfered]*). Scoring guidelines per question (*frequency score [0, 1.5, 3.5, 5, 10], discomfort score [1,2,3] and interference score [1,2,3]*) for the CMDQ were followed (Hedge et al., 1999).

Interview schedule

A semi-structured interview schedule (Appendix 6) was created for this study. The interview schedule was based on the COM-B constructs (Capability, Opportunity and Motivation) and TDF domains (knowledge; skills; memory; attention and decision processes; behavioural regulation; social/professional role and identity; beliefs about capability; optimism; beliefs about consequences; intentions; goals; reinforcement; emotion; environmental context and resources; social influences). Table 18 illustrates examples from the interview schedule based in both COM-B constructs and TDF domains and addressing the target behaviour.

The interview schedule was ‘field tested’ (Kallio et al., 2016) with two people (one PhD student from the University of Edinburgh, and one office worker WFH but not part of the University of Edinburgh). After pilot testing the interview schedule, amendments were made to the interview schedule (e.g., changes in syntax and order of questions), and the final interview schedule (Appendix 6) was used with the participants of the study.

Online interviews were carried out through Microsoft Teams, and video recorded through the same platform. Additionally, the ‘live’ transcription function, available in Microsoft Teams, was activated to support the transcription process. Descriptive data were collected during the online interviews (age, gender, type of work, full-time/part-time contract, time working for the University of Edinburgh and country of origin), to describe the participants. Additionally, data on occupational sitting time, breaks from sitting, days working from home, and workstations settings WFH were collected during the online interview. All data collected through the interview (e.g., videos, notes from interviews) were uploaded to a One Drive password protected folder.

Table 18

COM-B constructs and TDF domains informing an interview schedule.

Target behaviour	COM-B constructs	COM-B sub-constructs	TDF	Examples for interview schedule
Breaking up sitting time in desk-based workers with MSK symptoms WFH	Capability	Physical	Skills	*In relation to your pain and discomfort. Could you tell me to what extent do you feel physically able to interrupt your sitting time?*
		Psychological	Knowledge	*Are you aware of any expert advice on managing sitting time?*
			Memory, attention and decision processes	*What are the main differences that you have noticed between sitting time at the office and sitting time while working from home?*
			Behavioural regulation	*Do you have a system or strategy to monitor your sitting time and breaks from sitting while working at home?*
	Opportunity	Social	Social influences	*Is there anybody in your household that influences your sitting time and breaks from sitting while working from home?*
		Physical	Environmental context and resources	*What resources would make it easier for you to take more regular breaks from sitting while working from home?*
	Motivation	Automatic	Reinforcement	*What would be an incentive for you to break up your sitting while working from home?*
			Emotion	*How do you think your mood (e.g., feeling happy, stressed, low) during the day influences your sitting?*
		Reflective	Social/Professional role and identity	*To what extent breaking up your sitting time would affect your role?*
			Beliefs about capabilities	*How confident do you feel to break up your sitting time while you work from home?*
			Optimism	*To what extent do you feel confident to continue breaking up your sitting time while working at home?*
			Intentions/Goals	*Do you anticipate increasing your breaks from sitting while working from home?*
			Beliefs about consequences	*What effects do you think taking breaks from sitting time has on your pain and discomfort?*

Note: Adapted from Ojo et al. (2019b).

Data analysis

Musculoskeletal symptoms (CMDQ)

The CMDQ scores (1-2 times a week, 3-4 times a week, once every day and several times every day) from the first question (*During the last work week how often did you experience pain and discomfort?*) were combined to find the most prevalent MSK symptoms areas within participants of the study. All the CMDQ questions were reported into percentages and results were portrayed into graphs.

The Framework Method

The Framework method (Gale et al., 2013) was selected to analyse the interview data. This method was selected because of its systematic approach while analysing qualitative data. The framework method was useful to have a deeper understanding of the data, and to compare and contrast the sub-themes between participants by using the matrix rows and columns. The framework matrix (Appendix 7) was key to reduce and summarise the data. Furthermore, the framework was useful to be able to map the data to theory (COM-B and TDFs).

The framework method consists of seven stages. The first stage, transcription of the interviews was a useful process to familiarise and immerse into the data. The transcription process also provided an opportunity to discover initial codes, and to note down observations within the data. Video-recorded interviews were uploaded to Microsoft Stream to facilitate the transcription process. Microsoft Word was used to transcribe the interviews using a Microsoft Teams transcription file and amending transcription mistakes from the automatic transcription. Participants' identity, places of work, and mention of family and name of colleagues were anonymised to avoid data identification. All the transcribed interviews were imported to NVivo software (QSR International Pty Ltd, 2018, NVivo Version 12).

The second stage from the framework method is familiarisation with the interview. The familiarisation of the interviews was done initially after each interview. This step was useful to be familiarised with the data and to record analytical notes and impressions by using the interview material. After transcribing the interviews, the main researcher used the transcriptions to note down initial codes in the transcription Word document.

The third stage was coding, and it was used to assign codes by interpreting the interview data line by line. Considering this study is based in the COM-B model and TDFs, pre-defined codes were set in advance using these models' components. Coding was carried out in NVivo by using the COM-B and TDFs domains to create a list of codes containing both models' concepts, and inductive codes were added to the same list. Afterwards, codes were double-checked by the lead researcher and inserted into an Excel spreadsheet to create the framework matrix (Appendix 7). A matrix output (rows and columns), was used for the data analysis by arranging the data by case and by code, thus facilitating data reduction systematically.

The fourth stage, developing an analytical framework, was created after coding five interviews. Gale et al. (2013) suggest using just a few transcriptions to develop the analytical framework. However, it was decided by the lead researcher to code five transcripts to identify further codes appearing in the data, and to be able to apply the analytical framework to the rest of the transcripts. The matrix portrayed different categories grouped by the COM-B and TDFs model and included the inductive themes arising from the data.

The fifth stage, applying the analytical framework, was done by using the existing categories and codes to index the rest of the existing transcriptions. Although Gale et al. suggests assigning several abbreviations to the codes, the full name of the codes were used to facilitate coding the transcriptions. To ensure the thoroughness of the framework application, the transcriptions were indexed in both NVivo and Excel by the lead researcher.

The sixth stage, charting data into the framework matrix, was used to condense the data and chart the existing codes into the framework matrix in the Excel spreadsheet. As suggested by Gale et al. (2013) a space to include pertinent quotes referring to the codes was added to the framework matrix. The matrix included a row per participant and a column per code.

The seventh and final stage was interpreting the data. The framework matrix was used to identify the main themes related to the research question within the coding. Afterwards, results were interpreted and reported in accordance with the COM-B and TDFs.

Enhancing rigour

Smith and McGannon (2018) suggest various strategies to enhance rigour, and the involvement of a 'critical friend' was key to ensure further insight in the analysis process. Other strategies involving further insights from the participants were considered to enhance the rigour of this research (e.g., 'member reflections'). However, it was decided that further input from the participants would be inconvenient due to their workload. As Smith and McGannon (2018) suggest, the role of the critical friend was used to "encourage reflection upon, and exploration of multiple and alternative explanation and interpretations as these emerged in relation to the data and writing" (p. 13).

Meetings with the critical friend involved meeting fortnightly. The use of a critical friend provided unprejudiced advice (as the person was not involve in the project) to the main researcher during the data analysis process. The critical friend approach was particularly valuable during the transcriptions and coding stage. Moreover, the views of another researcher concerning the data were key to achieve a broad insight by identifying codes found in the transcriptions and identifying further codes within the data. Additionally, discussing the application of the framework with the critical friend in the transcription stage was an essential. Due to time constraints, solely the main researcher did data interpretation. However, a previous discussion with the critical friend about the approach to be taken to interpret the data was made in advance of this stage. This discussion reinforced the main researcher's idea to combining the COM-B and TDFs concepts to fully interpret the data and create the final report sub-themes.

Results

Seventeen (n=17) desk-based staff from various University of Edinburgh departments were interviewed in this study. The mean age of participants was 47.1 (SD 9.4) years, and most of the participants were female (n=14, 82%). Most of the staff were working in professional services (n=12, 70%), and the other participants (n=5, 30%) were in the academic area. The majority had a full-time equivalent contract (n=15, 88%) and been working for the University of Edinburgh for a mean of 4.6 (SD 4.0) years. The nationality of participants were varied (10 UK, 4 European, and 3 Latin American). The mean occupational sitting time of participants was 7.7 (SD 1.5) hours per day, with mean of breaks 0.8 (SD 0.6) per hour.

Musculoskeletal pain and discomfort

Results from the screening questionnaire (CMDQ) indicated the most prevalent areas of discomfort for the participants. The total prevalence indicated the most prevalent areas were lower back (92.3%), neck (86.6%), hips and buttocks (71.4%) right shoulder (71.4%) and right wrist (60.0%). Figure 12 illustrate the MSK symptoms frequency per area and divided using CMDQ categories (Never, 1-2 times per week, 3-4 times per week, several times every day).

For pain level of discomfort, pain level amongst participants seemed to be slightly uncomfortable for most of the areas. From all the areas, pain in right shoulder was reported by 63.6% of participants as being moderate. Figure 13 illustrate the frequency of MSK discomfort per area and divided using CMDQ categories (slightly, moderately, very uncomfortable).

Pain interference with work was mainly null for most of the participants. Yet, many participants reported slight interference with work, and the highest prevalence were in lower back (6 people) and hips and buttocks (5 people). Only two areas were reported to substantially interfere with work, lower back (2 people), and hips and buttocks (3 people). Figures 14 illustrate the MSK symptoms interference with work per area divided using CMDQ categories (not at all, slightly interfered, substantially interfered).

Figure 12

Pain frequency per week CMDQ scores prevalence presented by body area.

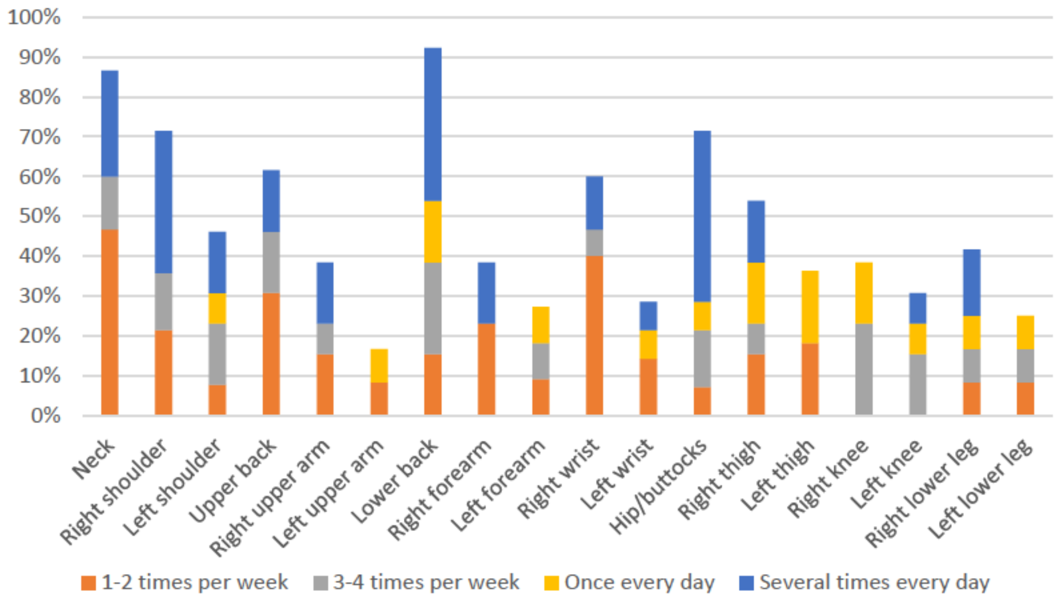


Figure 13

Pain level of discomfort scores prevalence presented by area.

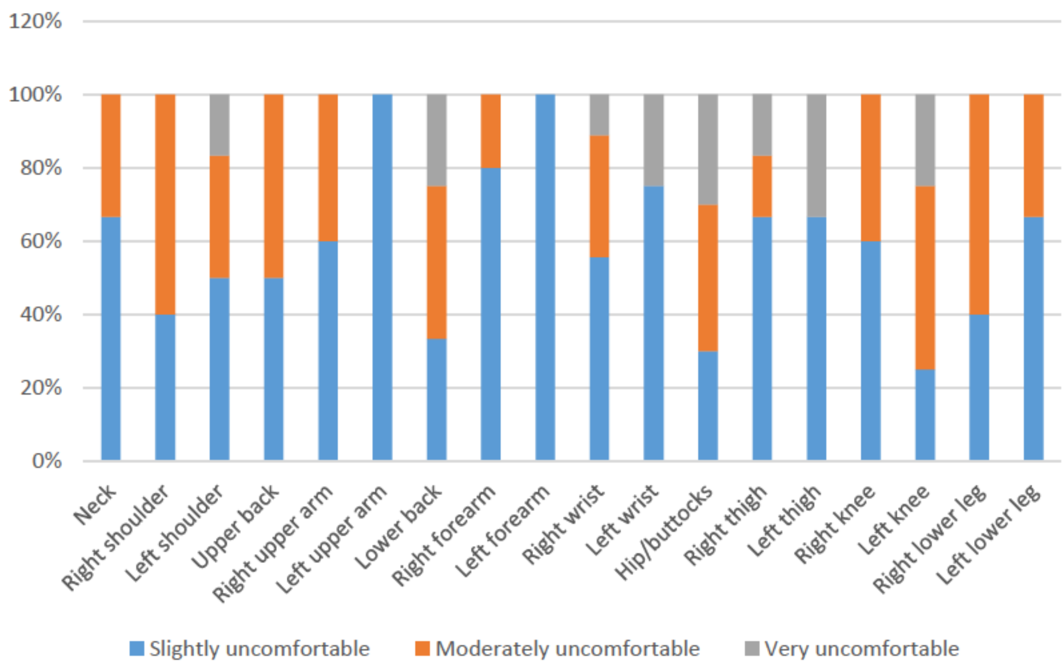
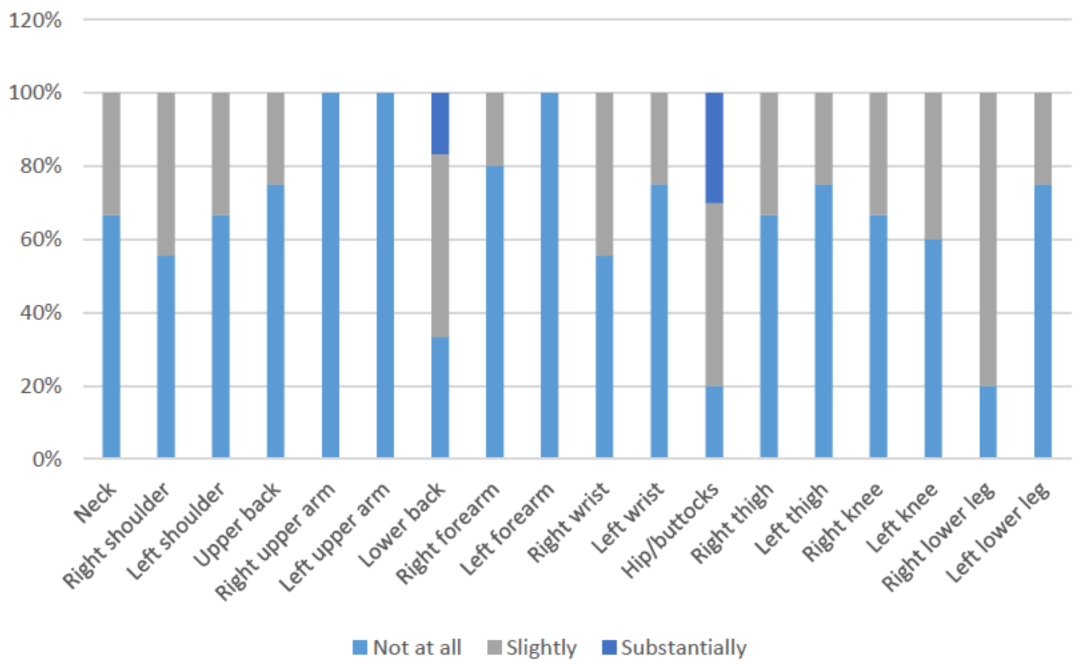


Figure 14

Pain interference with work scores prevalence presented by area.



COM-B

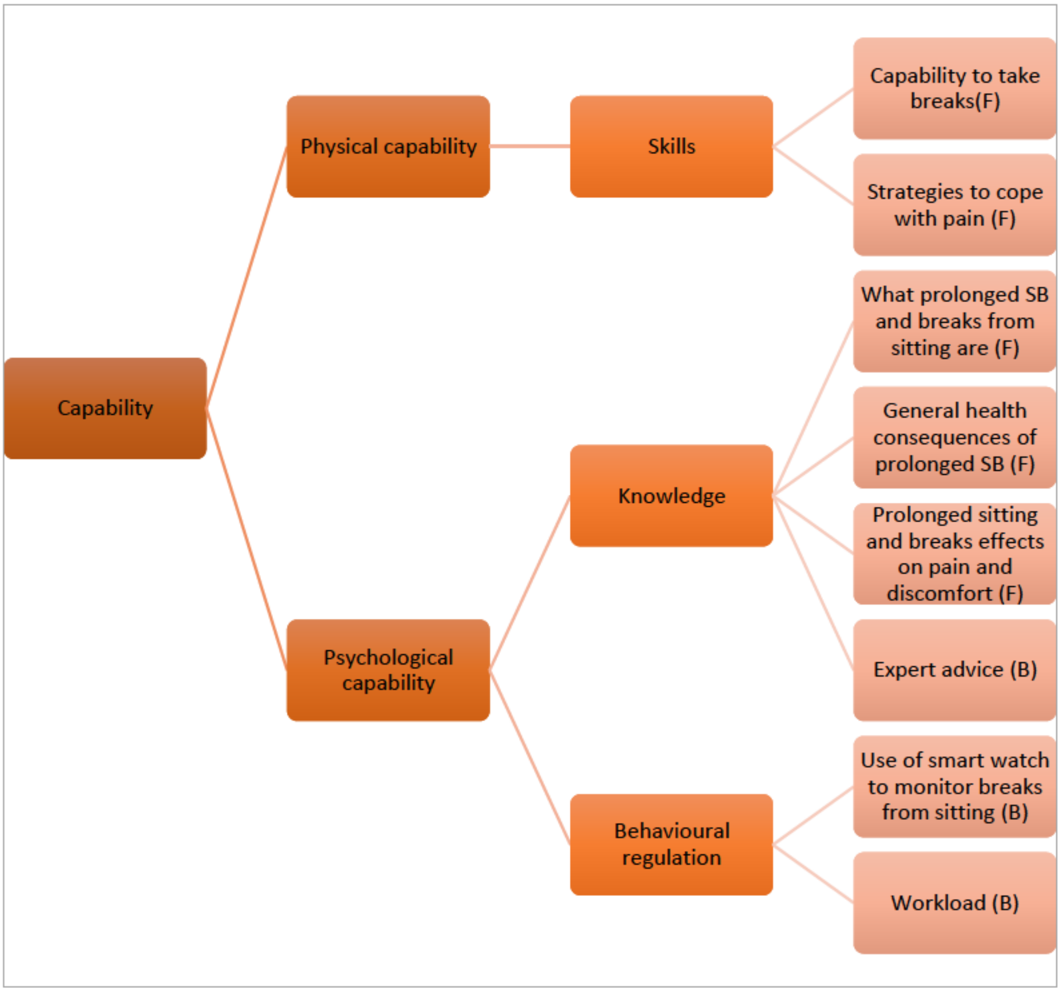
Results from the interviews were mapped to the COM-B and TDF domains. Both deductive and inductive themes were embodied into the framework matrix to carry out the data interpretation. Sub-themes are presented within each TDF domain, and participants' quotations are used to illustrate these sub-themes.

Capability

Figure 15 summarises the emergent sub-themes within the Capability construct, micro-constructs and the linked TDFs. Additionally, barriers and facilitators are signalled in the figure.

Figure 15

Emergent sub-themes within the Capability construct, and linked TDF domains.



Note: Barriers (B) and facilitators (F) to break up sitting time are marked for each sub-theme.

Physical capability. In relation to physical capability, there were two themes identified which aligned with the TDF category 'skills'.

TDF domain: Skills. The first sub-theme from this TDF domain, was labelled as 'capability to take breaks' and it was defined as an ability to carry out an action through practice. Within this theme, participants discussed their physical ability to take breaks due to their pain and discomfort. Most of the participants considered themselves physically able to break up their sitting while WFH regardless of their pain and discomfort. However, a few participants felt that pain and discomfort, as well as stiffness due to sitting discouraged them to take breaks from sitting. For example, participant 5 mentioned:

> "And I'll tell you another thing, because of the discomfort that I have, sometimes I don't feel like moving. If that makes sense, but you know you're sitting, and you're feeling… and then you say: No, I need to stand up and go somewhere, and you say no, I can't be bothered. So it kind of fits onto it if you know what I mean. The more discomfort that you have, the less you want to move. It makes you lazy" (female, 54).

The theme 'strategies to cope with pain' was mentioned among various participants. These participants mentioned having had to either purchase resources (e.g., ergonomic keyboard or mouse) to help with the pain, having to adapt their posture, or resource to medical help or medication to be able to continue working. For example, participant 4 mentioned:

> "(about episodes of pain) I do tend to fidget a lot, and I do tend to adjust my seat quite a lot. And when it does get too bad, then as I said I kneel, and then you know and then I kneel for maybe about an hour and then I'll go back and sit in my seat. But then the pain starts again. It just sometimes it just gets too much, especially if I'm really, really busy. Then I take painkillers" (female, 48)

Psychological capability. Within the psychological capability construct, relevant themes to the TDF domains of 'knowledge' and 'behavioural regulation' were identified.

TDF domain: Knowledge. The TDF 'knowledge' domain was defined as the awareness or knowledge of a certain topic. Sub-themes relating to sedentary behaviour and breaks from sitting were found within this domain. Firstly, participants demonstrated a good understanding of prolonged sedentary time and breaks from sitting. This understanding was related to 'what prolonged sedentary time and breaks from sitting are', 'general health consequences of prolonged sedentary time', 'effects of prolonged sedentary time/breaks in pain' and 'expert advice'. In relation to the first sub-theme, 'what prolonged sedentary time is', some participants considered prolonged sedentary time as unhealthy but also necessary to carry out their work. For example, participant 7 mentioned:

> "Well, I know it's a bad thing. Let's start with it, you know. Uhm, but it's kind of necessary if you're concentrating on something, it's quite hard to do you know, if I'm updating documents or if I'm writing documents" (male, 54).

Included in this sub-theme, participants mentioned 'what breaks from sitting are'. Participants understanding of this sub-theme was that breaks were any type of PA or to not remain static. For example, participant 5 said: "And it's really about changing the position, I think it's what comes to mind, not being in the same position constantly. But also just having physical activity must be good" (female, 54).

The second sub-theme 'general health consequences of prolonged sedentary time' reflected participants understanding on how prolonged sedentary time was harmful to their physical health. For example, participant 9 mentioned:

> “Uhm, I think I, it might be associated with uhm, suddenly negative effects. I don't think there are any positive effects that can come from prolonged sitting. I think uhm psychologically and maybe, maybe associated with laziness and from a physical perspective I feel like I can imagine that it might cause problems with circulation, and it probably doesn't do anything for general levels of health and fitness if you're sitting for long periods of time, because your body doesn't have to work very hard” (female, 30).

Finally, some participants mentioned to be aware that ‘prolonged sedentary time had effects in their pain and discomfort’. Specifically, most of participants had the notion that sitting for work was causing their pain and discomfort. For example, participant 15 mentioned:

> “I think it, it's all down to how little we move from the desk, and when I say we it's because I speak to my colleagues as is, it happens to them as well. Because of the type of work we do, it, it requires a lot of concentration. So you start something and just stay 3 hours locked on the screen doing it. So with the pain is like you know it's, it's kind of a stiffness from being on the same posture or very similar posture” (female, 54).

Within the sub-theme ‘knowledge on expert advice’, participants understanding was limited to posture and ergonomic settings while WFH. For example, participant 12 stated:

> “I know there are guidelines in the University website, it's just quite difficult to uhm, keep that posture going while trying to look at a screening and look down at what I'm doing, and look at screening, look down at what I’m doing. I had to get too involved in the work and that that takes over... So, I know there is advice out there, but I find it difficult to put into action” (female, 61).

Within this sub-theme, other participants mentioned that their 'knowledge of expert advice' was related to breaking up their sitting or to not remain static. For example, participant 1 mentioned: "I should move every 30 minutes or so. Uhm, then don't stay in the same position and try to, the next position is the better position" (male, 32).

TDF domain: Behavioural regulation. Behavioural regulation was defined as the approach from individuals to manage or change identified behaviours. Within the TDF domain 'behavioural regulation' two sub-themes were found. The use of 'smart watches to monitor breaks from sitting' and 'workload'. From the first sub-theme, participants mentioned that using a smart watch was a form for they to monitor their breaks from sitting while WFH. However, it was also mentioned that timing and lack of flexibility of these devices were inconvenient to interrupt work. Additionally, smart watches seemed to have an inflexible adjusting, discouraging participants to take breaks from sitting. Within the second sub-theme, 'workload', participants felt that even though they were keen to take breaks, their 'workload' and deadlines took over their needs to remain seated and not taking breaks. For example, participant 7 mentioned:

> "I know absolutely what I need to do, it's just whether it's more because I, I'm, I can get very focused on one task. And I just I, I prefer to get things done and then I've done it and then I can, you know, take a break" (male, 54).

On the other hand, and within the same sub-theme, few participants have actively decided to change their sitting behaviour by adding breaks into their work schedule and deal with their workload. As participant 6 mentioned:

> "(about sitting due to their workload) But, but recently I've realized that as a very stupid thing to do, because it's always going to be hectic. My email is always

going to be bad. So, I instead I go and get a tea have a walk around for 10 minutes and then I come back and do that. So, I have consciously changed that strategy. And from one of acting with urgency, to one of realising it's always going to be urgent, you're going to just have to take a break" (female, 51).

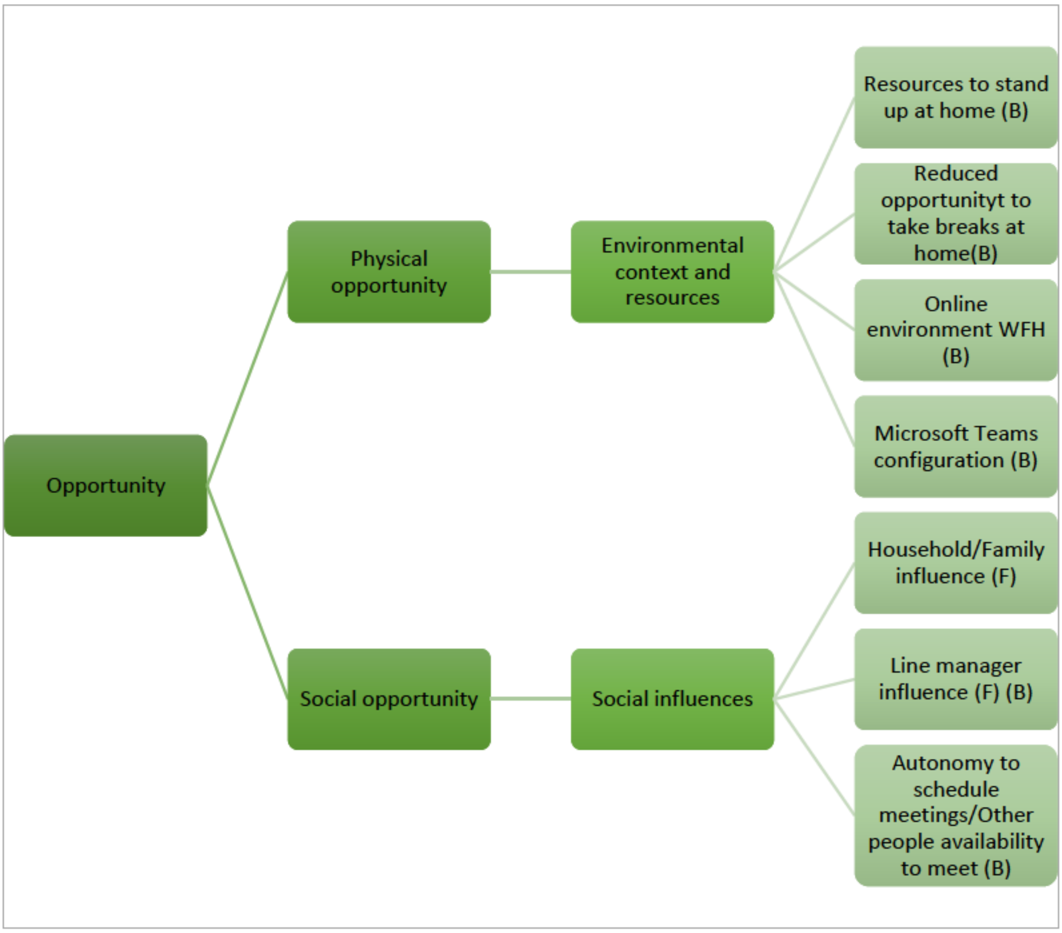
Opportunity

Figure 16 illustrates the emergent sub-themes related to the Opportunity construct, micro-constructs and the linked TDFs. Additionally, barriers and facilitators are signalled in the figure.

TDF: Environmental context and resources. The TDF 'environmental context and resources' was defined as personal or environmental circumstances of an individual that encouraged or discouraged certain behaviours. Linked to the first sub-theme 'resources to stand up at home', many participants mentioned that an impediment to reduce their sitting at home was not having a dedicated standing space at home, where they could continue working while standing. For example, participant 1 mentioned: "Yeah, I mean I'm sitting in front of the computer working. It's not like I can just stand uhm, since I don't have a standing desk, I just need to sit. If not, I'll just be awkward to work" (male, 32).

Figure 16

Emergent sub-themes within the Opportunity construct, and linked TDFs.



Note: Barriers (B) and facilitators (F) to break up sitting time are marked for each sub-theme.

A second sub-theme was 'reduced opportunity to take breaks at home', where participants mentioned that the limited space at home, and breaks being more automatic at the office reduced the opportunity to have a higher step count. For example, participant 2 mentioned:

> "(Referring to breaks at the office versus breaks WFH) And, you know, there's places to go. Whereas at home, it's really a case of I kind of I can stand up. Our house is very small so I can stand up, walk up and down the stairs and come back to my desk. There's nowhere to go really" (male, 48).

A third sub-theme was in relation to the ‘online environment while WFH’. Several participants mentioned they did not feel they have the opportunity to take breaks or reduce sitting, as meetings and teaching were done while seated. For example, participant 13 mentioned:

> “During you know, working from home there is no need to actually stand up, and find you know some other colleagues from another, I don't know from another department and ask for an advice. Because you'll just type or phone, or you know Zoom or make Teams call” (female, 45).

Lastly, ‘Microsoft Teams configuration’ was also mentioned as a common barrier to reduce sitting while WFH. Many participants mentioned that the configuration for Microsoft Teams to set up meetings was automatic for meetings to be scheduled as back-to-back meetings. For example, participant 6 stated:

> “But (Microsoft) Teams isn't particularly well set up for that because it defaults to half an hour an hour...You know, so people just use that that time and so. It's almost as if we have, a kind of bad habit of accepting Teams meetings back-to-back, you know, rather than trying to force gaps in between” (female, 51).

Social opportunity. In relation to social opportunity, three sub-themes were identified within the TDF domain ‘social influences’.

TDF domain: Social influences. The TDF domain ‘social influences’ was defined as interpersonal interactions that can cause people to change their behaviour. Three main themes were ‘household/family influence’, ‘line manager influence’ and ‘autonomy to schedule meetings/other people’s availability to meet’. Within the ‘household/family influence’ participants mentioned been influenced by members of their household to take breaks from sitting and reduce sitting, especially partners and families. It was noticed also by some participants, that an additional household influence to reduce their sitting while WFH was having a dog. For example, participant 14 mentioned:

> “Well, there's no getting away from it if you have a dog, you have to go 'cause he, he will just stand at the door and bark at you if he needs to go out. So you, you that you know. So encouragement is in the form of the dog and also my husband will say, come on, let's go, you know, I'm, I'm, I need a walk or whatever” (female, 51).

In relation to the ‘line manager influence’ sub-theme participants stated mixed opinions on their influence on their sitting. Some participants mentioned that their line managers were advocates for sitting reduction and encouraged staff to reduce sitting while WFH. For example, participant 17 mentioned:

> “Yeah, I think there's you know, she knows that I'm going to be doing the things I need to do in terms of the, my workload and so you know. She's, she's very much you know if you need to, you know take a break in the middle of the day to do a walk, take a break in the middle of the day to do a walk. You know it's, it's I think it's generally acceptable to do that” (female, 42).

However, it was also noticed that without actual monitoring, or by seeing their managers not following their own advice, their encouragement was not convincing. Within the same sub-theme some participants stated that their line managers did not encourage breaks from sitting, or simply was not in their agenda. For example, participant 11 said: “It's not really a topic for her, not that she wouldn't, it's not as she doesn't care, is not just in, it's not in the agenda” (female, 41).

Within the sub-theme ‘autonomy to schedule meetings/other people’s availability to meet’. Many participants mentioned that their opportunity to take breaks was “removed” when they had to schedule meetings. This was due to two issues. First, other’s people availability to meet was an influential factor as participants wanted to be available for other staff to meet. Second, not having the full control of their schedule meant that other people were able to schedule meetings if they found a gap in their calendars. An example of this was given by participant 16:

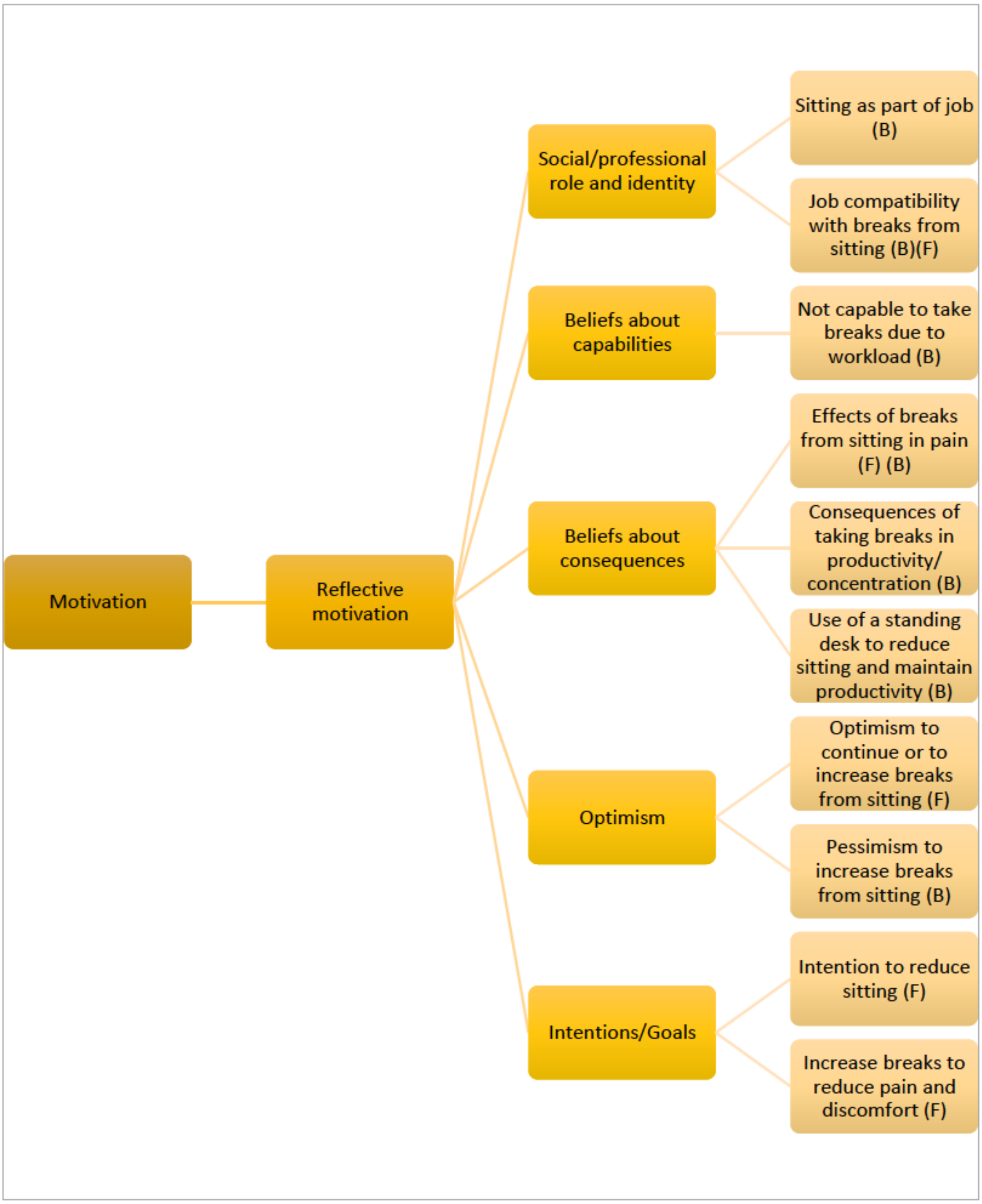
> “When I put gaps in my calendar to think about things or just go for, wee wander around the flat or do whatever you know, uhm, make a sandwich or whatever, they fill it with something. They say: Oh, I’ve found a slot in your diary, we can talk about that, and you're like (sighs) OK” (female, 56).

Motivation

Figure 17 and 18 illustrates emergent sub-themes related to the Motivation construct, and the Reflective and Automatic motivation constructs respectively. These are linked to the relevant TDFs. Additionally, barriers and facilitators are signalled in the figures.

Figure 17

Emergent themes within the Reflective motivation micro-construct and linked TDFs.



Note: Barriers (B) and facilitators (F) to break up sitting time are marked for each sub-theme.

Reflective motivation. In relation to reflective motivation sub-themes relevant to the TDF 'social/professional role and identity', 'beliefs about capabilities', 'beliefs about consequences', 'optimism' and 'intentions/goals' were found.

TDF domain: Social/Professional role and identity. This domain was defined as an individual's consistent behaviours or personal qualities that are displayed in either a social or work environment. The first sub-theme identified within the TDF 'social/professional role and identity' was 'sitting as part of job'. Participants agreed that sitting was a big element of their work especially since start WFH. For example, participant 4 mentioned:

> "Yeah, it's not the kind of job where you can just walk around. Cause I need my computers to do my work, so yeah. So, unfortunately impossible to do any other to do it in any other way, to put it that way" (female, 48).

A second sub-theme within this domain was the 'job compatibility with breaks from sitting'. Many participants did not feel that taking breaks was possible due to their work. However, it was mentioned by a few participants that even though sitting was part of their role, they felt that breaks from sitting were useful and could be integrated to their work schedule. For example, participant 5 mentioned:

> "(about taking breaks) I'm a great advocate that actually taking a break is really good for your mental health…So from, from my sort of research and teaching perspective, I don't, I don't see taking breaks as a threat to my work and my achievement. I see it as enhancing" (female, 54).

TDF Domain: Beliefs about capabilities. The domain 'beliefs about capabilities' was defined as the belief and acceptance of the truth, reality and validity about their capacities that a person can put to constructive use. A main sub-theme arose within this domain. Participants expressed feeling 'not capable of taking breaks due to workload'. Some participants mentioned not feeling capable to take breaks due to their high workload. As an example, participant 12 mentioned:

> "(about taking breaks while WFH) Do I feel like could do it? Uhm, I think I should do it, I think it's just generally the workload that keeps me pinned to the desk. Uhm, I mean everyone saying the same thing at the moment. I know we're all about pushed for time" (female, 61).

TDF domain: Beliefs about consequences. The domain 'beliefs about consequences' was defined as the individual's acceptance of the truth or reality of an expected outcome for a behaviour in a particular situation. There were three main sub-themes mentioned within this domain. First, some participants mentioned their belief on how 'breaks from sitting affected their pain'. Mixed opinions were voiced within this sub-theme. Some participants believed that the effects from breaks from sitting had a positive effect on their pain and discomfort. On the other hand, some participants mentioned that when pain and discomfort was too strong breaks from sitting were not helpful to reduce chronic pain. For example, participant 3 mentioned: "(about breaks) I just realize that when the discomfort is too much, it doesn't help that much. It does improve a little bit, but it doesn't help that much" (female, 42).

A second sub-theme was the 'consequences of taking breaks in productivity or concentration'. Many participants felt that breaking up their sitting would be detrimental to their workload or productivity/concentration. For example, participant 1 mentioned:

> "It's not exactly by taking the breaks itself, like if you are focused doing something. If you just continue doing it, you will finish in one hour, while if you

> take a break then you need to come back and uh… let's say catch up with what you were doing. You waste a little bit of time. Then you will end up doing one hour and a half. Just because you take a break" (male, 32).

A last sub-theme arose with many participants mentioned believing that a useful form to reduce their sitting would be the 'use of a standing desk to reduce sitting and maintain productivity'. For example, participant 1 mentioned: "Yeah, I mean. Yeah, it is easier for me to change from sitting to standing and continue work, instead of just standing and then distracting myself and then come back to work" (male, 32).

TDF domain: Optimism. The domain 'optimism' was defined as the confidence of individuals for things to happen for the best or for goal attainment. In this definition, this confidence could be either a positive or negative view (optimism or pessimism). Some participants mentioned having 'optimism to continue or to increase breaks from sitting' while WFH. Although it was expressed that their breaks routine might be interrupted if going back to the office. For example, participant 9 mentioned: "I think I'll be able to continue with the with the, the breaks while I'm working from home. Uhm I'm not sure how feasible it would be to continue that when we get back to the office" (female, 30).

Another sub-theme was 'pessimism to increase breaks from sitting'. A few participants expressed not feeling optimistic to increase their breaks from sitting while WFH. This view was related to the thinking that breaks from sitting have no effect on pain and discomfort, or the notion that pain would have to be unbearable to increase these breaks. An example of this was mentioned by participant 10:

> "I don't think there's anything else I can do. I've sometimes though if I could free up some workspace, work surface in the kitchen area to try and stand sometimes. But that would mean doing a lot of re, re organizing my kitchen. So I think I would have to be in a bit of great pain" (female, 61).

TDF domains intention/goals. The domains 'intention/goals' were combined and defined as the conscious decisions and mental representations of participants to achieve a behaviour. Two sub-themes were identified from this domain. First, sub-theme was the participants 'intention to reduce sitting' while WFH. For example, participant 8 mentioned: "(about intention to reduce sitting) Oh yeah, absolutely. I would like to be more disciplined, and better monitor my sitting and standing up habits, and yeah, more discipline" (female, 31).

Other participants mentioned they wanted to 'increase breaks to reduce pain and discomfort'. For example, participant 3 mentioned:

> "Uhm, just avoid pain. No yeah, so avoid pain, and be more active as well. So not being, sitting down all day and definitely going more out of the house. So not really related to well, related to sitting down, so avoiding sitting down actually are my goals" (female, 42).

Automatic motivation. In relation to automatic motivation sub-themes relevant to the TDF 'emotion' and 'reinforcement' were found.

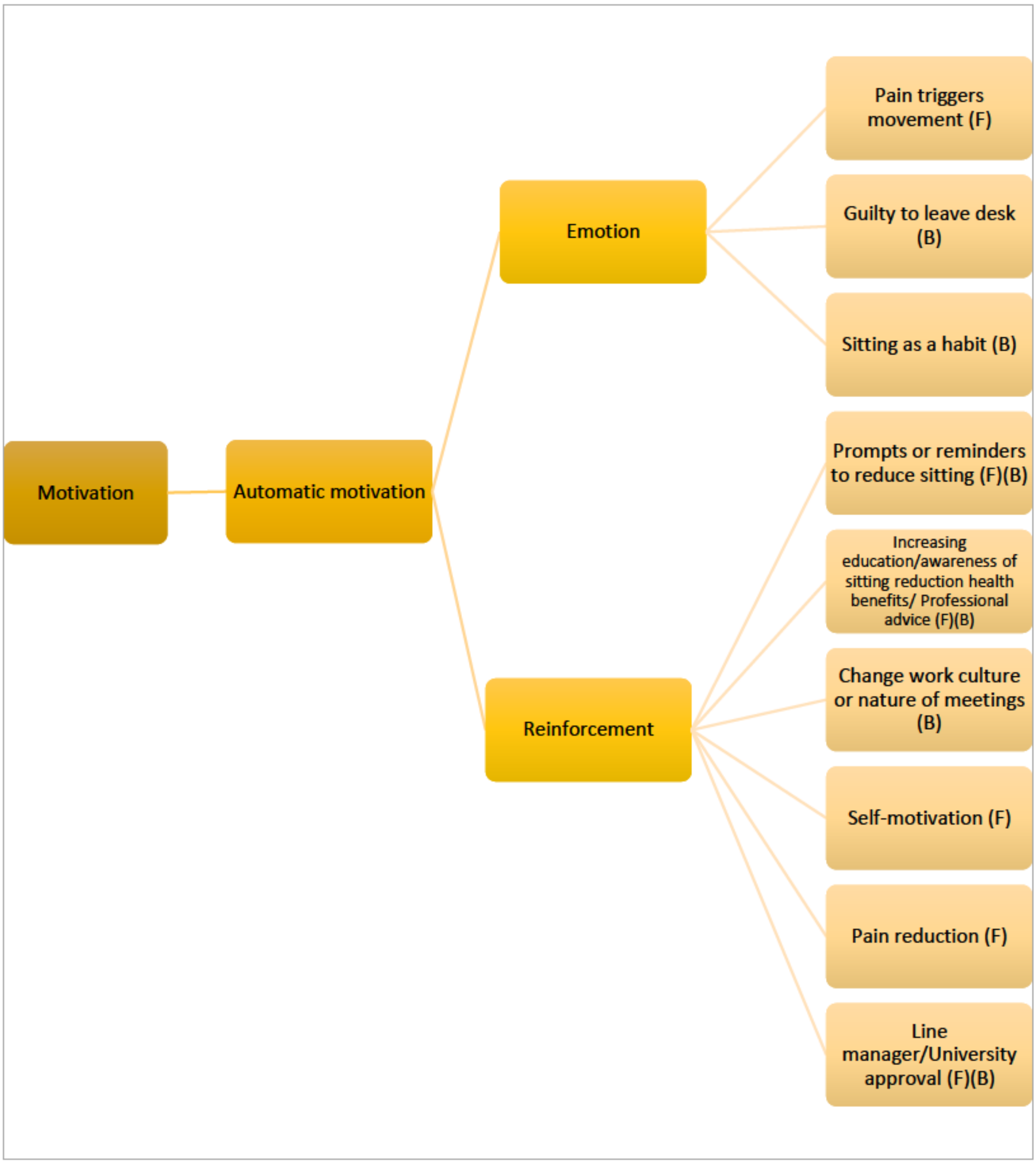
TDF domain: Emotion. The domain 'emotion' was defined as an evoked reaction pattern where the individual tries to deal with any event or occurrence. The sub-theme 'pain triggers movement' was mentioned by some participants. It seemed that pain was a prompt to take breaks from sitting in these participants. For example, participant 7 mentioned:

> "And I think often if, if I'm in pain that is a trigger, which I will then go and stretch. So like, when talking to you, I got up because it was it's the end of the day and I've been sitting for a long time, and I needed to move. So if conversely,

if I've got no pain, and my back feels fine, I might stay sitting for longer because I've got no trigger to remind me" (male, 54).

Figure 18

Emergent themes within the motivation construct, the Automatic motivation micro-construct and linked TDFs.



Note: Barriers (B) and facilitators (F) to break up sitting time.

The sub-theme ‘guilt to leave desk’ was mentioned by many participants. These participants stated feeling guilty to leave their desk due to the amount of workload. For example, participant 15 mentioned:

> “Uhm, so sometimes I actually look at the at the clock and I say: you haven't moved for three hours! You know. And, and you're aware of the time, but you are so busy and then, I will tell you more. Sometimes you actually feel guilty leaving the desk” (female, 54).

Lastly, many participants mentioned the sub-theme ‘sitting as a habit’. It was stated that sitting for prolonged periods was a habit or routine. As an example, participant 3 said: “But in the past I was sitting down just because of this habit of I start one thing, it's a very long thing and I don't finish until I'm very, very I'm exhausted” (female, 42).

TDF domain: Reinforcement. The TDF domain ‘reinforcement’ was defined as the likelihood to increase an individual’s response by arranging a dependent relationship between the response and an incentive. Various sub-themes were developed from this domain. Most of the participants mentioned that introducing ‘prompts or reminders to reduce sitting’ or emails would be useful to encourage them to take more breaks from sitting. For example, participant 2 mentioned:

> “More kind of intelligent reminders let's say, 'cause I seem to spend most of my life on calls like this. And let's say that Microsoft 365 knows when I'm in meetings and it could give me reminders at convenient times to say: Looks like you've got half an hour free, why don't you go for a walk? That would be app would actually be really useful” (male, 48).

Another sub-theme within this domain, was ‘increasing education/awareness of sitting reduction health benefits’. Participants mentioned that education would be an effective strategy for staff to be encouraged to take more breaks from sitting while WFH. For example, participant 9 mentioned:

> "And I think also increased awareness, I don't, I don't think this area of research is very high on the average person's agenda. And so I don't, I don't think it's something that is particularly, uhm... Yeah I don't, I don't think is something that it's particularly well known about in certainly in the professional services population, so I think it would be interesting to have more information disseminated to staff, so people could then make positive changes off the back of" (female, 30).

Within this sub-theme, a few participants felt that they would feel encouraged to take more breaks if professional advice (e.g., physiotherapy consultation, live exercise classes with a professional trainer) were provided by the University. Moreover, to learn what type of breaks are beneficial to reduce their pain and discomfort. For example, participant 8 mentioned:

> "Having a stretching routine, and also some physio exercises that I can do to reduce that (pain). And if you know prescribed by a professional, I think that would be amazing. It could even be a University policy you know to have once a year a free consultation with a physio. To talk about this (pain) and then have a kind of stretching and exercising routine that you can do during your breaks. That would be amazing" (female, 31).

Another common sub-theme was changes in the 'work culture or nature of meetings' to be able to reduce sitting. Some suggestions were instigating a work culture to take breaks during online meetings. For example, participant 17 mentioned:

> “What would be really good is, you know. I had an exam board meeting last week for example, and the person who scheduled it scheduled it for 90 minutes. And that's great. But an exam board is never ever going to take 90 minutes. It's always going to be 2 and a half to 3 hours. And actually it would have been really good for the person convening that meeting to have paused halfway through the meeting and say: right, we're gonna have break now, we’re gonna have a comfort break, get up and do whatever. And actually, that culture needs to be embedded more into how we're doing things. Because you would never sit in a room for three hours. It would, you know, if we're doing an exam board in person, that would have been catered, someone would have brought coffee halfway through and everyone would have got up and had it wander around. But because we're doing online it’s like there's people forget how bodies work some, somehow”. (Female, 42).

A few participants mentioned that personal motivations or ‘self-motivation’ were necessary to reduce prolonged sedentary time, otherwise this would never take place. An example from participant 15: “I think if you are self-motivated enough, there would be, there's is more flexibility at home to take more regular breaks, but you still need to be personally motivated to do that” (female, 54).

‘Pain reduction’ was stated also by few participants who indicated that the reducing discomfort while WFH was sufficient as an incentive to reduce their sitting. For example, participant 17 mentioned:

> “(about taking breaks on pain) I mean I don't, I don't need an incentive anymore because I obviously I can see the direct benefit of doing it. That the, my quality of life is vastly improved, and if I can avoid ending up in the situation where I was last summer, where I was just sore all the time and uncomfortable and miserable about that” (Participant 17, female, 42).

Lastly, the importance of the ‘line manager or University approval’ was mentioned by most of participants. It was stated that it would be more acceptable for staff to follow strategies for sitting reduction if line managers or the University introduced or approved these strategies. For example, participant 12 mentioned:

> “If I got something like you know, a prompt and everything, and he (line manager) came to me and he’ll said it's OK to do it, that's OK just to take those 5 minutes to do that wee bit stretching. I think that would allow people to have the permission to do it” (female, 61).

Discussion

WFH has become the regular workplace for many desk-based workers since the start of the COVID-19 pandemic. Chapter 3 (study 2) results signalled that University of Edinburgh staff tend to engage in occupational SB for the majority of their day. Also, higher levels of occupational SB during their day indicated a higher prevalence of MSK symptoms. Therefore, the aim of this study was to carry out a behavioural diagnosis of University of Edinburgh staff with MSK symptoms while WFH. This behavioural diagnosis was oriented to identify the most relevant factors influencing SB reduction in these workers while WFH. The COM-B model (Michie et al., 2011) and the TDF framework (Cane et al., 2012) are useful frameworks to identify what factors influence behaviours and perform a behavioural diagnosis. Thus, both models were used to align this study findings. To the authors knowledge this is the first study to carry out a behavioural diagnosis in desk-based workers with MSK symptoms while WFH.

Main findings indicated that the most important sources and domains of behaviours for University of Edinburgh staff to reduce their SB were related to their ‘physical and social opportunity - environmental context and resources and social influences’, ‘reflective motivation – social/professional role and identity, beliefs about capabilities, beliefs about consequences, intentions/goals, optimism', and 'automatic motivation – emotion, reinforcement'. Although sub-themes within capability were not within the main barriers for sitting reduction, findings for this construct are reported due to their importance to this study.

Capability

About psychological capability, and TDF domain 'knowledge', most of the participants had an adequate knowledge of prolonged sedentary time, and health problems related to this. Furthermore, participants considered that prolonged sedentary time was an unhealthy behaviour and that it had direct MSK health consequences. This was in agreement with Niven et al. (2022) where participants showed high levels of 'knowledge' to reduce their SB at home.

On the other hand, conflicting evidence related to 'knowledge' has been indicated in office-based literature. Lack of knowledge of prolonged sedentary time expert advice, and health consequences have been indicated as common barriers to reduce SB in the workplace (MacDonald et al., 2018; Munir et al., 2018; Ojo et al., 2019a, 2019b). However, staff knowledge in this study was not a barrier to reduce their sitting. These findings may be indicative of university staff been more aware of health consequences related to prolonged sedentary time. Other possible reason for staff having sufficient knowledge might be the release of an informative program (Cardinus – Online health and safety training) released by the Health and Safety department from the University of Edinburgh. This training program contained information about healthy work (e.g., wellbeing, setting up ergonomic workstations) at home during and after COVID-19 which could have been useful to create awareness for University of Edinburgh staff while WFH. Still, this was not an explored outcome in this study and its real influence on participants cannot be established.

Regarding physical capability and the TDF 'skills', surprisingly most of participants with MSK symptoms felt capable to break up their sedentary time regardless their pain and discomfort. With only a few participants stating that pain and discomfort discourage them to stand up more. Nevertheless, they still felt able to take breaks from sitting and have found strategies to cope with pain and discomfort that allowed them to continue working. Comparable evidence from De Cocker et al. (2015) targeting SB reduction in desk-based workers in the workplace, also noticed that participants with MSK symptoms did not consider that pain was a barrier to reduce their SB. On the other hand, these findings are contrary to other authors findings, where desk-based workers with MSK symptoms remained static and took less breaks due to pain and discomfort (Bontrup et al., 2019; Zemp et al., 2016). Regardless of the MSK symptoms prevalence and work interference reported in the screening questionnaire, staff SB did not seem to be influenced by their MSK symptoms.

These findings suggest that MSK symptoms are not an influential factor for symptomatic staff to reduce their SB at home. Moreover, other factors appear to be more influential (e.g., workload, resources to stand up at home) for UoE staff to reduce their SB. Although participants did not consider MSK symptoms as a barrier, they still have MSK prevalence been higher in lower back (92%), neck (86%), hips and buttocks and right shoulder (71% all). Therefore, it would be of importance targeting pain reduction in these workers to improve their daily activities.

Opportunity

In relation to opportunity, most of the barriers discussed by participants were related to both micro-constructs (physical and social). The TDF domain 'environmental context and resources' (physical opportunity) while WFH seemed to be an important barrier to increase breaks from sitting for staff. The most common themes were the lack of opportunities while WFH to stand up for work activities (e.g., online meetings), as well as the lack of office resources a home such as standing desks. Nevertheless, few participants that had purchased sit-stand adaptations overcome this barrier.

It was also noticed that the change from the workplace to the WFH environment was a barrier to reduce SB, as participants felt that breaks were more natural and automatic at the office, as well as distances were further away than at home. These findings show consistency with Niven et al. (2022), where participants reported the home environment was less conducive for SB reduction when compared to the office. Similarly, those participants also mentioned lacking standing desks or appropriate furniture to stand and continue working at home.

Further office-based literature indicated some consistencies with this study findings. Previous literature has also signalled that lack of resources to stand up in the office environment are important barriers to remain seated for work (MacDonald et al., 2018; Munir et al., 2018; Ojo et al., 2019a, 2019b). Nevertheless, many participants from this study mentioned having more resources to stand up at the office. Therefore, this statement challenges current literature of office environments, as the workplace is not commonly equipped with sit-stand desks.

Related to the TDF domain 'social influences (social opportunity)' both barriers and facilitators to break up sitting while WFH were indicated. WFH present social challenges such as isolation from peers (Clair et al., 2021). However, it seemed that many participants felt encouraged by their spouses or partners, their children, and dogs to take more breaks from sitting at home. Thus, facilitating sitting reduction. In agreement with this finding, research from Oliver et al. (2021) also indicated that participants were highly encouraged by their families to increase their breaks from sitting. Although these findings were from an office environment and not while WFH. Therefore, further research of the influence of household characteristics (e.g., marital or partnership status, children in the household, owning a dog or pet) would be of interest to understand if these factors influence SB reduction in the home environment.

Line managers' influence was also an important theme. It seemed that many line managers were interested in the staff wellbeing at home and encouraged them to take breaks. Nonetheless, an important barrier was found within the same theme, as participants felt that having the advice but not monitoring from their managers (or University) to take breaks was a barrier to not reduce their SB. Along with this finding was the notion that if line managers also took breaks would seem like the staff had authorisation from the University to reduce their SB. This theme shows agreement with De Cocker et al. (2015) research on the feasibility of sitting reduction interventions in the office. Participants of that study mentioned that to overcome the lack of encouragement or monitoring as a barrier, line managers should act as 'role models' to motivate workers to increase their breaks from sitting. Differently to current literature (Munir et al., 2018; Niven et al., 2022; Ojo et al., 2019a, 2019b), participants from this study did not mention to feel 'watched over' by other peers or line managers to remain in their desks all day. As a result, this was not a barrier to break up their sitting.

An important barrier pointed out by most of the participants was not having autonomy over their online schedule. This was reflected in two main issues; first people could easily schedule meetings in their gaps. Second, staff were worried about other's people availability to meet, which ultimately determined their availability, both reflecting in their opportunity to reduce sitting. Although these findings have not been explored by other researchers, it would be of interest to understand if staff having autonomy over their schedule would reduce SB while WFH.

Motivation

In relation to motivation, specifically reflective motivation, all the sub-themes within the TDF domains presented relevant barriers to reduce SB at home. Sub-themes associated with 'social and professional role and identity' indicated relevant barriers to reduce sitting. Most of the participants had the notion that sitting was either a high or a total percentage of their job role. This perception seemed to influence participants to remain seated for work for most of their day. Consistently, Munir et al. (2018) mentioned also that desk-based workers had higher sedentary time due to the nature of their role. Differently, a few participants from this study had overcome the notion of sitting as necessary for office work and taken action to reduce their sitting.

In relation to 'belief about capabilities' most of participants felt confident to take breaks from sitting while WFH. However, a common barrier linked to this theme, was having a substantial amount of workload. Workload was considered a powerful limitation for staff to reduce their sitting while WFH. Workload was also mentioned at 'beliefs about consequences', as participants felt capable to take breaks, but taking breaks from sitting would interrupt their focus, concentration and productivity. This finding seems also to be linked to 'Emotion', as participants also mentioned having feelings of guilt to leave their desk due to their workload.

Current research of desk-based workers in the workplace also mentioned guilt as a common theme amongst these workers. From this evidence it was suggested that desk-based workers felt guilty to leave their desks due to the high amount of workload and this was a barrier to reduce their SB (Ojo et al., 2019a; Oliver et al., 2021). Research at the home environment also signalled that participants beliefs to reduce SB at home were affected due to their workload (Niven et al., 2022).

Findings also suggested that participants believed increasing their breaks from sitting would impact their productivity. Systematic review evidence has indicated that breaks from sitting show no adverse effects on work productivity (Waongenngarm et al., 2018). However, this evidence comes from highly heterogeneous studies. Further primary evidence on sitting reduction effects on productivity has found no association between SB and productivity (Rosenkranz et al., 2020). These authors reported that workers spending less sedentary time for work have higher job satisfaction and lower fatigue in comparison with workers with highest sedentary time. Nevertheless, evidence of the direct effects of breaks from sitting on productivity is still needed. Developing strategies to spread awareness of the effects of breaks from sitting on productivity and concentration are essential to reduce SB in this population.

Regarding the influence of MSK symptoms on sitting time, various sub-themes fitted within the construct ‘motivation’. First, and related to the TDF domain ‘beliefs about consequences’, a facilitator for some participants was the belief that taking breaks from sitting would reduce their pain. Second, and linked to ‘emotion’, it was mentioned by some participants that pain and discomfort was a trigger to reduce their sitting. Even though these sub-themes seemed to be facilitators to reduce sitting in staff, these workers observed not achieving SB reduction. It is evident from this research that although staff was aware of the possibility of reducing MSK symptoms by taking breaks this still did not prompt them to take more breaks.

Themes related to ‘Intentions/Goals’ and ‘Optimism’ showed similar barriers to reduce SB. Participants had strong intentions and goals to maintain and/or increase their breaks from sitting while WFH. Equally, they felt optimistic to reduce their SB in the home environment. Similar to these findings, current research has also signalled that desk-based workers had strong intentions to reduce their SB at the office (Munir et al., 2018; Ojo et al., 2019a, 2019b), and while WFH (Niven et al., 2022). It is important to point out that a few staff mentioned not having intentions to increase or take breaks from sitting. Comparably, MacDonald et al. (2018) findings also indicated lack of intention as a barrier to reduce SB at the workplace.

However, this could also be attributed to the participant's pessimism of breaks from sitting not reducing their pain and discomfort.

It can be noticed that changes on sitting behaviour are not inherently related to desk-based workers intentions or goals to reduce their SB. On the other hand, motivations in these workers seem strongly related to the workload. Therefore, strategies to manage workload might be necessary for these workers to be able to reduce their SB at home.

Lastly, the lack of 'reinforcement' of strategies to reduce SB while WFH seem to be an important barrier for participants of this study. It was evident that many participants were keen to change their desk-time while WFH. Nevertheless, there was a perception that more institutional (University) input or approval was necessary to achieve this reduction. Changes in the work culture to make breaks socially acceptable would be also necessary. Additionally, changes in the online environment such as the inclusion of prompts to take breaks through emails or Microsoft Teams appeared to be essential for participants to feel both intrinsic (self-motivated) and extrinsic (University approval) motivated to reduce their sitting. In agreement with this, current research also signalled that work culture and institutional changes are necessary for desk-based workers to feel motivated to reduce their SB (MacDonald et al., 2018; Munir et al., 2018; Ojo et al., 2019a, 2019b).

Strategies to reinforce desk-based workers to reduce their SB while WFH are also necessary. A recent rapid review by Morton et al. (2022) analysed the transferability of strategies to reduce SB from the office to the home environment. Findings indicated that the use of prompts, role models, educational materials and incentives were the most promising strategies to be transferred from the office to the home environment. Additional research is still needed to understand if these identified strategies are helpful to achieve behaviour change in desk-based staff WFH.

Table 19 illustrates the main barriers found by symptomatic UoE staff to reduce their SB while WFH, and some recommendations to overcome these.

Table 19

Main barriers to reduce SB at home and recommendations to overcome these barriers.

Barriers to reduce SB while WFH	Recommendations to overcome barriers
Lack of sit-to-stand resources at home	- University assistance to restructure the working space at home, e.g., Provide adaptable equipment for home, such as desk risers. - Educational resources or training to set-up DIY standing desks.
Reduced opportunity to take breaks at home	- Provide education and training of the types of breaks that can be done while WFH. E.g., exercises while boiling the kettle, doing laundry, walking.
Online environment while WFH	- Changes in work culture and nature of meetings, e.g., departments with a positive agenda for taking breaks from sitting during online meetings. - Increase and encourage the acceptability of breaks and/or active meetings. E.g., standing, stretching, walking meetings. - Software to help encourage breaks during the working day, e.g., prompts embedded on MS Teams suggesting PA breaks.
MS Teams settings	- Discourage back-to-back meetings, e.g., encourage 50-minute meetings. - Add software to MS Teams to allow staff to block periods of time to take short breaks during the working day.
Line manager influence	- Workplace policy/agenda urging line managers to promote the health benefits of active breaks and reducing SB while WFH.
Autonomy to schedule meetings	- Training staff to configure their online calendars. E.g., educate staff about how blocking their calendar slots to avoid other staff book without authorisation.
Sitting as part of job or as a habit/Job incompatibility with breaks from sitting	- Create and deliver educational resources to increase knowledge on SB health consequences, expert health advice, and how to fit breaks into the working day.

Workload/Guilt to leave desk	- Changes within the workplace, including policies in relation to workload and time management. - Institutional/organisational input or approval for SB reduction while WFH, e.g., workplace policies supported by the university targeting the acceptability to reduce SB by increasing breaks. - Guidance for line managers to encourage staff to take breaks and reduce their SB regardless their workload. - Provide encouragement to staff to attain to work schedule while WFH, e.g., not overstretching their working hours.
Consequences of taking breaks on productivity/ concentration	- Increasing awareness of the health benefits of reducing SB, including productivity and concentration.
Pessimism that taking breaks will not reduce pain/discomfort	- Provide staff with pain/discomfort professional health advice about reducing pain, e.g., one-time free physiotherapy appointment. - Create exercise programmes for staff with pain/discomfort to reduce their SB at home and at the office.

Strengths and limitations.

Both strengths and limitations are acknowledged in this study. To the author's knowledge this was the first study to explore factors influencing SB in university staff with MSK symptoms WFH. A main strength of this study is the collection of rich data through semi-structured interviews based in both models (COM-B and TDFs). The use of the framework method (Gale et al., 2013) to align the results from the interviews to deductive and inductive themes within theory ensured a systematic and robust approach to the data analysis. The use of a second researcher as a 'critical friend' to support the data analysis process was key to enhance the rigour of this study. Another strength is that most of participants (15 of 17) had taken part of the second study (study 2). Therefore, this provided a follow-up scenario from the second study, which was useful as a starting point for the data collection.

An important limitation of this study was the time constraints that derived in the use of the critical friend in the early stages, but not in the data interpretation due to resource and time constraints. This potentially limited additional insights during this stage. An additional limitation is the gender distribution in this study, with most female participants (14 of 17). Although generalisation is not an objective of qualitative data, further representation of other genders would be relevant to comprehend if there are gender inherent differences to prolonged sedentary time.

It is also important to mention that during the data collection period (November 2021 to January 2022) restrictions for the workplaces from the UK Government changed meaningfully due to the Omicron variant detected on the 10th of December 2021 (UK Health Security Agency, 2021). During this period, Scotland moved from protection level 3 (work from home where possible) to level 4 (work from home exclusively). Thus, encouraging desk-based workers to remain WFH during that period. Therefore, data from the interviews during this time might be influenced uniquely by these factors.

Lastly, due to time constraints only a behavioural diagnosis could be carried out in these participants. Consequently, it was not possible to undertake the identification of intervention functions and policy categories which can be used to create a possible WFH intervention to reduce sitting. Mapping the most common sub-themes to the BCTs would have been useful to develop a specific intervention for people with MSK symptoms to reduce their sitting (although pain and discomfort was not a barrier to increase breaks from sitting in this population).

Implications for practice and research

Various implications for practice and research can be made from this study. Firstly, study findings would be useful in development of future WFH interventions targeting sedentary time reduction in desk-based workers with MSK symptoms. Considering the global prevalence of MSDs, further research to reduce MSK symptoms in risk populations such as desk-based workers WFH is still necessary. This would allow these workers to be able to make their daily life pain free and reducing job absenteeism and disability.

Secondly, it would be relevant that institutions such as universities be able to design strategies for workers to reduce their desk-time. Specifically in the home environment, where workers lack of physical opportunity and environmental resources to reduce their desk-time. Institutions should be able to encourage workers to manage their workload by highlighting the importance of physical and mental health. Similarly, institutions should promote mindfulness of changes on work culture and acceptability of breaks from sitting while working. The rapid review by Morton et al. (2022) has provided information about strategies transferable from the workplace to the home environment. These could be used in combination with this study findings providing an initial backdrop to create strategies to reduce SB at home.

Finally, additional research on SB patterns while WFH using device assessed methods would be useful to understand comprehensively SB and breaks management at the home environment.

Conclusion

The COM-B model and the TDFs proved to be useful tools in identifying both barriers and facilitators to reducing occupational SB and increase breaks from sitting in this population. UoE staff with MSK symptoms had the psychological and physical capability to reduce their sitting. Interestingly, their pain and discomfort was not a barrier to reduce SB at home.

The most important barrier for participants was their current workload and various barriers associated to this. Participants' behavioural regulation to take breaks was also directly influenced by their workload. To encourage staff with MSK symptoms reduce their sitting while WFH, barriers related to physical (e.g., standing-desks) and social opportunity (e.g., work culture), automatic (e.g., guilt to leave the desk) and reflective motivation (e.g., beliefs and strategies to reinforce breaks from sitting) need to be tackled.

These findings are useful to support desk-based workers to reduce both SB and MSK symptoms while WFH. The findings can also be used in future research as well as to inform the design and implementation of strategies and interventions to increase breaks from sitting at home in people with MSK symptoms. Institutional and/or organisational changes are necessary for this population to be able to manage their workload and reducing SB at home.

Chapter summary

This chapter aimed to identify the most relevant factors influencing desk-based staff with MSK symptoms to reduce their SB and increase their breaks from sitting at home. Findings provided valuable insights of the factors influencing SB in desk-based university staff with MSK symptoms WFH. Interestingly, MSK symptoms were not a barrier for these workers to reduce SB at home. Moreover, workload seemed to be the most influential barrier for UoE staff to reduce their SB at home.

Despite not being a barrier to reduce SB, MSK symptoms were still prevalent in this population and participants had to find strategies to cope with pain to keep working. This study's findings are useful to support UoE staff to reduce their SB prevalence at home while targeting MSK symptoms reduction.

The next chapter will focus on discussing the main findings, strengths and limitations from this thesis and the implications and future directions for research.

Chapter 5. Thesis discussion

The purpose of this chapter is discussing the thesis as a whole. This includes summarising the key findings, the contribution to the research field, strengths and limitations, implications for practice and future research directions.

Summary of the thesis, key findings and contribution to knowledge

The overall aim of this PhD thesis was to expand the knowledge of the role of breaks from sitting as a strategy to reduce MSKs symptoms and occupational SB in desk-based workers. This was explored in two work settings: the office and home. The thesis used a comprehensive mixed-methods approach, and three studies were undertaken to address each research objective. The summary of each study, key findings and contribution to knowledge are described below.

Research objective 1. Systematically review literature of the effectiveness of breaks from sitting on MSK spinal outcomes in adults with sedentary occupations

The first study (chapter 2) was a systematic review created to address the lack of evidence exploring the effects of breaks from sitting on spinal MSK outcomes. Most of the available evidence was based on self-reported measurements. Two review objectives were established to address this dearth in literature. The first objective was to review literature of the effects of breaks from sitting on device assessed spinal MSK outcomes in sedentary workers. The second objective was to compare the effects from device assessed spinal outcomes, with its effects on self-reported MSK spinal outcomes, when available.

From the 12 studies included in this review, it was evident that research exploring the effects of breaks from sitting on spinal MSK outcomes was limited. The key finding from this systematic review was that stretching breaks were the most useful type of break to reduce device assessed and self-reported MSK spinal outcomes in sedentary workers. Specifically, review findings suggested that stretching breaks from sitting were useful to decrease device assessed spinal MSK outcomes in acute single-session and medium to long-term interventions (2 weeks to 3 months). However, the findings from single-session interventions are taken cautiously due to the low number of studies reporting this outcome (one study).

Two important limitations of this study were identified. Firstly, the available evidence was taken from highly heterogeneous studies. These studies varied on type of breaks protocol, measurement tools, breaks type, duration and frequency which made difficult to generalise the findings. Secondly, the poor reporting (e.g., missing data) of the included studies limited the data synthesis process, which also made it difficult to make concluding remarks.

At the beginning of this PhD, it was noticeable that literature exploring the effects of breaks from sitting on MSK symptoms was limited to self-reported outcomes such as pain and discomfort (Agarwal et al., 2018; Luger et al., 2019; Parry et al., 2019; Waongenngarm et al., 2018). Previous evidence of device assessed effects of breaks from sitting on spinal MSK outcomes was restricted and focused mainly on cardio-metabolic and all cause-mortality outcomes (Honda et al., 2016; Saunders et al., 2018). To my knowledge, at the time of conducting the review, and the review update, there were no systematic reviews published assessing these outcomes.

This systematic review made an important contribution to knowledge by adding evidence of the effects of breaks from sitting to reduce MSK spinal symptoms in sedentary workers. First, by synthesising evidence of the device assessed effects of breaks from sitting on spinal MSK outcomes. Secondly, by complementing the device assessed spinal MSK outcomes with self-reported MSK spinal outcomes, which no systematic review had previously carried out. To my knowledge, to date there are still no published systematic reviews synthesising evidence of the effects of breaks from sitting on device assessed MSK spinal symptoms in sedentary occupations. The only comparable published systematic review by Waongenngarm et al. (2018) did not explore the effects on device assessed MSK spinal symptoms like this review did. Also, authors from that review only explored the effects of breaks from sitting on LBP, and not different spinal outcomes as this review did. Both reviews made apparent that breaks from sitting that include postural change are the most effective form to reduce MSK symptoms in the spine, which may be attributable to the postural change involving light bouts of PA.

Research objective 2. Explore SB and MSK symptoms in University of Edinburgh desk-based staff WFH

The second study (chapter 3) was a cross-sectional quantitative study designed to address changes in the work landscape due to the COVID-19 pandemic. These changes began with the COVID-19 pandemic and continued afterwards with desk-based workers WFH or engaging in hybrid working. The study aimed to explore differences in MSK symptoms prevalence between groups defined by occupational sitting, breaks from sitting and ergonomic chair settings. It was also hypothesised that higher levels of SB would reflect in higher MSK symptoms prevalence. Research objectives were to describe occupational sitting time, breaks from sitting (number and duration), ergonomic chair settings and musculoskeletal symptoms prevalence in UoE staff while working from home (WFH).

Key findings showed that UoE staff had an elevated prevalence for both occupational SB and MSK symptoms while WFH. Additionally, study findings indicated that groups with occupational sitting of over 8 hours per workday showed a higher prevalence of MSK symptoms. These findings confirmed the formulated hypothesis for the study. Another key finding was that groups of breaks from sitting number and duration did not differ significantly in MSK symptoms prevalence at the home environment. Nevertheless, a large percentage of UoE staff still took a high number of breaks compared to relevant SB literature. The ergonomic chair settings scores also appeared to not be influential for MSK symptoms prevalence in UoE staff. The most prevalent areas for MSK symptoms were neck, lower back, and right shoulder.

The second study of the thesis made a valuable contribution to literature by acknowledging the lack of evidence around a novel work setting after a global pandemic, the home environment. During the design of this study, evidence of SB was restricted to the office environment, with very limited research of SB in the home environment. Only two studies comparing SB at both the workplace and at the home environment were identified before this research (Olsen et al., 2018a, 2018b). There was also limited evidence in relation to the prevalence of MSK symptoms and SB at home. For example, the existing studies were not focused solely on desk-based workers (Moretti et al., 2020; Šagát et al., 2020; Yang et al., 2017). This study collected key data for many unexplored outcomes in the home environment such as occupational sitting, breaks from sitting, and ergonomic chair settings in university staff. In addition, this study also assessed MSK prevalence in home settings in desk-based workers which had not been explored yet adding to the growing literature of the home environment.

Further evidence has become available after the completion of this study. These evidence has also found increases on SB in desk-based workers WFH (Javad Koohsari et al., 2021; Ráthonyi et al., 2021). In contrast to the second study of this thesis, recent evidence has accounted for PA levels, which seems to provide benefits to reduce MSK symptoms in this population. For example, evidence from Rodríguez-Nogueira et al. (2020) found that desk-based female staff from two universities, who had increased their PA during the confinement periods had lower MSK symptoms prevalence. In the second study of this thesis, this factor was unaccounted for.

Research objective 3. Identify factors influencing SB and breaks from sitting in desk-based University of Edinburgh staff with MSK symptoms while WFH

The third study (chapter 4) was a qualitative study created to explore factors influencing SB and breaks from sitting in UoE staff with MSK symptoms while WFH. The study was based in two theoretical models. The COM-B model (Capability, Opportunity, Motivation) which allowed a behavioural diagnosis of UoE staff. The Theoretical Domains Framework (TDF) informed the identification of the most common barriers and facilitators influencing SB in the home environment.

Key findings from this study indicated that UoE staff were physically (e.g., physically able to take breaks) and psychologically capable (e.g., had knowledge to reduce sitting) to reduce their SB while WHF. Interestingly, their MSK symptoms did not influence their SB in the home environment. Furthermore, participants had found strategies to cope with pain and were able to continue working regardless their pain and discomfort. Barriers to reduce SB were mainly associated with their physical (e.g., inadequate space to take breaks) and social (e.g., work culture to take breaks) opportunity, automatic (e.g., guilt to leave desk) and reflective motivation (e.g., strategies to reinforce breaks from sitting). The most relevant barrier for this population appeared to be related to their workload management which did not allow them to increase their breaks from sitting while WFH.

It is evident that during and after the COVID-19 pandemic, desk-based workers reported to have a higher prevalence of SB while WFH (Javad Koohsari et al., 2021; Ráthonyi et al., 2021). The third and final study of this thesis has contributed to the growing evidence exploring factors influencing SB while WFH. To my knowledge this is the first and only study exploring factors influencing SB in desk-based workers with MSK symptoms in the home environment by using behaviour change theories.

Prior to the pandemic, studies using the BCW, COM-B and TDFs aimed to understand factors influencing SB at the office (Munir et al., 2018; Ojo et al., 2019a, 2019b). Nevertheless, these authors did not focus on the home environment. Only one study from Niven et al. (2022) explored SB in university staff (UoE) working at home. This study found similar factors influencing SB in staff WFH. These factors were mapped to the COM-B model. Amongst these factors were high levels of capability, and lower levels on opportunity and motivation. However, these findings were taken from asymptomatic workers, rather than workers with MSK symptoms.

Findings from the third study deepen the current qualitative evidence at the home environment by using behaviour change theories. The study findings also highlighted how desk-based workers with MSK symptoms are adaptable to pain and discomfort by developing strategies to cope with pain, allowing them to continue working. These workers SB seems to be driven by their workload. This study findings are useful to support staff with MSK symptoms to reduce their SB at home. This study identified that strategies to reduce SB in symptomatic and symptom-free desk-based workers are similar. Strategies to manage workload may allow these workers to increase their breaks from sitting while WFH.

Implications for practice

The findings from this thesis have broader implications in both research and practice. Some of these have been considered briefly in each chapter. However, this section uses the whole thesis findings to expand on these.

Sedentary Behaviour and 24-hour movement guidelines

As mentioned in the introduction (chapter 1), the development of the SB guidelines are still in progress. The Canadian 24-hour movement guidelines advise to reduce SB by adding movement through the day (Canadian Society for Exercise Physiology, 2020). However, no further recommendations about the type of activities that can be done to reduce SB are made.

The research of the direct effects of breaks from sitting would be a valuable contribution to the SB guidelines which are still being outlined by various research bodies (e.g., Scottish government, WHO). Research exploring the most effective type, duration, and frequency of breaks to decrease the negative health outcomes from prolonged SB is still necessary to complement these and inform the public. Breaks from sitting are a low-cost strategy, which provide benefits to cardio-metabolic outcomes, and that could be easily followed by the general population. Still, more research about other health effects from breaks from sitting is still needed.

Considering the high global prevalence of MSDs and the contribution of prolonged SB into this prevalence, SB guidelines should also include recommendations to target MSK symptoms. Findings from the first study (chapter 2) suggested that breaks from sitting, specifically stretching breaks, are useful to decrease MSK symptoms. Using these findings could be key to both reduce SB and target MSK symptoms reduction. Thus, helping to reduce the high global prevalence of MSDs.

Implement strategies targeting SB and MSK reduction while working from home/hybrid working

The work landscape has changed permanently since the COVID-19 pandemic. Desk-based workers now either WFH or engage in hybrid working (working at the office and WFH) and plan to continue so (Office for National Statistics, 2022). One of the key findings from this thesis was providing evidence around the high prevalence of occupational SB in desk-based workers at the home environment. Moreover, these workers had also high levels of MSK symptoms prevalence in this work setting.

From the thesis findings it seems evident that the presence of MSK symptoms are exacerbated by prolonged SB. Therefore, strategies to reduce SB are necessary. From study three (chapter 4) it was apparent that desk-based UoE staff had not found MSK symptoms prevalence as an impediment to reduce their SB at home. To complete their work, staff had found strategies to cope with pain which allowed them to keep working. These findings suggest there is a need for workplaces and organisations to create programs or policies supporting workers to manage their workload. Thus, helping these workers to reduce their SB. This would be key to reduce the negative health outcomes related to SB, including the high prevalence of MSK symptoms.

The introduction of breaks from sitting would be a useful strategy for workers to reduce their SB while WFH. These breaks are low-time consuming and can be carried out during work, also they do not represent high cost for organisations. A recent rapid review by Morton et al. (2022) focusing on the transferability of strategies to reduce SB at the workplace to the home environment has suggested the use of educational materials, role models, incentives and regular prompts to encourage SB reduction at home. However, the feasibility and acceptability of these strategies for workers still needs to be implemented and tested. Therefore, further research is still necessary to address this.

From the findings of this thesis, it is also suggested that desk-based workers need to be encouraged or receive ‘permission’ from line managers, or directly from the organisations for this to be feasible. Systemic changes within workforces would be essential for workers to feel supported to be able take breaks from sitting during work. Therefore, strategies that combine these aspects should be also targeted by future research.

Implications for future research.

Within the broader context, suggestions for future research have been identified from the thesis findings. These suggestions are reported first considering the role of breaks from sitting to reduce SB in desk-based workers. Second, considering the role of breaks from sitting on reducing MSK symptoms in this population.

Tool Validation

It was evident from this research that standardisation to measure self-reported breaks from sitting is still required. Many authors have selected open-ended questions to assess this outcome. However, usually the validity and reliability of open-ended questions have not been tested. Therefore, results from these questions might fluctuate considerably from one study to another, which makes difficult to generalise findings.

Additional research is still needed to standardise and validate tool's reliability. This research needs to compare both SB and breaks from sitting with device assessed data (e.g., accelerometer) to test the consistency and adequacy of tools measuring these outcomes at both the office and the home environment. In this thesis, the Sudholz tool (Sudholz et al., 2018) was used to measure self-reported breaks from sitting at the home environment. This tool was selected due having fair to good construct validity and test retest reliability (Bakker, Hartman, et al., 2020). However, the Sudholz tool only measures total sitting time per workday and number of breaks, without measuring the total breaks duration. Measuring the duration of breaks can also provide insights of how long a break must be to provide health benefits. On the other hand, the SITBRQ (Pedisic et al., 2014) measures number and duration of breaks from sitting but has been reported to have poor construct validity (Bakker, Hartman, et al., 2020). Research focusing on the refinement of tools assessing self-reported breaks from sitting is still necessary. This research would aid with the standardisation of the self-reported assessment of breaks from sitting which is key to SB literature.

Feasibility studies to reduce occupational SB while WFH

Interventions to reduce occupational SB in desk-based workers WFH are also essential to the current SB literature. Findings from study 3 (chapter 4) provided information about what barriers need to be tackled to reduce SB in the home environment in workers with MSK symptoms. Also, as mentioned in the previous section, findings from Morton et al. (2022) provide relevant data for what type of strategies in the workplace might be transferable to the home environment. To address these findings, feasibility studies are required to understand what strategies are useful and acceptable for desk-based workers to reduce their occupational SB in the home working environment. These would be crucial for desk-based workers to reduce the detrimental health issues related to SB, including MSK symptoms.

Device assessed effects of breaks from sitting on MSK outcomes

Since the start of this PhD, it was apparent that the measurement of MSK symptoms in sedentary workers was mainly focused on self-reported outcomes. However, musculoskeletal disorders (MSDs) are characterised by changes in mechanical structures which its measurement would be important to understand their development. Considering the high prevalence of MSK symptoms in desk-based workers found in study 2 (chapter 3), addressing this shortage of literature is needed. Further research exploring the direct effects on device assessed MSK outcomes is needed to understand what the most ‘effective’ form to reduce MSK symptoms in desk-based workers is.

The first study (chapter 2) provided some relevant pointers in relation to this. Findings suggested that stretching breaks can favour various device assessed MSK spinal outcomes. However, this evidence came from highly heterogeneous studies. Therefore, research using experimental designs (e.g., RCTs), and testing the effects of various types of breaks from sitting (e.g., stretching, standing, walking) on muscle activity, range of motion, and spinal height (which seemed benefited while using stretching breaks), still needs to be undertaken. Further exploration of these outcomes would also be necessary in acute and long-term (over 3 months) intervention settings to understand the lasting effects of breaks from sitting. The exploration and assessment of these outcomes would also be valuable to prevent job absenteeism and disability caused by MSDs.

Target the reduction on MSK symptoms in sedentary workers

MSDs are highly prevalent globally, leading to mobility issues and job absenteeism (Abrams et al., 2020). However, it is frequent to find evidence of the effects of SB and breaks from sitting mainly on physical chronic illnesses (e.g., cardiovascular, metabolic) (Saunders et al., 2018). Research about the most useful form to reduce SB and MSK symptoms in desk-based workers is still limited. Therefore, interventions using breaks from sitting focused on the decrease of MSK symptoms are needed.

The findings of the first study (chapter 2) provided evidence of the benefits of stretching breaks on device assessed (e.g., increased spinal range on motion, reduced spinal shrinkage, increased spinal muscle activity), and self-reported MSK spinal outcomes (e.g., decreased spinal pain and discomfort). These benefits were indicated in acute single-session and medium to long-term (2 weeks to 3 months) interventions settings. However, these findings were from highly heterogeneous studies. Also, the studies included in the systematic review only had follow-up periods up to 3 months.

Additional research around acute and long-term (over 3 months) effects of breaks from sitting on MSK symptoms is also necessary. Overall, studies would need to address the gap on research exploring the acute, medium, and long-term effects of breaks from sitting in desk-based workers while WFH. In addition, it is still important for further research to explore and quantify the most helpful form of break (including number, duration and frequency), for sedentary workers to reduce their MSK symptoms at the office or while WFH. Findings addressing these shortcomings could also be used to inform the SB and 24-hour movement guidelines.

Strengths of the thesis

This thesis adds new evidence to the SB and MSDs field by using a comprehensive methodology. Firstly, with a systematic review which helped synthesise evidence from literature available from the research subject. Secondly, a quantitative study which provided statistical data from a novel work setting. Thirdly, a qualitative study which provided a behavioural diagnosis on what factors need to be addressed for desk-based workers with MSK symptoms to increase their breaks from sitting while WFH.

The strengths for the individual studies chapters are considered within the respective chapters (chapter 2, 3 and 4). These are briefly summarised below in relation to the whole thesis and expanded accordingly.

The methodological quality of the three individual studies is a strength of this thesis. From the inception of the systematic review (chapter 2), it was intended to achieve a high methodological process. The valuable use of the PICO guidelines (Higgins et al., 2022) helped to formulate a well-developed research question. Following the Synthesis Without Meta Analysis (SWiM) (Campbell et al., 2020) guidance were important to improve the reporting of the systematic review narrative synthesis and enhance transparency and clarity. The use of three experienced researchers as reviewers for the full-text screening showed to benefit the review process and to be an invaluable learning opportunity.

Strengths of the second study (chapter 3), was the incorporation of tools that showed good to fair validity and reliability to assess the outcomes of interest. This provided higher quality from the assessed data, which allowed to collect indispensable information from the WFH environment. The inclusion of the OSPAQ (Chau et al., 2011) was key for this research and allowed to make comparisons with wider literature exploring SB. The use of the Sudholz tool (Sudholz et al., 2018) which has a fair to good construct validity and test-retest reliability also provided key information of breaks from sitting at home, which might have been lost by using a non-validated tool (e.g., open-ended questions).

For the third study (chapter 4), the sample was mainly recruited (15 of 17 participants) from participants that took part of the second study. This provided a 'follow-up' scenario to the third study which was a useful starting point for the research and data collection. The use of the framework method (Gale et al., 2013) facilitated to perform a systematic analysis of the qualitative data for this study. The matrix used for this analysis was effective to compare findings allowing to have a deeper understanding of the data. Lastly, the use of a 'critical friend' (Smith & McGannon, 2018) during the third study of the thesis was invaluable to enhance the rigour of the research. Moreover, to gain valuable insights from another qualitative researcher which helped to identify additional codes within the data.

In relation to contribution to literature, each study provided key information to current research. Considering the high prevalence of MSDs globally, the systematic review (chapter 2) from this thesis adds valuable evidence of the role of breaks from sitting and its effects to reduce spinal MSK symptoms in a risk population (sedentary workers). The review findings also add to literature more understanding about the different types of breaks from sitting (e.g., breaks with postural change, breaks including walking and/or stretching) and its effectiveness on MSK symptoms.

For the second study (chapter 3), a valuable outcome was attempting to measure ergonomic chair settings which can be related to MSK symptoms (Galof & Šuc, 2021; Yorulmaz et al., 2022). This information was useful to understand if chair settings were risk factors for MSK symptoms at home, which have not been explored by previous literature. However, this came with limitations which are signalled in the limitations section.

The third study (chapter 4) provided views and insights from desk-based workers with MSK symptoms in the home environment, which had not been explored yet. These findings can be used to support desk-based workers with MSK symptoms at home. Also, results highlighted the notion that university staff had higher levels capability against other COM-B constructs, which can be used for future interventions implementation.

Overall, a thesis strength was the exploration of the home environment as a workplace. This has provided novel data from this work setting which has gained popularity amongst desk-based workers due to various advantages (e.g., increased flexibility, better work – life balance).

Limitations of the thesis

Limitations of this thesis are also acknowledged. The limitations for individual studies are considered in each individual chapter. To summarise, in study one (chapter 2), a meta-analysis was not performed in the systematic review. This might have added a more accurate effect size of the effects of breaks on spinal MSK outcomes. Nevertheless, it was chosen to follow the Cochrane handbook for systematic reviews recommendation (Higgins et al., 2022) which advises to not perform a meta-analysis when studies are heterogeneous, as these could be misrepresent the findings. Other limitation was not updating the systematic review after the last update (March 2020). This was mainly to focus on the current changes to the work landscape, and the novelty of the WFH environment. Additionally, this was considered impractical as it would imply the involvement from other reviewers to carry out further work.

In study 2 (chapter 3), the cross-sectional nature of the research did not allow to understand the causality of events. For example, findings indicated that staff with occupational SB of over 8 hours per day seemed to have higher MSK symptoms prevalence. However, this could also mean that workers with higher prevalence of MSK symptoms tend to sit for longer. Further experimental research is still needed to complement WFH and SB literature.

Limitations for the third study (chapter 4) are that although collected, due to time constraints, the data were not used to map the findings to other BCW layers, such as policy categories or intervention functions or to the BCTs. Although this would have been key to design an intervention directed to staff WFH, this would have also implied further input from the 'critical friend' which was considered unfeasible due to time constraints from both researchers.

An overall limitation of this PhD thesis is related to the use of reporting guidelines. Only the systematic review followed the SWiM guidelines (Campbell et al., 2020) to report study results. Afterwards, it was decided not to follow up any reporting guideline and continue the process empirically. This meaning that the reporting was done similarly to other relevant papers in the field. The appropriateness of the reporting guidelines (Equator network), such as the COREQ checklist components (Tong et al., 2007), especially during the qualitative research study seemed unfit (e.g., research team reflexivity, credentials), during the writing stage. Regardless, the studies from this thesis still presented thoroughly detailed information of the methodological process of individual studies, data collection and analysis, and reporting the findings. The use of guidelines are important to increase transparency, clarity, and replication of the research, while permitting critical appraisal. Therefore, if published, studies two and three (chapter 3 and 4) would use the STROBE (cross-sectional) and COREQ (qualitative) guidelines to improve the report transparency and clarity.

Although not a limitation itself, from the beginning of the PhD project, a dearth of evidence around device assessed MSK symptoms was found. A main objective of this PhD was to address this gap of knowledge. As mentioned in the introduction (chapter 1) and study 1 (chapter 2), the original methodology of this PhD was to undertake a laboratory study to test the acute effects of breaks from sitting on device assessed spinal MSK outcomes (spinal shrinkage and spinal range of motion), and self-reported MSK outcomes (pain and discomfort). However, this was unfeasible due to the COVID-19 confinement periods, the closure of universities and research centres, in combination with close contact measures that the study involved. Therefore, this gap in knowledge still needs to be addressed. Supplementary research still needs to take place to understand what the effects of breaks from sitting on MSK symptoms are.

Conclusion

In conclusion, this thesis has advanced knowledge around the role of breaks from sitting as a strategy to reduce MSK symptoms prevalence and SB in two working environments (office and home). From this body of research, it is suggested that breaks from sitting, specifically stretching breaks, are a useful strategy to reduce MSK spinal symptoms in sedentary workers at the office. Contemplating the change from the office to the home environment, it appears the prevalence of MSK symptoms is unaffected by the number and duration of breaks from sitting in workers WFH. On the other hand, engaging in prolonged occupational SB for over eight hours do appear to affect this prevalence.

Changes around workload management are necessary for desk-based workers with MSK symptoms to reduce their SB while WFH, and subsequently reduce their MSK symptoms prevalence. Future research should focus on exploring the direct effects of breaks on MSK symptoms during working hours at the office and the home environment. Understanding what the most effective type, duration and frequency of breaks from sitting is key for sedentary populations to reduce the negative health effects of SB.

References

Abrams, E. M., Akombi, B., Alam, S., Alcalde-Rabanal, J. E., Allebeck, P., Amini-Rarani, M., Atnafu, D. D., Ausloos, M., Ayanore, M. A., Azari, S., Azene, Z. N., Babaee, E., Bante, A. B., Bisanzio, D., Bohluli, M., Breitborde, N. J. K., Briant, P. S., Castelpietra, G., Cunningham, M., . . . Yip, P. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet (British edition)*, *396*(10258), 1204-1222. https://doi.org/10.1016/S0140-6736(20)30925-9

Aegerter, A. M., Deforth, M., Johnston, V., Sjøgaard, G., Volken, T., Luomajoki, H., Dratva, J., Dressel, H., Distler, O., Elfering, A., & Melloh, M. (2021). No evidence for an effect of working from home on neck pain and neck disability among Swiss office workers: Short-term impact of COVID-19. *Eur Spine J*, *30*(6), 1699-1707. https://doi.org/10.1007/s00586-021-06829-w

Agarwal, S., Steinmaus, C., & Harris-Adamson, C. (2018). Sit-stand workstations and impact on low back discomfort: a systematic review and meta-analysis. *Ergonomics*, *61*(4), 538-552. https://doi.org/10.1080/00140139.2017.1402960

Ainsworth, B. E., Haskell, W. L., Herrmann, S. D., Meckes, N., Bassett, D. R., Jr., Tudor-Locke, C., Greer, J. L., Vezina, J., Whitt-Glover, M. C., & Leon, A. S. (2011). 2011 Compendium of Physical Activities: a second update of codes and MET values. *Med Sci Sports Exerc*, *43*(8), 1575-1581. https://doi.org/10.1249/MSS.0b013e31821ece12

Althubaiti, A. (2016). Information bias in health research: definition, pitfalls, and adjustment methods. *J Multidiscip Healthc*, *9*, 211-217. https://doi.org/10.2147/jmdh.S104807

Andrade-Gómez, E., García-Esquinas, E., Ortolá, R., Martínez-Gómez, D., & Rodríguez-Artalejo, F. (2017). Watching TV has a distinct sociodemographic and lifestyle profile compared with other sedentary behaviors: A nationwide population-based study. *Plos One*, *12*(12), e0188836-e0188836. https://doi.org/10.1371/journal.pone.0188836

Ardahan, M., & Simsek, H. (2016). Analyzing musculoskeletal system discomforts and risk factors in computer-using office workers. *Pakistan Journal of Medical Sciences*, *32*(6), 1425-1429. https://doi.org/10.12669/pjms.326.11436

Argus, M., & Pääsuke, M. (2021). Effects of the COVID-19 lockdown on musculoskeletal pain, physical activity, and work environment in Estonian office workers transitioning to working from home. *Work*, *69*(3), 741-749. https://doi.org/10.3233/wor-210033

Arntz, F., Markov, A., Behm, D. G., Behrens, M., Negra, Y., Nakamura, M., Moran, J., & Chaabene, H. (2023). Chronic Effects of Static Stretching Exercises on Muscle Strength and Power in Healthy Individuals Across the Lifespan: A Systematic Review with Multi-level Meta-analysis. *Sports Medicine*, *53*(3), 723-745. https://doi.org/10.1007/s40279-022-01806-9

Aunger, J., & Wagnild, J. (2022). Objective and subjective measurement of sedentary behavior in human adults: A toolkit. *Am J Hum Biol*, *34*(1), e23546. https://doi.org/10.1002/ajhb.23546

Australian Government Department of Health. (2021). *Physical activity and sedentary behaviour guidelines – adults (18 to 64 years) – fact sheet.*

https://www.health.gov.au/resources/publications/physical-activity-and-sedentary-behaviour-guidelines-adults-18-to-64-years-fact-sheet

Babski-Reeves, K., & Calhoun, A. (2016). Muscle Activity and Posture Differences in the Sit and Stand Phases of Sit-to-Stand Workstation Use: A Comparison of Computer Configurations. *IIE Transactions on Occupational Ergonomics and Human Factors*, *4*(4), 236-246. https://doi.org/10.1080/21577323.2016.1226991

Bakker, E., Hartman, Y., Hopman, M., Hopkins, N., Graves, L., Dunstan, D., Healy, G., Eijsvogels, T., & Thijssen, D. (2020). Validity and reliability of subjective methods to assess sedentary behaviour in adults: a systematic review and meta-analysis. *INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY*, *17*(1), 1-31. https://doi.org/10.1186/s12966-020-00972-1

Bakker, E. A., Hopman, M. T. E., Lee, D.-c., Verbeek, A. L. M., Thijssen, D. H. J., & Eijsvogels, T. M. H. (2020). Correlates of Total and domain-specific Sedentary behavior: a cross-sectional study in Dutch adults. *BMC Public Health*, *20*(1), 220. https://doi.org/10.1186/s12889-020-8316-6

Balci, R., & Aghazadeh, F. (2003). The effect of work-rest schedules and type of task on the discomfort and performance of VDT users. *Ergonomics*, *46*(5), 455-465. https://doi.org/10.1080/0014013021000047557

Bao, S., & Lin, J. H. (2018). An investigation into four different sit-stand workstation use schedules. *Ergonomics*, *61*(2), 243-254. https://doi.org/10.1080/00140139.2017.1353139

Basakci Calik, B., Yagci, N., Oztop, M., & Caglar, D. (2022). Effects of risk factors related to computer use on musculoskeletal pain in office workers. *International Journal of Occupational Safety and Ergonomics*, *28*(1), 269-274. https://doi.org/10.1080/10803548.2020.1765112

Bauman, A., Ainsworth, B. E., Sallis, J. F., Hagströmer, M., Craig, C. L., Bull, F. C., Pratt, M., Venugopal, K., Chau, J., & Sjöström, M. (2011). The descriptive epidemiology of sitting. A 20-country comparison using the International Physical Activity Questionnaire (IPAQ). *Am J Prev Med*, *41*(2), 228-235. https://doi.org/10.1016/j.amepre.2011.05.003

Biddle, S. J. H., Bennie, J. A., De Cocker, K., Dunstan, D., Gardiner, P. A., Healy, G. N., Lynch, B., Owen, N., Brakenridge, C., Brown, W., Buman, M., Clark, B., Dohrn, I. M., Duncan, M., Gilson, N., Kolbe-Alexander, T., Pavey, T., Reid, N., Vandelanotte, C., . . . Vincent, G. E. (2019). Controversies in the Science of Sedentary Behaviour and Health: Insights, Perspectives and Future directions from the 2018 Queensland Sedentary Behaviour Think Tank. *Int J Environ Res Public Health*, *16*(23). https://doi.org/10.3390/ijerph16234762

Billy, G. G., Lemieux, S. K., & Chow, M. X. (2014). Changes in Lumbar Disk Morphology Associated With Prolonged Sitting Assessed by Magnetic Resonance Imaging. *PM&R*, *6*(9), 790-795. https://doi.org/10.1016/j.pmrj.2014.02.014

Biswas, A., Oh, P. I., Faulkner, G. E., Bajaj, R. R., Silver, M. A., Mitchell, M. S., & Alter, D. A. (2015). Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. *Ann Intern Med*, *162*(2), 123-132. https://doi.org/10.7326/m14-1651

Blasche, G., Pfeffer, M., Thaler, H., & Gollner, E. (2013). Work-site health promotion of frequent computer users: Comparing selected interventions. *Work*, *46*(3), 233. https://doi.org/10.3233/WOR-121520

Blond, K., Brinkløv, C. F., Ried-Larsen, M., Crippa, A., & Grøntved, A. (2020). Association of high amounts of physical activity with mortality risk: a systematic review and meta-

analysis. *Br J Sports Med*, *54*(20), 1195-1201. https://doi.org/10.1136/bjsports-2018-100393
Bloom, N., Liang, J., Roberts, J., & Ying, Z. J. (2015). Does working from home work? Evidence from a chinese experiment [Article]. *Quarterly Journal of Economics*, *130*(1), 165-218, Article qju032. https://doi.org/10.1093/qje/qju032
Bontrup, C., Taylor, W. R., Fliesser, M., Visscher, R., Green, T., Wippert, P.-M., & Zemp, R. (2019). Low back pain and its relationship with sitting behaviour among sedentary office workers. *Applied Ergonomics*, *81*, 102894. https://doi.org/https://doi.org/10.1016/j.apergo.2019.102894
Borg, G. A. (1982). Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*, *14*(5), 377-381.
Boring, B. L., Walsh, K. T., Nanavaty, N., Ng, B. W., & Mathur, V. A. (2021). How and Why Patient Concerns Influence Pain Reporting: A Qualitative Analysis of Personal Accounts and Perceptions of Others' Use of Numerical Pain Scales. *Frontiers in psychology*, *12*, 663890-663890. https://doi.org/10.3389/fpsyg.2021.663890
Boscolo, M. S., & Zhu, W. (2017). Sedentary behavior and low-back pain. In W. Zhu & N. Owen (Eds.) Sedentary behavior and health: Concepts, evidence, assessment and intervention (pp. 139–150). In: Champaign, IL: Human Kinetics.
Bureau of Labor Statistics. U.S. Department of Labor. (2018). *The Economics Daily, 21.8 million employed in office and administrative support occupations, May 2018*. https://www.bls.gov/opub/ted/2019/21-point-8-million-employed-in-office-and-administrative-support-occupations-may-2018.htm
Campbell, M., McKenzie, J. E., Sowden, A., Katikireddi, S. V., Brennan, S. E., Ellis, S., Hartmann-Boyce, J., Ryan, R., Shepperd, S., Thomas, J., Welch, V., & Thomson, H. (2020). Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. *BMJ*, *368*, l6890. https://doi.org/10.1136/bmj.l6890
Canadian Society for Exercise Physiology. (2020). *24-Hour Movement Guidelines*. https://csepguidelines.ca/downloads/
Candotti, C. T., Loss, J. F., Pressi, A. M. S., de Souza Castro, F. A., La Torre, M., de Oliveira Melo, M., Araújo, L. D., & Pasini, M. (2008). Electromyography for Assessment of Pain in Low Back Muscles. *Physical Therapy*, *88*(9), 1061-1067. https://doi.org/10.2522/ptj.20070146
Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation science : IS*, *7*(1), 37-37. https://doi.org/10.1186/1748-5908-7-37
Caputo, G., Di Bari, M., & Naranjo Orellana, J. (2017). Group-based exercise at workplace: short-term effects of neck and shoulder resistance training in video display unit workers with work-related chronic neck pain—a pilot randomized trial. *Clinical Rheumatology*, *36*(10), 2325-2333. https://doi.org/10.1007/s10067-017-3629-2
Caromano, F., Aparecida Padoin de Amorim, C., de Fátima Rebelo, C., Maria Contesin, A., Favero, F., Costa, J., Kawai, M., & Voos, M. (2015). *Prolonged sitting and physical discomfort in university students* (Vol. 22). https://doi.org/10.5935/0104-7795.20150034
Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports (Washington, D.C. : 1974)*, *100*(2), 126-131. https://pubmed.ncbi.nlm.nih.gov/3920711

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1424733/

Celik, S., Celik, K., Dirimese, E., Taşdemir, N., Arik, T., & Büyükkara, İ. (2018). Determination of pain in musculoskeletal system reported by office workers and the pain risk factors [journal article]. *International Journal of Occupational Medicine and Environmental Health*, *31*(1), 91-111. https://doi.org/10.13075/ijomeh.1896.00901
Chaikumarn, M., Nakphet, N., & Janwantanakul, P. (2018). Impact of rest-break interventions on the neck and shoulder posture of symptomatic VDU operators during prolonged computer work. *International Journal of Occupational Safety and Ergonomics*, *24*(2), 251-259. https://doi.org/10.1080/10803548.2016.1267469
Chan, S., Ferguson, S., & Gantenbein-Ritter, B. (2011). The effects of dynamic loading on the intervertebral disc. *European Spine Journal*, *20*(11), 1796-1812. https://doi.org/10.1007/s00586-011-1827-1
Chau, J. Y., van der Ploeg, H. P., Dunn, S., Kurko, J., & Bauman, A. E. (2011). A tool for measuring workers' sitting time by domain: the Workforce Sitting Questionnaire. *Br J Sports Med*, *45*(15), 1216-1222. https://doi.org/10.1136/bjsports-2011-090214
Chau, J. Y., Van Der Ploeg, H. P., Dunn, S., Kurko, J., & Bauman, A. E. (2012). Validity of the occupational sitting and physical activity questionnaire. *Med Sci Sports Exerc*, *44*(1), 118-125. https://doi.org/10.1249/MSS.0b013e3182251060
Chu, A. H. Y., Ng, S. H. X., Tan, C. S., Win, A. M., Koh, D., & Müller-Riemenschneider, F. (2016). A systematic review and meta-analysis of workplace intervention strategies to reduce sedentary time in white-collar workers. *Obesity Reviews*, *17*(5), 467-481. https://doi.org/10.1111/obr.12388
Cini, A., de Vasconcelos, G. S., & Lima, C. S. (2017). Acute effect of different time periods of passive static stretching on the hamstring flexibility. *Journal Of Back And Musculoskeletal Rehabilitation*, *30*(2), 241. https://doi.org/10.3233/BMR-160740
Clair, R., Gordon, M., Kroon, M., & Reilly, C. (2021). The effects of social isolation on well-being and life satisfaction during pandemic. *Humanities and Social Sciences Communications*, *8*(1), 28. https://doi.org/10.1057/s41599-021-00710-3
Clarke, V., & Braun, V. (2013). *Successful qualitative research: a practical guide for beginners*. SAGE.
Clemes, S. A., O'Connell, S. E., & Edwardson, C. L. (2014). Office workers' objectively measured sedentary behavior and physical activity during and outside working hours. *J Occup Environ Med*, *56*(3), 298-303. https://doi.org/10.1097/jom.0000000000000101
Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Routledge.
Cote, P., van Der Velde, G., Cassidy, J. D., Carroll, L., Hogg-Johnson, S., Holm, L., Carragee, E., Haldeman, S., Nordin, M., Hurwitz, E., Guzman, J., & Peloso, P. (2008). The burden and determinants of neck pain in workers - Results of the bone and joint decade 2000-2010 task force on neck pain and its associated disorders. In *Eur. Spine J.* (Vol. 17, pp. S60-S74).
Cucinotta, D., & Vanelli, M. (2020). WHO Declares COVID-19 a Pandemic. *Acta Biomed*, *91*(1), 157-160. https://doi.org/10.23750/abm.v91i1.9397
Cui, A., Emery, K., Beaudoin, A.-S., Feng, J., & Côté, J. N. (2020). Sex-specific effects of sitting vs standing on upper body muscle activity during text typing. *Applied Ergonomics*, *82*. https://doi.org/10.1016/j.apergo.2019.102957
Daneshmandi, H., Choobineh, A., Ghaem, H., & Karimi, M. (2017). Adverse Effects of Prolonged Sitting Behavior on the General Health of Office Workers. *Journal of lifestyle medicine*, *7*(2), 69-75. https://doi.org/10.15280/jlm.2017.7.2.69
Davis, K. G., Kotowski, S. E., Daniel, D., Gerding, T., Naylor, J., & Syck, M. (2020). The Home Office: Ergonomic Lessons From the “New Normal”. *Ergonomics in Design*, *0*(0), 1064804620937907. https://doi.org/10.1177/1064804620937907

De Cocker, K., Veldeman, C., De Bacquer, D., Braeckman, L., Owen, N., Cardon, G., & De Bourdeaudhuij, I. (2015). Acceptability and feasibility of potential intervention strategies for influencing sedentary time at work: focus group interviews in executives and employees. *Int J Behav Nutr Phys Act*, *12*, 22. https://doi.org/10.1186/s12966-015-0177-5

de Luca, K., Briggs, A. M., French, S. D., Ferreira, M. L., Cross, M., Blyth, F., & March, L. (2022). Disability burden due to musculoskeletal conditions and low back pain in Australia: findings from GBD 2019. *Chiropractic & Manual Therapies*, *30*(1), 22. https://doi.org/10.1186/s12998-022-00434-4

de Rezende, L., Lopes, M., Rey-Lopez, J. P., Matsudo, V., & Luiz, O. (2014). Sedentary Behavior and Health Outcomes: An Overview of Systematic Reviews. In *Plos One* (Vol. 9).

Department of Health and Social Care. (2019). *UK Chief Medical Officers' physical activity guidelines*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/832868/uk-chief-medical-officers-physical-activity-guidelines.pdf

Dieleman, J. L., Cao, J., Chapin, A., Chen, C., Li, Z., Liu, A., Horst, C., Kaldjian, A., Matyasz, T., Scott, K. W., Bui, A. L., Campbell, M., Duber, H. C., Dunn, A. C., Flaxman, A. D., Fitzmaurice, C., Naghavi, M., Sadat, N., Shieh, P., . . . Murray, C. J. L. (2020). US Health Care Spending by Payer and Health Condition, 1996-2016. *JAMA*, *323*(9), 863-884. https://doi.org/10.1001/jama.2020.0734

Dillon, K., Hiemstra, M., Mitchell, M., Bartmann, N., Rollo, S., Gardiner, P. A., & Prapavessis, H. (2021). Validity of the occupational sitting and physical activity questionnaire (OSPAQ) for home-based office workers during the COVID-19 global pandemic: A secondary analysis. *Appl Ergon*, *97*, 103551. https://doi.org/10.1016/j.apergo.2021.103551

Ding, Y., Cao, Y., Duffy, V. G., & Zhang, X. (2020). It is Time to Have Rest: How do Break Types Affect Muscular Activity and Perceived Discomfort During Prolonged Sitting Work. *Safety and health at work*, *11*(2), 207-214. https://doi.org/10.1016/j.shaw.2020.03.008

Dockrell, S., Bennett, K., & Culleton-Quinn, E. (2015). Computer use and musculoskeletal symptoms among undergraduate university students. *Computers & Education*, *85*, 102.

Dunstan, D., Howard, B., Healy, G., & Owen, N. (2012). Too much sitting - A health hazard. In *Diabetes Res. Clin. Pract.* (Vol. 97, pp. 368-376).

Dzakpasu, F. Q. S., Carver, A., Brakenridge, C. J., Cicuttini, F., Urquhart, D. M., Owen, N., & Dunstan, D. W. (2021). Musculoskeletal pain and sedentary behaviour in occupational and non-occupational settings: a systematic review with meta-analysis. *INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY*, *18*(1), 159. https://doi.org/10.1186/s12966-021-01191-y

Edwardson, C. L., Yates, T., Biddle, S. J. H., Davies, M. J., Dunstan, D. W., Esliger, D. W., Gray, L. J., Jackson, B., O'Connell, S. E., Waheed, G., & Munir, F. (2018). Effectiveness of the Stand More AT (SMArT) Work intervention: cluster randomised controlled trial. *BMJ*, *363*, k3870. https://doi.org/10.1136/bmj.k3870

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A. E., & Lee, I.-M. (2019). 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. *British Journal of Sports Medicine*, *53*(14), 886-894. https://doi.org/10.1136/bjsports-2017-098963

Ekelund, U., Tarp, J., Fagerland, M. W., Johannessen, J. S., Hansen, B. H., Jefferis, B. J., Whincup, P. H., Diaz, K. M., Hooker, S., Howard, V. J., Chernofsky, A., Larson, M. G., Spartano, N., Vasan, R. S., Dohrn, I.-M., Hagströmer, M., Edwardson, C., Yates, T., Shiroma, E. J., . . . Lee, I. M. (2020). Joint associations of accelerometer-measured physical activity and sedentary time with all-cause mortality: a harmonised meta-analysis in more than 44 000 middle-aged and older individuals. *British Journal of Sports Medicine*, *54*(24), 1499. https://doi.org/10.1136/bjsports-2020-103270

Ellingson, L. D., Meyer, J. D., Shook, R. P., Dixon, P. M., Hand, G. A., Wirth, M. D., Paluch, A. E., Burgess, S., Hebert, J. R., & Blair, S. N. (2018). Changes in sedentary time are associated with changes in mental wellbeing over 1 year in young adults. *Preventive Medicine Reports*, *11*, 274-281. https://doi.org/10.1016/j.pmedr.2018.07.013

Equator network. *Enhancing the QUAlity and Transparency Of health Research*. https://www.equator-network.org/

Fahrenberg, J. (1995). Somatic complaints in the German population. *Journal of Psychosomatic Research*, *39*(7), 809-817. https://doi.org/https://doi.org/10.1016/0022-3999(94)00151-0

Fang, H., Jing, Y., Chen, J., Wu, Y., & Wan, Y. (2021). Recent Trends in Sedentary Time: A Systematic Literature Review. *Healthcare*, *9*(8), 969. https://www.mdpi.com/2227-9032/9/8/969

Farrahi, V., Kangas, M., Walmsley, R., Niemelä, M., Kiviniemi, A., Puukka, K., Collings, P. J., Korpelainen, R., & Jämsä, T. (2021). Compositional Associations of Sleep and Activities within the 24-h Cycle with Cardiometabolic Health Markers in Adults. *Med Sci Sports Exerc*, *53*(2), 324-332. https://doi.org/10.1249/mss.0000000000002481

Farrahi, V., Rostami, M., Dumuid, D., Chastin, S. F. M., Niemelä, M., Korpelainen, R., Jämsä, T., & Oussalah, M. (2022). Joint Profiles of Sedentary Time and Physical Activity in Adults and their Associations with Cardiometabolic Health. *Med Sci Sports Exerc*. https://doi.org/10.1249/mss.0000000000003008

Fukushima, N., Machida, M., Kikuchi, H., Amagasa, S., Hayashi, T., Odagiri, Y., Takamiya, T., & Inoue, S. (2021). Associations of working from home with occupational physical activity and sedentary behavior under the COVID-19 pandemic. *J Occup Health*, *63*(1), e12212. https://doi.org/10.1002/1348-9585.12212

Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, *13*(1), 117. https://doi.org/10.1186/1471-2288-13-117

Galof, K., & Šuc, L. (2021). Exploring Teachers' Back Pain Concerning Their Habits, Rules, Leisure Activities, and Physical Activity Breaks at Work. *INQUIRY: The Journal of Health Care Organization, Provision, and Financing*, *58*, 00469580211060256. https://doi.org/10.1177/00469580211060256

Gao, Y., Cronin, N. J., Pesola, A. J., & Finni, T. (2016). Muscle activity patterns and spinal shrinkage in office workers using a sit-stand workstation versus a sit workstation. *Ergonomics*, *59*(10), 1267-1274. https://doi.org/10.1080/00140139.2016.1139750

Garber, E. C., Blissmer, R. B., Deschenes, A. M., Franklin, J. B., Lamonte, C. M., Lee, P. I. M., Nieman, P. D., & Swain, P. D. (2011). Quantity and Quality of Exercise for Developing and Maintaining Cardiorespiratory, Musculoskeletal, and Neuromotor Fitness in Apparently Healthy Adults: Guidance for Prescribing Exercise. *Medicine & Science in Sports & Exercise*, *43*(7), 1334-1359. https://doi.org/10.1249/MSS.0b013e318213fefb

Gardner, B., Smith, L., Lorencatto, F., Hamer, M., & Biddle, S. J. (2016). How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour

reduction interventions among adults. *Health Psychol Rev*, *10*(1), 89-112. https://doi.org/10.1080/17437199.2015.1082146
Gerding, T., Syck, M., Daniel, D., Naylor, J., Kotowski, S. E., Gillespie, G. L., Freeman, A. M., Huston, T. R., & Davis, K. G. (2021). An assessment of ergonomic issues in the home offices of university employees sent home due to the COVID-19 pandemic. *Work*, *68*, 981-992. https://doi.org/10.3233/WOR-205294
Gimigliano, F., & Negrini, S. (2017). The World Health Organization "Rehabilitation 2030: a call for action". *Eur J Phys Rehabil Med*, *53*(2), 155-168. https://doi.org/10.23736/s1973-9087.17.04746-3
González-Menéndez, E., López-González, M. J., González Menéndez, S., García González, G., & Álvarez Bayona, T. (2019). Major health consequences a rising from the continued use of new electronic devices with visual display units. *Rev Esp Salud Publica*, *93*. (Principales consecuencias para la salud derivadas del uso continuado de nuevos dispositivos electrónicos con PVD.)
Gore, M., Sadosky, A., Stacey, B. R., Tai, K.-S., & Leslie, D. (2012). The Burden of Chronic Low Back Pain: Clinical Comorbidities, Treatment Patterns, and Health Care Costs in Usual Care Settings. *Spine*, *37*(11). https://journals.lww.com/spinejournal/Fulltext/2012/05150/The_Burden_of_Chronic_Low_Back_Pain__Clinical.22.aspx
Grgic, J., Dumuid, D., Bengoechea, E. G., Shrestha, N., Bauman, A., Olds, T., & Pedisic, Z. (2018). Health outcomes associated with reallocations of time between sleep, sedentary behaviour, and physical activity: a systematic scoping review of isotemporal substitution studies. *INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY*, *15*(1), 69. https://doi.org/10.1186/s12966-018-0691-3
Guler, M. A., Guler, K., Guneser Gulec, M., & Ozdoglar, E. (2021). Working From Home During a Pandemic: Investigation of the Impact of COVID-19 on Employee Health and Productivity. *J Occup Environ Med*, *63*(9), 731-741. https://doi.org/10.1097/jom.0000000000002277
Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet Global Health*, *6*(10), e1077-e1086. https://doi.org/10.1016/S2214-109X(18)30357-7
Hadgraft, N. T., Healy, G. N., Owen, N., Winkler, E. A., Lynch, B. M., Sethi, P., Eakin, E. G., Moodie, M., LaMontagne, A. D., Wiesner, G., Willenberg, L., & Dunstan, D. W. (2016). Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. *Prev Med Rep*, *4*, 184-191. https://doi.org/10.1016/j.pmedr.2016.06.011
Harris-Adamson, C., Bao, S. S., & Evanoff, B. (2017). Musculoskeletal Disorders. In *Occupational and Environmental Health* (7 ed.). Oxford University Press. https://doi.org/10.1093/oso/9780190662677.003.0023
Hartvigsen, J., Hancock, M. J., Kongsted, A., Louw, Q., Ferreira, M. L., Genevay, S., Hoy, D., Karppinen, J., Pransky, G., Sieper, J., Smeets, R. J., & Underwood, M. (2018). What low back pain is and why we need to pay attention. *The Lancet*, *391*(10137), 2356-2367. https://doi.org/10.1016/S0140-6736(18)30480-X
Hassan, H., Ali, A. S., & Nuruddin, A. R. (2013). Understanding the Working from Home Concept in Built Environment. *The International Journal of the Constructed Environment*, *2*(4), 19-32. https://doi.org/10.18848/2154-8587/CGP/v02i04/37349
Hawker, G. A. (2017). The assessment of musculoskeletal pain. *Clin Exp Rheumatol*, *35 Suppl 107*(5), 8-12.

Hedge, A., Morimoto, S., & McCrobie, D. (1999). Effects of keyboard tray geometry on upper body posture and comfort. *Ergonomics*, *42*(10), 1333-1349. https://doi.org/10.1080/001401399184983

Heidari, H., Soltanzadeh, A., Asemabadi, E., Rahimifard, H., & Mohammadbeigi, A. (2019). Ergonomic posture analysis of different postures in laptop users at non-official places and related musculoskeletal disorders by rapid upper limb assessment method. *Advances in Human Biology*, *9*(2), 135-142. https://doi.org/10.4103/AIHB.AIHB_85_18

Heneghan, N. R., Baker, G., Thomas, K., Falla, D., & Rushton, A. (2018). What is the effect of prolonged sitting and physical activity on thoracic spine mobility? An observational study of young adults in a UK university setting. *BMJ Open*, *8*(5), e019371. https://doi.org/10.1136/bmjopen-2017-019371

Heron, L., Neill, C., McAneney, H., Kee, F., & Tully, M. A. (2019). Direct healthcare costs of sedentary behaviour in the UK. *Journal of Epidemiology and Community Health*, *73*(7), 625. https://doi.org/10.1136/jech-2018-211758

Higgins, J., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M., & Welch, V. (2022). *Cochrane Handbook for Systematic Reviews of Interventions version 6.3 (updated February 2022)*. www.training.cochrane.org/handbook.

Honan, M. (2015). Mobile work: Ergonomics in a rapidly changing work environment. *Work-A Journal Of Prevention Assessment & Rehabilitation*, *52*(2), 289-301. https://doi.org/10.3233/WOR-152164

Honda, T., Chen, S., Yonemoto, K., Kishimoto, H., Chen, T., Narazaki, K., Haeuchi, Y., & Kumagai, S. (2016). Sedentary bout durations and metabolic syndrome among working adults: a prospective cohort study.(Report). *BMC Public Health*, *16*(1). https://doi.org/10.1186/s12889-016-3570-3

Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M.-P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M.-C., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) Version 2018 for Information Professionals and Researchers. *Education for Information*, *34*(4), 285-291. https://doi.org/10.3233/EFI-180221

Huang, Y., Li, L., Gan, Y., Wang, C., Jiang, H., Cao, S., & Lu, Z. (2020). Sedentary behaviors and risk of depression: a meta-analysis of prospective studies. *Translational Psychiatry*, *10*(1), 26. https://doi.org/10.1038/s41398-020-0715-z

Ingram, M., & Symmons, D. P. M. (2018). The burden of musculoskeletal conditions. *Medicine*, *46*(3), 152-155. https://doi.org/10.1016/j.mpmed.2017.12.005

Jansen, K., Luik, M., Reinvee, M., Viljasoo, V., Ereline, J., Gapeyeva, H., & Pääsuke, M. (2013). Musculoskeletal discomfort in production assembly workers. *Acta Kinesiologiae Universitatis Tartuensis*, *18*, 102. https://doi.org/10.12697/akut.2012.18.11

Javad Koohsari, M., Nakaya, T., Shibata, A., Ishii, K., & Oka, K. (2021). Working from Home After the COVID-19 Pandemic: Do Company Employees Sit More and Move Less? *Sustainability*, *13*(2), 939. https://www.mdpi.com/2071-1050/13/2/939

Jiang, L., Cao, Y., Ni, S., Chen, X., Shen, M., Lv, H., & Hu, J. (2020). Association of Sedentary Behavior With Anxiety, Depression, and Suicide Ideation in College Students [Original Research]. *Frontiers in Psychiatry*, *11*. https://doi.org/10.3389/fpsyt.2020.566098

Jo, H., Lim, O. B., Ahn, Y. S., Chang, S. J., & Koh, S. B. (2021). Negative Impacts of Prolonged Standing at Work on Musculoskeletal Symptoms and Physical Fatigue: The Fifth Korean Working Conditions Survey. *Yonsei Med J*, *62*(6), 510-519. https://doi.org/10.3349/ymj.2021.62.6.510

Jun, D., Zoe, M., Johnston, V., & O'Leary, S. (2017). Physical risk factors for developing non-specific neck pain in office workers: a systematic review and meta-analysis. *International Archives of Occupational and Environmental Health*, *90*(5), 373-410. https://doi.org/10.1007/s00420-017-1205-3

Kallio, H., Pietilä, A. M., Johnson, M., & Kangasniemi, M. (2016). Systematic methodological review: developing a framework for a qualitative semi-structured interview guide. *J Adv Nurs*, *72*(12), 2954-2965. https://doi.org/10.1111/jan.13031

Katzmarzyk, P. T., Powell, K. E., Jakicic, J. M., Troiano, R. P., Piercy, K., & Tennant, B. (2019). Sedentary Behavior and Health: Update from the 2018 Physical Activity Guidelines Advisory Committee. *Med Sci Sports Exerc*, *51*(6), 1227-1241. https://doi.org/10.1249/mss.0000000000001935

Kett, A. R., Sichting, F., & Milani, T. L. (2021). The Effect of Sitting Posture and Postural Activity on Low Back Muscle Stiffness. *Biomechanics*, *1*(2), 214-224. https://www.mdpi.com/2673-7078/1/2/18

Ku, P.-W., Steptoe, A., Liao, Y., Hsueh, M.-C., & Chen, L.-J. (2018). A cut-off of daily sedentary time and all-cause mortality in adults: a meta-regression analysis involving more than 1 million participants. *BMC Medicine*, *16*(1), 74. https://doi.org/10.1186/s12916-018-1062-2

Kuorinka, I., Jonsson, B., Kilbom, A., Vinterberg, H., Biering-Sørensen, F., Andersson, G., & Jørgensen, K. (1987). Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon*, *18*(3), 233-237. https://doi.org/10.1016/0003-6870(87)90010-x

Li, T., Higgins, J. P., & Deeks, J. J. (2019). Collecting data. In *Cochrane Handbook for Systematic Reviews of Interventions* (pp. 109-141). https://doi.org/https://doi.org/10.1002/9781119536604.ch5

Liguori, G., Feito, Y., Fountaine, C., & Roy, B. A. (2021). *ACSM's Guidelines for Exercise Testing and Prescription, 11th Edition* [Book review

Brief article]. https://link-gale-com.ezproxy.is.ed.ac.uk/apps/doc/A694929894/AONE?u=ed_itw&sid=bookmark-AONE&xid=7735ff7a

Linn, R. L., & Slinde, J. A. (1977). The Determination of the Significance of Change Between Pre- and Posttesting Periods. *Review of Educational Research*, *47*(1), 121-150. https://doi.org/10.3102/00346543047001121

Livoreil, B., Glanville, J., Haddaway, N. R., Bayliss, H., Bethel, A., de Lachapelle, F. d. r. F., Robalino, S., Savilaakso, S., Zhou, W., Petrokofsky, G., & Frampton, G. (2017). Systematic searching for environmental evidence using multiple tools and sources. *Environmental Evidence*, *6*(1). https://doi.org/10.1186/s13750-017-0099-6

López-Valenciano, A., Mayo, X., Liguori, G., Copeland, R. J., Lamb, M., & Jimenez, A. (2020). Changes in sedentary behaviour in European Union adults between 2002 and 2017. *BMC Public Health*, *20*(1), 1206. https://doi.org/10.1186/s12889-020-09293-1

Loyen, A., Chau, J. Y., Jelsma, J. G. M., van Nassau, F., & van der Ploeg, H. P. (2019). Prevalence and correlates of domain-specific sedentary time of adults in the Netherlands: findings from the 2006 Dutch time use survey. *BMC Public Health*, *19*(Suppl 2), 538. https://doi.org/10.1186/s12889-019-6764-7

Loyen, A., Chey, T., Engelen, L., Bauman, A., Lakerveld, J., van der Ploeg, H. P., Brug, J., & Chau, J. Y. (2018). Recent trends in population levels and correlates of occupational and leisure sitting time in full-time employed Australian adults. *Plos One*, *13*(4), e0195177. https://doi.org/10.1371/journal.pone.0195177

Luger, T., Maher, C. G., Rieger, M. A., & Steinhilber, B. (2019). Work-break schedules for preventing musculoskeletal symptoms and disorders in healthy workers. *Cochrane Database Syst Rev*, *7*(7), Cd012886. https://doi.org/10.1002/14651858.CD012886.pub2

MacDonald, B., Fitzsimons, C., & Niven, A. (2018). Using the COM-B model of behaviour to understand sitting behaviour in U.K. office workers.

Malterud, K., Siersma, V. D., & Guassora, A. D. (2016). Sample Size in Qualitative Interview Studies: Guided by Information Power. *Qual Health Res*, *26*(13), 1753-1760. https://doi.org/10.1177/1049732315617444

Mathers, C. D. (2020). History of global burden of disease assessment at the World Health Organization. *Archives of Public Health*, *78*(1), 77. https://doi.org/10.1186/s13690-020-00458-3

Mathiassen, S., & Winkel, J. (1996). Physiological comparison of three interventions in light assembly work: reduced work pace, increased break allowance and shortened working days. *International Archives of Occupational and Environmental Health*, *68*(2), 94-108. https://doi.org/10.1007/BF00381241

Matsugaki, R., Muramatsu, K., Tateishi, S., Nagata, T., Tsuji, M., Hino, A., Ikegami, K., Fujino, Y., & Matsuda, S. (2021). Association between telecommuting environment and low back pain among Japanese Telecommuting workers [Article]. *Journal of Occupational and Environmental Medicine*, *63*(12), E944-E948. https://doi.org/10.1097/JOM.0000000000002412

McLean, L., Tingley, M., Scott, R. N., & Rickards, J. (2000). Myoelectric signal measurement during prolonged computer terminal work. *Journal of Electromyography and Kinesiology*, *10*(1), 33-45. https://doi.org/10.1016/S1050-6411(99)00021-8

McLean, L., Tingley, M., Scott, R. N., & Rickards, J. (2001). Computer terminal work and the benefit of microbreaks. *Applied Ergonomics*, *32*(3), 225-237. https://doi.org/10.1016/S0003-6870(00)00071-5

Messenger, J. C. (2017). Working anytime, anywhere: The evolution of telework and its effects on the world of work. *IUSLabor. Revista d'anàlisi de Dret del Treball*(3).

Michie, S., Atkins, L., & West, R. (2014). *The behaviour change wheel : a guide to designing interventions*. Great Britain : Silverback Publishing.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Science*, *6*(1), 42. https://doi.org/10.1186/1748-5908-6-42

Mohamed, M. A., & Radwan, N. L. (2017). OPTIMAL WORK-REST SCHEDULE FOR COMPUTER USERS. *International Journal of Physiotherapy*, *4*(2). https://doi.org/10.15621/ijphy/2017/v4i2/141944

Moretti, A., Menna, F., Aulicino, M., Paoletta, M., Liguori, S., & Iolascon, G. (2020). Characterization of Home Working Population during COVID-19 Emergency: A Cross-Sectional Analysis. *Int J Environ Res Public Health*, *17*(17). https://doi.org/10.3390/ijerph17176284

Morton, S., Fitzsimons, C., Jepson, R., Saunders, D. H., Sivaramakrishnan, D., & Niven, A. (2022). What works to reduce sedentary behavior in the office, and could these intervention components transfer to the home working environment?: A rapid review and transferability appraisal. *Front Sports Act Living*, *4*, 954639. https://doi.org/10.3389/fspor.2022.954639

Munir, F., Biddle, S. J. H., Davies, M. J., Dunstan, D., Esliger, D., Gray, L. J., Jackson, B. R., O'Connell, S. E., Yates, T., & Edwardson, C. L. (2018). Stand More AT Work (SMArT Work): using the behaviour change wheel to develop an intervention to reduce

sitting time in the workplace. *BMC Public Health*, *18*(1), 319. https://doi.org/10.1186/s12889-018-5187-1
Nagel, L. (2020). The influence of the COVID-19 pandemic on the digital transformation of work. *International journal of sociology and social policy*, *40*(9/10), 861-875. https://doi.org/10.1108/IJSSP-07-2020-0323
Nakagawa, T., Koan, I., Chen, C., Matsubara, T., Hagiwara, K., Lei, H., Hirotsu, M., Yamagata, H., & Nakagawa, S. (2020). Regular Moderate- to Vigorous-Intensity Physical Activity Rather Than Walking Is Associated with Enhanced Cognitive Functions and Mental Health in Young Adults. *Int J Environ Res Public Health*, *17*(2). https://doi.org/10.3390/ijerph17020614
Nakphet, N., Chaikumarn, M., & Janwantanakul, P. (2014). Effect of Different Types of Rest-Break Interventions on Neck and Shoulder Muscle Activity, Perceived Discomfort and Productivity in Symptomatic VDU Operators: A Randomized Controlled Trial. *International Journal of Occupational Safety and Ergonomics*, *20*(2), 339-353. https://doi.org/10.1080/10803548.2014.11077048
Niven, A., Baker, G., Coral-Almeida, E., Fawkner, S. G., Jepson, R., Manner, J., Morton, S., Nightingale, G., Sivaramakrishnan, D., & Fitzsimons, C. (2022). "Are We Working (Too) Comfortably?": Understanding the Nature of and Factors Associated with Sedentary Behaviour When Working in the Home Environment. *Occupational Health Science*, 1-18. https://doi.org/10.1007/s41542-022-00128-6
Nunes, A., Espanha, M., Teles, J., Petersen, K., Arendt-Nielsen, L., & Carnide, F. (2021). Neck pain prevalence and associated occupational factors in Portuguese office workers. *International Journal of Industrial Ergonomics*, *85*, 103172. https://doi.org/https://doi.org/10.1016/j.ergon.2021.103172
Office for National Statistics. (2022). *Half a million more people are out of the labour force because of long-term sickness* https://www.ons.gov.uk/employmentandlabourmarket/peoplenotinwork/economicinactivity/articles/halfamillionmorepeopleareoutofthelabourforcebecauseoflongtermsickness/2022-11-10
Office for National Statistics. (2021, 3 March 2021). *Sickness absence in the UK labour market: 2020*. Retrieved 20 June 2022 from https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/labourproductivity/articles/sicknessabsenceinthelabourmarket/2020
Office for National Statistics. (2022). *Is hybrid working here to stay?* https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/ishybridworkingheretostay/2022-05-23
Ojo, S. O., Bailey, D. P., Brierley, M. L., Hewson, D. J., & Chater, A. M. (2019a). Breaking barriers: using the behavior change wheel to develop a tailored intervention to overcome workplace inhibitors to breaking up sitting time. *BMC Public Health*, *19*(1), 1126. https://doi.org/10.1186/s12889-019-7468-8
Ojo, S. O., Bailey, D. P., Brierley, M. L., Hewson, D. J., & Chater, A. M. (2019b). Perceived Barriers and Facilitators to Breaking Up Sitting Time among Desk-Based Office Workers: A Qualitative Investigation Using the TDF and COM-B. *Int J Environ Res Public Health*, *16*(16). https://doi.org/10.3390/ijerph16162903
Okezue, O. C., Anamezie, T. H., Nene, J. J., & Okwudili, J. D. (2020). Work-Related Musculoskeletal Disorders among Office Workers in Higher Education Institutions: A Cross-Sectional Study. *Ethiopian journal of health sciences*, *30*(5), 715-724. https://doi.org/10.4314/ejhs.v30i5.10

Oliver, M., Rodham, K., Taylor, J., & McIver, C. (2021). Understanding the psychological and social influences on office workers taking breaks; a thematic analysis. *Psychology & Health*, *36*(3), 351-366. https://doi.org/10.1080/08870446.2020.1764954

Olsen, H. M., Brown, W. J., Kolbe-Alexander, T., & Burton, N. W. (2018a). A Brief Self-Directed Intervention to Reduce Office Employees' Sedentary Behavior in a Flexible Workplace. *J Occup Environ Med*, *60*(10), 954-959. https://doi.org/10.1097/JOM.0000000000001389

Olsen, H. M., Brown, W. J., Kolbe-Alexander, T., & Burton, N. W. (2018b). Flexible Work: The Impact of a New Policy on Employees' Sedentary Behavior and Physical Activity. *J Occup Environ Med*, *60*(1), 23-28. https://doi.org/10.1097/JOM.0000000000001190

Olsen, H. M., Brown, W. J., Kolbe-Alexander, T., & Burton, N. W. (2018c). Physical activity and sedentary behaviour in a flexible office-based workplace: Employee perceptions and priorities for change. *Health Promot J Austr*, *29*(3), 344-352. https://doi.org/10.1002/hpja.164

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, *372*, n71. https://doi.org/10.1136/bmj.n71

Parry, S., & Straker, L. (2013a). The contribution of office work to sedentary behaviour associated risk. *BMC Public Health*, *13*(1), 296. https://doi.org/10.1186/1471-2458-13-296

Parry, S. P., Coenen, P., Shrestha, N., O'Sullivan, P. B., Maher, C. G., & Straker, L. M. (2019). Workplace interventions for increasing standing or walking for decreasing musculoskeletal symptoms in sedentary workers. *Cochrane Database Syst Rev*, *2019*(11). https://doi.org/10.1002/14651858.CD012487.pub2

Parry, S. P., & Straker, L. M. (2013b). The contribution of office work to sedentary behaviour associated risk. *BMC Public Health*, *13*(1), 296. https://doi.org/10.1186/1471-2458-13-296

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J., Edwards, P., Woodcock, J., Brage, S., & Wijndaele, K. (2018). Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol*, *33*(9), 811-829. https://doi.org/10.1007/s10654-018-0380-1

Peachey, M. M., Richardson, J., V Tang, A., Dal-Bello Haas, V., & Gravesande, J. (2020). Environmental, behavioural and multicomponent interventions to reduce adults' sitting time: a systematic review and meta-analysis. *British Journal of Sports Medicine*, *54*(6), 315. https://doi.org/10.1136/bjsports-2017-098968

Peddie, M. C., Kessell, C., Bergen, T., Gibbons, T. D., Campbell, H. A., Cotter, J. D., Rehrer, N. J., & Thomas, K. N. (2021). The effects of prolonged sitting, prolonged standing, and activity breaks on vascular function, and postprandial glucose and insulin responses: A randomised crossover trial. *Plos One*, *16*(1), e0244841. https://doi.org/10.1371/journal.pone.0244841

Pedisic, Z., Bennie, J. A., Timperio, A. F., Crawford, D. A., Dunstan, D. W., Bauman, A. E., & Salmon, J. (2014). Workplace Sitting Breaks Questionnaire (SITBRQ): an assessment of concurrent validity and test-retest reliability. *BMC Public Health*, *14*(1), 1249. https://doi.org/10.1186/1471-2458-14-1249

Phimphasak, C., Swangnetr, M., Puntumetakul, R., Chatchawan, U., & Boucaut, R. (2016). Effects of seated lumbar extension postures on spinal height and lumbar range of motion during prolonged sitting. *Ergonomics*, *59*(1), 112-120. https://doi.org/10.1080/00140139.2015.1052570

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., Britten, N., Roen, K., & Duffy, S. (2006). *Guidance on the conduct of narrative synthesis in systematic reviews: A product from the ESRC Methods Programme*. https://doi.org/10.13140/2.1.1018.4643

Pope, M. H., Goh, K. L., & Magnusson, M. L. (2002). Spine Ergonomics. *Annual review of biomedical engineering.*, *4*(1), 49-68. https://doi.org/10.1146/annurev.bioeng.4.092101.122107

Posadzki, P., Pieper, D., Bajpai, R., Makaruk, H., Könsgen, N., Neuhaus, A. L., & Semwal, M. (2020). Exercise/physical activity and health outcomes: an overview of Cochrane systematic reviews. *BMC Public Health*, *20*(1), 1724. https://doi.org/10.1186/s12889-020-09855-3

Prieto-González, P., Šutvajová, M., Lesňáková, A., Bartík, P., Buľáková, K., & Friediger, T. (2021). Back Pain Prevalence, Intensity, and Associated Risk Factors among Female Teachers in Slovakia during the COVID-19 Pandemic: A Cross-Sectional Study. *Healthcare*, *9*(7), 860. https://www.mdpi.com/2227-9032/9/7/860

Rabal-Pelay, J., Cimarras-Otal, C., Berzosa, C., Bernal-Lafuente, M., Ballestín-López, J. L., Laguna-Miranda, C., Planas-Barraguer, J. L., & Bataller-Cervero, A. V. (2019). SPINAL SAGITTAL ALIGNMENT, SPINAL SHRINKAGE, AND BACK PAIN CHANGES IN OFFICE WORKERS DURING A WORKDAY. *International journal of occupational safety and ergonomics : JOSE*, *ahead-of-print*(ahead-of-print), 1. https://doi.org/10.1080/10803548.2019.1701238

Radulović, A. H., Žaja, R., Milošević, M., Radulović, B., Luketić, I., & Božić, T. (2021). Work from home and musculoskeletal pain in telecommunications workers during COVID-19 pandemic: a pilot study. *Arh Hig Rada Toksikol*, *72*(3), 232-239. https://doi.org/10.2478/aiht-2021-72-3559

Ráthonyi, G., Kósa, K., Bács, Z., Ráthonyi-Ódor, K., Füzesi, I., Lengyel, P., & Bácsné Bába, É. (2021). Changes in Workers' Physical Activity and Sedentary Behavior during the COVID-19 Pandemic. *Sustainability*, *13*(17), 9524. https://www.mdpi.com/2071-1050/13/17/9524

Restaino, R. M., Holwerda, S. W., Credeur, D. P., Fadel, P. J., & Padilla, J. (2015). Impact of prolonged sitting on lower and upper limb micro- and macrovascular dilator function. *Experimental physiology*, *100*(7), 829-838. https://doi.org/10.1113/EP085238

Rodrigues, M. S., Leite, R. D. V., Lelis, C. M., & Chaves, T. C. (2017). Differences in ergonomic and workstation factors between computer office workers with and without reported musculoskeletal pain. *Work*, *57*(4), 563-572. https://doi.org/10.3233/wor-172582

Rodríguez-Nogueira, Ó., Leirós-Rodríguez, R., Benítez-Andrades, J. A., Álvarez-Álvarez, M. J., Marqués-Sánchez, P., & Pinto-Carral, A. (2020). Musculoskeletal Pain and Teleworking in Times of the COVID-19: Analysis of the Impact on the Workers at Two Spanish Universities. *Int J Environ Res Public Health*, *18*(1). https://doi.org/10.3390/ijerph18010031

Rohatgi, A. (September 2022). *WebPlotDigitizer 4.6*. In (Version 4.6) https://automeris.io/WebPlotDigitizer

Rosenkranz, S. K., Mailey, E. L., Umansky, E., Rosenkranz, R. R., & Ablah, E. (2020). Workplace Sedentary Behavior and Productivity: A Cross-Sectional Study. *International Journal of Environmental Research and Public Health*, *17*(18), 6535. https://doi.org/10.3390/ijerph17186535

Ryan, C. G., Dall, P. M., Granat, M. H., & Grant, P. M. (2011). Sitting patterns at work: objective measurement of adherence to current recommendations. *Ergonomics*, *54*(6), 531-538. https://doi.org/10.1080/00140139.2011.570458

Saeidifard, F., Medina-Inojosa, J. R., Supervia, M., Olson, T. P., Somers, V. K., Prokop, L. J., Stokin, G. B., & Lopez-Jimenez, F. (2020). The Effect of Replacing Sitting With Standing on Cardiovascular Risk Factors: A Systematic Review and Meta-analysis. *Mayo Clin Proc Innov Qual Outcomes*, *4*(6), 611-626. https://doi.org/10.1016/j.mayocpiqo.2020.07.017

Šagát, P., Bartík, P., Prieto González, P., Tohănean, D. I., & Knjaz, D. (2020). Impact of COVID-19Quarantine on Low Back Pain Intensity, Prevalence, and Associated Risk Factors among Adult Citizens Residing in Riyadh (Saudi Arabia): A Cross-Sectional Study. *Int J Environ Res Public Health*, *17*(19). https://doi.org/10.3390/ijerph17197302

Sañudo, B., Fennell, C., & Sanchez-Oliver, A. (2020). Objectively-Assessed Physical Activity, Sedentary Behavior, Smartphone Use, and Sleep Patterns Pre- and during-COVID-19 Quarantine in Young Adults from Spain. *Sustainability*, *12*, 5890. https://doi.org/10.3390/su12155890

Saunders, T., Atkinson, H., Burr, J., MacEwen, B., Skeaff, C., & Peddie, M. (2018). The Acute Metabolic and Vascular Impact of Interrupting Prolonged Sitting: A Systematic Review and Meta-Analysis. *Sports Medicine*, *48*(10), 2347-2366. https://doi.org/10.1007/s40279-018-0963-8

Saunders, T., McIsaac, T., Douillette, K., Gaulton, N., Hunter, S., Rhodes, R. E., Prince, S. A., Carson, V., Chaput, J.-P., Chastin, S., Giangregorio, L., Janssen, I., Katzmarzyk, P. T., Kho, M. E., Poitras, V. J., Powell, K. E., Ross, R., Ross-White, A., Tremblay, M. S., & Healy, G. N. (2020). Sedentary behaviour and health in adults: an overview of systematic reviews. *Applied Physiology, Nutrition, and Metabolism*, *45*(10 (Suppl. 2)), S197-S217. https://doi.org/10.1139/apnm-2020-0272 %M 33054341

Schulz, K. F., Altman, D. G., & Moher, D. (2010). CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. *BMC Med*, *8*, 18. https://doi.org/10.1186/1741-7015-8-18

Shariat, A., Lam, E., Kargarfard, M., Tamrin, S., & Danaee, M. (2017). The application of a feasible exercise training program in the office setting. *Work*, *56*(3), 421. https://doi.org/10.3233/WOR-172508

Shariat, A., Tamrin, S., Arumugam, M., Danaee, M., & Ramasamy, R. (2016). Comparative reliability of different instruments used to measure the severity of musculoskeletal disorders in office workers. *Work*, *54*(3), 753. https://doi.org/10.3233/WOR-162313

Sheahan, P. J., Diesbourg, T. L., & Fischer, S. L. (2016). The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work. *Applied Ergonomics*, *53*, 64-70. https://doi.org/10.1016/j.apergo.2015.08.013

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018a). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *12*(12), CD010912. https://doi.org/10.1002/14651858.CD010912.pub5

Shrestha, N., Kukkonen-Harjula, K. T., Verbeek, J. H., Ijaz, S., Hermans, V., & Pedisic, Z. (2018b). Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev*, *6*(6), Cd010912. https://doi.org/10.1002/14651858.CD010912.pub4

Smith, B., Mallick, K., Monforte, J., & Foster, C. (2021). Disability, the communication of physical activity and sedentary behaviour, and ableism: a call for inclusive messages. *Br J Sports Med*, *55*(20), 1121-1122. https://doi.org/10.1136/bjsports-2020-103780

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology*, *11*(1), 101-121. https://doi.org/10.1080/1750984X.2017.1317357

Smith, M. D., Vicenzino, B., Brown, W. J., Gilson, N. D., Gane, E. M., & Johnston, V. (2022). Symptom characteristics in office workers using standing workstations: A cross-sectional study. *Braz J Phys Ther*, *26*(2), 100393. https://doi.org/10.1016/j.bjpt.2022.100393

Sonne, M., Villalta, D. L., & Andrews, D. M. (2012). Development and evaluation of an office ergonomic risk checklist: ROSA--rapid office strain assessment. *Appl Ergon*, *43*(1), 98-108. https://doi.org/10.1016/j.apergo.2011.03.008

Stanaway, J. D., Afshin, A., Gakidou, E., Lim, S. S., Abate, D., Abate, K. H., Abbafati, C., Abbasi, N., Abbastabar, H., Abd-Allah, F., Abdela, J., Abdelalim, A., Abdollahpour, I., Abdulkader, R. S., Abebe, M., Abebe, Z., Abera, S. F., Abil, O. Z., Abraha, H. N., . . . Zhang, H. (2018). Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *The Lancet*, *392*(10159), 1859-1922. https://doi.org/10.1016/S0140-6736(18)32335-3

Steel, N., Ford, J. A., Newton, J. N., Davis, A. C. J., Vos, T., Naghavi, M., Glenn, S., Hughes, A., Dalton, A. M., Stockton, D., Humphreys, C., Dallat, M., Schmidt, J., Flowers, J., Fox, S., Abubakar, I., Aldridge, R. W., Baker, A., Brayne, C., . . . Murray, C. J. L. (2018). Changes in health in the countries of the UK and 150 English Local Authority areas 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Steel , N , Ford , J A , Newton , J N , Davis , A C J , Vos , T , Naghavi , M , Glenn , S , Hughes , A , Dalton , A M , Stockton , D , Humphreys , C , Dallat , M , Schmidt , J , Flowers , J , Fox , S , Abubakar , I , Aldridge , R W , Baker , A , Brayne , C , Brugha , T , Capewell , S , Car , J , Cooper , C , Ezzati , M , Fitzpatrick , J , Greaves , F , Hay , R , Hay , S , Kee , F , Larson , H J , Lyons , R A , Majeed , A , Mckee , M , Rawaf , S , Rutter , H , Saxena , S , Sheikh , A , Smeeth , L , Viner , R M , Vollset , S E , Williams , H C , Wolfe , C , Woolf , A & Murray , C J L 2018 , ' Changes in health in the countries of the UK and 150 English Local Authority areas 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016 ' vol. 392 , no. 10158 , pp. 1647-1661 . DOI: 10.1016/S0140-6736(18)32207-4*. https://doi.org/https://doi.org/10.1016/S0140-6736(18)32207-4

Stoll, C. R. T., Izadi, S., Fowler, S., Green, P., Suls, J., & Colditz, G. A. (2019). The value of a second reviewer for study selection in systematic reviews. *Research Synthesis Methods*, *10*(4), 539-545. https://doi.org/10.1002/jrsm.1369

Sudholz, B., Ridgers, N. D., Mussap, A., Bennie, J., Timperio, A., & Salmon, J. (2018). Reliability and validity of self-reported sitting and breaks from sitting in the workplace. *Journal of Science and Medicine in Sport*, *21*(7), 697-701. https://doi.org/10.1016/j.jsams.2017.10.030

The Scottish Government. (2020). *The Scottish Health Survey. 2020 edition - telephone survey main report. An Experimental Statistics Publication for Scotland*. https://www.gov.scot/publications/scottish-health-survey-telephone-survey-august-september-2020-main-report/documents/

The Scottish Parliament. (2023). *Timeline of Coronavirus (COVID-19) in Scotland*. https://spice-spotlight.scot/2023/05/10/timeline-of-coronavirus-covid-19-in-scotland/

The University of Edinburgh. (2021a). *Facts and figures*. https://www.ed.ac.uk/human-resources/about/facts-figures

The University of Edinburgh. (2021b, October 2021). *Research Staff Demographics*. https://support-for-researchers.ed.ac.uk/about-the-research-staff-hub/demographics

Thorp, A. A., Kingwell, B. A., Owen, N., & Dunstan, D. W. (2014). Breaking up workplace sitting time with intermittent standing bouts improves fatigue and musculoskeletal discomfort in overweight/ obese office workers. *Occupational and Environmental Medicine*, *71*(11), 765. https://doi.org/10.1136/oemed-2014-102348

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int J Qual Health Care*, *19*(6), 349-357. https://doi.org/10.1093/intqhc/mzm042

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S. F. M., Altenburg, T. M., Chinapaw, M. J. M., & Participants, S. T. C. P. (2017). Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. *Int J Behav Nutr Phys Act*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tsauo, J., Lee, H., Hsu, J., & Chen, C. (2004). Physical exercise and health education for neck and shoulder complaints among sedentary workers. *Journal of Rehabilitation Medicine 2004 Nov;36(6):253-257*. https://doi.org/10.1080/16501970410029807

UK Health Security Agency. (2021, December 31). COVID-19: Omicron daily overview. GOV.UK. https://www.gov.uk/government/publications/covid-19-omicron-daily-overview

University of Canberra. (2022, Nov 8, 2022). *Evidence-Based Practice in Health*. https://canberra.libguides.com/evidence

van Dommelen, P., Coffeng, J. K., van der Ploeg, H. P., van der Beek, A. J., Boot, C. R., & Hendriksen, I. J. (2016). Objectively Measured Total and Occupational Sedentary Time in Three Work Settings. *Plos One*, *11*(3), e0149951. https://doi.org/10.1371/journal.pone.0149951

van Vledder, N., & Louw, Q. (2015). The effect of a workstation chair and computer screen height adjustment on neck and upper back musculoskeletal pain and sitting comfort in office workers.(Original Research). *South African Journal of Physiotherapy*, *71*(1). https://doi.org/10.4102/sajp.v71i1.279

Versus Arthritis. (2021). *The State of Musculoskeletal Health 2021. Arthritis and other musculoskeletal conditions in numbers*. https://www.versusarthritis.org/about-arthritis/data-and-statistics/the-state-of-musculoskeletal-health/

Waongenngarm, P., Areerak, K., & Janwantanakul, P. (2018). The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials. *Applied Ergonomics*, *68*, 230-239. https://doi.org/10.1016/j.apergo.2017.12.003

Watson, B. (2020, March 24). *Coronavirus and homeworking in the UK labour market: 2019.* Office for National Statistics. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/coronavirusandhomeworkingintheuklabourmarket/2019

Wewers, M. E., & Lowe, N. K. (1990). A critical review of visual analogue scales in the measurement of clinical phenomena. *Research in Nursing & Health*, *13*(4), 227-236. https://doi.org/https://doi.org/10.1002/nur.4770130405

Williamson, S., Colley, L., & Hanna-Osborne, S. (2020). Will working from home become the 'new normal' in the public sector? *Australian Journal of Public Administration*, *79*(4), 601-607. https://doi.org/https://doi.org/10.1111/1467-8500.12444

World Health Organization. (2020a). WHO Director-General's opening remarks at the media briefing on COVID-19-11 March 2020. In: Geneva, Switzerland.

World Health Organization. (2020b). *WHO guidelines on physical activity and sedentary behaviour*. https://www.who.int/publications/i/item/9789240015128

Yang, L., Hipp, J. A., Lee, J. A., Tabak, R. G., Dodson, E. A., Marx, C. M., & Brownson, R. C. (2017). Work-related correlates of occupational sitting in a diverse sample of employees in Midwest metropolitan cities. *Preventive Medicine Reports*, *6*, 197-202. https://doi.org/https://doi.org/10.1016/j.pmedr.2017.03.008

Yorulmaz, D. S., Karadeniz, H., Duran, S., & Çelik, İ. (2022). Determining the musculoskeletal problems of academicians who transitioned to distance education during the COVID-19 pandemic. *Work*, *71*(3), 493-503. https://doi.org/10.3233/wor-210902

Yu, Z., James, C., Edwards, S., & Snodgrass, S. (2018). Differences in posture kinematics between using a tablet, a laptop, and a desktop computer in sitting and in standing. *Work*, *61*(2), 257. https://doi.org/10.3233/WOR-182796

Zemp, R., Fliesser, M., Wippert, P. M., Taylor, W. R., & Lorenzetti, S. (2016). Occupational sitting behaviour and its relationship with back pain - A pilot study. *Appl Ergon*, *56*, 84-91. https://doi.org/10.1016/j.apergo.2016.03.007

Zheng, C., Huang, W. Y., Sheridan, S., Sit, C. H., Chen, X. K., & Wong, S. H. (2020). COVID-19 Pandemic Brings a Sedentary Lifestyle in Young Adults: A Cross-Sectional and Longitudinal Study. *Int J Environ Res Public Health*, *17*(17). https://doi.org/10.3390/ijerph17176035

Appendices

Appendix 1. Online survey for study 2.

THE UNIVERSITY of EDINBURGH

Default Question Block

Sitting behaviour whilst working from home: Understanding how much we sit, what influences this behaviour, and how it may relate to our health

Participant Information Sheet (V1 March 2021)

You are being invited to take part in a research study examining the sitting behaviour of University of Edinburgh employees whilst working from home. This independent research is being led by the Physical Activity for Health Research Centre (PAHRC), and we have consulted with the Home and Hybrid Working Group, Human Resources, Health and Safety, and the Centre for Sport and Exercise in developing this study to optimise its value. Before you decide to take part, it is important that you understand why the research is being conducted and what it will involve. Please take time to read the following information carefully. A downloadable version of this information is available (link), should you wish to save a PDF for future reference.

What is the purpose of this research?

COVID-19 has changed the way we work. Due to lockdown restrictions, for many of us working at home has become the 'new normal', and in the future it is likely that we will have a more flexible approach to work location. Whilst there are many advantages to working from home, there are also some potential negative consequences. The aim of this study is to focus specifically on sitting behaviour whilst working from home. We are interested in understanding more about sitting patterns across the working day and breaks from sitting, what factors influence this behaviour, and also how this behavior is related to our health (including body pain and discomfort, and mental health and work well-being).

Why have I been invited to take part?

You have been invited to take part because you are a member of staff at the University of Edinburgh aged 18 and over who is currently working from home, and has access to a computer to complete the questionnaire.

Do I need to take part?

No you don't need to participate. Your participation in this study is entirely voluntary. If you wish to withdraw from this study, you can do so at any time during completion of the questionnaire, and by just exiting the online questionnaire (close the window). Due to the method of data collection, following submission of the questionnaire it will not be possible to withdraw your data from the study because we will not be able to identify your responses. Deciding not to take part or withdrawing from the study will not affect your employment in any way.

If I agree to participate, what will I be asked to do?

You will be asked to show you are happy to take part in this study by reading through a consent form (see below) and ticking each statement to demonstrate that you consent to participating. Following your consent to participate in the study, you will be asked to complete an online questionnaire.

The online questionnaire is divided into seven sections. The first section focuses on demographic information about you. The questions in the second section will assess sitting behaviour whilst working from home. The purpose of the third section is to identify what factors influence our ability to reduce our sitting whilst working from home. The next sections focus on assessing health outcomes that may be influenced by our sitting behaviour including musculoskeletal pain/ discomfort (Section 4), mental health (Section 5), and well-being at work (Section 6). The final section (Section 7) focuses on the ergonomic set-up of your working from home environment.

We estimate that it will take an average of 15-20 minutes to complete the questionnaire. At the end of the questionnaire, there is an option to register your interest to receive information about participation in further research in this area.

What are the potential risks?
We do not anticipate any significant risks from participating in this study. If completing some of the questions makes you feel uncomfortable, then please use the arrow at the bottom of the page to move to the next section, and we will only use the sections that you do complete. Additionally, at the end of the questionnaire we have provided some links to helpful resources on the topics covered in the questionnaire, if you would like further information.

What are the potential benefits of taking part in the research?
We hope that you will find completing the questionnaire an interesting exercise. By sharing your responses you will be contributing to novel research regarding sitting behaviour in the working from home environment. These findings will be shared with partners in the University in order to inform strategies to best support staff when working at home. For more immediate support, please see links to useful information at the end of the questionnaire.

As a token of appreciation for your time and input in completing the questionnaire, **you have the opportunity to be entered into a prize draw for one of five £50 amazon vouchers.** If you would like to enter the draw then please leave your email on the final page. The email addresses for the prize draw will be stored separately from the questionnaire data, and we will use a random number generator to identify the prize winners.

Will my taking part be confidential?
Your data will be processed in accordance with Data Protection Law, and the data are collected under public task. All information collected about you will be kept strictly confidential. The research data (questionnaire responses) will be downloaded from Qualtrics, anonymised and stored on secure university servers for the life of the project (reviewed at 24 months - April 2023). The anonymous data will then be stored permanently on Datashare as an open access data-set. This means that the data can be used by other researchers in ethically approved research.

If you choose to be entered into the prize draw, your email address will be stored separately from your research data on secure university servers, and will be disposed of on completion of the prize draw. If you win the prize draw, if requested then your name will be shared to verify the draw.

If you choose to be contacted about taking part in future research studies, your email address will be stored separately from the research data on secure university servers. We will review this dataset at 24 months (April 2023) and will either retain for a further two years or dispose of the data at this point, depending on the status of the programme of research

The University of Edinburgh is the sponsor for this study based in the United Kingdom. We will be using information from you in order to undertake this study and will act as the data controller for this study. This means we are responsible for looking after your information and using it properly. The University of Edinburgh will keep identifiable information (i.e., email addresses provided for future research) for at least 24 months (April 2023). For general information about how we use your data go to the Privacy Notice.

What will happen to the information collected?
The data collected will provide useful insight into staff's working from home experiences, and the anonymised summarized findings will be shared with the Home and Hybrid Working Group, Health and Safety, Human Resources, Centre for Sport and Exercise, and other departments in order to inform future developments on how best to support colleagues when working from home. Please note that you will NOT be identifiable in any of these findings. The anonymised data will also be used as a part of a PhD project, potential MSc projects, and will be published in scientific journals and/or presented at research conferences. The anonymous data may also be pooled with data collected in the future, and used in subsequent ethically approved projects.

Ethics approval:
This study has been reviewed and given a favourable opinion by the Moray House School of Education and Sport Ethics committee (ref#AN17022021-1), and has been granted sponsorship by the University of Edinburgh.

Who can I contact?
If you have any further questions about the study prior to participating, then please contact the

lead researcher Dr Ailsa Niven (ailsa.niven@ed.ac.uk).

If you would like to discuss this study with someone independent of the study, or make a complaint about the study then please contact Dr Fiona O'Hanlon (Chair of Moray House School of Education and Sport Ethics Committee (Fiona.O'Hanlon@ed.ac.uk).

Participant Consent:

In order to complete the questionnaire, please indicate that you provide informed consent for participation by indicating 'Yes' for each of the following statements. If you do not consent to participate, then please simply close the questionnaire.

	Yes
I confirm that I have read and understood the information provided about this study (PIS v1 date)	○
I have been given the opportunity to consider the information provided, ask questions, and have had these questions answered to my satisfaction.	○
I understand that my participation is entirely voluntary, and that I can withdraw at any time just by exiting the questionnaire, without giving a reason and without my employment or legal rights being affected.	○
I understand that my anonymised data will be stored securely throughout the duration of the project, then permanently in a publically available dataset, and may be used in future ethically approved research.	○
I understand that if I provide my email address (and I may choose not to provide my email address), then it will be stored separately from the research data for the purpose of entry into the prize draw and/or to be potentially contacted for future research	○
I understand that if I complete and submit the survey, I cannot have my responses removed at a later date.	○
I understand that relevant sections of my data collected during the study may be looked at by individuals from the Sponsor (University of Edinburgh), where it is relevant to my taking part in this research. I give permission for these individuals to have access to my data	○
I agree to take part in the above study	○

SECTION 1: Demographic information and working from home set-up

SECTION 1: Demographic information

Please answer the following demographic questions so that we can understand more about who the research participants are:

How old are you?

- 18-30
- 31-40
- 41-50
- 51-60
- 61+

Do you self-identify as:

Male	Female	Non-binary / third gender	Prefer not to say
O	O	O	O

What is your ethnic group? (NB - we are using the high level categories from the 2022 Scottish Census)

- African, Scottish African or British African
- Asian, Scottish Asian or British Asian
- Caribbean or Black
- Mixed or multiple ethnic groups
- White
- Other ethnic group
- Prefer not to say

If you selected other ethnic group, please specify your ethnic group (please leave blank if you *prefer not to say)*

What is your approximate height (cm)? (please leave blank if you prefer not to say)

What is your approximate weight (kilograms)? (please leave blank if you prefer not to say)

Do you have any physical condition(s) that prevents you from being able to stand for 15 minutes

- Yes
- No
- Prefer not to say

If you are happy to, please provide brief details on the condition that prevents your from standing (e.g., lower back issue from previous occupation):

How would you classify your job type?

- Professional services
- Academic
- Technician
- Other
- Prefer not to say

If 'other' please specify your job type

Do you work full or part-time?

- Full-time (1.0 FTE)
- Part-time (≥ 0.6 FTE)
- Part-time (< 0.6 FTE)

How long have you worked at the University?

- less than 1 year
- 1-10 years
- 11-20 years
- 20+ years

For how long has 'working from home' been your main mode of working?

Years [ ]

Months [ ]

Has the last 7 days been a normal working week for you?

- Yes
- No (due to annual leave/ illness/ other)

Have you had the opportunity to complete the Cardinus Home Working (remote working) training package offered via the Health and Safety Department web site?

- Yes
- No
- I was unaware of this training package

SECTION 2 – How much do we sit?

SECTION 2 - How much do we sit whilst working at home?

The next series of questions ask about your sitting and physical activity behaviour during working time, and at other points during the week. If **questions refer to 'at work' please view this as during your working hours**. There are some questions that are similar, but please answer them all. We are aiming to identify which question set best captures the behaviour of interest.

How many hours did you work in the last 7 days? (please report using numbers e.g., 35)

[ ]

During the last 7 days, how many days did you work ?

- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7

The next question asks you to consider what percentage of your working day is made up of sitting, standing, walking, and heavy labour activities. Please review the example before completing.

Example:

Jane is an administrative officer. Her work day involves working on her computer at her desk, answering the phone, filing documents, photocopying, and some walking around the office. Jane would describe a typical work day in the last 7 days like this:

Sitting (including driving)	= 90%
Standing	= 5%
Walking	= 5%
Heavy labour or physically demanding tasks	= 0%
Total	= 100%

How would you describe your typical WORKING day in the last 7 days? (This involves only your work day, and does not include travel to and from work, or what you did in your leisure time) Please choose a percentage for each activity. All activities must sum up to 100%.

% Sitting (including driving for work activities)	0
% Standing	0
% Walking	0
% Heavy labour or physically demanding tasks	0
Total	0

During the last 7 days, (on average) how much time did you usually spend sitting at work on a single weekday?

Total hours

Total minutes

In the last 7 days, (on average) how many breaks from sitting did you take per hour, while at work? This could include standing, stretching, taking a short walk. Do not count lunch or tea breaks.

On average, how long were these breaks?

Minutes

During the last 7 days, please estimate how much time you usually spend SITTING in each of the following activities on a WORKING day and a NON-WORKING day.

	Working day		Non-working day	
	Hours	Minutes	Hours	Minutes
For transport (e.g. in car, bus, train, etc)				
At work (e.g. sitting at a desk or using a computer)				
Watching TV				
Using a computer at home (e.g. email, games, information, chatting)				
Other leisure activities (e.g. listening to music, reading, arts and crafts, socialising, but NOT including TV or computer use)				

SECTION 3 – What influences our ability to reduce our sitting time?

SECTION 3 - What influences our ability to reduce our sitting time?

Please rate your ability and willingness to ***reduce the time you spend sitting whilst working from home.***

On a scale from 0 (strongly disagree) to 10 (strongly agree)

I have the PHYSICAL opportunity to reduce the time I spend sitting whilst working from home (e.g., sufficient time, equipment, space, reminders)	
I have the SOCIAL opportunity to reduce the time I spend sitting whilst working from home (e.g., support from people I live with, friends, family, work colleagues)	
I am MOTIVATED to reduce the time I spend sitting whilst working from home (e.g., I have the desire to, I feel the need to)	
Reducing the time I spend sitting whilst working from home is something that I do AUTOMATICALLY (e.g., reducing sitting time is something I do before I realise I am doing it)	
I am PHYSICALLY able to reduce the time I spend sitting whilst working from home (e.g., I have sufficient physical stamina, I can overcome disability, I have sufficient physical skills)	
I am PSYCHOLOGICALLY able to reduce the time I spend sitting whilst working from home (e.g., having the ability to engage in appropriate memory, attention and decision making processes – such as noticing I've been sitting for some time and remember to reduce sitting)	
I have the KNOWLEDGE to reduce the time I spend sitting whilst working from home (e.g., know how to prompt a change in sitting)	

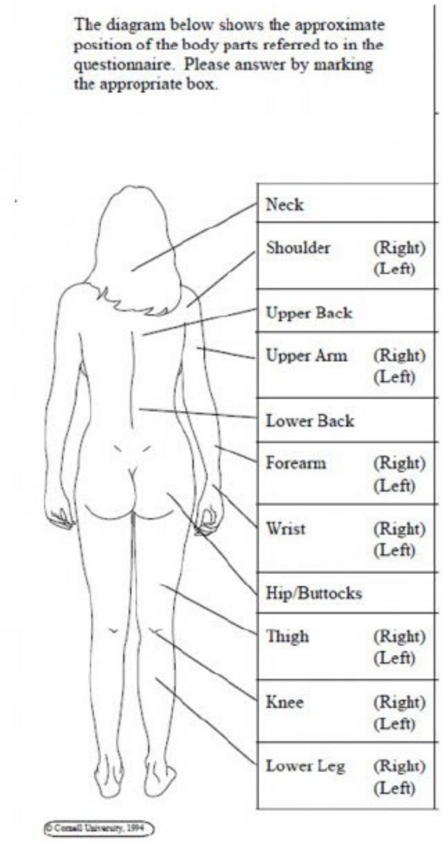
Please feel free to add any other comments related to your ability and willingness to reduce your time spent sitting whilst working from home?

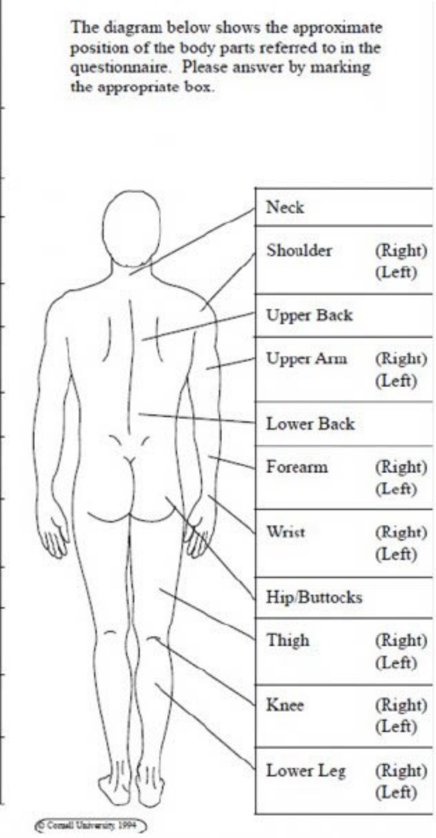
SECTION 4: Have you been experiencing pain and discomfort?

SECTION 4: Pain and discomfort. Cornell Musculoskeletal Discomfort Questionnaire (CMDQ).

The next set of questions are looking to explore musculoskeletal pain and discomfort in the past 7 days.

Please take the following images as a reference to answer the questions below.





Please read the instructions carefully (note if you are using a phone, please scroll across).

- Tick one answer for each question (1,2,3) if relevant.

- If you select one or more body areas in question 1, please continue to questions 2 and 3. Answer questions 2 and 3 considering the body areas marked in question 1. Please select the ***'forward'*** *arrow button when you finish.*

- If you mark ***'Never'*** *in all the options provided in question 1, please skip to the next section by selecting the* ***'forward'*** *button.*

-

	1. During the last week of work how often did you experience ache, pain, discomfort in:					2. If you experienced ache, pain, discomfort, how uncomfortable was this?			3. If you experience pain, discomfort, c interfere with your to work?		
	Never	1-2 times	3-4 times	Once every day	Several times every day	Slightly	Moderately	Very	Not at all	Slightly	Subst
Neck	○	○	○	○	○	○	○	○	○	○	
Right shoulder	○	○	○	○	○	○	○	○	○	○	
Left shoulder	○	○	○	○	○	○	○	○	○	○	
Upper back	○	○	○	○	○	○	○	○	○	○	
Right upper arm	○	○	○	○	○	○	○	○	○	○	
Left upper arm	○	○	○	○	○	○	○	○	○	○	
Lower back	○	○	○	○	○	○	○	○	○	○	
Right forearm	○	○	○	○	○	○	○	○	○	○	
Left forearm	○	○	○	○	○	○	○	○	○	○	
Right wrist	○	○	○	○	○	○	○	○	○	○	
Left wrist	○	○	○	○	○	○	○	○	○	○	
Hip/buttocks	○	○	○	○	○	○	○	○	○	○	
Right thigh	○	○	○	○	○	○	○	○	○	○	
Left thigh	○	○	○	○	○	○	○	○	○	○	
Right knee	○	○	○	○	○	○	○	○	○	○	
Left knee	○	○	○	○	○	○	○	○	○	○	
Right lower leg	○	○	○	○	○	○	○	○	○	○	
Left lower leg	○	○	○	○	○	○	○	○	○	○	

SECTION 5 – The Warwick and Edinburgh Mental Well-Being Scale (WEMWBS)

SECTION 5 - The Warwick and Edinburgh Mental Well-Being Scale (WEMWBS)

Below are some statements about feelings and thoughts.

Please tick the box that best describes your experience of each over the last 2 weeks.

	None of the time	Rarely	Some of the time	Often	All of the time
I've been feeling optimistic about the future	○	○	○	○	○
I've been feeling useful	○	○	○	○	○
I've been feeling relaxed	○	○	○	○	○
I've been feeling interested in other people	○	○	○	○	○
I've had energy to spare	○	○	○	○	○
I've been dealing with problems well	○	○	○	○	○
I've been thinking clearly	○	○	○	○	○
I've been feeling good about myself	○	○	○	○	○
I've been feeling close to other people	○	○	○	○	○
I've been feeling confident	○	○	○	○	○
I've been able to make up my own mind about things	○	○	○	○	○
I've been feeling loved	○	○	○	○	○
I've been interested in new things	○	○	○	○	○
I've been feeling cheerful	○	○	○	○	○

SECTION 6: Work & Well-being Survey (UWES) ©

SECTION 6: Work & Well-Being Survey (UWES) ©

The following 9 statements are about how you feel at work. Please read each statement carefully and decide if you ever feel this way about your job. If you have never had this feeling, select the '0' (zero) from the dropdown list. If you have had this feeling, indicate how often you feel it by selecting the appropriate number (from 1 to 6) from the dropdown list that best describes how frequently you feel that way.

1. At my work, I feel bursting with energy
2. At my job, I feel strong and vigorous
3. I am enthusiastic about my job
4. My job inspires me
5. When I get up in the morning, I feel like going to work
6. I feel happy when I am working intensely
7. I am proud of the work that I do
8. I am immersed in my work
9. I get carried away when I am working

SECTION 7: Working from home facilities

SECTION 7: Working from home facilities

The following questions are related to your work space at home. If you cannot find an option that describes your settings accurately use the 'Other' box to describe in your own words.

Where do you work at home? (please select all that are applicable)

- ☐ In a home office
- ☐ In a spare room adapted for working
- ☐ In another room that is also used for non-work activities (e.g., kitchen, bedroom)
- ☐ Other

If you selected other, please provide further details of where you work at home:

[ ]

What type of computer device do you use at home? Mark as many as you need.

- ☐ Desktop workstation (including monitor, keyboard and mouse)
- ☐ Laptop workstation (including mouse) connected to an external monitor
- ☐ Laptop (no mouse or external keyboard)
- ☐ Laptop with mouse
- ☐ Laptop with external keyboard
- ☐ [ ] Other

How many monitors do you use at home? Please mark one option.

- 1 monitor
- 2 monitors
- [ ] Other

What type of work surface do you use for working at home? Mark one option or use the 'Other' box to specify if you use more than one type of desk.

- Sitting desk
- Standing desk
- Sitting table (i.e. dinner table)
- [ ] Other

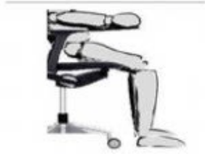
The next questions are related specifically to your **primary** chair settings while working from home (i.e., where you spend most of your time sitting). Please use the images as reference.

Mark as many as you need to describe your chair height.

- ☐ Knees at 90° angle

- ☐ Knee angle less than 90°

- ☐ Knee angle greater than 90°



- ☐ Feet do not touch the floor

- ☐ Insufficient space under desk, which does not allow to cross your legs.

- ☐ Non-adjustable height

Please mark as many as you need to describe your seat depth.

- [ ] Approximately 3 inches of space between knee and edge of seat

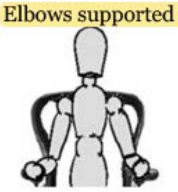
- [ ] Less than 3 inches of space between knee and edge of seat

- [ ] More than 3 inches of space between knee and edge of seat

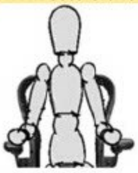
- [ ] Non-adjustable seat depth

Please mark as many as you need to describe your chair armrests.

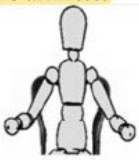
- ☐ Elbows supported in line with shoulders, relaxed shoulders



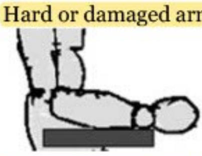
- ☐ Armrests either too high (shoulders shrugged), or too low (arms unsupported)



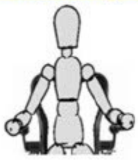
- ☐ No armrests



- ☐ Hard or damaged armrests surface



- ☐ Armrests are placed too wide



- ☐ Non-adjustable armrests

Please mark as many as you need to describe your chair back support.

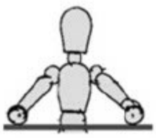
- ☐ Lumbar support - Chair reclined between 95°-110° angle

- ☐ No lumbar support, or lumbar support is not positioned in lumbar area

- ☐ Back angle is far back (greater than 110° angle) or too forward (less than 95° angle)

- ☐ No back support or leaning forward working position

- ☐ Work surface is too high (shoulders shrugged)



- ☐ Non-adjustable back rest

Block 9

SECTION 8: Anything else?

If there is anything else you would like to tell us about your experience of sitting whilst working from home, please do so below:

Block 10

Thank you for taking the time to complete this questionnaire.

As a token of our appreciation for your participation, if you would like to be entered into the prize draw for one of five £50 Amazon vouchers then please add your email address below. This information will be stored separately from the responses to the questionnaire:

If you would like to be contacted about participating in future studies in this research area of sitting behaviour and working at home, please add your email address below. This information will be stored separately from the responses to the questionnaire.

Powered by Qualtrics

Appendix 2. Ethics approval for study 3

THE UNIVERSITY *of* EDINBURGH
Moray House School of Education and Sport

Research, Knowledge Exchange and Impact Office
Moray House School of Education and Sport
The University of Edinburgh
Old Moray House
Holyrood Road
Edinburgh EH8 8AQ

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www.ed.ac.uk

Ref: ECOR09092021

Eva CORAL ALMEIDA
Moray House School of Education and Sport

Date: 04th November 2021

Dear Eva,

Title: Barriers and facilitators to break up sitting time in office workers with musculoskeletal symptoms currently working from home

The School of Education and Sport Ethics Sub-Committee has now considered your request for ethical approval for the studies detailed in the above application.

This is to confirm that the Sub-Committee is happy to approve your application and that the research meets the School Ethics Approval criterion for this particular project. A standard condition of this ethical approval is that should any amendment, or deviation from the original protocol outlined in your application need to be made to carry out or continue your research, please notify the Ethics Sub-Committee at MHSES-Ethics@ed.ac.uk

The Committee also needs to be notified if there are any unexpected results or events once the research is underway that raise questions about the safety of the research.

Should you receive any formal complaints relating to the study you should notify the MHSE Ethics Committee immediately by email to MHSES-Ethics@ed.ac.uk

Yours sincerely,

On behalf of:
Dr Fiona O'Hanlon
Director of Ethics

Appendix 3. Recruitment flyer for study 3

WORKING FROM HOME?

Are you currently experiencing musculoskeletal pain or discomfort?

We are looking for:

University of Edinburgh staff:

- Aged 18 to 64 years old.
- Carrying out work at a desk with frequent computer use (professional, academic, secretarial, management and others).
- Working from home (over 50% of working week).
- With musculoskeletal pain or discomfort in one or more area (i.e. neck pain, back pain)

What will you participation involve?

- You will have to fill out a screening questionnaire to determine your study participation.
- If you fit the criteria, you will be invited to attend to an online interview through Microsoft Teams. The interview will last around 45 – 50 minutes.
- In the interview, we will discuss topics related to your musculoskeletal pain and discomfort, as well as what factors influence your sitting time and breaks from sitting while working from home.

Contact information:

If you wish to obtain more information about this study, please contact me at: eva.coral@ed.ac.uk, or scan the QR code below.

Thank you for your attention!!

SCAN ME

Appendix 4. Participants information sheet for study 3

INFORMATION SHEET

Project title: Factors influencing breaking up sitting time in office workers with musculoskeletal symptoms while working from home.

You are being invited to take part in this research. Before you decide to take part, it is important that you understand why the research is being conducted and what it will involve. Please take time to read the following information carefully.

What is the purpose of this research?

Working from home became the most frequent work setting for office workers since the COVID-19 pandemic. However, it has been indicated that nowadays office workers are engaging in hybrid working, both attending to the office and work from home. Literature suggests that working from home has meant that office workers increase their sitting time, and consequently this has translated into the development musculoskeletal symptoms (pain and discomfort). Office workers with musculoskeletal symptoms such as pain and discomfort tend to sit for longer periods (and take fewer breaks from sitting) than people without symptoms breaks from sitting. Due to this, this research aims to understand what factors influence breaking up sitting time while working from home in office workers with musculoskeletal symptoms.

Can I participate?

You can take part in this research if you are:

- An adult aged 18-64?

- An office worker (professional, academic, secretarial, management, and others) working from home (50% of working week), and with frequent computer use (4-hours or over), desktop or laptop use.
- Have musculoskeletal pain or discomfort in one or more area.

You should not take part in this study if you:

- Do not carry out office work.
- If you are not able to WFH most of the week.
- If you have any reason (such as mobility problems) that prevent you from interrupting sitting time.

If you meet the requirements, you are invited to take part of this study.

So, what will happen if you take part in this study?

If you agree to participate in this study this is what will happen. A link to a screening questionnaire to examine your pain and discomfort will be sent to you by email. After questionnaire completion, the lead researcher (myself) will examine your responses, and if you fulfil the inclusion criteria, you will receive an email confirming your participation in this study. If you do not fulfil the inclusion criteria your questionnaire responses will be deleted.

You will be asked to attend an online interview with the lead researcher. The interview will be semi-structured and will last around 45 – 50 minutes. These interviews will be scheduled at your convenience, and they will be carried out through an online platform (Microsoft Teams). In the interview, we will discuss topics related to your musculoskeletal pain and discomfort, as well as what factors influencing your sitting time and breaks from sitting while working from home.

The interview will be recorded through the online platform, and the recordings will be stored in a University of Edinburgh online storage (One Drive). All data collected will be used to inform a PhD thesis, and other research outputs (e.g., conferences, journal publications).

Do I need to take part in this study?

Your participation in this study is entirely voluntary. If you wish to withdraw from this study, you can do so at any time without providing any reason, and just by expressing your wish of withdrawal. Please note that your data may be used in the production of formal research outputs (e.g. journal articles, conference papers, theses and reports) prior to your withdrawal and so you are advised to contact the research team at the earliest opportunity should you wish to withdraw from the study.

What are the potential risks of taking part in this study?

There are no risks associated to this research.

Are there possible benefits for me if I take part of the research?

You will contribute to novel research related to sedentary behaviour, breaks from sitting, and musculoskeletal disorders while working from home. Also, you may benefit from discussing your sitting behaviour, and make positive changes. The collected information will be used to tailor an intervention aiming to reduce sitting time in people with musculoskeletal symptoms while working from home.

How is my data used?

The overall findings will be used to inform the lead researcher's PhD thesis. The study report will be written in a way that no one can work out that you took part in the study. Additionally, results from this study may be published in a scientific journal and presented at research conferences. All data will be destroyed after the lead researcher (myself) graduates or after the data have fulfilled publication purposes. Collected datasets may be accessed by other researchers as an open access data. However, this would be only through correspondence with myself and by reasonable request, and your data would be still anonymised.

How is my privacy protected?

A participant number will be assigned to you and data describing you (age, gender, type of contract, household) will be stored separately to your interview transcription. Your consent information will be also kept separately from your responses in order to minimise risk.

Ethics approval

This study has been reviewed and approved by the Moray House School of Education and Sport Ethics committee at the University of Edinburgh.

Where can I get more information?

Eva Coral-Almeida at the University of Edinburgh is leading this research as part of their PhD studies. If you require for more information about this research, please contact Eva at You can also contact my main supervisor Dr Ailsa Niven at , if you have further enquiries.

Appendix 6. Online consent form for study 3

PARTICIPANTS CONSENT FORM

Study Title: Factors influencing breaking up sitting time in office workers with musculoskeletal symptoms while working from home

Researcher's name and contact details: Eva Coral-Almeida,

Participant's name: _______________

1. I confirm that I have read and understood the participants' information sheet for the above study.

2. I have been given the opportunity to consider the information provided, ask questions, and have had these questions answered to my satisfaction.

3. I understand that my participation is voluntary and that I can withdraw from the study at any time without giving a reason.

4. I understand that my anonymised data will be stored as detailed in the participants' information sheet.

5. I understand that the questionnaires filled out before my interview are for participant screening purposes, and if I do not pass the criteria my data will be discarded.

6. I understand that my anonymised data may be made open access (upon request) to other researchers.

7. I agree to my interview being video recorded.

8. By ticking this box, I agree to take part in the above study. ☐

Appendix 6. Interview scheduled for study 3

INTRODUCTION AND DESCRIPTIVE DATA

Question	Prompt/Elaboration	Why? (Rationale)
Thank you for agreeing to being interviewed as a part of this study. As mentioned on the information sheet we are going to discuss your sitting time, breaks from sitting and your pain and discomfort. The interview should last around 45-50 minutes. Before we start, do you have any question for me?		Introductory remarks
- What is your age?		Descriptive characteristics
1. Tell me a bit more about your job. What do you do? 2. When did you start this job? (time working for the university) 3. Are you working part time or full time? 4. Currently how many days do your work from home? 5. What have made you choose to work from home for the majority of the week?	Prompt: Is this an academic role? Prompt: Does this vary or is consistent? Do you also work at an office? Prompt. Are there advantages/disadvantages when compared to the office?	Job context
6. Please tell me what your workspace is like when you are working at home? 7. Where do you carry out your work activities while working at home?	Prompt: Or do you share your workspace with someone else? Prompt: Do you have another workspace?	Personal/Household context

8. In a normal weekday, how many hours approximately do you spend sitting for work? 9. Approximately, how many breaks from sitting do you take per hour?		Sitting time and breaks from sitting
10. Thanks for completing the screening questionnaire – You marked these areas in your screening questionnaire (mention areas/share questionnaire). Can you tell me a bit more about your current discomfort?	Prompt: How long have you have pain and discomfort? Follow-up: Is there any area that was not marked at your questionnaire where you feel pain now?	Musculoskeletal symptoms

INTERVIEW SCHEDULE RELATED TO COM-B AND TDFS COMPONENTS.

COM-B components	**TDF**	**Question**	**Prompt/Elaboration**
Psychological capability	Knowledge	11. What is your understanding about prolonged sitting? 12. Are you aware of any expert advice on managing sitting time? 13. Are you aware of any health consequences from too much sitting? 14. How do you think sitting time could be reduced in a working environment?	Prompt. Guidelines? Chief Medical Officer? Prompt. Have you heard about breaks from sitting? What is your understanding of breaks from sitting?
Reflective motivation	Beliefs about consequences	15. What effects do you think taking breaks from sitting time has	Prompt: What would be a positive/negative effect?

		on your pain and discomfort? 16. Do you feel that reducing your sitting will reflect onto your pain and discomfort?	Prompt: Tell me more about it. Would this reflect positively or negatively?
Reflective motivation	Social/Professional role and identity	17. To what extent do you think sitting time is part of your role at work? 18. And, to what extent breaking up your sitting time would affect your role?	
Psychological capability	Memory, attention and decision processes	19. What are the main differences that you have noticed between sitting time at the office and sitting time while working from home? 20. How do your breaks at home differ from breaks in the office?	Prompt. What type of breaks do you take at the office? What about breaks at home?
Psychological capability	Behavioural regulation	21. Do you have a system or strategy to monitor your sitting time and breaks from sitting while working at home?	Prompt: If you do, what are these strategies? If you don't, what system/strategy would you think would be useful to keep track of your sitting/breaks?
Physical capability	Physical Skills	22. In relation to your pain and discomfort. Could you tell me to what extent do you feel physically able to interrupt your sitting time?	Prompt: Could you elaborate on this?
Automatic motivation	Emotion	23. How do you think your mood (e.g., feeling happy, stressed, low) during	Prompt. Now, to what extent do you think your mood is influenced by

		the day influences your sitting?	your pain and discomfort?
Social opportunity	Social influences	24. Is there anybody in your household that influences your sitting time and breaks from sitting while working from home? 25. What about your work bosses, do they have any influence on breaking up your sitting time?	Prompt. How do they influence you?
Reflective motivation	Belief about capabilities	26. How confident do you feel to break up your sitting time while you work from home?	Prompt: does time influences this decision?
Physical opportunity	Environmental context and resources	27. Regarding to sitting time, what challenges have you come across while working from home? 28. What resources would make it easier for you to take more regular breaks from sitting while working from home?	Prompt. What about advantages? Prompt: Could you mention a resource that you think will facilitate this?
Social opportunity	Reinforcement	29. What would be an incentive for you to break up your sitting while working from home?	
Reflective motivation	Goals and Intentions	30. Are there any specific goals that you would like to accomplish regarding your sitting while working from home?	Prompt. What kind of steps would you follow to reduce your sitting? What would be helpful?

		31. Do you anticipate increasing your breaks from sitting g at home?	
Reflective motivation	Optimism	32. To what extent do you feel confident to continue breaking up your sitting time while working at home?	
	Final question	33. Is there anything else you would like to add?	

Appendix 7. Framework method matrix for study 3

RESEARCH QUESTION: WHAT FACTORS INFLUENCED OFFICE WORKERS WITH MUSCULOSKELETAL SYMPTOMS TO BREAK UP SITTING TIME WHILE WORKING FROM HOME?

COM-B components	COM-B sub-themes	TDFs	Emerging themes	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9
CAPABILITY	Physical capability	Skills	Strategies to cope with pain				Has a strategy to cope when pain is too bad Q					
			Difficulty to take breaks or change posture because of pain				Tend to stay still because of pain Q					
			Ability to take breaks	Feels physically able to take breaks	Feels physically able to take breaks			Feels physically able to take breaks	Feels physically able to take breaks		Feels physically able to take breaks	Feels physically able to take breaks
			Other health conditions						Health condition prevents prolonged standing (vertigo)			
	Psychological capability	Knowledge	General health consequences			Circulation problems		Leads to unhealthy conditions	Various health outcome (i.e. gain weight, thrombosis)	Gain weight	Obesity	Lots of conditions as a results of prolonged sitting QQQ
			Knowledge of expert advise on sitting	Is important not to stay in the same position QQ	Takin regular breaks	Taking breaks every 45-50 mins	Taking regular breaks			Take breaks every 30 mins		
			Consequences of sitting on MSK health	Back pain as a consequence		Muscle and bone problems			Back pain as a consequence	Back pain as a consequence	Muscle atrophy, shortened muscles	Pressure on joints
			Understanding of prolonged sitting	Staying in the same position for a long period	People who sits a lot due to their job	Sitting for more than 45 mins QQQ		Sitting feels unhealthy (different category?)		Unhealthy to sit for long periods, but necessary for work QQ	Sitting is a bad habit QQ	Sitting has no positive effects
			Understanding of breaks from sitting	Standing, stretching, changing posture		Doing complex movements for some minutes	Short breaks lasting a couple of minutes	Be less stationary and move around QQ	Going around doing active breaks Q	Anything but sitting (i.e. move around, stretching)	It's good to stretch	A 5 minute break from being sat down, including some sort of PA
		Memory, attention, decision processes	Posture while sitting								Noticed that changing posture decreases pain	
			Pain changed from the office to WFH									
			Awareness that sitting/PA changed due to the pandemic			PA changed due to the pandemic, and people don't move as much. QQ						
		Behavioural regulation	Flexibility		Smart watch reminders are not flexible							
			Self-monitoring		Takes breaks when has pain			Takes breaks when has pain QQ	Plans schedule to maintain health/Has changed breaks strategy QQ			Commited to take a lunch walk as a break Q
			Timing is inconvenient		Smart watch breaks reminders are inconveniently timed QQ				Regulates sitting with smart watch at home, but not at the office			
			Weather infuencing PA		Weather does not allow for more PA while WFH			Weather influence PA increase while WFH QQ				

Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 16	Participant 17	Possible quotes
		Rely on medication to treat pain Q						P4. I do tend to fidget a lot, and I do tend to adjust my seat quite a lot. And when it does get too bad, then as I said I kneel, and then you know and then I kneel for maybe about an hour and then I'll go back and sit in my seat. But then the pain starts again. It just sometimes it just
					Discomfort makes them want to move less QQ	Changing posture after sitting for a while is difficult due to pain		don't tend to move. /P5. And I'll tell you another thing, because of the discomfort that I have, sometimes I don't feel like moving. If that makes sense, but you know you're sitting, and you're feeling oh and then you say: No, I need to stand up and go somewhere, and you say no, I can't be bothered. So it kind of fits onto it, if if you know what I mean. The more
Feels physically able to take breaks			Feels physically able to take breaks	Feels physically able to take breaks	Feels physically able to take breaks, but sometimes stiffness discourages to stand up QQ	Feels physically able to take breaks	Feels physically able to take breaks	P15. But because of the pressure of the work and because you know you sit for two hours and then you say I'm going to take a break, but you're all stiff, so you don't want to move. So I would say that the discomfort, I would say it would be 50% of the time, well, maybe 40% of the time, that the discomfort stops me from taking that break. The other 60% will be, you know, laziness or finishing having to, to, pressure for finishing something. But yeah, 40% sometimes it's like: Oh I can't be bothered. Because I feel stiff, yeah.
Affects physical and general outlook		Being inactive is not good for your health	Sitting leads to health conditions including physical and mental	Bad for every body system QQQ	Chronic health issues	Bad for organs, lead to diabetes, circulation problems		P14. It's really bad for people really, really bad. I know it's bad for every system in the body, including digestion, blood flow, it's the human body is not meant for sitting/P9.Uhm I think I, it might be associated with uhm, suddenly negative effects. I don't think there are any positive effects that can come from prolonged sitting. I think uhm psychologically and maybe,
Take breaks every 30 mins	Posture/ ergonomics related advice	Posture/ ergonomics related advice	Posture related		Ergonomic related/ Taking breaks	Posture related	Advice on posture, sitting, breaks QQ	to, the next position is the better position/P3. What I've heard off is that we should take breaks every 45 to 50 minutes or something like that? And take a break of, you know, stretch and just move a little bit. But this is it. I may be confusing with other stuff/P17. Yeah, I mean,
MSK and other health problems	Promotes curved spine, bad posture, losing muscle strenght		Bodily MSK pain	Muscle wastage		MSK issues	Increase in back and buttocks pain	P13. Of course. You can have back problems, neck and shoulder problems. Uhm, uhm you can, you can have wrist problems because you know how we are handling keyboards and mouse and and everything. You can also have, I think you're all, your arms can be painful as well if you don't have the right posture. Uhm, basically the whole body can hurt../P17. I know
Sitting is not good for you	Sitting for a long time	Not good for your health	Need to be careful about your posture QQQ		Sitting more than one hour without a break	Bad for your posture, leading to MSK symptoms	It's really bad for you	P3. Prolonged sitting to me when I hear it. I imagine that is sitting for more than 45 minutes./P8. Well that it's a bad habit, and that I should be more disciplined and not do it./P7. Well I know it's a bad thing. Let's start with it's, you know. Uhm, but it's kind of necessary if you're concentrating on something, it's quite hard to do you know, if I'm
Have a walk, keep joints moving	Take a 5 min break every hour	Get up for a couple of minutes every hour	Take 1-2 min PA breaks every half an hour	Take a break every hour, the more movement the better	Not familiar with concept		Breaks can be active or stationary	and get a bit of physical exercise rather than just... or physical activity. And, it's really about changing the position I think. It's what comes to mind, not being in the same position constantly. But also just having physical activity must be good./P6. Uhm someone going
Aware that holds tension in shoulders when sitting, and changes behaviour QQ	Noticed that hunches and lumps when is busy with work	Noticed that hunches and lumps when is busy with work	Noticed that posture is not ideal when works with 2 screens					P10. I've always been bad for holding tension in my shoulders and the back of my neck. So sometimes when I'm sitting, I have to be very aware of that, especially during some Teams calls. To remember to keep my shoulders down.
		Pain is stronger while WFH as sits for longer periods			Noticed during holidys pain doesn't get much pain	Pain is stronger while WFH as sits for longer periods		
							Used to sit less pre-pandemic	P3. I really started realising how it improves my health because, because of the pandemic. Actually, before uhm, I moved every day and so we kind of don't realize that. But with the pandemic, because of these all the restrictions, I realised how much moving was important.
Tries to follow Cardinus training and have a cushion to reduce sitting and discomfort			Plans tea breaks to get more steps					whatever it might be. I need, I need to move, I need to change the position. But, maybe I shouldn't wait until my body is sore before I do that/P6. But, but recently I've realized that as a very stupid thing to do, because it's always going to be hectic. It's the my. My email is always going to be bad. So I instead I come up with that meeting, I go and get a tea have a
		Phone reminds to stand up but workload takes over QQQ				Smart watch prompts to move, but would disrupt meetings		P2. My watch keeps reminding me to do it. Uh, and I just and I just end up ignoring it because it never happens at the right time, I think/P12.Ah, workload takes over. So no, I don't think I do. I've just got too much to get through, to, to have that much. I mean, I have I have a phone that if it's working you know will beat me if I've sat too long, uhm, but as I said, if I've
								P5. The biggest thing is actually in the winter. I get really cold. So I need to be standing up. I need to be moving around because it's just cold.

OPPORTUNITY	Physical Opportunity	Environmental context and resources	Standing desk to maintain productivity	Standing desk to reduce sitting but maintain productivity						Standing desk to reduce sitting but maintain productivity Q	Standing desk to reduce sitting but maintain productivity	
			Space at home limits PA	Movement is restricted at home	Less opportunity for PA at home Q	Feels that move less at home						
			Breaks are more automatic at office					Breaks at the office are more practical QQ	Moves around more at the office to take calls			
			No resources to stand up at home	Sitting for prolonged periods because does not have a standing desk Q			Can't stand much because doesn't have standing desk at home QQ			Sitting for prolonged periods because does not have a standing desk QQ		
			Works allows PA									Can walk during some meetings QQ
			Furniture at home is not ergonomic									
			Online meetings/teaching reduce breaks									
			Online training helps to have better WFH settings							Health and safety provided by the uni helped to set up workstation correctly QQ		
			Microsoft Teams						Back to back meetings don't allow breaks Q			
	Social opportunity	Social influences	Partner/family influence		Wife tell to stand more but don't take notice	Wife motivates to get up Q			Daughter encourages to sit less and move more	Wife encourages having breaks	When partner is around encourages taking more breaks	Partner encourages to change hunched posture
			Line manager/boss influences				Line manager encourages to take breaks, but doesn't monitor breaks QQ				Employers provided advise on sitting and posture	No influence from bosses
			Dogs help increase PA at home					Take dogs for a walk while WFH	Puppy encourages to move more at home			
			No autonomy to schedule meetings						Not fully in control of schedule			
			Other people's availability influences sitting						Feels that needs to accept meetings because other people are available to meet Q			
			Institutional/Work culture									
			Prompts/reminders as reinforcement to reduce sitting		Intelligent reminders might make them take breaks QQ	Watch reminders to reduce sitting		Phone reminders would encourage to take more breaks	Computer prompts suggesting exercises	Use of a reminder to stand up would annoy if work is interrupted Q		
			Association of breaks with productivity			Associating breaks and productivity concepts would motivate them to take more breaks Q						
			Incentives/ Strategies to reduce sitting				Incentives to reduce sitting would be impractical due to workload QQQ					

	Has a standing desk at home and allows to stand more than at the office QQ							P7. (referring to sitting) But it's kind of necessary if you're concentrating on something, it's quite hard to do you know, if I'm updating documents or I'm writing documents, I really, it's harder for me to do it standing up, unless I've got a dedicated stand up desk./P11. But I do try to stand up every day. And that's something I cannot do when I'm in the office, it has to
								It's really a case of I kind of I can stand up. Our house is very small so I can stand up, walk up and down the stairs and come back to my desk. There's nowhere to go really. So, in terms of in a work environment, it's really… it's really about having… having things to do that would
It's easier move around from one place to another in the office	Tends to move more at the office than at home as spaces are further away						Breaks were natural thing at campus QQQ	P5. At the office, the breaks seem to be more, uhm, practical. So, I will have to get up and go somewhere to do something, or to meet somebody somewhere else. At home, I have to make myself take a break./P17. Yeah, and just just as a natural thing, that's what would happen. You know on campus, but I'm, I am, I am having breaks from sitting but they have
						Having a standing desk was helpful to reduce sitting at the office		P1. Yeah, I mean I'm sitting in front of the computer working. It's not like I can just, uh, since I don't have a standing desk, I just need to sit. If not, I'll just be awkward. /P4. Uh, well actually at work when I'm in the one day a week. We do have desks where we can stand up. So when I'm going on a Monday, I choose a desk that I can re-stock and stand, and that's a lot better. So I do about this, I do couple of hours standing and a couple of hours sitting. And and that,
								P9. I'm not always able to do this, but if I have if I have meetings where I'm not required to look at the screen and I'm not required to have my camera on, I will have the meeting in my headphones and I will walk around the house, and, and listen to the meeting and participate
Chair and desk don't have right height						Work arrangements are not flexible to allow standing QQ		P16. and because you haven't got a flexible arrangement where I had a hydraulic desk, it just what I'm going to stand up and goes up now. I would have to move this, and get a box 2 on top, get the chair out the way.
		Online teaching has to be seated QQQ	Online meetings are seated QQ			Online meetings are seated	Online teaching has to be seated	I wouldn't be sitting if I was, when I'm physically teaching I don't sit in lectures, or do workshops like yeah, yeah. But the rest of time, even online lecturing is all seated./P13. During you know, working from home there is no need to actually stand up and find you
								P7. I think I, the reason I changed my sitting at home was I did one of these uhm, the health and safety working at home, learning, online learning, and it reminded me, you know, to, it checked to make sure of it your sitting position was correct and mine wasn't, so it did force me to adjust it. …So I benefited from that 'cause it it reminded me that my setup wasn't correct and I've changed it now it's better.
								P6. But teams isn't particularly well set up for that because it defaults to half an hour an hour…You know, so people just use that that time and so. It's almost as if we don't have, a kind of bad habit of accepting teams meetings back to back, you know, rather than trying to
	Husband encourages to take more breaks from sitting, and be vigilant with posture			Partner and dog encourages to take walks at lunch time				P3. So she (referring to wife) sometimes when I'm sitting too much like for 3-4 hours she comes and say you really need to get up.
	Breaks encouragement is not in line manager's agenda QQQ	Line manager encourages to have walking meetings	No encouragement nor discouragement to take breaks	No influence from bosses or co-workers	Line manager encourages breaks		Support from line manager to take breaks, but not from University	P4. I mean he's always telling us remember to take breaks, remember to get up. You know, he's always constantly telling us to do that… but again, you know he's not here, so I just take a break 'cause I'm working from home, so he doesn't know how many breaks I take to be quite honest. And, I would imagine it's not something that gets monitored to be honest./P17.
				Dog encourages go for walks QQQ			Dog encourages go for walks	P14.Well, there's no getting away from it if you have a dog, you have to go 'cause he, he will just stand at the door and bark at you if he needs to go out. So you, you that you know. So encouragement is in the form of the dog and also my husband will say, come on, let's go, you
						Not fully in control of schedule QQQ	Not fully in control of schedule QQ	P16. When I put gaps in my calendar to think about things or just go for, wee wander around the flat or do whatever you know, uhm make a sandwich or whatever they fill it with something. So: Oh I've found a slot in your diary, we can talk about that, and you're like
	Helping other staff needs, doesn't help to set limits for workload QQQ					Feels that needs to accept meetings because other people are available to meet		P6.No, no. Because I can, I can manage my week in terms of the tasks that I need to do. The only thing I'm not really, well, I am in control to a large extent of when I accept meetings. But the importance of those meetings means that there's lots of people there who are very busy who have a very full schedule, and that I I don't want to change to suit me when it suits them./P11. I tend to work for everyone else so everybody has information they need to do
							Support from colleagues to take more breaks QQQ	P17. My colleagues have been really supportive, and I think everyone has been really understanding of the fact that you know, we're working differently while we're working at home. And I think you know, uhm, Teams is great because you can switch in and out on your
Reminder to take breaks every 20 minutes		Email prompts with breaks suggestions to reduce sitting	University prompts to monitor working settings and sitting time	Tip of the day prompts to reduce sitting QQQ		Fitbit could prompt to increase steo count		P2. …more kind of intelligent reminders let's say, 'cause I seem to spend most of my life on calls like this. And let's say that Microsoft 365 knows when I'm in meetings and it could give me reminders at convenient times to say. Looks like you've got half an hour free. Why don't you go for a walk? That would be app would actually be really useful. P7. P7.Well, I mean I
						<		P3. And then therefore, when I think about taking breaks, I would need to remind myself or to connect the breaks to being more productive than doing the things all at once.
					Forced to take a break by computer locking	Standing desk adaptation to sit less	Pain decrease as an incentive QQQ	honest with you, because another second point is I do like my job, and so I like do the work anyway. So you know how well an incentive would work to a degree, but then it would be how much then would you get fed up of the incentive? If you know what I mean it. And how would that impact my workload. That's the thing. And will incentives be practical in our

	Automatic motivation	Reinforcement	Socialisation								Socialisation would encourage more breaks while WFH QQ	
			Change nature of meetings					Scheduling meetings that include breaks or PA QQ				Have walking meetings instead of sitting
			Health or expert advise								Reduce sitting with exercises prescribed by a physiotherapist QQQ	
			Education/ Awareness to reduce sitting		Awareness of health consequences would discourage from taking breaks QQ					University tips to improvise standing desk at home		Increase awareness in staff of health consequences would reduce siting QQ
			Change in work culture									
			Approval from bosses/University									
			Personal motivations							Take breaks requires self motivation while WFH QQ		
		Emotion	Low mood due to pain	Pain and discomfort makes them grumpy		Irritated mood when pain is too much	Sitting for longer when has pain Q	Pain and discomfort makes them grumpy	Pain and discomfort makes them grumpy	Pain and discomfort makes them grumpy	Pain causes anger and affects concentration QQ	Irritated mood when pain is too much
			Sitting all day causes low mood		Low mood due to be sitting all day for work	Low mood due to be sitting all day for work			Feelings of dread when spent sitting all day QQ			Low mood due to be sitting all day for work
			Pain triggers movement					Tries to move more when pain and workload are heavy QQ		Pain is a trigger to move more QQQ	Pain prompts to move more	
			Guilt to leave desk								Feels guilt to tleave desk while WFH QQ	
			Feelings of enjoyment							Reduce sitting gives feelings of enjoyment QQ		
			Mood as influence for sitting									
			Sitting or taking breaks as a habit			Sitting as a habit QQ						
		Social/Professional role and identity	Sitting is a large percentage of role	Sitting is a large percentage of role	After COVID need to be seated for work most of the day	Need to be seated for work a high percentage of the day	Needs to be seated to do work QQ		Sitting is a large percentage of role		Sitting is 100% part or their role	Finds difficult to not sit for 80% of workday
			Job compatibility with breaks							Breaks don't interfere with work QQ		
			Sitting as an assumption for office workers									
			Job has different facets					Job has different facets that can help alternate sitting/standing				
OTIVATION			Workload influences breaks	Taking breaks would be too distracting from work			Breaks are impractical due to workload Q		Confident to take breaks, but rather prioritise work than making day longer	Confident to take breaks, except when has a dealine QQ	Workload influences sitting and breaks QQQ	

	Walking groups			Walking groups				P8. Or if you live with someone or, uhm, yeah, I think forms of, any form of socialization will be prompt you to take a break from home, like when you work at home.
								P5. perhaps and scheduling meetings so that they have breaks in the middle of them or that there aren't long. You know there is walking, and traveling and moving time in between meetings and teaching would be good
					Optional hourly exercise session QQQ			And if you know prescribed by a professional, I think that would be amazing. It could even be a university policy you know to have once a year a free consultation with a physio, to talk about this and then have a kind of stretching and exercising routine that you can do during
Being more mindful and not sit for prolonged periods		Advise on tips for sitting would be helpful to reduce sitting	impact of breaks on health and productivity would be	Spread information about health benefits of breaks as people don't know or care				P9. And I think also increased awareness, I don't, I don't think this area of research is very high on the average person's agenda. And so I don't, I don't think it's something that is particularly, uhm... Yeah I don't, I don't think is something that it's particularly well known about in certainly in the professional services population, so I think it would be interesting to
						Instigate work culture to make breaks possible QQ	Make breaks as part of meetings QQ	P16. Uhm, I would have to instigate a culture. So it would affect my work colleagues and uhm, wider teams that I work with. And so if we would all to respect the break thing, everyone would have to do it and the diaries would have to change. /P17. what what would be really good is, you know, I had an exam board meeting last week for example, and it was
		Line manager approving breaks would allow people to take more breaks QQQ			If exercise session would be provided by Uni wouldn't feel guilty to take an exercise break QQQ		Taking breaks as a department/ institutional policy Q	P12. I mean, my, my line manager is just a brilliant chap, it's not that he's an ogre or anything like that. Far from it, he's just absolutely fantastic, but it would you know if I got something like you know, a prompt everything and it came to me and he'll said it's OK to do, that's OK just to take that 5 minutes to that wee bit stretching...), I think that would allow people to have the permission to do it, and, uhm, you know, because they have played up a lot about
			Motivated other colleagues to do walking meetings during the pandemic					P5. But I think if you are self-motivated enough, there would be, there's is more flexibility at home to take more regular breaks, but you still need to be personally motivated to do that.
	Low mood because pain doesn't allow to deliver workload	Bothered by pain and discomfort			Pain causes to feel bitter		Low mood and pain makes them want to sit more QQ	sometimes I think why bother? Why bother moving. It just depends on how severe the pain is to be quite honest./P8. Uh, yeah, it's it's definitely have an influence. It's like the pain, you know it's. It makes you feel. It annoys me and I think it also makes me on the edge of being
				Sitting all day causes pain, and pain causes to sit all day QQQ				dread at Tuesday morning absolutely dread it. Because I know that I'm going to be stuck here for that amount of time, not able to move around or, or go for a drink or whatever./P14. (about pain influencing mood) Yeah it does. If I am, but it it's kind of a vicious circle really
	Take breaks when body pain is bothering			Hand pain prompts to take a break			Buttocks pain prompts to take a break	P5.I think my mood, if I'm feeling stressed under a heavy workload, I'm more tense and I get more pain, and so I'll probably notice to move more. /P7. And I think often if, if I'm in pain that is a trigger, which I will then go and stretch. So like, when talking to you, I got up because it was it's the end of the day and I've been sitting for a long time, and I needed to move. So if
					Feels guilt to tleave desk while WFH	Feels guilt to tleave desk while WFH QQ		P8. if during the lunch break I want to you know buy coffee or, or go buy a book to the next library or to the next book shop. I would. I would do that and when I'm at home, I don't. I don't do tha.t 'Cause I feel also like I think part of the explanation is that I would feel kind of
			Being active reflects into mental health QQ					P7. But generally, if I take exercise or active I feel better. You know, because I enjoy being active so you know. Generally if I can have been standing more rather than sitting, I'll feel a bit more alert, energized./P13. It's definitely then the more you sit, the more pain you have,
				Need to take breaks to work better	Good mood makes to move more QQ	Has to sit regardless mood		P15. the happier I am, or the less stressed I am, the more I move./P16. I'm really happy today, but I'm going to be sitting all day.
						Breaks are not part of routine QQ		P3. But in the past I was sitting down just because of this habit of I start one thing, it's a very long thing and I don't finish until I'm very, very I'm exhausted.
		Sitting is a large percentage of role	Sitting is 100% part or their role	Sitting is a large percentage of role	Needs to be seated to do work	Sitting is 100% part or their role	Sitting is 100% part or their role	P4. Yeah, it's not the kind of job where you can just walk around. Cause I need my computers to do my work, so yeah. So, unfortunately impossible to do any other to do it in any other way, to put it that way./P9.the way that my job is at the moment I would find it very hard to do any more than 20% of my job standing, standing up. So I, I have, I probably
Job is compatible with breaks, but would end working a longer day if takes too many breaks			Takes a break when needs to, regardless of workload	Needs to move around to continue with work QQ			Needs to take standing breaks to continue with work	If I go for a lunch time run, I just work we bit later. So it's not, it's not competing with my work/P14. I mean if if I'm, if I'm in pain, I'm not able to help anybody really. So that's, you know I have to have to get off and move around to be able to help somebody else.
	Sitting is part of work culture but not mandatory							P11. Well, it's not like it is in my job description. And I know I'm lucky for having an standing desk. But I, I guess like, it is it is given for granted or or this is it is assumed that it will be sitting down. No, no questions asked
			Job has different facets that can help alternate				Job has different facets that can help alternate	
	Sometimes feels that workload is more important than taking breaks	Workload influences sitting and breaks QQQ	Sometimes feels that workload is more important than taking breaks	Feels unable to take breaks due to workload	Job pressure does not allow breaks QQQ	Feels unable to take breaks due to workload QQQ		P4. And if you have meetings within the day as well, it's not practical, you can't, it's not practical to take breaks as well. 'cause we have two or three meetings directly, one after each other, so you can't take a break./P8. I mean if I have to finish a paper I can sit 10 hours straight, or almost you know if I'm stressed out I won't, I won't take breaks so I won't. I won't

M	Reflective motivation	Belief about capabilities	Confidence to take breaks from sitting					Feels confident to take breaks while working QQ		Tries to move at least once an hour		Confident to continue taking breaks while WFH
			Self-discipline									
		Optimism	Optimism for taking breaks	Hopes that pain goes away if takes breaks more often		Confident that will continue taking breaks WFH	Hopes that workload can reduce to take more breaks Q	Confident on having an effective system to break up sitting time	Confident that will continue taking breaks WFH	Confident that will continue taking breaks WFH	Hopes that pain goes away if takes breaks more often	Confident that will continue taking breaks WFH, but unsure to continue taking breaks at the office
			Pessimism for strategies to increase breaks		No incentives would help to reduce sitting		Software to increase breaks would not be useful due to workload					
			Pessimism for effects of taking breaks on pain and discomfort									Breaks will have no effect in shoulders pain
		Intentions/Goals	Goals		Sit less and take more breaks	Have a plan to take more breaks to avoid pain		Reduce sitting		Take a break every half an hour to build it up as habit	Monitor sitting and standing more often to create a conscious routine	Make breaks more productive QQ
			Intention to increase breaks	Will increase breaks if pain gets worse	Has no intention of increasing breaks from sitting Q	Intention to increase breaks to reduce sitting and increase concentration	Don't anticipate to get more breaks from sitting	Doing more active breaks like walking	Happy with the amount of breaks in schedule	Intends to increase breaks from sitting		Intends to make breaks lenghtier
		Beliefs about consequences	Possitive effects of breaks/sitting reduction in pain	Breaks might reduce pain in theory		Taking breaks reduces pain	Short breaks don't benefit pain, but longer breaks do		Breaks alleviate discomfort QQ	Sitting reduction will reflect positively on pain and discomfort		
			Mixed effects of breaks in pain			When pain is too much breaks don't help Q		When pain is too much breaks don't help				
			No effects of breaks in pain		Haven't noticed effects of breaks in pain							Breaks have no effects in shoulder pain
			Breaks are beneficial					Breaks are beneficial for mental health		Breaks are good for concentration	Breaks relieve tension and stress	
			Productivity/concentration/Focus	Breaks from sitting would distract from work/Lose focus from work	Breaks distracting from work Q	Breaks would break concentration	Breaks would decrease productivity			Prolonged sitting reduces attention and productivity		
			Sitting increases pain			Sitting for work increases pain and tension	Pain feels worse as the working week progresses		Sitting in the same position increases pinching pain	Sitting for prolonged periods increases nerve pain QQ	Sitting in the same position increases muscle tension	
			Standing desk improves pain				Having a standing desk decreases pain when using it in the office	The use of a standing break has reduce pain while WFH				
			Working/ergonomic settings increase pain					Writing in a laptop regardless position increases pain in shoulder QQ		WFH settings exacerbated pain and discomfort/Use of mouse increases pain in neck and shoulder QQ		

Breaks are quite natural	Confident to continue breaking up sitting with standing	Feels 50% confident to continue taking breaks	Confident to continue taking breaks while WFH	Confident to continue taking breaks while WFH	70% Confident to continue taking breaks while WFH	Confident to continue taking breaks while WFH	Confident to continue taking breaks while WFH, but not having autonomy of schedule	P5. here's a lot of what I do where I am in control of whether I move or not. So, if I'm if I need too...when I'm teaching, we can all take a 5 minute break. That's good for everybody, not just me. And then I can, you know, move position.
	Internalising breaks behaviour would make them take more breaks QQQ		Internalising breaks behaviour would make them take more breaks	Internalising breaks behaviour would make them take more breaks				P11. Well, that that system that I had with the alarm used to be good. But because the, the nature of my job now is different, it doesn't suit me, doesn't suit me anymore. And I don't know any other. Maybe maybe it's just like self-discipline of just saying is 1 hour that I'm answering emails and after these hour that's it, I'm going. Like nothing external is going to tell
		Feels can do 5-10 mins of exercise if gets encouragement from Uni						P4.(on increasing breaks) I'm hoping so, because, we are getting a new person in our team. So, that's will take some of the workload off. Uhm, so that would improve basically my chance to have more breaks. Uh, so I'm hoping that it's going to improve my workload. Well, obviously will improve my workloads and therefore I will be able to take more breaks, which would be good.
Would be difficult to modify workspace to try to stand more at home					Would like to take stretching breaks but don't think to be able to achieve it			
Don't think that breaks will reduce pain						Breaks won't have any effects on pain and discomfort		
	Stand up more for work	Reduce sitting, and sit pain free	Take more beraks and check working posture	Reduce sitting and take more breaks	Take breaks more often and move around and stretch	Not sit as much	Keep an active approach to work and take breaks	P9. I would maybe moving forward like to make the breaks that I do take a bit more productive. I think at the moment, but I probably do is 20 minutes of work and then a one minute break, whereas I could maybe make my brakes a little bit longer in a bit more useful rather than just kind of running to the kitchen for a drink and coming back.
Happy with current sit-stand arrangements	Happy with current sit-stand arrangements		Take more breaks and not just focusing on work		Has intention to take more breaks, but doesn't seem to be able to achieve it	Intends to increase standing by getting an standing desk	Intention to spend half day standing and half day sitting	P2. (about increasing breaks) Yeah no, no realistically, probably not...Just that I...I find it difficult to change my habits.
Short breaks don't benefit pain, but longer breaks do QQ		Thinks breaks have a positive effects on pain and discomfort	Stretching breaks and reducing sitting reduce discomfort	Sitting reduction reduces pain and discomfort	Using a standing desk adaptation has reduced stifness and pain		Breaks reduce pain and discomfort	P6. (About breaks) Uh, it definitely alleviates the situation. Any, any numbness that you have or, will go away and and if you've got any joint pain from sitting, you say you're getting a cramp or whatever, or you're starting to, to feel the effects of sitting for too long when you get up and move around, you almost feel that sensation of freeing that freeing off./P10. If I
	Prolonged standing as a break can cause pain and discomfort too					Breaks need to be consistent to make a difference in pain and discomfort	Prolonged standing as a break would cause pain and discomfort too	P3. (about breaks) I just realize that when the discomfort is too much, it doesn't help that much. It does improves a little bit, but it doesn't help that much.
Breaks don't have any effect in chronic pain QQ								P10. (about effects of breaks on pain and discomfort) Uhm it doesn't really change it because I think it's now quite deep seated and more chronic than anything else.
			Breaks are beneficial for productivity	Breaks are beneficial for pain and discomfort QQ	Breaks would be beneficial in pain and discomfort if taken			P14. So I suppose any, in my experience, any kind of movement, even if I just run up and down the stairs a couple of times it kinda releases tension, and therefore gets blood flow going and brings nutrients to the muscles and the other parts of the body that needs to be
					Concentration would be interrupted by taking breaks QQ			P2 So if I was going to do it, let's say I did it at the last five minutes of every hour, I'd find that quite disruptive, because I might have to leave a meeting early, or I might. It might interrupt my train of thought or something like that./P15. I can stop anytime that I want. But I don't do it because when I need the concentration to, I, I don't have the time to, to break.
Sitting for long periods makes pain worse	When was working sitting in the sofa pain was strong/After getting an ergonomic chair felt pain was less	Sit for longer periods for work increases pain	Sitting is worse during weekdays due to prolonged sitting	Feels that sitting is causing pain and discomfort	working for hours while sitting causes pain and discomfort QQ	Typing for hours increases discomfort Q	Knows that pain and discomfort are related to sitting QQ	P7. I tend to have if I sit for too long, I tend to get you know, nerve pain down my, down my legs and, but it's just tends to be worse at your buttocks because it's just you know, it's like a trapped nerve in your back, lower back which get deferred pain. /P15. Because of the type of work we do, it, it requires a lot of concentration. So you start something and just stay 3 hours locked on the screen doing it. So with the pain is like you know it's, it's kind of a stiffness from being on the same posture or very similar posture. You know you cross one leg, then you
	Having a standing desk improved pain and discomfort Q				Has less pain since start using standing platform		Has less pain since start using standing platform	P11. And Ihave fixed like that. This height is perfect for my wrist, like with here I have my, my wrist precisely at the same level of my elbows. So it's perfect, so I never have a problem. The problem comes when I'm sitting down.
Not having a task chair makes pain worse	Before buying standing desk, pain and discomfort were exacerbated by WFH settings		WFH settings and posture increase discomfort	Wrong WFH settings caused pain and discomfort		Using laptop instead of desktop increases discomfort		P5. . And, the pain in my shoulder, again, it started when I was doing lots of writing and I thought it was the writing and it probably is the writing. But I've tried everything as far as sitting in different positions, standing up, and yeah and nothing seems to make any difference./P7. And I mentioned my neck and my shoulders because I find that that's really just from using the mouse you, you tend to if it's a repetitive strain injury.

			Consequences of taking breaks in workload	Taking breaks would make them work for longer hours Q						Breaks are not feasible sometimes due to workload QQ	Taking breaks would be an obstacle to finish workload	
		Pain and discomfort	WFH ergonomic settings	Start getting pains when sitting at desk WFH	Sitting for too long at home exacerbates pain	Pain exacerbated during pandemic due to inadequate work settings Q				WFH settings exacerbated pain and discomfort QQQ		
			Sought medical help	Went to physioterapist but is difficult to follow up exercise routine		Went to chiropractor but pain is still there		Went to osteopath for pain in wrists, pain still there	Went to physioterapist but is difficult to follow up exercise routine	Physio advised to sit less		
			Used to pain and discomfort									
		Advantages WFH	Better office settings at home					Feels work settings at home are more comfortable	*Using face mask would be bad for asthma	Feels office building is unsafe		
			Commuting time			Commuting time can be used for other activities	Reducing commuting reduced sititng time	Reducing commuting reduced sititng time	Commuting would exacerbate other health conditions			
			Higher productivity WFH/Less distractions	WFH is more quiet than office			Productivity is higher at home, there's less disturbance than at the office				More privacy for videocalls	
			More space at home than at the office				Office is cramped with people					
			Flexibility			Opportunity for more PA around working hours QQ		Be able to take free time when necessary	Working schedule can be more flexible and suits to having other health conditions			More opportunities to multitask (standing and do house chores) during meetings
			Life work balance			Can spend time with wife			Work-life balance is better WFH			Work-life balance is better WFH QQQ
			More opportunity for PA at home			Can practice other PA activities when WFH				Can do yoga at home, but not at the office		
	Inductive themes											
			Office resources	Has better working furniture at the office		Furniture was a challenge when WFH started				Has a standing desk at the office	Has better working furniture at the office	Didn't have ergonomic furniture for most of the pandemic
			Breaks as a social opportunity in the office		Move around more at the office to talk to colleagues					Move around more at the office to talk to colleagues	Move around more at the office to talk to colleagues	Move around more at the office to talk to colleagues
			Movement reduction at home	Space is limited at home		Move less at home			Take less breaks at the office to be able to miss rush hour			

	Taking breaks is difficult because of the workload	Taking long breaks wold make them work an extra day	When workload is too much breaks are not feasible				Taking breaks is difficult because of the workload	P1. It's not exactly by taking the breaks itself, like if you are focused doing something. If you you just continue doing it, you will finish in one hour, while if you take a break then you need to come back and uh... let's say catch up with what you were doing. You waste a little bit of time. Then you will end up doing one hour and a half. Just because you take a break./P7. So I
	WFH settings exacerbated pain and discomfort			Changing WFH settings helped with pain and discomfort				P3. So we started getting, you know, pain for being here in a non you know prepared environment. Uh, and then I decided to, buy some things that would allow me to work better at home. /P7.Actually I was getting a bit of a sore neck when I was working at home, and I realized my monitors were on wrong height. And it took me about nine months to put them
		Went to physioterapist but is difficult to follow up exercise routine		Went to physio but although pain reduced, is there all the time			Osteopath advice helped with pain and discomfort	
	Has a standing desk that helps with pain and discomfort	Doesn't has own desk at office "hot desk"			Office settings were detrimental for health	Office settings were detrimental for health		
	Reducing commuting reduced sititng time	Commuting to meetings would increase working hours		Lives in the country and commuting would take lots of time		Reduce risk of COVID contagion in trains	Long comutting time, less spending in trains	
More privacy for videocalls	More productivity at home as office is too loud and has too many distractions	Less distractions at home/Feels more productive at home	More privacy for videocalls					
					Has more space to move at home than at the office/ Cramped office QQQ			P5. we work in an open plan, but the team has grown quite a lot. So we really are in top of each other, and then at some point I was really on the centre of the room looking at a wall and I, I had to say no. I cannot sit here. It was, you know, so yeah. Here I can move around
			Schedule flexibility, do house chores, exercising, dressing code QQ				Schedule flexibility, can walk dogs whenever	P3. Yes, so I think that working from home gives more flexibility in terms of all the activities you can do a round the work. In my case for example, I'm, you know, uh, practice some physical activities./P13. . But I think after a while you got used to the routine. I have more free time I can take my dog for a walk. I can go running before work. We don't need to put makeup on and fancy clothes if we are working from home like I am today in my. Uhm, and,
	Been at home is more convenient for meals, chores, and standing							P9.Well I think for some people, myself included, it is easier to manage uhm, my my home life while working from home, than it is when you're in the office full time.
				Can do yoga at home, but not at the office				
			Has better working furniture at the office			Has a standing desk at the office	Didn't have ergonomic furniture for most of the pandemic	
		Meeting students and other colleagues helped to move more at the office						
	Had the opportunity to take a meditation break at the office but not at home				Movement is natural at the office			

Disadvantages WFH	Opportunity for walking at the office	There's more opportunity for walking at the office		Walking was automatic at the office	Walking was automatic at the office	Walking was automatic at the office		Walking was automatic at the office	Walking was automatic at the office	Walking was automatic at the office
	Sitting for longer WFH		Sitting longer hours at home	All activities WFH are taken while sitting			Work for longer hours		Work for longer hours as WFH is less structured than the office environment	
	Social interactions		Social interactions allowed to stand and move more at the office	Isolation from colleagues			Isolation from colleagues	Social interactions allowed to stand and move more at the office	Social interactions allowed to stand and move more at the office	Social interactions allowed to stand and move more at the office
COVID	Work changed due to COVID									
	Office restrictions						Office restrictions made them WFH	Changing facilities closed made inconvenient to run to work	Office restrictions made them WFH	Office restrictions made them WFH
Motivated by interview to change sitting behaviour						Feels talking about sitting and breaks will encourage them to reduce sitting		Feels talking about sitting and breaks will encourage them to reduce sitting		Feels talking about sitting and breaks will encourage them to reduce sitting

Possible quote by level of usage
Q: Illustrative quote
QQ: Illustrative quote, usable for report.
QQQ: High illustrative quote for report.

		Walking was automatic at the office	Walking was automatic at the office				There's more opportunity for walking at the office	
Used to work for long hours at the beginning of the pandemic	Feels that sits for longer at home, but is happy to have everything near at home		Work for longer hours				Can sit for meetings all day	
			Isolation from colleagues		Social interactions allowed to stand and move more at the office	Social interactions allowed to stand and move more at the office/isolation from colleagues	Isolation from colleagues	
						Job changed due to COVID QQ	Job changed due to COVID QQ	[illegible] chronic than anything else/P17.Although you know if I was on campus, I'd be going, you know, doing things, walking between meetings rather than sitting down all the time.
Office restrictions made them WFH	Wearing a face mask at commuting and office is uncomfortable			Office restrictions made them WFH	Office restrictions made them WFH	Is pointles going to the office with COVID restrictions QQ		[illegible] everybody or we figure out how to do hybrid and, have a behaviour that we get used to. Uhm, but preferably for people not to be wearing masks whilst they're there, and that's the issue.
Feels talking about sitting and breaks will encourage them to reduce sitting						Feels talking about sitting and breaks will encourage them to reduce sitting		[illegible] us as members of staff questions about how often we take breaks and how how we vary our position. You know our seating, sitting, standing position, the better able it gives it more visibility, but it also gives a kind of endorsement that it's OK to take breaks. Or you know, and to move around. So I think somewhere one of the questions is what would help me more. And I suppose it's it's maybe not me, but generally. That that recognition, and that that reminder from from my bosses with or within the school. You know, don't forget to take breaks. Don't sit down too often those or you know. I think they should be in school./ P7.