THE UNIVERSITY OF QUEENSLAND

AUSTRALIA

Reducing Office Workers' Sedentary Time

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A thesis submitted for the degree of Doctor of Philosophy at

The University of Queensland in 2015

School of Public Health

Abstract

Background: Due to technological advances, adults living in industrialised countries now spend the majority of their waking hours sedentary (i.e. sitting down and expending little energy). Given that high volumes of sedentary time are linked to increased risk of poor health and premature mortality, interventions to reduce sedentary time have been identified as a key public health priority. To increase the effectiveness of such interventions, settings-based approaches have been suggested. Desk-based office workers comprise a large occupational sector and spend an average of 75% of the workday sitting. The office-based workplace has thus been identified as a particularly opportune target setting to address this behaviour.

A recent evidence review of workplace strategies to reduce office workers' sedentary time concluded that provision of activity-permissive workstations may be needed to achieve meaningful reductions in sedentary time. Activity-permissive workstations allow office workers to stand, walk, or pedal while undertaking their usual computer and desk-based job tasks. Studies have reported sedentary time reductions of over two hours per working day following installation of such workstations. However to date, this evidence, including what is known about the feasibility and impact on health- and work-related outcomes, has not been systematically summarised. Furthermore, ecologic models and workplace health promotion frameworks suggest that the provision of such workstations should be integrated with additional strategies targeting personal health resources and the psychosocial work environment. However, published reports of such interventions are few. Hence, there is limited evidence supporting their feasibility and efficacy.

Aim: The overall aim of this thesis research is to contribute to the evidence informing interventions using activity-permissive workstations to reduce workplace sedentary time in office workers. This was accomplished through three studies.

Methods and Results:

1) Study 1 comprised a systematic literature review and meta-analysis examining the impact of activity-permissive workstations on office workers' sedentary time, health- and work-related outcomes. This review also summarised the evidence on the feasibility of such workstations in office workplaces. Results showed that the use of activity-permissive workstations was well accepted among office workers and led to an average reduction in sedentary time of 77 minutes across included studies. Health- and work-related outcomes

remained predominantly unchanged following intervention. However, there was considerable heterogeneity among the studies in the way that the workstations were implemented.

2) Study 2 consisted of the systematic and iterative development of a multi-component intervention to reduce office workers' sedentary time. This intervention included activity-permissive workstations as well as strategies targeting personal health resources and the psychosocial work environment consistent with workplace health promotion frameworks.

3) The effectiveness of the above-mentioned multi-component intervention was evaluated in a 3-arm trial within Study 3 of this PhD research. Here, the effectiveness of the multi-component intervention developed in Study 2 was compared to an intervention comprising activity-permissive workstations only and a (usual workplace-practice) control group. Following intervention, participants receiving the multi-component intervention reduced their workplace sedentary time by an average of 89 minutes per 8-hour workday (95% CI= -130, -47 minutes; $p<0.001$) relative to the control group, while the group receiving the workstations only reduced their sedentary time by 33 minutes per 8-hour workday (95% CI= -74, 7 minutes, $p=0.285$). Following the end of the additional intervention components (i.e. strategies targeting personal health resources and the psychosocial work environment) at 3 months, sedentary time increased by 23 minutes per 8-hour workday in the multi-component intervention group, while reductions in the workstations-only group were largely sustained. However, there was still a substantial difference regarding sedentary time reductions between these two groups 12 months post baseline.

Conclusions: Results from these PhD studies suggest that activity-permissive workstations, if the chosen model is suitable to individual needs and job tasks, can be an effective means to reduce sedentary time in office-workplaces. However, a change in workplace culture around adopting more active routines is needed to achieve more substantial reduction in sedentary time. This can be facilitated through strategies targeting the psychosocial work environment and/or personal health resources as suggested by workplace health promotion frameworks. Ongoing provision of such strategies may be needed to sustain sedentary time reductions in the long-term.

More research is needed to examine the sustainability of sedentary time reductions as well as the potential impact of longer-term reductions on health-related outcomes and work

performance indicators. Furthermore, future studies should examine the effectiveness of the multiple intervention components in isolation. In order to facilitate the adoption of less sedentary routines in workplaces, integrating a focus on reducing sedentary time into occupational health and safety policies is likely to be needed.

Declaration by Author

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. I have clearly stated the contribution by others to jointly-authored works that I have included in my thesis.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original research work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma in any university or other tertiary institution. I have clearly stated which parts of my thesis, if any, have been submitted to qualify for another award.

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Publications during candidature

Peer-reviewed papers

Neuhaus, M., Healy, G.N., Dunstan, D.W., Owen, N., Eakin, E.G. (2014). *Workplace Sitting and Height-Adjustable Workstations: A Randomized Controlled Trial.* American Journal of Preventive Medicine 46(1):30–40.

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interventions. Oral presentation at the UQ/QUT Research Higher Degree Conference. Brisbane, November 2013.

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Publications included in this thesis

Neuhaus, M., Eakin, E.G., Straker, L., Owen, N., Dunstan, D.W., Reid, N., Healy, G.N. (2014). *Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations.* Obesity Reviews DOI 10.1111/obr.12201; Impact factor = 7.86 (5-yr IF= 7.02); incorporated as Chapter 2.2.

Contributor	**Statement of contribution**
Neuhaus, M. (Candidate)	Conceptualised literature search (60%) Conducted search (90%) Analysed data (70%) Wrote paper (60%)
Eakin, E.G.	Conceptualised literature search (10%) Analysed data (15%) Edited paper (10%)
Straker, L.	Conceptualised literature search (10%) Conducted search (5%) Edited paper (5%)
Owen, N.	Edited paper (5%)
Dunstan, D.W.	Edited paper (5%)
Reid, N.	Conducted search (5%)
Healy, G.N.	Conceptualised literature search (20%) Analysed data (15%)

	Edited paper (15%)

Neuhaus, M., Healy, G.N., Fjeldsoe, B.S., Lawler, S., Owen, N., Dunstan, D.W., LaMontagne, A.D., Eakin, E.G. (2014). *Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting.* International Journal of Behavioral Nutrition and Physical Activity 11:21; Impact factor = 3.68 (5-yr IF= 4.47); incorporated as Chapter 3.3.

Contributor	**Statement of contribution**
Neuhaus, M. (Candidate)	Developed individual-level intervention elements (45%) Developed organisational-level intervention elements (20%) Designed intervention material (70%) Managed and implemented workstation pilot study (80%) Conceptualised and conducted qualitative interviews (80%) Wrote the paper (50%)
Healy, G.N.	Developed individual-level intervention elements (20%) Developed organisational-level intervention elements (20%) Designed intervention material (10%) Contributed to workstation pilot (10%) Conceptualised qualitative interviews (10%) Edited paper (15%)
Fjeldsoe, B.S.	Developed individual-level intervention elements (10%) Designed intervention material (5%) Edited paper (5%)
Lawler, S.	Developed individual-level intervention elements (5%) Edited paper (5%)
Owen, N.	Developed organisational-level intervention elements (30%) Edited paper (5%)
Dunstan, D.W.	Developed organisational-level intervention elements (30%) Edited paper (5%)
LaMontagne, A.D.	Developed organisational-level intervention elements (10%)
Eakin, E.G.	Developed individual-level intervention elements (20%) Developed organisational-level intervention elements (30%)

	Designed intervention material (10%) Contributed to workstation pilot (10%) Conceptualised qualitative interviews (10%) Edited paper (20%)

Neuhaus, M., Healy, G.N., Dunstan, D.W., Owen, N., Eakin, E.G. (2014). *Workplace Sitting and Height-Adjustable Workstations: A Randomized Controlled Trial.* American Journal of Preventive Medicine 46(1):30–40; Impact factor = 4.28 (5-yr IF= 5.09); incorporated as Chapter 4.2.

Contributor	**Statement of contribution**
Neuhaus, M. (Candidate)	Developed intervention material (90%) Managed and conducted field study (65%) Wrote paper (60%)
Healy, G.N.	Developed intervention material (5%) Contributed to field study (15%) Edited paper (10%)
Dunstan, D.W.	Contributed to field study (5%) Edited paper (5%)
Owen, N.	Contributed to field study (5%) Edited paper (5%)
Eakin, E.G.	Developed intervention material (5%) Contributed to field study (20%) Edited paper (20%)

This field study was led, managed and conducted by the candidate. Furthermore, the candidate was responsible for the research concept and study design, development of study materials, study implementation and data collection, data analysis and interpretation, preparation and revision of the manuscript. Co-authors have contributed to the study design, development of study materials, data interpretation, and all aspects of the preparation and revision of the manuscript.

Contribution by others to the thesis

Prof Elizabeth Eakin, Dr Genevieve N Healy, Prof David Dunstan and Prof Neville Owen assisted in the development of the research objectives, interpretation of the results and the revision of the content of the thesis.

Statement of parts of the thesis submitted to qualify for the award of another degree

None.

Acknowledgements

I would like to thank the many people who have made this PhD research possible and supported me throughout the time it took to complete these studies.

First and foremost, I am deeply grateful for the constant support and commitment from my advisory team: Prof. Elizabeth Eakin, Dr. Genevieve Healy, Prof. Neville Owen and A/Prof. David Dunstan. Liz, thank you for having been such a dedicated mentor for me and for your constant support. Gen, thank you for inspiring me to 'push harder' and for constant availability - no matter how busy you were. Neville, I would have never come this far without the many opportunities you provided to me throughout my time at the CPRC – thank you for your generosity and for teaching me to see 'the bigger picture'. David, I thank you for your constant encouragement, expertise and instant feedback.

I am very grateful to be working among such an inspiring and supportive group of people at the CPRC. Special thanks to my fellow PhD students, in particular my dear friends Kasia Bolsewicz, Lauren Spark and Megan Wheelan for your endless support, inspiration and hysterical laughs. Bri Fjeldsoe, Paul Gardiner and Ana Goode, thank you for mentoring and supporting me throughout this journey. Lis Winkler, thank you for years of statistical advice. Cathy Swart, Mary Roset and Deirdre McLaughlin - thank you for making anything bureaucratic happen so seamlessly in the background.

I would like to express my gratitude to the participants of the *Stand Up UQ* Study, in particular their very cooperative managers Jenny Sutton, Vicki McNabb and Janelle Zhamel.

This PhD would not have been possible without my generous funding sources – the Australian Postgraduate Award; the Top-up Scholarship and PhD funds from UQ's School of Public Health; the CPRC and Baker IDI Heart and Diabetes Institute for providing the resources to conduct the *Stand Up UQ* Study; and, Dr Genevieve Healy for an unforgettable tandem ride through San Diego ;)

Finally, my gratitude goes to my friends and family who offer continual encouragement, support, and love. Anna, thank you for endless therapeutic chats throughout this journey. Dozer, Seth and Taylor - you are the most beautiful, loving and supportive family one could ask for.

Keywords

sedentary behaviour, sitting time, physical activity, postural transitions, workplace intervention, office workers, activity-permissive workstations, height-adjustable desks, sit-stand

Australian and New Zealand Standard Research Classification (ANZSRC)

ANZSRC code: 111712; Health Promotion 50%

ANZSRC code: 170106; Health, Clinical and Counselling Psychology 40%

ANZSRC code: 111706; Epidemiology 10%

Fields of Research (FoR) Classification

FoR code: 1117; Public Health and Health Services 70%

FoR code: 1106; Human Movement and Sports Science 30%

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List of Abbreviations

BMI	Body mass index
CPRC	Cancer Prevention Research Centre
CI	Confidence interval
CM	Centimetre
GLU	Blood Glucose
HDL	High-density lipoprotein cholesterol
KG	Kilogram
LDL	Low-density lipoprotein cholesterol
LPL	Lipoproteinlipase
MET	Metabolic equivalent
MIN	Minute(s)
MVPA	Moderate- to vigorous-intensity physical activity
OHS	Occupational Health and Safety
OR	Odds Ratio
SCT	Social Cognitive Theory
TC	Total cholesterol
TRG	Triglyceride
UQ	The University of Queensland
WHO	World Health Organization

Overview, context, and significance of the thesis

Excessive time spent in sedentary behaviour - sitting or lying down while expending little energy – is now identified as a common and serious health risk. Over the past few decades, technological advances and associated labour-saving devices have led to rapid increases in sedentary time and associated declines in incidental physical activity. It is currently estimated that adults spend more than half of their waking hours in sedentary behaviours. Interventions to reduce sedentary time have therefore been identified as a key public health priority.

Sedentary behaviour occurs across multiple domains, including during leisure, within the home environment and in the workplace. The office-based workplace has been recognised as a particular high-risk setting, with desk-based office workers spending approximately 75% of their work hours sitting. Notably, a large proportion of this time is spent in prolonged, unbroken bouts of 30 minutes or more: an accumulation pattern that may place them at higher risk for poor health. In industrialised countries such as Australia, most adults spend a third of their waking hours in the workplace. Here, they share a common physical (e.g. the office building design) and psychosocial (e.g. organisational norms and routines, management support etc.) environment with established communication channels. Office-based workplaces thus offer the opportunity to reach a large number of people via multiple pathways and are therefore an opportune setting for sedentary behaviour intervention.

One potential strategy to reduce sedentary time in desk-bound office workers is the use of activity-permissive workstations. *Activity-permissive workstations* allow office workers to stand, walk, or pedal while working at their usual computer and desk-based job tasks. Examples of activity-permissive workstations include treadmill desks, stepping or pedal devices that are fitted underneath the desk, and sit-stand workstations. *Sit-stand workstations* include desks or desk mounts that are adjustable to full standing height. They enable office workers to conduct their desk-based tasks while alternating between sitting and standing and thus to change their posture frequently, as is recommended within occupational health and safety standards. Traditionally acquired for the prevention of musculoskeletal problems, their potential to reduce sitting time for broader preventive-health benefits is increasingly being recognised. However, to date, the evidence regarding the efficacy and feasibility of such workstations is limited. Furthermore, the workplace health promotion literature suggests that multi-dimensional interventions are key to

successful and sustained improvements of worker health. Such interventions include strategies targeting personal health resources and the psychosocial work environment in addition to modification of the physical office environment. However, with respect to reducing workplace sedentary time, there is little empirical evidence to guide the development of such interventions, and limited evidence to support their feasibility and efficacy. The focus of this thesis is thus to contribute to this evidence by systematically summarising the evidence pertaining to the effectiveness of activity-permissive workstations to reduce workplace sedentary time and by developing and evaluating a multi-component intervention in line with workplace health promotion frameworks and models. Results from this thesis research will help to inform policy, practice and future research on sedentary behaviour interventions within the workplace, with particular relevance to workplace policies and occupational health and safety guidelines.

There are five chapters in this thesis, with Chapters 2, 3 and 4 including peer-reviewed published journal articles.

Chapter 1 provides an overview of the background and research aims of this thesis. This includes a definition of sedentary behaviour and terminology used throughout the thesis, as well as a review of methods to measure workplace sedentary time and patterns and of the epidemiological literature pertaining to its associations with chronic disease. This is followed by a description of the distribution and determinants of sedentary time, pointing to the office-based workplace as being a key setting for sedentary behaviour interventions. Subsequently, the current evidence base regarding modifiable influences on workplace sedentary time is presented. This includes an introduction to the Healthy Workplace Model - the World Health Organization's model guiding workplace health promotion, which was used as a guiding framework for this thesis. Finally, workplace interventions to reduce sedentary time are reviewed and gaps in this literature identified. This chapter closes with a detailed description of the research aim and specific objectives of this thesis research.

Chapter 2 includes a systematic literature review of the feasibility of activity-permissive workstations in office-based workplaces and their impact on office workers' sedentary time, health-, and work-related outcomes. This review was published in *Obesity Reviews*.

Chapter 3 comprises a description of the systematic and iterative development of the *Stand Up Australia* intervention: a multi-component intervention, including activity-permissive workstations as well as strategies targeting personal health resources and the

psychosocial work environment to reducing sedentary time in office workers. This paper was published in the *International Journal of Behavioral Nutrition and Physical Activity*.

Chapter 4 describes the methods and outcomes of *Stand Up UQ*: a 3-arm controlled field study that compared the effectiveness of the *Stand Up Australia* intervention to reduce office workers' sedentary time to the installation of activity-permissive workstations only, over 12 months. This study also examined the impact of sedentary time reductions on health- and work-related outcomes. The main outcomes 3 months after baseline (end-of-intervention) of this study were published in the *American Journal of Preventive Medicine*. Additional methods and results at 12 months as well as the feasibility of the *Stand Up UQ* intervention are also provided.

Chapter 5 briefly summarises the research findings of these PhD studies and provides an integrated discussion of their implications, limitations and recommendations for future research, policy and practice.

CHAPTER 1. Background and aim of the thesis

Sedentary behaviour is prominent throughout the daily lives of many people. Due to an increase in screen-based recreation, greater reliance on cars, and labour-saving technology, the lifestyle in industrialised countries has become increasingly sedentary over the last century (1). Studies using objective measures have shown that adults living in industrialised countries spend the majority of their waking hours in sedentary behaviours (2-6). This high proportion of sedentary time throughout the day, coupled with the emerging evidence regarding the health impacts of this behaviour (described in Section 1.3), has led to the inclusion of sedentary behaviour-specific recommendations in the Australian physical activity guidelines in 2014 (7). These guidelines now suggest to reduce *sitting time*, with an emphasis on breaking up long periods of sitting as often as possible (7). Similar recommendations have been stated in the USA (8), UK (9) and Canada (10), and interventions are now starting to specifically target the reduction of prolonged sedentary time. This reflects an important paradigm shift in the physical activity field, where the emphasis has moved from a focus on participation in leisure time moderate- to vigorous-intensity physical activity (which constitutes a small (~5%) fraction of waking hours) to consideration of activity behaviours across the entire day and intensity spectrum, including those classified as sedentary.

As demonstrated by the evidence reviewed in this chapter, the workplace is a key setting for interventions aiming to reduce sedentary time. Desk-based office workers constitute a large occupational sector and spend approximately 3/4 of their working hours sitting on average (11). This puts them at high risk for developing a number of chronic conditions as well as premature mortality (12-14). Addressing sedentary time in the office workplace thus forms the primary focus of the PhD research summarised in this thesis.

1.1 Definition of sedentary behaviour

Sedentary behaviour is defined as any waking activity characterized by an energy expenditure ≤ 1.5 metabolic equivalents (METs; an estimate of the energy expended during physical activity) and a sitting or reclining posture (15). The term “sedentary” (from Latin ‘sedere’ = ‘sitting’) has been used inconsistently within the scientific literature. Previously, this term was used to describe individuals who did not meet the current physical activity guidelines or expended energy of a certain minimum threshold (16).

However, individuals can be physically active (i.e. meeting these guidelines) and yet be highly sedentary (the *Active Couch Potato* phenomenon (17)). For example, a desk-based office worker who spends the majority of the day sitting at the desk and then exercises at the gym after work before spending the evening on the couch while watching TV. Conversely, some individuals are physically inactive (i.e. they do not meet the current guidelines for moderate to vigorous physical activity), but have low sedentary time (18). Here, an example is a nurse who is on the feet for most of the working day without doing any structured physical activity and remains active around the house during the evening. As Section 1.3 will show, these distinct behaviour classifications potentially have unique implications for health (19). Consistent use of the terminology in this field is thus critical. In this thesis, the term sedentary behaviour will be used in line with the above definition. Additional terms used include:

- *sedentary time,* which refers to time spent in sedentary behaviours; and,
- *workplace sedentary time,* which refers to sitting time occurring in the workplace.

Sedentary behaviours can occur across multiple domains. The three main domains in which adults typically accumulate sedentary time are: domestic environments (e.g. while watching TV), during travel (e.g. driving in the car), and in workplaces (e.g. desk-based office work) (20, 21). Figure 1.1 depicts a sedentary behaviour taxonomy. This taxonomy, which is adapted from a more comprehensive ecologic model of sedentary behaviour (22), shows examples of the multiple sedentary behaviour domains and some of the specific sedentary behaviours associated with them.

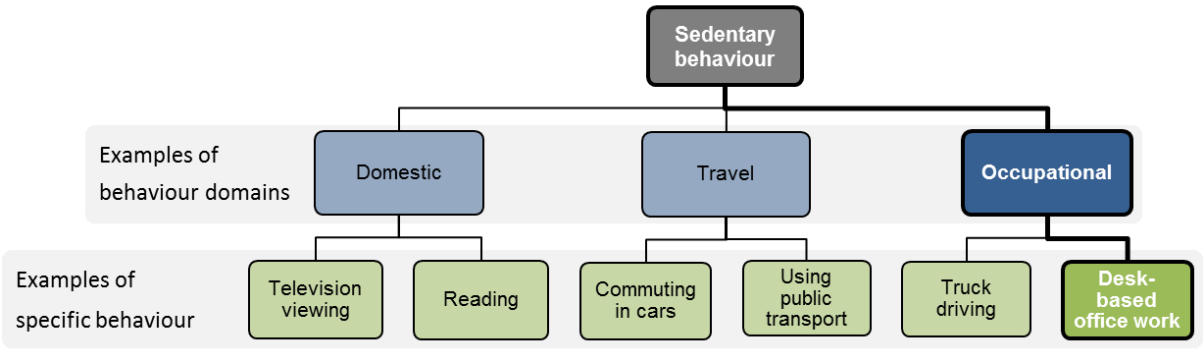

Figure 1.1 Simplified taxonomy of sedentary behaviours

To date, the majority of sedentary behaviour research has examined either sedentary time accrued in the domestic domain (often self-reported TV viewing time or other screen time),

or overall sedentary time (i.e. sedentary time accrued across all domains) (23). While a summary of this research evidence will be provided, the main focus for this chapter and the thesis overall is on workplace sedentary time. The next section describes the methods used to measure sedentary time.

1.2 Measuring sedentary time

Similar to the measurement methods used in physical activity research, methods to determine sedentary time can broadly be categorised into self-report and objective methods.

Self-report measurement methods of sedentary behaviour include self- or interviewer-administered questionnaires assessing sedentary time as a total across the whole day (such as by the PAST questionnaire (24)), domain-specific (such as the workplace; e.g. Occupational Sitting and Physical Activity Questionnaire (OSPAQ) (25)) and/ or across specific activities (e.g. while watching TV such as assessed by the Marshall Sitting Questionnaire (26)). They are relatively inexpensive and easy to administer on a wide scale, with a comparatively low burden for participants. Importantly, they provide an opportunity to measure the context of time spent in sedentary behaviour – a feature that is particularly important when measuring workplace sedentary time. Here, domain-specific questionnaires such as the OSPAQ (25) or the Workforce Sitting Questionnaire (WSQ) (27) have been developed. However, a typical disadvantage of self-report measures in general is that they are subject to random and systematic reporting error (28). Another disadvantage is that they measure the total volume of sedentary behaviour only, without taking into account the number, frequency and duration of long periods of uninterrupted sedentary time. While some self-report measures include questions on the number of breaks from sedentary time, they fail to accurately reflect time-specific patterns thereof, which is important when considering the health impacts of sedentary time as shown in Section 1.3. This disadvantage can be overcome by using objective measurement means.

Objective measurement methods of sedentary behaviour include direct observation and the use of monitoring devices. The former is likely to be the most accurate measure but it is also resource-intense and intrusive. Device-based measurement of sedentary behaviour is being increasingly used in epidemiological research studies. Two commonly used devices to measure sedentary time, both worn on the body, are accelerometers such as the ActiGraph (LLC, Fort Walton Beach, FL) and the activPAL inclinometer/accelerometer

(PAL Technologies Limited, Glasgow, UK). Most epidemiological studies that included objective measures of sedentary time have used hip-worn ActiGraph devices. ActiGraph monitors predominantly measure ambulatory movement. They distinguish different intensity levels of physical activity and derive sedentary time from low movement counts (which are associated with low energy expenditure). However, they do not accurately capture posture (e.g. standing upright or sitting/ lying down) (29) and are therefore not optimal for sedentary behaviour measurement. This is particularly important to note in the context of workplace intervention studies, where the replacement of sitting with standing (e.g. in meetings) is likely to be a suggested strategy to reduce workplace sedentary time. ActivPAL activity monitors, in contrast, are worn on the thigh and contain acceleration as well as inclination logging technology. This enables the detection of whether an individual is upright (i.e. the thigh is in a vertical position) and standing or stepping, or sitting/ lying down (i.e. the thigh is in a horizontal position). The activPAL device has been shown to be both valid and responsive to sedentary time change (30). Both ActiGraph and activPAL devices record data specific to date and time. However, they are relatively expensive and require specific data processing software as well as specific knowledge for data analysis.

To accurately capture sedentary behaviour in the workplace, it is important to measure both the time spent in the workplace as well as the volume and pattern of sedentary time. Time at the workplace can be measured through diaries, work timesheets or assumed times (e.g. 9am to 5pm). As described above, the volume and pattern of sedentary time is ideally captured through an objective, posturally-based measure, such as the activPAL activity monitor. Details on the measurement methods used to capture workplace sedentary time in these PhD studies are described in Sections 3.3 and 4.2 of this thesis.

1.3 Health impacts of high sedentary time

Historically, the first time sedentary behaviour was identified as a contributor to detrimental health was in the 18th century. The Italian physician Bernardino Ramazzini wrote in his observations ‘‘De Morbis Artificum Diatriba’’ (Diseases of Workers) that *“those who sit at their work suffer from general ill-health and an excessive accumulation of unwholesome humors caused by their sedentary life”* (Ramazzini, 1713, 1964 translation, pages 281-285) (31). Approximately 250 years later, Morris et al. compared the health outcomes of workers employed in sedentary occupations with those employed in more physically demanding jobs in the UK. Morris reported that London bus drivers, who sat for the greater

part of their shift, had a significantly higher risk of coronary heart disease than the bus conductors, who typically climbed 750 steps to and from the top deck every working day (2.7/1000 per year versus 1.9/1000 per year respectively) (32). Similar results were observed in another study that compared the incidence of coronary heart disease of postal workers, who cycled or walked to deliver the mail, with civil servants occupied in sedentary tasks (32). However, in the decades since these studies, the focus of human movement and public health research on inactivity and health outcomes has revolved around the health benefits of participating in moderate- to vigorous-intensity physical activity (33).

In the 1980s, bed rest studies and space medicine research began to examine the deleterious impact of extreme sedentariness, weightlessness and lack of physical variation on a number of physiological parameters such as muscular impairments, bone density and joint health (34). Simultaneously, occupational ergonomic research studied the musculoskeletal consequences of sedentary work, consistently reporting incidences of symptoms such as lower back and neck pain (35-38).

In 2000, Owen and colleagues published a seminal review highlighting the need to consider sedentary behaviour in addition to physical activity behaviour as an independent health risk behaviour within public health research (39). Since then, there has been a rapid escalation in the number of studies examining the relationship of sedentary behaviour and health. To date, the majority of these studies have used self-report measures of sedentary time and focussed on the general population, with workplace-specific studies having emerged in more recent years.

1.3.1 Evidence from the general population on the health impacts of sedentary time

Observational studies from the broader public health research disciplines have demonstrated detrimental associations of high self-reported sedentary time (relative to lower amounts of sedentary time) with premature mortality (40-44). This has been observed across several self-reported sedentary behaviours including television viewing time (RR per 2 hours/day= 1.15) (43), time spent in cars (HR= 1.5 for more than ten hours/week compared to reporting less than four hours/week) (45), being sedentary during leisure (HR= 1.15 for 8 to <11 hours/day and HR=1.40 for ≥11 hours/day compared with <4 hours/day) (42) and working in sedentary occupations (44, 46). According to results from a recent meta-analysis, the risk of all-cause mortality increases by 5% for each 1-

hour increment in daily self-reported sitting time per day for adults who sit ≥7 hours/day (12). Detrimental associations of high self-reported sedentary time with physical health have been further established in relation to overweight and obesity (47-50); type 2 diabetes (48, 51, 52); biomarkers of cardio-metabolic disease (53, 54); the metabolic syndrome (55, 56); colon, endometrial and lung cancer (57); and, to mental disorders such as dysthymia and depression (58, 59). In many of these studies the observed risks have been shown to remain in those meeting the moderate- to vigorous-intensity physical activity guidelines (although in some of these the relationship has been partially attenuated).

As noted above, the vast majority of these studies have relied on self-report measures of sedentary time. The increasing use of objective tools has significantly advanced this research field. Through the use of devices it has been shown that not only the total volume of sedentary time is linked to health outcomes, but also the *pattern* in which sedentary time is accrued over the course of the day. Specifically, prolonged, unbroken sedentary time has been associated with musculoskeletal symptoms (60) and biomarkers of cardio-metabolic health such as body mass index, waist circumference, two-hour fasting blood glucose and triglycerides (61). Conversely, regularly interrupting sedentary time has been found to be beneficially associated with biomarkers of cardio-metabolic health (62, 63). These findings were used to support the updated physical activity and sedentary behaviour recommendations to reduce and regularly interrupt sedentary time mentioned in the introduction of this chapter.

Based on these epidemiological findings laboratory-based experimental studies have emerged. Here, benefits of regularly interrupting sedentary time have been observed on blood biomarkers of cardio-metabolic health such as postprandial (i.e. after a meal) glucose (64, 65), insulin levels (64-66), triglycerides (66), non-HDL (66), cholesterol (66), and apolipoprotein B plasma (a lipoprotein responsible for carrying LDL cholesterol to tissues) (66). The beneficial impact on insulin levels was observed even in comparison to highly sedentary individuals who exercise vigorously for one hour per day (66), suggesting that this detrimental health impact of high sedentary time cannot be offset even when physical activity guidelines are met.

While the underlying physiological mechanisms that link sedentary behaviour to poor health outcomes are yet to be fully understood, it has been proposed that these include

the lack of muscle contractile activity, reduced gravitational force and the resulting lowered energy expenditure. Specifically, using electromyography, it has been shown that the muscular activity during sedentary behaviour is minimal, particularly in the lower limbs (67). In laboratory rodent studies, this lack of muscular contraction has been observed to lead to the suppression of lipoprotein lipase, an enzyme responsible for the uptake of free fatty acids into skeletal muscle (67). Notably, in line with the epidemiological findings described above, the link between lipoprotein lipase inactivity during sedentary behaviour appears to be qualitatively different from the link between lipoprotein lipase and physical activity, where the enzymatic suppression occurs in different muscle tissue and to a lesser extent (67, 68). Episodes of sedentary behaviour have further been observed to lead to impaired carbohydrate metabolism through decreases in glucose transporter protein concentration (69). Finally, studies observing vascular activity during sedentary behaviour have reported reduced functioning of the endothelium (i.e. the inner lining of blood vessels) (70) and decreases in peripheral vascular function and subsequent decreases in brachial arterial diameter and elevated blood pressure (71, 72). Consequently, high volumes of sedentary time can lead to elevated blood pressure, glucose and lipid levels in the blood stream, and lower energy expenditure and thus to an increased cardio-metabolic risk. While further experimental evidence is needed to fully explain the mechanisms of sedentary behaviour, these findings largely support the epidemiological observations noted above.

1.3.2 Evidence from workplace studies on the health impacts of sedentary time

As described above, some of the first evidence on the detrimental associations of high sedentary time with health outcomes was observed in the workplace (31, 32). In 2010, a systematic review summarised the evidence from 43 studies regarding the relationship of workplace sedentary time and the outcomes of body mass index, cancer, cardiovascular disease, diabetes mellitus, and mortality (73). This review reported that occupational sitting was associated with a higher risk of diabetes mellitus and premature mortality, whereas uncertain results were found regarding an association of workplace sedentary time with overweight and cancer. However, this review also noted that the included studies were significantly heterogeneous regarding the observed associations, making it difficult to draw firm conclusions. Of particular note, and in line with the summarised studies in Section 1.2.1, all of the included studies used self-reported measures of workplace sedentary time,

with the review highlighting the need for further studies specifically targeting workplace sitting time, and objectively measuring this behaviour (73).

Laboratory studies involving office workers have shown that alternating bouts of sitting and standing (74) and replacing sitting with standing for half of a work shift (75) can lead to improved postprandial blood glucose. As the next section will elaborate on, examination of the impact of standing on health and its role as a potential alternative to sitting is particularly important in the context of interventions to reduce sedentary time in office-based workplace settings. Considering the high volume of sedentary time typically accumulated by office workers throughout the working day, there is a large potential for the displacement of some sedentary time with upright light-intensity physical activity such as standing and/ or moving.

1.4 Distribution and determinants of sedentary time

1.4.1 Sedentary time in the general adult population

In Australia, adults spend approximately 90% of their leisure time in sedentary behaviours (76). A study using a self-report measure of sedentary time across 20 countries worldwide reported a median of 5 hours of daily sitting time in adults (77). Studies using objective measures have consistently reported higher volumes of adults' sedentary time compared to self-reported figures. These range from 7.7 hours per day in Sweden (2) and the US (3), to 8.4 hours per day in Australia (4), and close to ten hours per day in Canada (5) and England (6). The majority of the remainder waking hours are spent in light-intensity physical activity and, to a small fraction, in moderate- to vigorous-intensity physical activity (78). While the evidence pertaining to the determinants of this high sedentary time is limited to date, they are assumed to be multifactorial.

1.4.2 Determinants of sedentary time

Adults' sedentary behaviour is determined by a multitude of factors. The ecologic model of sedentary behaviour (Figure 1.2), while still in early stages, helps to understand these influences on sedentary behaviour across the domains leisure, household, transport and occupational (22). Here, it is suggested that sedentary behaviours (as well as other health behaviours) are influenced via multiple inter-influencing levels ranging from more proximal, inherent factors such as genes or demographic characteristics to more distal factors such as local policies. Specifically, they include intra-individual, inter-individual/ social,

organisational, physical-environmental, community, and policy level influences that are specific to the domains the sedentary behaviours occur in (79). For example, sedentary behaviour occurring during travel has been shown to be inversely associated with the availability of public transport in a certain area (80); in the home environment, sedentary time is likely to occur during TV viewing (81); during leisure, a lot of time is spent sedentary while using the computer (82); and, in the occupational domain, work tasks such as computer work typically involve high volumes of sedentary time (11).

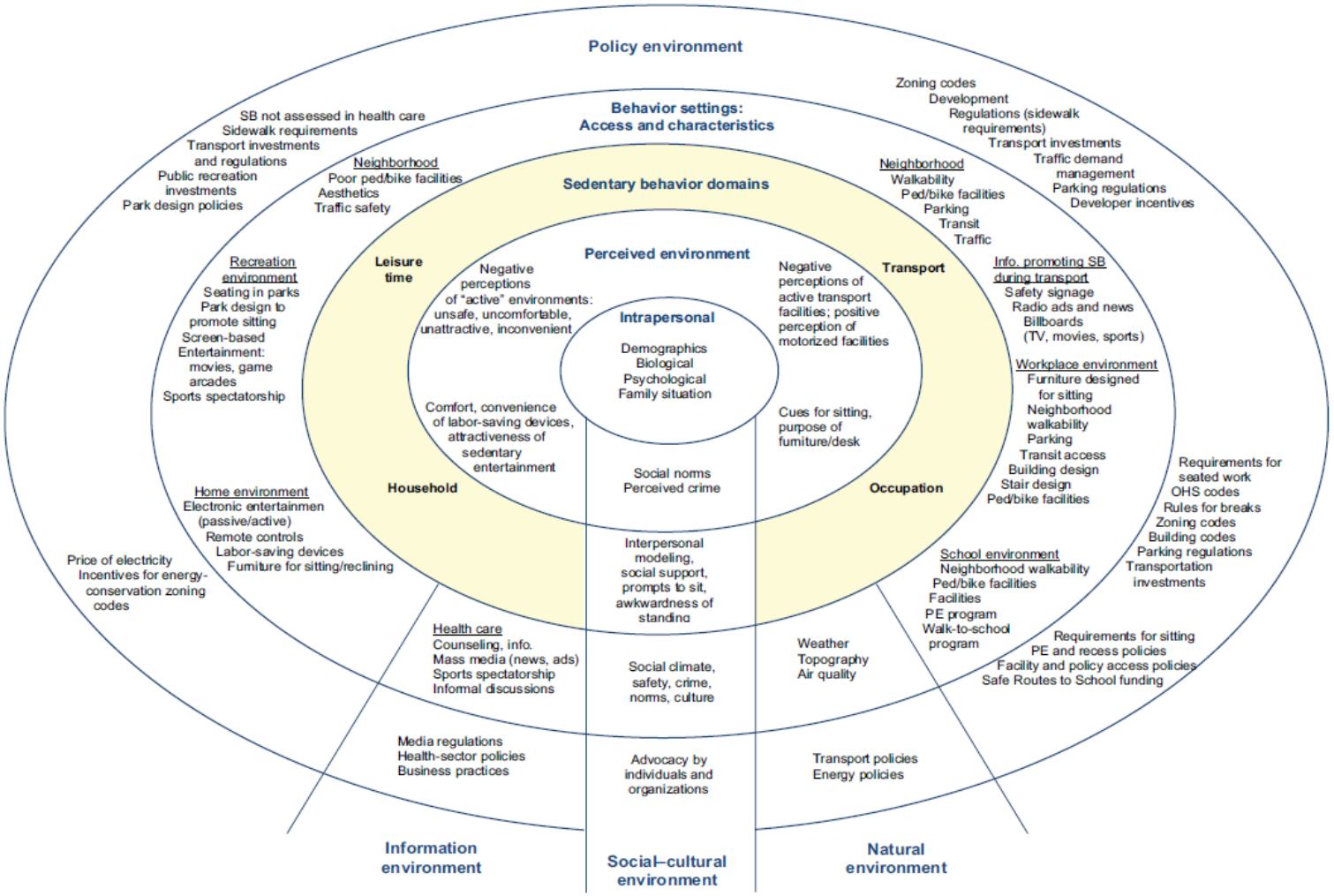

Figure 1.2. Ecologic model of sedentary behaviour; copy from Owen et al., 2011 (22)

To date, the evidence-base regarding determinants of sedentary behaviour is limited, with the majority being based on cross-sectional studies identifying ‘correlates’ rather than causal relationships (22, 83). Furthermore, the multiple influences on sedentary behaviour proposed by the ecologic model can vary significantly between individuals (22). Settings-based approaches have therefore been identified as a key strategy for health promotion intervention (84).

As the following sections will describe, in the context of reducing sedentary time, the office-based workplace setting has been recognised as a particularly opportune setting (85-87). This is due to office-based workplace interventions having the potential to reach a large number of individuals; and, because being employed in office-based occupations is a strong determinant of high volumes of sedentary time.

1.4.3 The office-based workplace is a key setting for sedentary behaviour intervention

Workers represent half of the world’s population (86) and spend approximately a third of their lives in the workplace (88-90). In the workplace, workers share a physical and psychosocial work environment. The physical work environment includes features such as the building design or individual workspaces. The psychosocial work environment includes organisational aspects such as OHS policies or managerial support for lifestyle interventions, as well as the workplace culture and social norms (91). Moreover, workplaces typically have established infrastructures such as team structures and communication systems. This combination of features within the workplace setting mean that health behaviour change interventions conducted in workplaces have the potential to reach a large number of individuals via multiple pathways.

In line with the increasing volumes of sedentary time that have been observed in the general population over recent decades, workplaces now include tasks that involve more seated work than ever before (92, 93). Occupations that traditionally required heavy physical demands such as in the production industry are increasingly reliant on technology (88). While in the 1950s every second worker was employed in a physically active job, current figures indicate that this is now only one in five (92, 94). The current widespread use of computers has led to a large and increasing proportion of industrial sectors now involving desk-based office work (88, 95). And, among desk-based office workers, volumes of sedentary time are increasing. While typically, poor lifestyle choices are

associated with lower socio-economic status, workplace sedentary time appears to pose an exception. Studies using objective measures have shown that desk-based office workers spend approximately 75% of their working hours sitting (11, 96-99). This high volume of workplace sedentary time has been shown to account for nearly half of adults' total weekly sedentary time (100). A significant proportion of this time is accrued in prolonged unbroken bouts of 30 minutes or more (11), which are particularly detrimental to health as noted in the previous section. Furthermore, in addition to the high volumes of sedentary time during work hours, there is some evidence that office workers are not less sedentary during non-work time (101). In fact, recent evidence has shown a positive correlation between high sedentary time at work and during non-work hours in office workers (102, 103). Workers employed in desk-based office jobs have therefore been identified as a high-risk group and key target for sedentary behaviour intervention (100, 104-106). To develop effective interventions aiming to reduce office workers' sedentary time, an understanding of the modifiable influences on workplace sedentary time is crucial.

1.5 Influences on workplace sedentary time

In line with the limited knowledge of sedentary behaviour determinants in the general adult population, the evidence regarding influences on workplace sedentary time is even more limited. A recent study examining potential correlates of workplace sedentary time reported that psychosocial factors (such as self-efficacy, social support and perceived behavioural control, all of which are typically important to change higher-intensity physical activity behaviours (107)) were not associated with workplace sedentary time (106). Moreover, among a sample of call-centre workers, knowledge regarding the importance of regular interruptions in workplace sedentary time was also unrelated to sedentary behaviour outcomes (108). In the absence of more specific evidence regarding determinants of workplace sedentary time, well established workplace health promotion models/frameworks can be used to guide intervention development.

1.5.1 Workplace health promotion frameworks and models

Workplace health promotion frameworks offer insights into facilitators and barriers to changing workers' health behaviours. To date, these have predominantly been applied to workplace interventions targeting health behaviours such as physical activity, dietary behaviour, smoking cessation, or alcohol consumption. Nonetheless, they provide guidance for interventions to reduce workplace sedentary time. Commonly used models include the *Healthy Workplace Framework and Model* by the World Health Organization

(WHO) (109), the *Essential elements of effective workplace programs and policies for improving worker health and wellbeing* published by the US Department of Health and Human Services (110), the *Best-practice guidelines: Workplace health in Australia* from the Workplace Health Association Australia (91), as well as other guiding workplace health promotion literature (111-113).

Throughout this PhD thesis, the WHO's *Healthy Workplace Framework* will be used as an overarching framework. The key reason for choosing this framework is that it has a global focus and combines many of the elements contained in other relevant frameworks as well as the workplace health promotion literature. The *Healthy Workplace Framework* (Figure 1.3) proposes four broad levels of influence relevant to reducing workplace sedentary time:

1) Personal health resources: These include but are not limited to cognitive resources such as health literacy (e.g. knowledge about the detrimental health impacts of high volumes of sedentary time, motivation to reduce sedentary time, self-efficacy (i.e. the confidence to be able to reduce sedentary time) and positive outcomes expectations. Other personal health resources include work capacity, financial resources and family circumstances.

2) The psychosocial work environment: This includes social and organisational norms, values, support, and regulations. Among these are attitudes (and demonstration thereof) regarding health behaviours among colleagues and supervisors, existing occupational health & safety policies, and exposures to psychosocial stressors at work such as job demands, job control and security, harassment, supervisor and co-worker social support. Examples for the context of workplace sedentary behaviour include management attitudes and values towards efforts to reduce workplace sedentary time or norms and acceptability around standing in staff meetings.

3) The physical work environment: This includes the office layout and design, furniture, machines, and availability of resources such as sit-stand desks (see Section 1.6.3 for more details) and of communal workplace spaces such as meeting rooms or kitchens.

4) Enterprise community involvement: This includes activities, expertise, as well as social and physical resources of the immediate local environment. In the context of reducing workplace sedentary time, this could include educational and counselling sessions around reducing sedentary time or other planned physical activities that may replace time spent in sedentary behaviour in the community (109).

Figure 1.3. The *Healthy Workplace Framework* (109)

The *Healthy Workplace Framework* emphasizes the inter-influential nature of the four workplace dimensions and highlights the importance of addressing these through multiple intervention components. Furthermore, through placing workplace ethics and values at its core, this framework recommends a participatory approach in the development and implementation of interventions. This means that ideally, staff from all levels as well as key stakeholders are involved in the development and implementation processes of workplace interventions. This is important to maximise the relevance of interventions to specific workplace characteristics and their workers; and, because the taking a participatory approach has been shown to positively impact on the use of intervention strategies over time (112). Finally, the *Healthy Workplace Framework* provides a step-by-step guideline for intervention implementation under consideration of these core principles. These include higher-level management buy-in, health behaviour assessment and prioritisation, intervention development, implementation and evaluation.

As the next section will show, the number of intervention studies targeting reductions in workplace sedentary time is still limited. In particular, a systematic approach to reducing workplace sedentary time using workplace health promotion models such as the *Healthy Workplace Framework* or other guiding literature is yet to be implanted, evaluated and published.

1.6 Interventions to reduce workplace sedentary time

It has been argued that sedentary behaviour interventions are conceptually different from interventions targeting changes in moderate- to vigorous-intensity physical activity behaviour (19). In contrast to physical activity (a behaviour targeted to increase in time-limited and planned sessions through intervention), sedentary behaviour is much more ubiquitous and often determined by the constraints of the physical environment, particularly in the workplace (114). Further, sedentary behaviour is not likely to be eliminated entirely (like smoking), but rather reduced and/or regularly interrupted.

Similar to the epidemiologic studies summarised in Section 1.3, intervention studies aiming to interrupt and/or reduce sedentary time in office workers have emerged from multiple disciplines, including occupational ergonomic research as well as the broader public health research disciplines. Many of the original studies originated from the ergonomic field, with an emphasis on regular interruptions in sitting and postural changes for avoiding musculoskeletal symptoms. In more recent years, there has been a rapid increase in evidence from the public health field, where the emphasis has been on the prevention of cardio-metabolic diseases.

In 2012, I co-authored an evidence review as part of the *Stand Up Australia* program of research, which summarised interventions to reduce workplace sedentary time with the aim to identify best-practice strategies (115). Several of the conclusions from that review remain relevant today:

a) The quantity and quality of the evidence-base in this research field is still limited, particularly regarding the methods used to measure sedentary time and patterns.
b) Multi-component approaches in line with the workplace health promotion literature are recommended, however yet to be applied; and,
c) Modifications of the physical work environment, in particular through provision of activity-permissive workstations (see Section 1.6.3 for more details), may be the key to achieving meaningful reductions in workplace sedentary time.

The next three sections summarise the evidence in relation to workplace strategies aiming to increase interruptions in sitting and using educational approaches and/ or modifications to the physical work environment to reduce sedentary time.

1.6.1 Strategies to increase interruptions in sedentary time

A systematic review published in 2007 summarised 15 studies that examined the impact of more frequent interruptions in office workers' sedentary time on musculoskeletal symptoms (116). While none of the reviewed studies measured participants' sedentary time (limiting the insight into the effectiveness of more frequent breaks on total or prolonged sedentary time), this review reported that participants' compliance with 'break schedules' was inconsistent (116). In a more recent study, participants were provided with a breaks-reminder software in combination with counselling sessions about ergonomics, body posture and the importance of frequent breaks from sedentary time (117). Here, the observed outcome was a significant increase in self-reported regular sitting breaks by more than half. Studies emanating from the broader public health discipline have used computer prompts with the aim to increase the number of interruptions in workplace sedentary time in order to reduce the cardio-metabolic health risks described in Section 1.3 (118-120). These have reported significant decreases in the number (118-120) and duration (118, 119) of prolonged sedentary bouts. However, only one of these studies observed a significant reduction in total workplace sedentary time (-18 minutes/ workday as measured via activPAL devices) (119). In light of the small number of these studies, further research is needed to examine the effectiveness of break schedules to increase interruptions in sedentary time and reduce total workplace sedentary time.

1.6.2 Educational approaches to reducing workplace sedentary time

Another approach to reducing workplace sedentary time has been to provide participants with education or awareness training about this behaviour. In one study, a group of overweight office workers participated in an educational session about the health risks associated with high sedentary time (121). These participants were also provided with a list of strategies to replace sedentary time with light-intensity physical activity at home, in the workplace, and during recreation and transport; and, they received a checklist for self-monitoring purposes over seven days. This study reported significant reductions in sedentary time of 37 minutes on weekdays (i.e. not limited to work hours), as measured by activPAL devices (121). In another study, intervention group participants self-reported workplace sedentary time reductions of just over an hour per week following mindfulness training, coaching sessions and facilitation of lunch walks to change lifestyle behaviours in a group of office workers (122). However, in this study, control group participants reported much larger sedentary time reductions (122). The effectiveness of strategies to reduce

sedentary time through education or awareness training thus also requires further examination.

1.6.3 Modifications of the physical work environment

The physical work environment can be considered at a macro-level such as the entire work building, or a more immediate, micro-level such as arrangement and design of office furniture. Industry interest in the potential benefits of activity-based working has led to an increase in the number of buildings that are specifically designed to promote movement. Simultaneously, there has been an increase in collaboration between industry workplaces with architects/designers and public health experts, which has created opportunities for natural experiments examining the impact of activity-based workplaces on office workers' movement patterns - including sedentary time. One such study documented the move of office workers from conventional office spaces (predominantly closed design without standing options) into a new 'activity-permissible' building (123). This new building was purpose-built for this group of office workers and included an internal glass-enclosed stairwell with aesthetic views, standing options in meeting rooms and other common areas, centralised printers and supplies, and the location of key destinations across different floors. Following transition, office workers' sedentary time significantly reduced by 20 minutes/ 8-hour workday as measured by activPAL devices (123).

Other studies have focused on modifying office workers' individual desk spaces through the provision of activity-permissive workstations. Activity-permissive workstations allow office workers to stand, walk, or pedal while working at their usual computer and desk-based job tasks. Examples of activity-permissive workstations include treadmill desks, stepping or pedal devices that are fitted underneath the desk, and height-adjustable workstations (Figure 1.4). Sit-stand workstations include desks or desk mounts that are adjustable to full standing height. They enable office workers to conduct their desk-based tasks while alternating between sitting and standing and thus to change their posture frequently, as is recommended in occupational health & safety standards (124).

Figure 1.4. Activity-permissive workstations (sit-stand desks [left; www.eyoungonline.com]; treadmill desk [top right; www.trekdesk.com]; pedal device [bottom right])

A recent narrative review reported that activity-permissive workstations are a well-accepted alternative to conventional sitting desks among office workers (125). Traditionally, activity-permissive workstations were acquired for the prevention of musculoskeletal problems, with some of the first studies having emerged in the 1980s (126-128). More recently, their potential to reduce workplace sedentary time for broader preventive health benefits has been recognised, with studies reporting reductions in workplace sedentary time of more than two hours per 8-hour workday following installation (96, 99). Furthermore, it was shown that workstations such as treadmill desks or cycle-ergometers can lead to significant increases in energy expenditure (125). They may thus also constitute an opportunistic means to achieve weight loss and maintenance.

As indicated above, coinciding with the increased scientific interest in sedentary behaviour interventions, there is rapidly emerging industry interest and thus translation of the recommendation to reduce sedentary time in the workplace. This includes an increased uptake of activity-permissive workstations into office-based workplaces. However, to date, the number of studies using activity-permissive workstations and measuring their impact on sedentary behaviour is limited and the effectiveness of such workstations to reduce sedentary time is yet to be systematically summarised. Furthermore, the impact of such workstations on biomarkers of cardiovascular health and on work performance indicators

is not well understood (99, 129-131). A systematic literature review examining the impact of activity-permissive workstations on office workers' sedentary time, health-, and work-related outcomes was thus conducted forming Study 1 of this PhD research (Chapter 2).

In addition, while activity-permissive workstations may be an effective means to reduce workplace sedentary time, knowledge regarding a best-practice application of such workstations is limited. In particular the installation of activity-permissive workstations may work best in conjunction with elements additionally targeting personal health resources, and the psychosocial work environment as suggested by workplace health promotion frameworks such as the *Healthy Workplace Model* (109, 115). Such a multi-component intervention has therefore been developed as Study 2 of this PhD research (Chapter 3). However, in recognition of the typically extensive resource implications of such multi-component approaches, the effectiveness of this intervention was compared to the installation of activity-permissive workstations alone and to a control group in a 3-arm field study, forming Study 3 (Chapter 4).

1.7 Summary and research objectives

High volumes of sedentary time have now been recognised as a population-wide health-risk. Desk-based office workers comprise a highly sedentary occupational group in industrialised countries, who spend approximately 75% of their working hours sitting down. Health issues arising from high volumes of sedentary time such as musculoskeletal symptoms, overweight, and diabetes are well documented and the associated economic burden is likely to be high. Workplace interventions targeting reductions in sedentary time are an important public health initiative. However, evidence guiding their implementation such as a (cost-) effective alignment with workplace health promotion frameworks, is scarce. The aim of this PhD research is therefore to contribute to the evidence to inform interventions using activity-permissive workstations to reduce workplace sedentary time in desk-based office workers.

The aim of this thesis research will be accomplished through three specific objectives:

Objective 1: To conduct a systematic literature review and meta-analysis examining the impact of activity-permissive workstations on office workers' sedentary time, health-related outcomes and work performance indicators; and, summarising the evidence on the feasibility of such workstations in office-workplaces.

Objective 2: To develop a multi-component intervention based on the key elements of the WHO *Healthy Workplace Framework* to reduce office workers' sedentary time, including activity-permissive workstations as well as strategies targeting personal health resources and the psychosocial work environment.

Objective 3: To conduct a controlled trial evaluating the effectiveness of this multi-component intervention to reduce office workers' sedentary time; and, to evaluate the potential for dissemination.

These PhD studies will provide evidence on the feasibility and effectiveness of a multi-component approach to reduce workplace sedentary time in office workers, including the use of activity-permissive workstations. They are embedded in the broader *Stand Up Australia* program of research. The *Stand Up Australia* program was established in 2009 and constitutes a research collaboration between the Baker IDI Heart & Diabetes Institute, The University of Queensland's Cancer Prevention Research Centre and other university, government and non-government organisations in Australia. It includes both evaluation and intervention studies, with the aim to investigate the benefits of reducing sitting time in the workplace. To date, the *Stand Up Australia* program entails seven intervention trials, with the flagship study being the *Stand Up Victoria* study. The *Stand Up Victoria* study uses the intervention whose development was a key study of this PhD research (Study 2) and is described in Chapter 3. The candidate's key role in this, with guidance from the PhD advisors, was the development and refinement of the intervention and associated materials, in particular the individual-level elements and parts of the organisational- and environmental-level elements. The *Stand Up UQ* study, which forms Study 3 of this PhD research and is described in detail in Chapter 4, is another study within the *Stand Up Australia* portfolio, which was fully led, implemented and evaluated by the PhD candidate.

CHAPTER 2. Impact of activity-permissive workstations on office workers' sedentary time, health- and work-related outcomes

2.1 Introduction

Chapter 1.5.1 described the *Healthy Workplace Framework* (109), which broadly distinguishes four levels of influence on workplace health behaviour: the physical work environment, personal health resources, the psychosocial work environment and enterprise community involvement. This chapter addresses the physical work environment aspect of the framework (highlighted in Figure 2.1).

The physical work environment can be addressed through broader environmental modifications (e.g., activity-permissive work building design, visible access to stair cases or provision of standing facilities in meeting rooms) as well as modifications to individual workspace (e.g., centralisation of printers or installation of activity-permissive workstations). This Chapter describes the impact of modifications to the individual workspace on sedentary time and reports the findings of Study 1: a systematic literature review of the effectiveness of activity-permissive workstations to reduce workplace sedentary time.

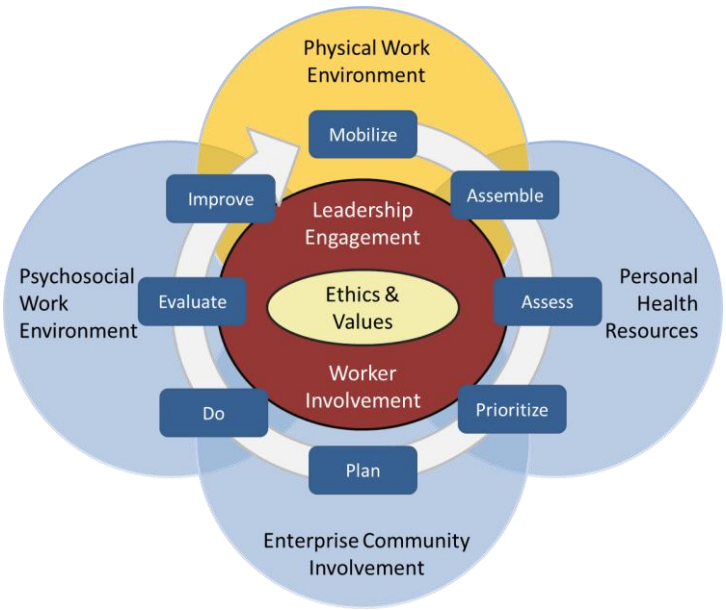

Figure 2.1. Dimension of the *Healthy Workplace Framework* addressed in the context of Study 1 of this PhD research (highlighted in yellow).

Recently, studies have begun to examine the efficacy of activity-permissive workstations to reduce sedentary time and there is now considerable interest from industry workplaces regarding the use of such workstations within office-based workplaces. However to date, studies are of mixed quality and design, with outcomes ranging from cardio-metabolic health biomarkers to sedentary time and work performance indicators. Importantly, the evidence pertaining to the effectiveness and broader impact of activity-permissive workstations is yet to be systematically summarised. The objective of Study 1 of this PhD research was therefore to systematically review the current evidence on the role of activity-permissive workstations on workplace sedentary time; their impact on health- and work-related outcomes; and, to summarise their feasibility in office-based workplaces.

This review was published in the peer-reviewed Journal *Obesity Reviews*, with a copy of the paper being provided in the next section.

2.2 Impact of activity-permissive workstations on office workers' sedentary behaviour, health, and work-related outcomes: a systematic review

Neuhaus, M., Healy, G.N., Straker, L., Dunstan, D.W., Owen, N., Eakin, E.G. (2014). *Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations.* Obesity Reviews DOI 10.1111/obr.12201

doi: 10.1111/obr.12201

Obesity Prevention

Reducing occupational sedentary time: a systematic review and meta-analysis of evidence on activity-permissive workstations

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Received 26 March 2014; revised 12 May 2014; accepted 29 May 2014

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Summary

Excessive sedentary time is detrimentally linked to obesity, type 2 diabetes, cardiovascular disease and premature mortality. Studies have been investigating the use of activity-permissive workstations to reduce sedentary time in office workers, a highly sedentary target group. This review systematically summarizes the evidence for activity-permissive workstations on sedentary time, health-risk biomarkers, work performance and feasibility indicators in office workplaces. In July 2013, a literature search identified 38 relevant peer-reviewed publications. Key findings were independently extracted by two researchers. The average intervention effect on sedentary time was calculated via meta-analysis. In total, 984 participants across 19 field-based trials and 19 laboratory investigations were included, with sample sizes ranging from $n = 2$ to 66 per study. Sedentary time, health-risk biomarkers and work performance indicators were reported in 13, 23 and 23 studies, respectively. The pooled effect size from the meta-analysis was –77 min of sedentary time/8-h workday (95% confidence interval = –120, –35 min). Non-significant changes were reported for most health- and work-related outcomes. Studies with acceptability measures reported predominantly positive feedback. Findings suggest that activity-permissive workstations can be effective to reduce occupational sedentary time, without compromising work performance. Larger and longer-term randomized-controlled trials are needed to understand the sustainability of the sedentary time reductions and their longer-term impacts on health- and work-related outcomes.

Keywords: Active workstations, height-adjustable desks, sedentary behaviour, workplace interventions.

obesity reviews (2014)

Introduction

High volumes of sedentary time – time spent sitting or lying down while expending little energy (1) – are associated with excess adiposity and other aspects of chronic disease risk, particularly when the sedentary time is accumulated in prolonged unbroken bouts (2–4). Much of the documentation of the detrimental health consequences of too much 'static sitting' originates from the field of ergonomics, with a focus on musculoskeletal outcomes (5). More recently, the broader public health implications of excessive sedentary time have been examined in the context of chronic disease risk. Here, studies have documented detrimental associations with several indicators of poor health including obesity (6), cardiovascular disease (7), type 2 diabetes (8), and some cancers (9,10), and with premature mortality (11).

In industrialized countries, most working adults spend a high proportion of their waking hours in the workplace (12), in increasingly sedentary occupations (13). Using objective measures, it has been observed that white-collar workers sit for the majority of their work hours and often in long, unbroken bouts (13–17). Accordingly, intervention studies conducted from both ergonomic and public-health perspectives have focused on reducing sedentary time in this occupational sector. Along with rapid advances in technology, office work increasingly involves (desk-based) computer work (14). Many of the studies aiming to reduce workplace sedentary time have therefore used activity-permissive workstations. These include treadmill desks, stepping or pedal devices that are fitted underneath the desk, and height-adjustable workstations, which enable office workers to stand, walk, or pedal while working at their usual computer- and other desk-based job tasks. Overall, findings from both laboratory- and field-based studies using such workstations suggest a range of positive benefits including reductions in workplace sedentary time (18), lower body mass index (19) and reduced musculoskeletal discomfort (20). A recent (narrative) literature review concluded that workstations such as treadmill or pedal desks have the potential to elevate office workers' energy expenditure by approximately 2–4 kcal min^{-1} (21). That same review further reported that the use of activity-permissive workstations is generally well accepted among participants, with mixed impacts regarding work performance measures. However, to date, the extant evidence has not been systematically summarized, in particular with regard to sedentary time, adiposity and other health-related outcomes.

The objective of our review was thus to systematically review the impact of activity-permissive workstations on office workers' sedentary time, adiposity and other health- and work-related outcomes; and, feasibility outcomes (acceptability to workers and potential adverse events).

Methods

Definitions

Sedentary behaviour is defined as any waking behaviour characterized by sitting or reclining while expending little energy (≤1.5 metabolic equivalents) (1). Given the considerable variation in sedentary behaviour terminology and the measurement methods thereof across the relevant publications, two overarching terms are used throughout this review: 'overall sedentary time' and 'workplace sedentary time'. Overall sedentary time refers to changes across the whole day (i.e. not just in the workplace) while 'workplace sedentary time' specifically refers to sedentary time occurring in the workplace. Notably, in two studies a direct measure of sedentary time was not available (22,23). Here, increases in activity (i.e. via the use of the workstations) were presumed to reflect reductions in workplace sedentary time.

The following workstations were regarded as activity-permissive: fixed standing desks (with or without provision of height-adjustable chairs), workstations adjustable to full standing height, treadmill desks, cycle ergometers and pedal devices fitted underneath the desk that can be used while doing usual desk-based job tasks.

Inclusion and exclusion criteria

Studies were included in this review if they: evaluated overall and/or workplace sedentary time, health-related (e.g. weight, musculoskeletal symptoms, blood risk markers), work-related (e.g. productivity, absenteeism) or feasibility outcomes (e.g. acceptability, adverse events) following the provision of an activity-permissive workstation; included an adult sample (aged ≥18 years); engaged in administrative (i.e. not manufacturing, but with reliance on engagement with a computer) tasks while using the activity-permissive workstations; reported at least two data collection points (i.e. baseline and follow-up); and were published in an English-language peer-reviewed journal. As much of the documentation from the ergonomics research field is published in conference proceeding papers, only relevant studies published in peer-reviewed conference proceedings papers were also included.

Search strategy

The following databases were searched on 18 July 2013: Web of Knowledge, Medline (through PubMed), Embase, CINAHL, SPORTDiscus, CENTRAL, Scopus, PsychInfo and AMED. An initial search was divided into two categories, separated by the Boolean phrase 'AND': (i) activity-permissive workstations (e.g. treadmills, height-adjustable desks) and (ii) workplace settings (e.g. workplace, office). There was no limiter on publication years. This search resulted in a total of 1,655 peer-reviewed publications. A second search was run to identify any papers related to workplace sedentary time that did not mention activity-permissive workstations specifically in the abstract and/or title. This search contained two clusters pertaining to sedentary time occurring in the workplace (e.g. office sitting, sedentary workplace) and the study design (e.g. intervention, study). A summary of the search strategy is provided in Supporting Information Table S1.

Study selection and data extraction

The study selection process is shown in Fig. 1. The search identified a total of 4,633 publications, of which 2,707 were initially excluded for being duplicates (n = 2,309), not

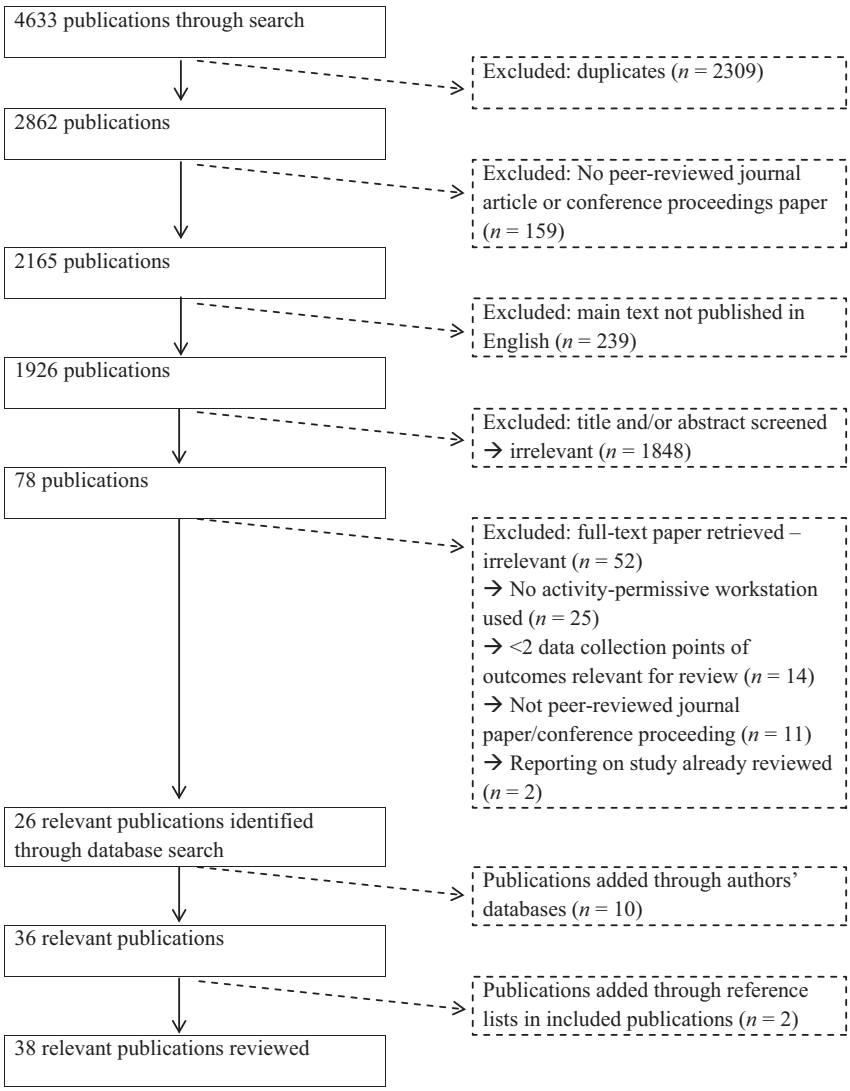

Figure 1 Study selection process.

being peer-reviewed ($n = 159$), and for being published in a language other than English ($n = 239$). This step was conducted by MN. Consecutively, NR and MN independently excluded irrelevant publications by screening titles and/or abstracts. This resulted in $n = 78$ unique publications remaining, which were screened in full text by MN and GNH independently, with an agreement regarding inclusion of 96% (calculated as studies agreed upon/studies screened in full text). Any disagreements ($n = 2$) were resolved through discussion.

Outcomes included in the review

Overall and workplace sedentary time were included as defined earlier. If both subjective and objective measures of sedentary time were reported, objective measures were prioritized for the summary and meta-analysis in this review. Similarly, reported changes in workplace sedentary time were prioritized over overall sedentary time. Workplace sedentary time changes reported in percentage were standardized to an 8-h work day (if not already done so in relevant publications). If studies included a further assessment in addition to a pre- and post-intervention assessment, the end-of-intervention outcomes are included in the main summary, with additional assessment outcomes reported separately.

Health-related outcomes

These included weight, waist circumference, blood-derived biomarkers, musculoskeletal symptoms, fatigue and other physiological measures reported. Given that the primary interest was in the implementation of activity-permissive workstations in real-world contexts, and the acknowledgement of a recently published review on the impact of such

workstations on energy expenditure (21), studies exclusively examining energy expenditure were not considered for inclusion.

Work-related outcomes

Defined as work performance (e.g. concentration or production levels), presenteeism, absenteeism or cultural–organizational outcomes (e.g. time spent in face-to-face interactions).

Feasibility outcomes

Includes any quantitative or qualitative employee ratings of the acceptability of the activity-permissive workstations, as well as reported adverse events related to their use.

Quality assessment

Study quality of the included publications was evaluated independently by MN and GNH using a published scoring system (24). Quality assessment was based on eight criteria relating to the reporting of study methods (description of recruitment, participants, allocation, measures, sample size) and results (description of variance, confounding, detail of results) with answer categories being 'yes', 'partial', 'no' and not applicable ('N/A'). The summary score was calculated as: total sum[(number of 'yes' × 2) + (number of 'partial' × 1)]/total possible sum[16 – (number of 'N/A' × 2)], with a maximum possible total score of 1. Interrater agreement was calculated as (proportion of quality scores given the same score by the reviewers/all quality scores provided). Any discrepancies between the assessors were resolved through discussion.

Meta-analysis

Studies using a controlled design and reporting overall and/or workplace sedentary time were eligible for inclusion in the meta-analysis. Between-group changes in sedentary time following intervention were entered as changes in minutes during work hours and standardized to an 8-h work day. The DerSimonian–Laird method was used to estimate the pooled effect of included studies (25). Statistical heterogeneity was tested using Egger's test (26). The small number of studies included, along with high heterogeneity precluded investigation of publication bias. All analyses were conducted using STATA 12 (StataCorp. 2011. Stata Statistical Software: Release 12; StataCorp LP, College Station, TX, USA).

Results

A total of 26 relevant publications were identified by the database search (16,18,19,22,27–48). A search of the authors' personal libraries and reference lists of identified papers resulted in an additional 12 relevant publications ($n = 10$ (20,23,49–56) and $n = 2$ (57,58), respectively). Thus, this review included a total of 38 peer-reviewed publications meeting the inclusion criteria, reporting on 45 independent comparisons (i.e. comparison of one or more activity-permissive workstations with a control or usual practice comparator). Seven publications were peer-reviewed proceedings of conference papers (31,40,42–44,53,55). All relevant data were extracted by GNH and MN independently and discussed in the event of disagreement. Corresponding authors of included publications were contacted to request any relevant data not reported in the published paper (details were followed up for four publications).

Study and sample characteristics and range of outcomes assessed

Table 1 provides a description of the included publications. Studies included a total of 984 participants across the 38 studies (one study did not report sample size), with an average sample size of 27 per study (range: 2–66). Twenty-three studies included samples of office workers. Other groups included 'adults' (not otherwise specified; $n = 7$), students ($n = 5$), 'university staff' (not otherwise specified; $n = 2$) and medical practitioners ($n = 1$).

Studies were conducted in North America ($n = 23$), Europe ($n = 4$), Asia ($n = 3$) and Australia ($n = 8$). Eighteen of the studies were laboratory experimental, with 20 studies being field-based (i.e. conducted within the workplace setting). Across the 45 independent comparisons, 17 evaluated height-adjustable desks (of which 12 were fully adjustable desks and five were height-adjustable desk mounts for the computer only), two evaluated standing desks with height-adjustable chairs, eight evaluated standing desks without height-adjustable chairs, 12 evaluated treadmill desks, two evaluated pedal devices, two evaluated cycle ergometers, one evaluated a stepping device, while one study (54) evaluated both treadmills and cycle ergometers. Of the studies evaluating height-adjustable desks, only six (of 15) reported whether these were electric or operated via alternative mechanisms (16,18,34,43,45,56).

In the experimental studies, the duration of the workstation exposure protocols was typically short: <1 d (range 1 h to 2 weeks). In the field studies, the mean intervention duration was 15 weeks (range: 1 d to 12 months). Three of the field studies included an additional follow-up assessment taken at 3 (18), 9 (37) and 12 months (38) post baseline. Twelve field studies implemented strategies in addition to the installation of activity-permissive workstations (e.g. instructions to stand for certain durations during the day; provision of pedometers; and/or motivational messages to increase physical activity/reduce sedentary time) (16,18–20,22,33,42,43,45,54,56).

Table 1 Summary of included publications

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
Laboratory-based studies				
(27) Aaras, 1997; Norway	20 experienced VDU workers aged 26–60 (15% F; mean age 52.5 years)	Standing desks without access to height-adjustable chair; block-randomized; 1 d	Sedentary: NA Health: posture when using keyboard ns; muscle load when using keyboard ns; upper trapezius 10%le ns; lumbar erector spinae 10%le ns; 3× head flexion (10%le ns, 50%le ns, 90%le ns), 3× head side flexion (10%le ns, 50%le ns, 90%le ns); upper arm flexion 50%le +, upper arm abduction ns; low shoulder moment periods ns; back flexion ns; side flexion ns Work: work pace ns Feasibility: NA	0.79
(28) Alderman, 2013; USA	66 students (59% F; 21.1 years SD 1.6)	Treadmill desks; crossover; 2 d	Sedentary: NA Health: NA Work: 2× cognitive performance: both ns; reading comprehension ns Feasibility: NA	0.86
(49) Beers, 2008; USA	24 office workers (50% F: mean age 31.3 years SD 9.1; 50% M: mean age 26.3 years SD 6.2)	Standing desk without access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: musculoskeletal comfort –, fatigue + Work: work performance ns Feasibility: choice –, liking –	0.83
(29) Chester, 2002; USA	18 students (39% F; mean age 21.9 years)	Standing desk without access to height-adjustable chair; crossover; 2 d	Sedentary: NA Health: leg volume ns; leg circumference –; body comfort: upper back ns, lower back ns, hips –, upper legs –, knees –, lower legs –, ankles –, feet –; fatigue ns Work: NA Feasibility: NA	0.57
(30) Cox, 2011; USA	31 adults (71% F; mean age 37 years SD 2.5)	Standing desk without access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: NA Work: 2× speech quality both ns Feasibility: NA	0.63
(30) Cox, 2011; USA†	31 adults (71% F; mean age 37 years SD 2.5)	Treadmill desk; crossover; 1 d	Sedentary: NA Health: NA Work: 2× speech quality both ns Feasibility: NA	0.63
(31) Davis, 2009; USA	35 call centre employees (77% F)	HAD; pre-post; 2 weeks	Sedentary: NA Health: body discomfort: overall ns, shoulders ns, hands and wrists +, upper back ns, lower back + Work: work performance: average number of calls/h ns, average time until call is answered ns, average time unavailable for calls ns Feasibility: NA	0.64
(31) Davis, 2009; USA†	35 call centre employees (77% F)	HAD (plus software reminder); pre-post; 2 weeks	Sedentary: NA Health: body discomfort: overall +, shoulders +, hands and wrists +, upper back +, lower back + Work: work performance: average number of calls per h +, average time until call is answered ns, average time unavailable for calls ns Feasibility: NA	0.64
(32) Ebara, 2008; Japan	24 adults aged 20–29 years and 60–69 years (50% F; mean age 21.2 years SD 1.1 and 62.7 years SD 1.6)	Standing desk with access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: body discomfort: right forearm –, right wrist/hand –, both lower legs –, neck both sides ns, shoulders ns, left forearm ns, left wrist/hand ns, upper and lower back ns, hip/thighs both sides ns; fatigue ns Work: work performance ns Feasibility: NA	0.86

Table 1 *Continued*

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
(57) Edelson, 1989; USA	5 adults with minimum typing speed of 50 word/min (80% F; mean age 26 years)	Treadmill desk; crossover; 2 weeks	Sedentary: NA Health: stress +, body complaints ns Work: work performance ns Feasibility: NA	0.64
(51) Funk, 2012; USA	24 university students and staff (63% F; mean age 23.2 years SD 3.2)	Treadmill desk; crossover; 1 d	Sedentary: NA Health: NA Work: typing performance: while walking at 1.3 km h^{-1} –, while walking at 2.25 km h^{-1} ns, while walking at 3.2 km h^{-1} – Feasibility: NA	0.79
(52) Hasegawa, 2001; Japan	16 adults (0% F; aged 19–25 years)	Standing desk without access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: fatigue: 2× dullness and drowsiness: + and ns, 2× body fatigue both ns Work: Work performance: 2× mental concentration: + and ns, 2× work load: + and ns, 2× error rate: + and ns; 2× miss rate both ns; 2× working motivation both ns Feasibility: NA	0.31
(35) Husemann, 2009; Germany	60 students aged 18–35 years (100% F; IG mean age 25.1 years SD 2.7; KG mean age 24.7 years SD 3.8)	HAD; RCT; 5 d	Sedentary: NA Health: physical well-being +, psychological well-being ns Work: work performance ns Feasibility: NA	0.69
(36) John, 2009; USA	20 students (45% F; mean age 26.4 years SD 4.0)	Treadmill desks; crossover; 2 d	Sedentary: NA Health: NA Work: work performance: mouse clicking test –, drag-and-drop test –, typing speed –, math –, selective attention ns, processing speed ns, reading comprehension ns Feasibility: NA	0.79
(53) Koren, 2013; Slovenia	13 office workers (100% F; mean age 30.6 years SD 3.8)	Cycle ergometer; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: typing speed –, typing errors ns Feasibility: preference +	0.67
(39) McAlpine, 2007; USA	19 'sedentary' adults (42% F; mean age 27 years SD 9)	Stepping device; pre-post; 1 d	Sedentary: NA Health: NA Work: NA Feasibility: adverse events: none, tolerance +	0.75
(41) Ohlinger, 2011; USA	50 university staff (mean age 43.2 years SD 9.3)	HAD; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: fine motor ns, 2× cognitive performance both ns Feasibility: NA	0.83
(41) Ohlinger, 2011; USA†	50 university staff (mean age 43.2 years SD 9.3)	Treadmill desk; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: fine motor –, 2× cognitive performance both ns Feasibility: NA	0.83

Table 1 *Continued*

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
(58) Seo, 1996; Japan	12 adults (33% F; mean age 24.1 years SD 1.2)	Standing desk without access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: musculoskeletal symptoms: leg swelling +, lower leg dullness –, low back pain ns, whole body fatigue – Work: NA Feasibility: NA	0.75
(46) Straker, 2009; Australia	30 office workers (53% F aged 22–64 years)	Standing desk without access to height-adjustable chair; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: typing speed ns, typing errors ns; mouse pointing speed ns; mouse pointing errors ns; combined keyboard and mouse task speed ns; combined keyboard and mouse task errors ns Feasibility: user perception + (83% of participants thought it was feasible); adverse events: 3 reports of leg discomfort	0.93
(46) Straker, 2009; Australia†	30 office workers (53% F aged 22–64 years)	Treadmill desks with participants walking at 1.6 km h^{-1} and 3.2 km h^{-1},; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: typing speed – (in both conditions), typing errors ns (in both conditions); mouse pointing speed – (in both conditions); mouse pointing errors – (in both conditions); combined keyboard and mouse task speed – (in both conditions); combined keyboard and mouse task errors ns (in both conditions) Feasibility: user perception: 50% of participants thought it was feasible; adverse events: 3 reports of dizziness, 2 reports of discomfort, 2 reports of leg discomfort	0.93
(46) Straker, 2009; Australia†	30 office workers (53% F aged 22–64 years)	Cycle ergometers with participants cycling at 5 and 30 watts; crossover; 1 d	Sedentary: NA Health: NA Work: work performance: typing speed – (when cycling at 5 W) and ns (when cycling at 30 W), typing errors ns (in both conditions); mouse pointing speed – (in both conditions); mouse pointing errors ns (when cycling at 5 W) and – (when cycling at 30 W); combined keyboard and mouse task speed ns (in both conditions); combined keyboard and mouse task errors ns (in both conditions) Feasibility: user perception: 63% of participants thought it was feasible; adverse events: 9 reports of hip or gluteal discomfort	0.93
(48) Thompson, 2011; USA	11 medical transcriptionists	Treadmill desks; crossover; 2 d	Sedentary: NA Health: NA Work: work performance: tape completion ns, transcription errors ns, transcription time –, self-reported quality ns Feasibility: Preference for APW used 100%; 9/11 participants disagreed/ strongly disagreed that they were more tired using the APW; no one agreed that the workstation was too noisy; mixed feedback on productivity levels, no one agreed that the workstation interfered with work quality	0.67
Field-based studies				
(18) Alkhajah, 2012; Australia*	32 office workers (18 IG: 94.4% F, mean age 33.5 years SD 8.7; 14 CG: 85.7% F, mean age 39.9 years SD 7.2)	HADM; CT; 3 months	Sedentary (ActivPAL): 1 week: –143 min per 8-h workday (95% CI = –184, –102); 3 months: –137 min per 8-h workday (95% CI = –179, –95) Health: at 3 months: BMI ns; weight ns; body composition: fat-free mass ns, fat mass ns; waist ns; blood profile: total cholesterol ns, HDL +, triglycerides ns, glucose ns; fatigue ns, eye strain ns, headache ns, digestion ns, sleep problems ns, musculoskeletal symptoms ns Work: at 3 months: absenteeism ns, work performance ns Feasibility: at 3 months: positive feedback on ease of use, comfortable, enjoyable; majority of participants agreed or strongly agreed that the workstations were easy to use (94%); enjoyable (94%); comfortable (83%); 83% disagreed/disagreed strongly that they would like rather return to their original workspace setup; some negative feedback on elements of workstation design	1

Table 1 *Continued*

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
(22) Carr, 2011; USA	18 full-time office workers (88% F; mean age 40.2 years SD 10.7)	Portable pedal machines; pre-post; 4 weeks	Sedentary (workstation software): participants pedalled on 12.2/20 d (SD 6.6) on average for 23.4 min (SD 20.4) Health: NA Work: NA Feasibility: majority of participants reported positive feedback (i.e. median ≥4/5) regarding preference, ease of use, comfort; no visual disturbance, no interference with work-tasks	0.83
(23) Carr, 2013; USA*	49 overweight and non-active uni staff working in desk-based jobs	Portable pedal machines; blinded RCT; 12 weeks	Sedentary (workstation software): –58.7 min/d; participants pedalled for approx. 32 min in total on days they had access to pedal machines, with an average of 16 mins per pedalling bout Health: waist +; weight ns; BMI ns; blood profile: total cholesterol ns, HDL ns, LDL ns, triglycerides ns Work: NA Feasibility: Majority of participants (i.e. median ≥4/5) rated the pedal machines as helpful in reducing their workplace sedentary time	1
(19) Ellegast, 2012; Germany*	25 office workers (24% F)	HAD; RCT; 12 weeks	Sedentary (CUELA): –80 min/8-h workday (95%CI = –123, –37) Health: BMI +, 2× emotional well-being both +, fatigue +, musculoskeletal health: maximum trunk strength: flexion ns, extension ns; muscle endurance: shoulders ns, back ns, abdomen ns Work: NA Feasibility: NA	0.56
(50) Fidler, 2008; USA	2 radiologists (100% F)	Treadmill desk; crossover; 8 months	Sedentary: NA Health: NA Work: work performance + Feasibility: NA	0.75
(33) Gilson, 2012; Australia	11 office workers (64% F; mean age 46.9 years SD 9.8)	HAD (shared 4/11); pre-post; 1 week	Sedentary (wrist-worn accelerometer): ns Health: NA Work: NA Feasibility: NA	0.83
(34) Grunseit, 2013; Australia	19 office workers (53% F; 27–59 years; median age 46 years)	HAD; pre-post; 3 months	Sedentary (self-report): –102 min during workplace time (95% CI = –192, –14) Health: NA Work: NA Feasibility: main outcome; overall high usability and acceptability	0.83
(16) Healy, 2013; Australia*	43 office workers (56% F, mean age 43.2 years SD 10.3)	HADM; CT; 4 weeks	Sedentary (ActivPAL): –125 min/8-h workday (95% CI = –161, –89 min) Health: weight ns; body composition: fat mass ns, fat-free mass ns; waist ns; blood profile: glucose +, cholesterol ns, triglycerides ns; fatigue ns, eye strain ns; headache ns; digestion ns; sleep problems ns; musculoskeletal symptoms ns Work: work performance: overall ns, absenteeism ns, presenteeism ns Feasibility: no adverse outcomes	1
(55) Hedge, 2004; USA	33 office workers (42% F; mean age 38.6 years SD 2.1 across two companies)	HAD; RCT and crossover; 4–6 weeks	Sedentary (self-report): –16.5% during work hours Health: 8× time-of-day and mean discomfort: home morning ns, start work ns, late morning ns, all other +; 28-item musculoskeletal symptoms scale: right eye ns, left neck ns, hip both sides ns, right thigh ns, both lower legs ns, both feet ns, both upper arms ns, left elbow ns, all other + Work: productivity + Feasibility: workstation ratings: keyboard +, mouse +, chair +, workstation +; preference +	0.5

Table 1 *Continued*

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
(37) John, 2011; USA	12 overweight/obese office workers (58% F; mean age 46.2 years SD 9.2)	Treadmill desks; pre-post; 9 months	Sedentary (ActivPAL): 3 months: –182 min during total waking hours; 9 months: –88 (from baseline) during total waking hours Health: 3 months: weight ns; BMI ns; waist +; body composition: body fat (%) ns, fat mass (kg) ns, fat-free mass ns, truncal fat ns; blood profile: LDL ns, VLDL ns, HDL ns, total cholesterol +, triglycerides ns, glucose ns, insulin ns, glycosylated haemoglobin +; 9 months (in comparison to outcomes at 3 months): weight ns; BMI ns; waist +; body composition: body fat (%) ns, fat mass (kg) ns, fat-free mass ns, truncal fat ns; blood profile: LDL +, VLDL ns, HDL ns, total cholesterol +, triglycerides ns, glucose ns, insulin ns, glycosylated haemoglobin +) Work: NA Feasibility: NA	0.79
(38) Koepp, 2013; USA	36 employees with sedentary jobs (69% F; mean age 42 years SD 9.9)	Treadmill desks; pre-post; 1 year	Sedentary (hip-worn accelerometer): 6 months: –91 min (SD 66) during total waking hours; 12 months: –43 min (SD 67; from baseline) during total waking hours Health: 6 months: weight +; waist +; body composition: body fat ns, fat mass ns, fat-free mass +; blood profile: glucose ns, haemoglobin A1c +, total cholesterol ns, triglycerides ns, HDL ns, LDL ns; 12 months (in comparison with outcomes at baseline): weight +, waist +; body composition: body fat ns, fat mass ns, fat-free mass ns; blood profile: glucose ns, haemoglobin A1c ns, total cholesterol ns, triglycerides ns, HDL +, LDL ns Work: 6 months: work performance: 2× overall both ns, 2× quality both ns, 2× quantity both ns; 2× interaction both ns; 12 months: work performance: 2× overall both ns, 2× quality both ns, 2× quantity both ns; 2× interaction both ns Feasibility: adverse events: none, tolerance +	0.79
(40) Nerhood, 1994; USA	Office workers at an American parcel service provider	HAD; pre-post; 9 months	Sedentary: NA Health: body part discomfort: eyes ns, neck ns, shoulders ns, upper back +, upper arm ns, middle back +, lower back ns, lower arms/elbows +, wrists ns, hands ns, buttocks +, thighs +, knees +, legs +, feet + Work: absenteeism ns; productivity + Feasibility: injuries +; cost of injuries +	0.21
(56) Neuhaus, 2014; Australia*	44 office workers (84% F; mean age 42.6 years SD 11.5)	HADM; RCT; 3 months	Sedentary (ActivPAL): –33 min per 8-h workday (95% CI = –74, 7) Health: weight ns; musculoskeletal ns Work: work performance: overall ns, absenteeism ns, presenteeism ns Feasibility: adverse events: 1 (body pain); acceptability +; feasibility +	1
(56) Neuhaus, 2014; Australia*†	44 office workers (84% F; mean age 42.6 years SD 11.5)	HADM (plus additional strategies); RCT; 3 months	Sedentary (ActivPAL): –89 min/8-h workday (95% CI = –130, –47) Health: weight ns; musculoskeletal ns Work: work performance: overall ns, absenteeism ns, presenteeism ns Feasibility: no adverse events; acceptability +; feasibility +	1
(54) Parry, 2013; Australia*	62 office workers (80.6% F; mean age 43.5 years SD 6.4)	Treadmill desk or treadmill desk with cycle ergometer (shared 1/9, 1/6, and 1/4); cluster RCT; 12 weeks	Sedentary (hip-worn accelerometer): –1.7% during work hours Health: NA Work: NA Feasibility: no adverse events	0.88
(43) Paul, 1995a; USA	12 office workers (75% F; mean age 37 years)	HAD; pre-post; 3 months	Sedentary: NA Health: psychological well-being: feeling bored ns, sluggish +, alert +, energetic +; fatigue + Work: NA Feasibility: NA	0.5

Table 1 *Continued*

First author, year; country	Sample (*n*; description; gender; age)	APW, design, duration	Overall findings	Quality score (0–1)
(42) Paul, 1995b; USA	13 VDT operators	HAD; pre-post; 1 d	Sedentary: NA Health: spinal shrinkage – Work: NA Feasibility: NA	0.64
(44) Paul, 1995; USA	6 office workers (84% F; mean age 39 years)	HAD; pre-post; 6 weeks	Sedentary: NA Health: foot swelling: at 12 pm +, at 1pm ns, at 5pm + Work: NA Feasibility: NA	0.42
(45) Pronk, 2012; USA*	34 office workers (IG: 96% F, mean age 38.4 years SD 11.4; CG: 80% F, mean age 44.2 years SD 11.9)	HADM; CT; 4 weeks	Sedentary (self-report): –83 min during work hours (95% CI = –173, 7) Health: musculoskeletal symptoms: upper back +, neck +, lower back ns; psychological well-being: vigour+, tension+, confusion+, depression+, total mood disturbance+, anger ns, self-esteem ns; fatigue+ Work: organizational-cultural: time spent in face-to-face interactions ns Feasibility: no adverse events; overall positive feedback: 87% felt more comfortable, 87% more energized, 75% healthier, 7% more focused, 66% more productive, 62% happier, 33% less stressed	0.63
(20) Roelofs, 2002; Australia	30 bank tellers (80 F; mean age 27 years)	Standing desk without access to height-adjustable chair; crossover; 3 d	Sedentary: NA Health: musculoskeletal symptoms: body discomfort –, back ns, lower limb –, upper limb ns Work: NA Feasibility: sit/stand preferred by 70%, just sit 20%, just stand 10%	0.79
(20) Roelofs, 2002; Australia†	30 bank tellers (80 F; mean age 27 years)	Standing desk with access to height-adjustable chair; crossover; 3 d	Sedentary: NA Health: musculoskeletal symptoms: body discomfort ns, back ns, lower limb ns, upper limb ns Work: NA Feasibility: sit/stand preferred by 70%, just sit 20%, just stand 10%	0.79
(47) Thompson, 2007; USA	25 employees in the executive health program	Treadmill desks; pre-post; 6 weeks	Sedentary: NA Health: NA Work: NA Feasibility: no adverse events; overall positive feedback: workstation is too noisy (mean score 1.8/5), productivity improved (mean score 2.9/5), increased fatigue at end of day (mean score3.0/5), workstation did not interfere with patient care (mean score 3.9/5), preference for APW (mean score 4.4/5)	0.64

*Publications included in meta-analysis.

†Same study population as earlier.

+, statistically significant improvement in outcome; –, statistically significant worsening in outcome; %le, percentile; APW, activity-permissive workstation; BMI, body mass index; CI, confidence interval; CG, control group; CT, controlled trial; F, female; HAD, fully height-adjustable desk; HADM, Height-adjustable desk mount for computer only; HDL, high-density lipoprotein; IG, intervention group; KG, kilogram; LDL, low-density lipoprotein; M, male; NA, not applicable; ns, statistically non-significant; RCT, randomized-controlled trial; SD, standard deviation; VDT, video display terminal; VDU, video display unit; VLDL, very low-density lipoprotein.

Sedentary time was reported in 13 studies (across 14 independent comparisons). These were reported as overall sedentary time ($n = 3$), workplace sedentary time ($n = 6$) or both ($n = 5$). Health-related outcomes were reported in 23 studies. These included musculoskeletal symptoms (including body part discomfort, muscle load, spinal shrinkage and bone mineral density), cardio-metabolic biomarkers (weight, body mass index, waist circumference, body composition and blood profile), fatigue, psychological well-being (stress, emotional well-being, mood, and nervosity), leg/foot swelling and other (eye strain, headache, digestion problems, sleep problems, physical well-being). Work-related outcomes were reported for 23 studies. Because of overlap in the terminology across included publications, for the purpose of this review, most work-related outcomes were summarized as a compound category of 'work performance'. This included reports of cognitive performance (e.g. selective attention), attention control/concentration, accuracy, maths and reading comprehension, short-term auditory verbal memory, work pace, work performance, production levels, typing performance, and productivity. Three other work-related outcome categories were separately summarized as absenteeism, presenteeism and cultural-organizational (quality of interactions with co-workers, perceived group interaction, and time spent in face-to-face interaction with co-workers). Feasibility outcomes were reported for 19 studies. These included acceptability (including preference, tolerance and enjoyment) and adverse events.

Study quality scores ranged from 0.21 to 1.0 (Table 1 and Supporting Information Table S2), with an interrater agreement of 96%. On average, most studies provided an adequate description of the study participants (0.84), measurement methods used (0.80) and results (0.93). However, group allocation procedures, sample size calculations and methods to control for confounding were less well reported and were only rated a 'yes' by four, eight and four studies, respectively.

Sedentary time outcomes

Of the 14 comparisons reporting sedentary time at both baseline and follow-up, 11 used objective methods {$n = 5$ ActivPAL (PAL Technologies Limited, Glasgow, UK; a thigh-worn activity monitor that derives sedentary time from both posture and motion) (16,18,37,56); $n = 2$ hip-worn accelerometer (sedentary time derived from motion only) (38,54); $n = 1$ wrist-worn accelerometer (sedentary time derived from motion only) (33); $n = 2$ software linked to workstation (22,23); and $n = 1$ CUELA system (Institut fuer Arbeitesschutz der Deutschen Gesetzlichen Unfallversicherung [IFA], Sankt Augustin, Germany; consisting of seven inertial accelerometers and gyroscopes placed on the back, arms and legs) (19)} and three used self-report measures ($n = 1$ 'Occupational Sitting and Physical Activity Questionnaire' (34), $n = 1$ questionnaire about work patterns [not further specified] (55), and $n = 1$ experience sampling methodology and participants' estimates of time spent sitting per day (45)). A significant intervention effect for sedentary time was reported in 11/14 comparisons with an average reduction in workplace sedentary time of 90 min per 8-h workday (range: −8 to −143 min; $n = 8$) and in overall sedentary time of 111 min per day (range: −59 to −182 min; $n = 3$). One study reported a reduction of workplace sedentary time through the use of portable pedal exercise machines on 12/20 d for 23 min each day (no further data regarding statistical significance or average workplace sedentary time reduction across the 20 d were available) (22). One study, using manually height-adjustable desk mounts, reported a (non-significant) reduction in workplace sedentary time of 33 min/8-h workday (95% confidence interval [CI] = −74, 7 min, $P = 0.285$) (56). One study reported no change in workplace sedentary time following installation of height-adjustable ('hot') desks (33).

Eight independent comparisons (derived from seven studies) were suitable for inclusion in the meta-analysis, with all of them reporting workplace sedentary time (16,18,19,22,45,54,56). The observed pooled effect size on workplace sedentary time was −77 min per 8-h workday (95% CI = −120, −35 min). Heterogeneity was high and statistically significant ($I^2 = 91\%$, $P < 0.001$; Supporting Information Figure S1).

Of the three studies including an additional assessment of sedentary time, all reported sedentary time occurring during work hours (18,37,38). One reported average workplace sedentary time reductions of 143 min per workday from baseline to 1 week (95% CI = −184, −102; $P < 0.001$), and of 137 min per workday (95% CI = −179, −95; $P < 0.001$) from baseline to 3 months (18). While the other two studies reported somewhat attenuated intervention effects at the additional follow-up, they also observed statistically significant workplace sedentary time reductions. One study reported reductions of 182 min from baseline to 3 months and of 88 min from baseline to 9 months (37); and the other one reported −91 min from baseline to 6 months and −42 min from baseline to 12 months (38).

Adiposity and other health- and work-related outcomes

Table 2 shows a summary of the findings for the health- and work-related outcomes. Twenty-three studies included measures of health across a total of 239 outcomes. For the majority of outcomes, no significant change was observed. Notable improvements were seen for waist circumference and psychological well-being in 5/6 and 12/15 studies, respectively. Worsening of outcomes was observed in two (of 10) health-related outcome categories: musculoskeletal outcomes and leg/foot swelling. Musculoskeletal outcomes

Table 2 Summary of health and work outcomes stratified by study duration

Outcome (*n*)	Number of studies		Worsening (*n*)		No change (*n*)		Improvement (*n*)	
Study duration*	Short	Long	Short	Long	Short	Long	Short	Long
Health-related								
Musculoskeletal (*n* = 127)	13	4	16	0	56	15	32	8
Weight (*n* = 9)	1	5	0	0	1	6	0	2
Body mass index (*n* = 5)	0	4	–	0	–	4	–	1
Waist circumference (*n* = 6)	1	3	0	0	1	0	0	5
Body composition (*n* = 19)	1	3	0	0	2	16	0	1
Blood profile (*n* = 34)	1	4	0	0	2	23	1	8
Fatigue (*n* = 10)	6	3	0	0	4	1	3	2
Psychological well-being (*n* = 15)	3	2	0	0	2	1	7	5
Leg/foot swelling (*n* = 5)	2	0	1	–	2	–	2	–
Other (*n* = 9)	2	1	0	0	4	4	1	0
Total health-related (*n* = 239)	15	8	17	0	74	70	46	32
Work								
Work performance (*n* = 99)	17	5	21	0	56	15	5	2
Absenteeism (*n* = 5)	1	3	0	0	1	4	0	0
Presenteeism (*n* = 3)	1	1	0	0	1	2	0	0
Cultural-organizational (*n* = 5)	1	1	0	0	1	4	0	0
Total work (*n* = 112)	18	5	21	0	59	25	5	2

*Study duration was defined as: short, <12 weeks; long, ≥12 weeks.

–, indicates that the outcome was not measured in any study of that particular duration.

worsened in 16/122 outcome reports among 6/17 studies, of which two used standing desks without height-adjustable chairs, three used standing desks with height-adjustable chairs, and one used height-adjustable desks. An increase in leg circumference was observed in one of five leg/foot swelling outcomes, with standing desks without height-adjustable chairs being used in this study. Twenty-three studies reported work-related outcomes across a total of 112 outcomes. The majority of work performance outcomes (84/112) remained unchanged following installation of activity-permissive workstations. Deleterious impacts were observed in 21/99 work performance outcomes across 7/23 studies, of which six used treadmill desks and one cycle ergometers.

Feasibility outcomes

Nineteen studies reported on the feasibility of activity-permissive workstations in the workplace setting. Because of the typically qualitative nature of the measures used, it was not possible to summarize them numerically. However, studies reported overall positive feedback from participants, with only one of 19 studies specifically reporting less 'liking' of standing posture when compared with sitting (49). Three studies reported negative feedback from participants regarding the workstation design (16,18,56). Seven studies collected data on adverse events with one study reporting an incident of a participant asking for removal of the workstation for reasons of body pain (56) and one study reporting leg discomfort in three participants (46). One study qualitatively examined the acceptability and usability of height-adjustable desks in the workplace as a main outcome and reported high acceptability feedback from participants (34). In this study, the use of activity-permissive workstations was strongly driven by perceived health benefits and improved productivity and suggestions for successful implementation and continued use were given (e.g. rearrangement of surrounding office furniture to standing height, and use of electric rather than wind-up mechanisms for height-adjustable desks).

Discussion

This is the first systematic literature review and meta-analysis to collate the evidence on the impact of activity-permissive workstations on office workers' sedentary time, health- and work-related outcomes, and their feasibility in office-based settings. It builds on an earlier narrative review that specifically focused on the potential of such workstations to increase energy expenditure, and on their use and acceptability among office workers (21). Our findings suggest that the installation of such workstations can lead to substantial reductions in sedentary time without impacting negatively on work-related outcomes; and that they are acceptable to workers. As many of the findings regarding adiposity and other health-related outcomes were based on evidence from short-term studies with weak-to-moderate designs and/or insufficient statistical power, the impact of activity-permissive workstations on health-related parameters is at this point inconclusive and warrants further

attention. While only three studies included an additional assessment of workplace sedentary time (i.e. 3–12 months), all of these studies observed sustained behaviour change suggesting the potential for long-term benefits.

The pooled intervention effect on workplace sedentary time of –77 min per 8-h workday across studies included in the meta-analysis is markedly higher than what has been observed in intervention studies without an environmental support element (ranging from –21 min/8-h workday, $P = 0.084$ (22) to –48 min/16-h waking day, $P < 0.05$ (22)) (59–61). Furthermore, the intervention effect seen in this review may be clinically relevant, with a recent meta-analysis reporting that the risk of all-cause mortality increased by 5% for each 1-h increment in daily sitting time per day for adults who sit 7 h or more per day (11). However, our findings should be interpreted with caution, given the methodological quality and sample size issues in many of the studies included in this review.

Strikingly few detrimental effects on health-related outcomes were reported across included studies and only in those with a short duration (i.e. <12 weeks), suggesting that the use of activity-permissive workstations is unlikely to cause harm in the workplace. However, as few of the studies included were sufficiently powered to detect changes in health-related outcomes (16), this finding should be interpreted with caution. Predominantly positive findings were observed on psychological well-being and waist circumference. The positive impact on psychological well-being is consistent with findings from epidemiological studies showing an association of sedentary time with lowered mood and depression (62,63). Whether this is mediated through increased perceived behavioural control (i.e. self-control in relation to work posture without being constrained to the chair) as suggested by occupational health psychology literature (64), remains to be examined. The reduction in waist circumference observed across several studies is consistent with epidemiological findings showing beneficial associations of breaks in sedentary time (i.e. regular postural transitions) with waist circumference (65), and may be the result of higher skeletal muscle activation of the postural muscles through more frequent postural changes and higher volumes of standing time (66–68). However, the evidence is still limited, and more studies are needed to confirm these results. Worsening of health-related outcomes was only observed in two of 10 categories (musculoskeletal symptoms and leg swelling). Notably, increases in musculoskeletal symptoms were predominantly observed in studies using standing (i.e. not height-adjustable) desks. While the amount of standing time (as well as the pattern of time spent sitting, standing and moving throughout the working day) may be an important predictor of these or other adverse health outcomes (69,70), none of the studies included in this review reported such information in detail. Furthermore, while provision of standing desks without access to a seated workstation enables office workers to decrease their workplace sedentary time, it is likely to result in increased discomfort as a result of the absence of postural variety opportunities (71,72). Standing-only workstations also do not conform to ergonomic recommendations encouraging postural variety through regular and frequent postural changes (14,73). Overall, to fully understand the impact of activity-permissive workstations and associated sedentary time reductions on health-related outcomes, larger-scale randomized-controlled trials are needed (74).

Intervention effects were also statistically non-significant for the majority of work-related outcomes. However, our review findings suggest that the use of treadmill desks or cycle ergometers during work time may lead to some decreases in work performance. Of the 112 work-related outcomes that were measured, 21 worsened. Of these, 16 were reported in studies using treadmill desks (36,41,46,48,51), with the other five reported in studies using cycle ergometers (46,53). A recent study suggested that a certain acclimatization period may be necessary for the improvement of work performance parameters when such activity-permissive workstations are used (75). Notably, the studies reporting worsening of work-related outcomes were all of acute duration of either one (41,46,51,53) or two days (36,48). Future studies using a longer-term follow-up should examine if a longer acclimatization period will lead to an offset of these negative impacts.

Half of the studies included in our review assessed at least some aspect regarding the feasibility of the implementation of activity-permissive workstations in office-based workplaces, with predominantly positive feedback from participants reported. However, some studies identified some negative feedback from participants on aspects of workstation design, suggesting that a range of workstation models should be considered and tailored to individual needs and work tasks. In relation to this, it is notable that only a minority of included publications reported on the mechanisms (i.e. electric vs. non-electric) of the height-adjustable workstations used, or the time it takes to adjust their height.

Longer-term maintenance of health behaviour change has been challenging in the context of other prevalent health-risk behaviours such as physical activity and diet and still not consistently measured and reported (76). In this review, we identified only three studies in which an additional assessment of workplace sedentary time was included, beyond an initial intervention period. Extended follow-up (i.e. >1 year) in future studies will further enable evaluation of the impact of activity-permissive workstations on longer-term outcomes such as cardio-metabolic disorders and productivity (including absenteeism and presenteeism), some of which are outcomes particularly relevant for informing the business case for their use.

The main strengths of this review include the extensive and cross-disciplinary literature search; the systematic summary of sedentary, health-related, work-related and feasibility outcomes across several hundred outcome measures; and the meta-analysis of sedentary time outcomes. However, when interpreting the results, the following limitations should be considered. (i) Non-English publications were excluded from review, the search was limited to peer-reviewed publications. (ii) Twelve of 38 included publications were identified through the authors' libraries and cross-references rather than the database search. This speaks to the multidisciplinary nature of the field and of the diverse and inconsistent use of terminology. While an extensive search strategy was applied to address this challenge, other relevant studies may have been missed. (iii) Some relevant evidence is likely to exist in the grey literature (e.g. business reports (77)), and while not peer-reviewed, such evidence could provide further useful insights particularly into work-related and feasibility outcomes. (iv) As most work-related outcomes were summarized as a compound category of 'work performance', potential differences between aggregated outcomes may have been missed. (v) While four studies received the maximum quality score, the list of quality scoring categories was not comprehensive and items such as duration of follow-up and generalizability of the study results were not explicitly scored. (vi) As per inclusion criterion, all participants of included studies had to be engaged in administrative (i.e. not manufacturing, but with reliance on engagement with a computer) tasks while using the activity-permissive workstations. However, the work tasks performed may have slightly differed between laboratory-based studies (e.g. fine-motor skills test) and field studies (i.e. 'typical' administrative tasks), which may have influenced sedentary time as well as other outcomes. (vii) Finally, as most work-related outcomes were summarized as a compound category of 'work performance', potential differences between aggregated outcomes may have been missed.

Based on the findings from this review, the following recommendations are provided for future studies. (i) In relation to the second limitation mentioned earlier, the use of common terminology for the reporting of outcomes is needed to facilitate comparability of future studies. (ii) Most studies including sedentary time measures reported on reductions in total sedentary time only. However, the pattern through which sedentary time is accrued throughout the day (i.e. through multiple smaller bouts and frequent posture changes) is also important for health-related outcomes (4,78) and should be reported in future studies. (iii) Larger-scale randomized-controlled trials with long-term follow-up (≥1 year) assessments are needed to fully understand potential long-term impacts of activity-permissive workstations and related reductions in sedentary time on health- and work-related outcomes. (iv) Finally, a number of different workstation types were included in this review, with models varying in both functionality and cost. Considering that the incorporation of activity-permissive workstations is likely to depend on both office design and work tasks undertaken, it is important for future studies to describe details on the make, model, target population and typical work tasks conducted during workstation use.

Conclusion

The installation of activity-permissive workstations in office-based workplaces is likely to be a feasible and acceptable means to reduce office workers' sedentary time, with mostly neutral or positive impacts on adiposity and other health- and work-related outcomes. Further intervention trials are required, particularly with more rigorously controlled study designs, adequate statistical power and longer-term follow-ups to identify impacts on health-related outcomes as well as long-term maintenance of sedentary time reductions.

Conflict of interest statement

Healy presented at an Office Ergonomics Research Committee (OERC) meeting in 2013. OERC covered travel and accommodation expenses and also provided an honorarium. Dunstan and Healy presented at the 'Juststand Wellness Summit', a conference organized by Ergotron, in 2012 and 2013, respectively. Ergotron covered travel and accommodation expenses. No further honoraria or imbursements were received. The funding bodies had no influence on the conduct or the findings of the study.

Acknowledgements

Neuhaus and Reid were supported by an Australian Postgraduate Award and a UQ School of Population Health Top-Up Scholarship. Eakin and Straker were supported by a National Health and Medical Research Council (NHMRC) Senior Research Fellowship grant (#511001 and #APP1019980, respectively). Owen and Healy were supported by an NHMRC Program Grant (#569940 and #569861, respectively). Owen was also supported by an NHMRC Senior Principal Research Fellowship (#1003960). Owen and Dunstan were supported by the Victorian Government's Operational Infrastructure Program. Dunstan was also supported by an Australian Research Council Future Fellowship (#FT100100918) and by the Victorian Health Promotion Foundation. Healy was also supported by a Heart Foundation (PH 12B 7054) fellowship. Eakin, Owen, Dunstan and Healy were supported by an NHMRC Centre for Research Excellence

Grant on Sitting Time and Chronic Disease Prevention – Measurement, Mechanisms and Interventions (APP1057608).

Supporting information

Additional Supporting Information may be found in the online version of this article, http://dx.doi.org/10.1111/obr.12201

Figure S1. Forest plot of workplace sedentary time reductions reported by studies included in the meta-analysis.
Table S1. Search strategy.
Table S2. Quality scores of included publications.

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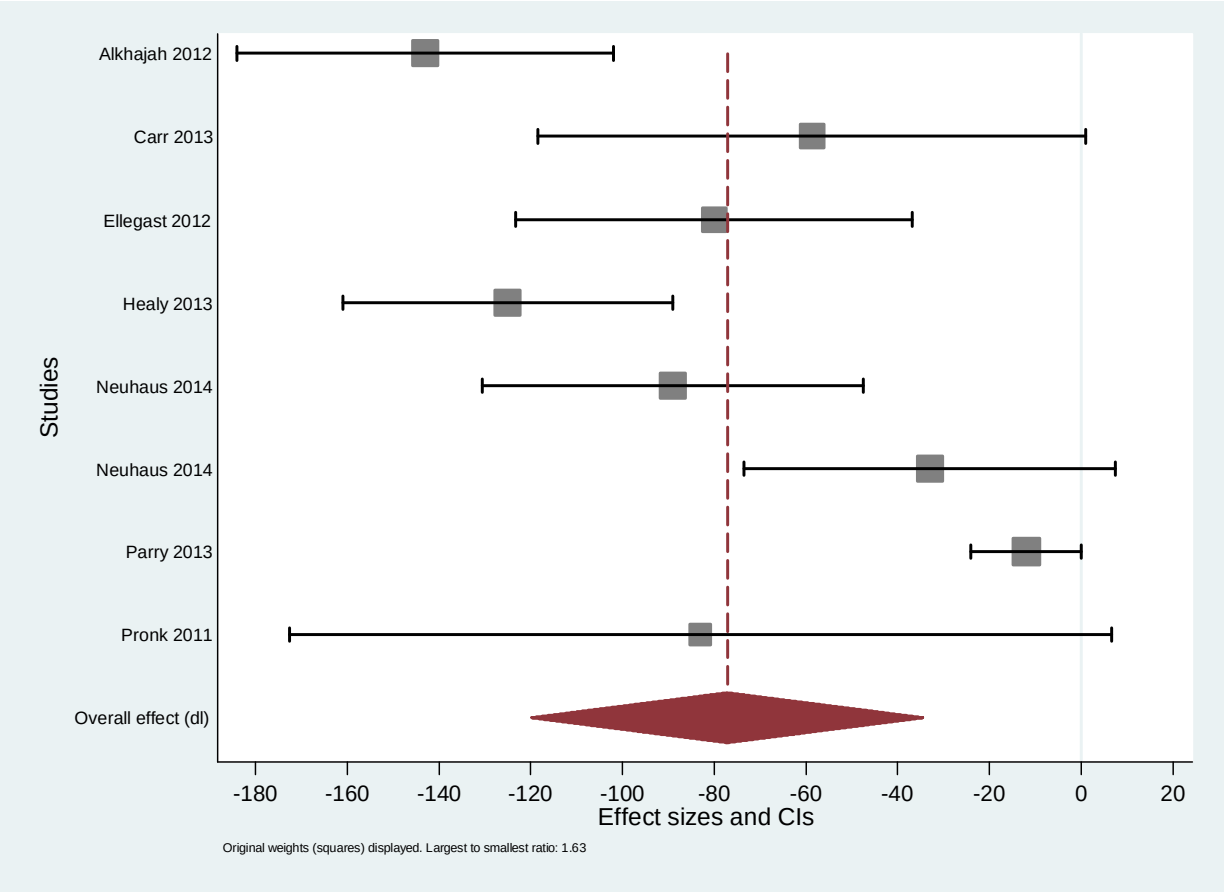
Supplementary Figure. Forest plot of workplace sedentary time reductions reported by studies included in the meta-analysis



* Pooled effect size = -77 minutes per 8-hour workday (95% CI= -120, -35 minutes; dotted line); weights are from random effects analyses

Supplementary Table 1. Search strategy

SEARCH I		**SEARCH II**	
Activity-permissive workstations	*Workplace*	*Workplace SB*	*Intervention*
"pedal device*" OR "pedal machine*" OR "stepping device*" OR "stepping machine*" OR "pedal exercise machine*" OR treadmill* OR "activity permissive" OR activity-permissive OR "height adjustable" OR height-adjustable OR "standing desk*" OR "standing hot desk*" OR "active workstation*" OR "standing workstation*" OR "walking workstation*" OR sit-to-stand OR sit-stand OR "sit to stand" OR "sit stand" OR "walk and work"	Workplace* OR worksite* OR company OR companies OR office* OR worker* OR employee* OR "call cent*" OR job OR jobs	"workplace standing" OR "workplace sitting" OR "office standing" OR "office sitting" OR "sedentary office*" OR "sedentary workplace*" OR "occupational sitting" OR "work posture" OR "work sitting" OR "sitting at work" OR “VDU work*” OR "VDT work*" OR "VDU user" OR "VDU users" OR "VDT user" OR "VDT users" OR "VDT office*" OR "VDU office*" OR "VDT operator*" OR "VDU operator*" OR “video display unit work*” OR "video display terminal work*" OR "video display unit user" OR "video display unit users" OR "video display terminal user" OR "video display terminal users" OR "video display terminal office*" OR "video display unit office*" OR "video display terminal operator*" OR "video display unit operator*" OR “visual display unit work*” OR "visual display terminal work*" OR "visual display unit user" OR "visual display unit users" OR "visual display terminal user" OR "visual display terminal users" OR "visual display terminal office*" OR "visual display unit office*" OR "visual display terminal operator*" OR "visual display unit operator*" OR "computer terminal user*" OR "computer terminal work*"	Intervention* OR program* OR trial* OR study OR studies OR RCT OR random*

Supplementary Table 2. Quality scores of included publications.

Study	Recruit.	Participants	Allocation	Measure	Sample size	Variance	Confounding	Results	TOTAL
Aaras, 1997	1	2	1	2	1	2	N/A	2	0.79
Alderman, 2013	2	2	1	2	1	2	N/A	2	0.86
Alkhajah, 2012	2	2	N/A	2	2	2	2	2	1.00
Beers, 2008	1	2	1	2	1	2	N/A	1	0.83
Carr, 2011	2	2	N/A	1	2	2	N/A	1	0.83
Carr, 2013	2	2	2	2	2	2	2	2	1.00
Chester, 2001	1	2	1	1	1	0	N/A	2	0.57
Cox, 2011	1	1	1	2	1	2	0	2	0.63
Davis, 2009	2	1	1	1	1	1	N/A	2	0.64
Ebara, 2008	2	2	1	1	2	2	N/A	2	0.86
Edelson, 1989	2	2	1	2	0	0	N/A	2	0.64
Ellegast, 2012	1	1	1	2	1	1	0	2	0.56
Fidler, 2008	1	2	N/A	2	1	1	N/A	2	0.75
Funk, 2012	1	2	1	2	1	2	N/A	2	0.79
Gilson, 2012	2	2	N/A	2	0	2	N/A	2	0.83
Grunseit, 2013	2	2	N/A	1	1	2	N/A	2	0.83
Hasegawa, 2001	0	1	0	1	1	0	0	2	0.31
Healy, 2013	2	2	N/A	2	2	2	2	2	1.00
Hedge, 2004	1	2	1	1	1	0	0	2	0.50
Husemann, 2009	1	1	1	2	1	2	1	2	0.69
John, 2009	1	2	1	2	1	2	N/A	2	0.79
John, 2011	2	2	N/A	2	1	2	0	2	0.79
Koepp, 2013	2	2	N/A	2	1	2	0	2	0.79
Koren, 2013	1	2	N/A	1	1	2	N/A	1	0.67
McAlpine, 2007	1	2	N/A	1	1	2	N/A	2	0.75
Nerhood, 1994	1	0	N/A	1	0	0	0	1	0.21
Neuhaus, 2014	2	2	2	2	2	2	2	2	1.00
Ohlinger, 2011	1	2	N/A	2	1	2	N/A	2	0.83
Parry, 2013	2	2	2	1	2	2	1	2	0.88
Paul, 1995a	1	2	N/A	0	1	0	N/A	1	0.42

Paul, 1995b	1	2	0	2	1	1	N/A	2	0.64
Paul, 1995	1	1	0	2	1	1	0	2	0.50
Pronk, 2012	2	2	1	2	1	0	0	2	0.63
Roelofs, 2002	2	2	1	1	1	2	N/A	2	0.79
Seo, 1996	1	2	N/A	1	1	2	N/A	2	0.75
Straker, 2009	2	2	2	2	1	2	N/A	2	0.93
Thompson, 2011	2	0	1	2	2	0	N/A	2	0.64
Thompson, 2007	2	0	N/A	2	1	1	N/A	2	0.67
TOTAL	0.74	0.84	0.55	0.80	0.57	0.71	0.33	0.93	

2.3 Discussion

Overall, the findings from this systematic review support the effectiveness of activity-permissive workstations to reduce workplace sedentary time. However, the way in which the workstations were implemented across studies varied considerably. For example, some studies addressed the physical work environment only (via installation of workstations (96, 132, 133)), while others additionally addressed personal health resources (e.g., via education on the benefits of reducing sedentary time (134)) or the psychosocial work environment (e.g., via public promotion of incidental office activity (135)). Notably, only a few of the studies addressed the multiple dimensions suggested by the *Healthy Workplace Framework* (109) and other workplace health promotion literature (111, 112). From a practical perspective, the extant evidence provides limited guidance to the most feasible and appropriate approaches to using activity-permissive workstations to reduce workplace sedentary time.

The next two chapters address this gap in practice-focussed evidence. Chapter 3 (Study 2) describes the systematic development of an evidence-based multi-component intervention to reduce workplace sedentary time which included activity-permissive workstations and strategies targeting personal health resources and the psychosocial work environment. Chapter 4 (Study 3) involves a comparison of the effectiveness of this multi-component intervention to an intervention comprising installation of activity-permissive workstations only, in a 3-arm trial.

CHAPTER 3. Development of a multi-component intervention to reduce workplace sedentary time

3.1 Introduction

The systematic literature review presented as Study 1 of this PhD research supported the effectiveness of activity-permissive workstations to reduce workplace sedentary time. However, this review also identified few commonalities in the manner in which such workstations were implemented across studies. In particular, only a few studies addressed the multiple levels of influence on workplace health behaviour. Study 2 of this PhD research therefore consisted of the evidence-guided and systematic development of *Stand Up Australia* - a multi-component workplace intervention to reduce sedentary time in office workers. This intervention includes strategies targeting three of the four broader dimensions of the *Healthy Workplace Framework* (109): 1) the physical work environment (through installation of height-adjustable workstations); 2) office workers' personal health resources (e.g. through individual face-to-face coaching); and, 3) the psychosocial work environment (e.g. through management consultations and training of workplace champions; Figure 3.1).

Figure 3.1. Dimensions of the *Healthy Workplace Framework* addressed in the context of Study 2 of this PhD research (highlighted in yellow).

Across these dimensions, the *Stand Up Australia* intervention incorporates strategies to facilitate behaviour change in line with its three key messages: *Stand Up, Sit Less, and Move More*. *Stand Up* is a prompt to break-up long, unbroken bouts of sitting of 30 minutes or more. The aim of *Sit Less* is to reduce total workplace sitting time through substituting some sitting with standing (primarily through the use of the sit-stand workstation supplied as part of the intervention). And, *Move More* aims to increase incidental (light-intensity) movement throughout the working day. As the next section will describe in more detail, these messages were derived from a combination of the current guidelines on sedentary behaviour, recommendations from the occupational ergonomic literature and results from recent laboratory studies examining different patterns of activity and sedentary behaviour.

3.2 Guidelines used to inform intervention messages

Physical activity guidelines around the globe increasingly recognise high volumes of sedentary time as a health risk factor and include advice to reduce sedentary time. For example, the American College of Sports Medicine's *Guidelines on Exercise for Health Professionals* advise that *"Reducing total time spent in sedentary pursuits and interspersing short bouts of physical activity and standing between periods of sedentary activity should be a goal for all adults, irrespective of their exercise habits"* (8). Guidelines from the Department of Health in the UK recommend that *"All adults should minimise the amount of time spent being sedentary (sitting) for extended periods"* (136). And, following the release of strategies to *"Sitting less for adults"* by the Australian National Heart Foundation in 2011 (137), the Australian National Physical Activity and Sedentary Behaviour Guidelines now also advise to *"minimise the amount of time spent in prolonged sitting"* and to *"break up long periods of sitting as often as possible"* (138). This uptake of the epidemiological evidence on the detrimental health impacts of excessive sitting into public health guidelines is an inevitable basis for the dissemination of public health efforts to reduce sedentary time. However, the vagueness of these recommendations to date is evident, limiting their practicality for use in intervention studies such as the *Stand Up Australia* intervention, where messages pointing to specific behavioural goals can be crucial for intervention success (22). The following additional guidelines from other disciplines were therefore used to inform the development of the key messages of the *Stand Up Australia* intervention.

As described in Chapter 1 of this thesis, the occupational ergonomic research discipline advocates to reduce episodes of prolonged static sitting to avoid musculoskeletal symptoms. The ergonomic literature thus suggests to break up prolonged sitting at least once every 20-30 minutes (139, 140). Simultaneously, it is emphasized in this literature that prolonged standing may be accompanied with health impairments such as leg and foot swelling (141, 142) or varicose veins (143, 144). Accordingly, another ergonomic recommendation is to adopt a variety of postures with regular postural changes between sitting, standing and moving (145). These ergonomic guidelines are supported by some recently published laboratory studies, in which regular breaks in sedentary time every 20 minutes (64) or 30 minutes (65, 74) with either light- to moderate-intensity physical activity had cardiovascular benefits such as lower insulin and blood glucose levels (see Section 1.3.1). Together, this evidence informed the first *Stand Up Australia* intervention message to *Stand Up* at least every 30 minutes. The message *Sit Less* was based on the substantial epidemiological evidence showing that high volumes are associated with numerous detrimental health impacts and premature mortality (see Section 1.3). And, *Move More* was based on evidence showing that light-intensity physical activity can play a significant role in daily energy expenditure and is thus an important contributor to overall health (146).

Results of Study 2 were published as a peer-reviewed paper in the *International Journal of Behavioral Nutrition and Physical Activity*, detailing the development of the *Stand Up Australia* intervention (Section 3.3). In this paper, a number of frameworks were used to inform intervention development, including but not limited to, the key dimensions of the *Healthy Workplace Framework* (109). Accordingly, the terminology used in the paper deviates as follows: strategies addressing the ‘physical work environment’ were referred to as ‘environmental’ intervention strategies; strategies addressing ‘personal health resources’ were referred to as ‘individual’ intervention strategies; and, strategies targeting the ‘psychosocial work environment’ were referred to as ‘organisational’ intervention strategies.

Interview protocols and summaries of both the pilot study examining the efficacy and feasibility of the *Stand Up Australia* intervention as well as of the workstation pilot study are provided in Appendix A. A comprehensive compilation of the *Stand Up Australia* intervention materials is supplied in Appendix B (see Section 4.1).

3.3 Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting

Neuhaus, M., Healy, G.N., Fjeldsoe, B.S., Lawler, S., Owen, N., Dunstan, D.W., LaMontagne, A.D., Eakin, E.G. (2014). *Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting.* International Journal of Behavioral Nutrition and Physical Activity 11:21.

INTERNATIONAL JOURNAL OF BEHAVIORAL NUTRITION AND PHYSICAL ACTIVITY

METHODOLOGY Open Access

Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting

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Abstract

Background: Sitting, particularly in prolonged, unbroken bouts, is widespread within the office workplace, yet few interventions have addressed this newly-identified health risk behaviour. This paper describes the iterative development process and resulting intervention procedures for the *Stand Up Australia* research program focusing on a multi-component workplace intervention to reduce sitting time.

Methods: The development of *Stand Up Australia* followed three phases. 1) Conceptualisation: *Stand Up Australia* was based on social cognitive theory and social ecological model components. These were operationalised via a taxonomy of intervention strategies and designed to target multiple levels of influence including: organisational structures (e.g. via management consultation), the physical work environment (via provision of height-adjustable workstations), and individual employees (e.g. via face-to-face coaching). 2) Formative research: Intervention components were separately tested for their feasibility and acceptability. 3) Pilot studies: *Stand Up Comcare* tested the integrated intervention elements in a controlled pilot study examining efficacy, feasibility and acceptability. *Stand Up UQ* examined the additional value of the organisational- and individual-level components over height-adjustable workstations only in a three-arm controlled trial. In both pilot studies, office workers' sitting time was measured objectively using activPAL3 devices and the intervention was refined based on qualitative feedback from managers and employees.

Results: Results and feedback from participants and managers involved in the intervention development phases suggest high efficacy, acceptance, and feasibility of all intervention components. The final version of the *Stand Up Australia* intervention includes strategies at the organisational (senior management consultation, representatives consultation workshop, team champions, staff information and brainstorming session with information booklet, and supportive emails from managers to staff), environmental (height-adjustable workstations), and individual level (face-to-face coaching session and telephone support). *Stand Up Australia* is currently being evaluated in the context of a cluster-randomised controlled trial at the Department of Human Services (DHS) in Melbourne, Australia.

Conclusions: *Stand Up Australia* is an evidence-guided and systematically developed workplace intervention targeting reductions in office workers' sitting time.

Keywords: Intervention development, Sedentary behaviour, Sitting time, Sit-stand, Physical activity, Postural transitions, Workplace, Workplace intervention, Office workers, Height-adjustable workstations

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Background

Sedentary behaviour – sitting or lying down while expending little energy [1] - is a newly identified health risk behaviour that is detrimentally associated with several health outcomes, including cardiovascular disease and premature mortality [2-4]. Emerging evidence suggests that both total sitting time and prolonged individual bouts thereof are linked to chronic diseases [5,6]. Further, sedentary behaviour is ubiquitous with adults spending more than half of their waking hours sitting down while watching television, travelling in cars, or working [7,8]. Thus, interventions aiming to reduce sitting time in adults have been identified as an important public health initiative [9].

An opportunistic, high-reach setting for sedentary behaviour intervention is the office-based workplace [10]. Office workers constitute one of the largest occupational groups in industrialised countries such as the US [11], who spend approximately half of their waking hours at work [12]. Importantly, recent studies have shown that they sit for an average of six hours during an eight-hour workday, with this sitting time often accumulated through prolonged unbroken bouts of 30 minutes or more [13-16]. Emerging evidence suggests that targeting workplace sitting through strategies such as modifying the physical work environment [13,17-20], the provision of education sessions and behaviour change advice [16,21,22], or a combination of these strategies [23,24], can be effective. However, information on the development processes of these interventions, such as behaviour change models used and the operationalisation of constructs into intervention messages is limited.

Detailed reporting of intervention development and content is vital to advance intervention research and intervention effectiveness in public health [25]. This should include the theoretical model, targeted context, and formative research and evaluation methods used [10,26-28]. While this type of work is increasingly being published across a number of disciplines including physical activity [29], nutrition [30], chronic disease management [31], and smoking cessation [32] interventions, to the best of our knowledge, no publications have described the development of an intervention to reduce workplace sitting time in adults.

The purpose of this paper is to systematically describe the evidence-based iterative development of the *Stand Up Australia* intervention whose primary aim is to reduce workplace sitting time in office workers. The increasing number of sedentary behaviour publications in both the scientific and popular press over the past decade has led to a demand from office-based workplace settings for assistance with reducing employee sitting. Such requests provided the opportunity for collaborative development of the *Stand Up Australia* intervention, particularly through the formative research phases described below. In accordance with the workplace health promotion literature [33,34] and ecological models of sedentary behaviour [35], *Stand Up Australia* considers the multiple influences on workplace sitting and addresses them via a multi-component approach including behaviour change strategies at the organisational/managerial, environmental, and individual level. The following intervention development description aims to provide a resource for researchers and public health practitioners with a level of detail beyond the restriction of a conventional intervention methods paper.

Methods

Identification of an intervention development framework

The systematic development of the *Stand Up Australia* intervention was guided by an intervention development framework. A number of frameworks informed the broader intervention development principles, including the PRECEDE-PROCEED model [36] and the Intervention Mapping approach [37]. Given the specific (workplace) context, a workplace health promotion framework was chosen as the core approach [34], with elements of two other frameworks [38,39] used to complement this method. This included the following key elements: a phased and iterative approach in the development of the intervention [38]; the use of quantitative and qualitative evaluation methods to inform the intervention content [38]; formative research with the target group [39]; and, integration of interrelated dynamics of intra-individual, social, organisational, political, and economic factors within the workplace context [34]. The development of the *Stand Up Australia* intervention involved three phases: 1) Conceptualisation (literature review and theoretical grounding); 2) Formative research (with the target audience); and, 3) Pilot testing of the efficacy, acceptability and feasibility of the integrated multiple components relative to a control group. More specifically, the additional value of the organisational and individual intervention components over an environment (height-adjustable workstations)-only intervention was examined in a three-arm trial. The pilot studies included objective measurement of office workers' sitting time, as well as quantitative and qualitative data collection from managers and staff.

Intervention development across 3 phases

Phase 1: conceptualisation

Stand Up Australia was based on social cognitive theory, which emphasizes the key constructs of self-efficacy, outcome expectancies (physical, social, and self-evaluative), and socio-structural factors (facilitators and impediments) [40]. Evidence on social-cognitive determinants as predictors of sedentary behaviour is still limited [35,41]. However, social cognitive theory has been widely and

successfully used in physical activity intervention studies [42]. The operationalisation of theoretical constructs into intervention strategies was guided by an intervention taxonomy [26,43].

Furthermore, *Stand Up Australia* was conceptualised as a multi-component approach to the workplace. Social ecological models of sedentary behaviour emphasize the importance of considering the multiple interrelated influences on individual behaviour. These include the policy environment, the physical and psychosocial environment, and intrapersonal factors [35]. Similarly, best-practice workplace health promotion frameworks identify these influences as key factors for behaviour change strategies in the workplace setting [34,44,45]. In accordance with these models and frameworks, this approach included strategies designed to address organisational structures and the office environment, as well as individuals. By targeting these multiple levels, the aim was to not only raise awareness of sitting behaviours in the workplace, but also to facilitate habitual change via addressing the environment and the workplace culture. Furthermore, key elements in workplace health promotion as identified by the World Health Organization [44] were applied to this sedentary behaviour intervention context as shown in Table 1.

Finally, based on evidence from successful intervention trials on workplace physical activity (the behaviour closest to the one of interest) *Stand Up Australia* is ideally delivered over the course of at least three months [46].

Conceptualisation of organisational-level strategies Effective workplace health promotion interventions address organisational structures and group dynamics through a participative approach and visible management support [33,45]. A participatory approach directly involves staff from all levels (in contrast to a top-down approach) in the identification of well-suited behaviour change strategies and barrier identification. This makes the intervention context-sensitive and appropriate, and thus likely to be implemented and sustained. Within *Stand Up Australia*, this participative approach was implemented through its iterative design including formative research, brainstorming sessions and qualitative feedback interviews. This involved all levels of staff including occupational health and safety (OHS) personnel, workplace safety advisors, and corporate ergonomists (depending on the size of the targeted workplace, this includes senior- and middle managers, as well as team leaders/team champions).

The implementation of *Stand Up Australia* began with initial contact with senior managers within the organisation to elicit support for the study. Further strategies included a representatives consultation workshop and a sedentary behaviour information and brainstorming session for staff, with an accompanying electronic information booklet. During the representatives consultation workshop team champions were selected. They played a crucial part in the identification of behaviour-change opportunities suited to their workplace and in delivering one of the organisational intervention components (sending management emails in support of the study to participating staff).

Conceptualisation of environmental-level strategies Activity-permissive workstations allow office workers to stand, walk, or pedal while working at their usual computer and desk-based job tasks. Examples of activity-permissive workstations include treadmill desks, stepping or pedal devices that are fitted underneath the desk, and height-adjustable workstations. Height-adjustable workstations enable office workers to complete their desk-based and/or computer tasks while alternating between sitting and standing without significant disruption of work practices. Traditionally acquired for the prevention of musculoskeletal problems [47,48], their potential to reduce sitting time for broader preventive-health benefits is increasingly being recognised [10].

Throughout all *Stand Up Australia* study development and implementation phases, manually height-adjustable workstations of the type *WorkFit-S* (manufactured and provided by Ergotron; www.ergotron.com) were used. These workstations were chosen as they enabled a 'retro-fit' to existing office furniture. They were also less expensive than fully height-adjustable desks. Other environmental-based strategies (e.g. centralisation of printers or in-office waste bins) could be identified in the brainstorming sessions, but the primary focus of this strategy was the use of the height-adjustable workstations.

Conceptualisation of individual-level strategies In line with evidence from successful health intervention programs [49], individual-level intervention strategies were mainly delivered through a face-to-face coaching session with follow-up support telephone calls using a motivational interviewing approach [50]. The face-to-face session followed a script which is very detailed but allowed the consultant to tailor the coaching to the needs of the individual. While there is no firm evidence for an ideal amount of telephone-delivered intervention contact, a recent review suggests that a higher number of telephone contacts is associated with better health behaviour outcomes [51]. In the case of *Stand Up Australia*, where there was an intervention period of three months, four calls were considered to provide an appropriate balance of participant support and time involvement for both participants and researchers.

Intervention messages *Stand Up Australia* targeted three key intervention messages in line with the evidence pertaining to sedentary behaviour and associated

Table 1 Application of "Five Keys to Healthy Workplaces" (World Health Organization) to the *Stand Up Australia* Intervention

Keys	Application to *Stand Up Australia* Intervention
1) Leadership commitment and engagement	- Senior management consultation (gaining leadership commitment, necessary permissions, resources, and support);
	- Representatives consultation workshop (mobilising and gaining commitment from major stakeholders including union representatives and OHS staff)
	- Manager emails (demonstrating continuous management support)
2) Involve workers and their representatives	- Representatives consultation workshop
	- Team champions
	- Staff information and brainstorming session
	- Individual coaching session and telephone support calls
3) Business ethics and legality	- Development of key messages, instructions, and workstation introduction in collaboration with ergonomists and OHS experts
	- Senior management consultation (aligning study principles with workplace policies)
	- Representatives consultation workshop (involvement of OHS staff)
4) Use a systematic, comprehensive process to ensure effectiveness and continual improvement	- Representatives consultation workshop (involving team of multidisciplinary experts)
	- Staff information and brainstorming session (including elaboration of organisational priorities)
	- Pre- and post-intervention assessment of workplace sedentary behaviour in line with key intervention messages
	- Feedback of study results to individuals and the organisation including consultation about future strategies and policy changes
	- Iterative development with continuous improvement of intervention components
5) Sustainability and integration	- Representatives consultation workshop (reducing isolation of work groups, and mobilisation of team champions)
	- Staff information and brainstorming session
	- Assessment of intervention acceptance, feasibility and fidelity
	- Assessment of sedentary behaviour change maintenance
	- Feedback of study results to individuals and the organisation including consultation about future strategies and policy changes

health impacts: *Stand Up, Sit Less, Move More. Stand Up* was a prompt to break-up long, unbroken bouts of sitting of 30 minutes or more. This suggestion was based on both epidemiological and laboratory-based evidence which has reported the cardio-metabolic benefits of regularly interrupting sedentary time [5,6]. Furthermore, this target is in line with the ergonomic literature [52,53], and could be practically implemented into office work routines. The message *Sit Less* aimed to reduce total workplace sitting time through substituting some sitting with standing (primarily at the new workstation) and/or moving, with the intent that the reductions in workplace sitting be substantial enough to reduce the health risks associated with high daily sitting time. Finally, the principle of *Move More* was to increase movement throughout the working day. The primary emphasis of this message was on the use of practical strategies (e.g. taking the stairs instead of the lift) to increase incidental physical activity – a key component of daily energy expenditure [54] - throughout the workday.

Table 2 illustrates how these conceptual elements were linked with specific behaviour change strategies related to the key intervention messages of *Stand Up, Sit Less, and Move More* across the three workplace levels (organisational, environmental, individual). This table shows the first iteration of the *Stand Up Australia* intervention. This version of the intervention was used in the formative work with the target audience.

Phase 2: formative research

The second phase included pilot testing of intervention components at all intervention target levels. This occurred across multiple studies and settings comprising the *Stand Up Australia* program of research.

At the organisational level, a consultation session was arranged between senior study investigators and the management of a medium-sized organisation interested in workplace health promotion [24]. This consultation identified this first session as key for gaining management 'buy-in', as well as for the identification of

Table 2 Map of *Stand Up, Sit Less, and Move More* intervention strategies across intervention target levels

	Stand Up	Sit Less	Move More
Principle	Breaking up prolonged periods of sitting	Reducing overall sitting time	Increasing energy expenditure
Key message	Stand up at least every 30 minutes	Reduce daily sitting time	Take every opportunity to be more active
Organization	*Focus:*		
	- Changing social norms (reinforcement & role modeling)		
	Strategies:		
	- Gain organisational/upper management support through consultation		
	- Identify site representatives as role models and spokespersons for employees		
	- Representatives to reinforce Ix messages (e.g. emails sent from them not research staff, articles in site newsletters)		
	- Establish new workplace policies & practices (e.g. standing meetings, no emails within organisational units- face visits instead, move waste bins, printers, supplies; tailored to each site)		
Environment	*Focus:*		
	- Prompts/Behavioral cues	- Use of height-adjustable workstations	- Increasing awareness
	Strategies:		
	- Prompts at desk (e.g. postcards, stickers)	- Installation of height-adjustable workstations	- Environmental changes to encourage movement (e.g. signs at lifts prompting use of stairs, centrally located printers & bins; tailored to each site)
	- Timer as visual cue to stand		
Individual	*Focus:*		
	- Prompts/Behavioral cues	- Goal setting for use of workstations	- Increasing awareness
	Strategies:		
	- Education on breaks in sitting & health	- Education on prolonged sitting & health	- Education on incidental activity & health
	- Encourage use of prompts (e.g. stand when telephone rings, when someone enters the office)	- SMART goal setting for use of workstations	- Encourage use of strategies (e.g. "imails" instead of emails (walk to colleague); walk to bathroom that is farthest away; use stairs instead of lift)
		- Self-monitoring using timer and chart	

organisational processes and structures important to study implementation (e.g. policies around workplace activity).

At the environmental level, a preliminary study was conducted testing the efficacy, acceptability, and feasibility of height-adjustable workstations in office workers (Intervention, n = 18; Comparison, n = 14; 94% and 86% women in the intervention and control group, respectively; 20-65 years) between February and June 2011. In this study, and in all other studies forming part of *Stand Up Australia*, evaluation of changes in workplace sitting time was assessed by the activPAL3 activity monitor (PAL Technologies Limited, Glasgow, UK). Detailed methods and results of this preliminary study are published elsewhere [13]. In brief, relative to the comparison group, intervention participants reduced their daily workplace sitting time by an average of 143 minutes per eight-hour day at the workplace following the installation of the workstations (95% CI = -184, -102; $p < 0.001$), without compromising work-performance. Acceptability of the workstations was high (94% stated that it was enjoyable and easy to use). However, generalisability of these findings was limited due to the intervention sample consisting of a group of public health researchers working in the area of sedentary behaviour research. Furthermore, these findings were limited to closed-plan office designs.

Addressing these limitations, another pilot study was conducted to test the acceptability of the height-adjustable workstations utilised in *Stand Up Australia* in open-plan offices (ethical approval granted by The University of Queensland's School of Population Health Research Ethics Committee on 4th August 2011; #MN 010811). A convenience sample of five desk-based employees (three women; 20-65 years) was recruited from administrative personnel from a university in Brisbane (Australia) to trial the workstations for two weeks. Following the trial period, all participants ('workstation group'), as well as another seven employees ('peer group'; six women; 20-65 years), who shared the same open-plan office and sat nearby the installed workstations, underwent a brief (five-minute) feedback interview on their experience. The interview was semi-structured, audio-recorded, and transcribed.

Workstation group feedback Overall, all five employees were satisfied with the workstations. While suggestions were made for the improvement of the workstation design, everyone appreciated the option to sit or stand while working at their computer – for example, one employee stated: *"It was nice to have the option to sit or stand. It took a lot of pressure off my lower back which usually tends to get sore after prolonged periods of sitting"*. On a 5-point scale (1='did not like it at all' to 5='found it great'), participants rated the workstations from 3 to 5 with an average of 3.9 points. None of the participants perceived any disturbance (visual or auditory) for colleagues working in their immediate environment. Four participants expressed interest in keeping their workstation.

Peer group feedback Six peer group participants did not feel disturbed in any way by others using the workstations. One participant however experienced distraction through the increased noise level and the fact that the 'workstation user' was able to look over the partition while standing up - *"We have staff come and see us about confidential/ personal information at our desks. It feels like someone is constantly staring at you*". Based on the feedback from this participant, a discussion about the purchase of cubicle dividers was taken into the protocol for the management consultation (details below) at the outset of the *Stand Up Australia* Intervention.

At the individual level, the feasibility of a face-to-face health coaching session was tested with two university employees (both women, 23 and 28 years) who were not otherwise involved in the *Stand Up Australia* program of research. Overall, the coaching session was received well by the two trial participants and the intended length of the session (30 minutes) was confirmed. Feedback on the key intervention messages led to further clarification of the distinction between *Stand Up* (i.e. standing up regularly to break up long bouts of sitting) and *Sit Less* (i.e. reducing the overall sitting time throughout the day by replacing some sitting time with standing and/or moving time).

Phase 3: pilot testing

Two pilot studies were conducted and are described below: '*Stand Up Comcare*,' a two-arm controlled trial that tested the efficacy, feasibility, and acceptability of the integrated multiple components; and, '*Stand Up UQ*,' a three-arm controlled trial that evaluated the additional value of the multiple components over height-adjustable workstations only.

***Stand Up Comcare* methods** An abridged, four-week version of the *Stand Up Australia* intervention was initially pilot tested with 43 employees (56% women; 26-62 years) in a two-arm controlled trial between July and September 2011 in an urban open-plan office (*Comcare*: the government agency responsible for workplace safety, rehabilitation and compensation for Australian government workplaces) in Melbourne, Australia [24]. The main purpose of this pilot was to test the combined implementation of all three intervention components. Following the pilot study, intervention group participants completed a telephone interview about their study experience and managers provided feedback in face-to-face sessions.

***Stand Up Comcare* results** Results from this pilot study are published elsewhere [24]. In brief, relative to the control group, participants in the intervention group reduced their workplace sitting time by just over two hours per eight-hour workday (mean change -125, 95% CI = -161, -89 minutes) following intervention, with sitting primarily replaced with standing (127, 95% CI = 92, 162 minutes). Of the 21 intervention group participants, 18 completed the telephone feedback interview. Overall, the height-adjustable workstations, as well as the organisational and individual intervention components (in particular the face-to-face coaching session), were evaluated very positively by both staff and managers (detailed below).

Intervention refinement based on *Stand Up Comcare* Based on the feedback from *Stand Up Comcare*, the *Stand Up Australia* intervention was modified at all three levels. Regarding *organisational-level* strategies, the majority of participants indicated that the initially standardised manager emails were mostly left unread due to email overload and not enough relevance – for example, *"I read one or two but don't remember more than that, didn't take much notice of them"*. Thus, the intervention was refined to tailor the manager email templates provided by the study to the managers' observations of their team's experience with the intervention. This could include the observation of potential problems (e.g. sore feet from increased levels of standing) and suggested solutions (e.g. keeping a spare pair of orthopaedic shoes at the desk). While the primary outcome targeted through *Stand Up Australia* is sitting at the workplace, it was decided to add a list of useful strategies to *Stand Up, Sit Less, and Move More* outside of the workplace to the second manager email. Further, during the management consultation, more emphasis was placed on the initiation of standing by managers/senior-level staff during staff meetings, as participants repeatedly expressed feeling 'awkward' to initiate standing by themselves - *"I find it hard to stand in a meeting when no one else is doing it - uncomfortable"*. Finally, the list of organisational strategies to promote standing proposed to managers was refined based on feedback on the most and least useful strategies identified by both staff and

managers. *At the environmental level*, a detailed ergonomic introduction to the height-adjustable workstations (involving internal OHS staff wherever available) was added to the intervention protocol. This introduction was delivered immediately following the workstation installation to address employee concerns about their limited experience in the correct use of these. During the *individual intervention contacts*, a stronger emphasis was placed on the importance of regular postural changes, and, as most participants experienced difficulties distinguishing the principles of *Stand Up* and *Sit Less,* a clearer and more detailed explanation of these recommendations was incorporated. Further, assisting participants with the set-up of a stopwatch or computer software to monitor their sitting/standing time if required was included in the protocol, as some participants experienced difficulties with doing this on their own. In line with the addition of a strategy list to *Stand Up, Sit Less,* and to give more emphasis to the target of *Move More* outside of the workplace, a discussion about these strategies was added to the protocol of the third telephone call in addition to the related list of strategies added to the second manager email. Finally, the email summaries sent following the telephone calls were removed from the intervention protocol, as feedback from employees indicated that these were generally not read due to an overload of emails.

The results of this pilot study addressed the efficacy considerations of the multi-component intervention on reducing workplace sitting time. However, as the participating employees were from a government agency for workplace safety, rehabilitation and compensation, the results may be limited in their generalizability. Furthermore, based on the two-group design it was not possible to determine the contribution of the organisational- and individual-level elements, as distinct from the provision of height-adjustable workstations alone. Considering the resource implications of these elements, this issue has important practical and financial implications. The second pilot study (*Stand Up UQ*) therefore involved a test of the efficacy of this multi-component intervention to a height-adjustable workstations-only intervention in a three-arm controlled trial involving a comparatively representative sample of office workers.

***Stand Up UQ* methods** Between January and June 2012, a group of desk-based office workers from three separate administrative units of The University of Queensland (Brisbane, Australia) participated in the '*Stand Up UQ*' study (multi-component intervention, n = 16; height-adjustable workstations-only, n = 14; comparison, n = 14; 84% women; 20-65 years). The multi-component intervention comprised all the *Stand Up Australia* intervention elements as refined following the *Stand Up Comcare* pilot study (detailed above), delivered over three months. Participants in the workstations-only intervention received height-adjustable workstations only.

***Stand Up UQ* results** Results are published elsewhere [55]. In brief, following intervention and relative to the comparison group, workplace sitting time in the multi-component group was reduced by 89 mins/8-hour workday (95% CI = -130, -47 minutes; $p < 0.001$) and 33 minutes in the workstations-only group (95% CI = -74, 7 minutes, $p = 0.285$). Furthermore, all participants in the multi-component intervention rated all intervention components as either useful or very useful. In particular, 12/13 rated the manager emails, which were mostly left unread in the *Stand Up Comcare* pilot and therefore tailored in the refinement, as either useful or very useful (one participant was neutral) – *"Her emails brought everyone onto the same page and encouraged [us] to try things, reinforcing support".*

Results (final intervention design)

The following section provides a detailed description of the resulting *Stand Up Australia* intervention protocol. The suggested timing of all intervention components is shown in Table 3.

Organisational intervention strategies

In brief, there are three key strategies targeting the organisational level: A senior management consultation, a representatives consultation workshop, and a staff information and brainstorming session including the provision of an information booklet.

Senior management consultation (approx. 30-45 mins)

During a consultation session between senior research staff (trained in the evidence of excessive sitting and detrimental health outcomes) and selected senior staff, details of the study timeline are presented and an explanation of the role of organisational and physical environmental factors in determining occupational sitting time is given. Furthermore, current organisational processes and structures important to study implementation are considered, the concept of the representatives consultation workshop is introduced, and relevant staff identified (more details below). Strategies to encourage employee participation are discussed and important OHS policies and resources identified (e.g. those relating to workplace activity). Finally, additional resources to support study targets are identified (e.g. headphones or higher partitions between desks).

Representatives consultation workshop (approx. 2-4 hours)

Staff representatives meet with senior research staff to identify strategies supportive of behaviour change (in line with *Stand Up Australia* key intervention messages) suitable to their organisation. Representatives ideally

Table 3 Intervention elements and timing of implementation

	Timing	Intervention level		
		Organisational	**Environmental**	**Individual**
Intervention elements	*Week 1*	Senior management consultation		
	Week 2	Representatives consultation workshop		
	Week 3	Staff information & brainstorming session; Manager email 1	Workstation installation	Coaching session & email summary
	Week 4			Phone call 1
	Week 5	Manager email 3		
	Week 6			Phone call 2
	Week 7	Manager email 4		
	Week 8			
	Week 9	Manager email 5		Phone call 3
	Week 10			
	Week 11	Manager email 6		
	Week 12			
	Week 13	Manager email 7		Phone call 4

include staff from each staff level (including senior and middle managers) as well as other important stakeholders such as OHS personnel, union representatives, workplace safety advisors, and corporate ergonomists. During the workshop, research staff present details on the research background and target behaviour, and representatives identify feasible workplace changes to *Stand Up, Sit Less, and Move More* suited to their organisation (e.g. standing meetings, or the relocation of printers and waste bins). Furthermore, a group of team champions is identified. Throughout the duration of the *Stand Up Australia* intervention, the role of team champions is: 1) to actively promote standing by using their height-adjustable desks and to encourage and initiate standing in staff meetings (e.g. by hanging up signs in meeting rooms that 'standing meetings are welcome' or by announcing in the beginning of a staff meeting that staff are welcome to stand); 2) to act as liaison between staff and the research team; and, 3) to distribute the management emails (one champion; typically a manager). Standard email templates supportive of the study targets are provided to this champion by the research team. The champion is asked to walk through the offices on a regular basis to observe and chat to staff about potential problems related to the new workstations or other study components. Any observations are subsequently integrated into the email templates. Six fortnightly emails are sent to staff (blind copied to the research team) over the course of the three-month intervention.

Staff information and brainstorming session and information booklet (approx. 30-45 mins)

Research staff facilitate a staff information and brainstorming session. This session addresses the detrimental health impacts of prolonged sitting and provides details about intervention participation, as well as feedback on the group's workplace sitting time collected from the activity monitors at baseline. Organisational strategies to *Stand Up, Sit Less, and Move More* as identified in the representatives consultation workshop are discussed, and staff are encouraged to further brainstorm strategies that may be specifically suited to their group. Following this information session, a summary email (provided by research staff) is sent from the responsible team champion to all staff. This email includes an electronic *Stand Up Australia* information booklet with details about: the study rationale (i.e. evidence on sedentary behaviour and health outcomes) and purpose; general guidelines on optimal workplace activity; specific behaviour change strategies related to the key intervention messages; and, general information about the study procedure and timeline.

Environmental intervention strategy

Height-adjustable workstation installation and ergonomic posture check

Each participating employee receives a height-adjustable workstation. In consultation with an OHS ergonomist, the authors adapted the manufacturer-provided workstation information sheet, which contains details about the correct ergonomic posture and tips on the use of the workstation, as well as the study recommendations on workplace sitting and activity. It is left on the workstation shelf for each participant to read upon the first contact with the new workstation. Following the workstation installation, the organisation's OHS staff confirm the correct ergonomic posture and address any workstation-related problems or questions. If OHS staff are unavailable, this

step is conducted by research staff following study-specific training.

Individual intervention strategies

In brief, the individual component consists of one face-to-face coaching session and four follow-up support telephone calls over the three months.

Face-to-face coaching

The workstation installation is followed by an individual 30-minute face-to-face coaching session delivered by a health coach (trained in motivational interviewing techniques) in a private room at the work site. First, the participant and coach review the participant's individual feedback document [55]. This analytic feedback document reflects the participant's activity and posture (as recorded during the baseline assessment week) in relation to each of the key messages *Stand Up, Sit Less, and Move More*. This includes both overall proportions of sitting, standing, and moving time across the day and during work hours only, as well as a 24 hour 'heatmap' showing times at which these activities occurred for each day during the assessment week. Then, potential disparities between the baseline and target behaviours are established, and specific goals for each key message are elaborated on using motivational interviewing methods. For example, tasks undertaken during long periods of sitting visible on the heat map are discussed and solutions to achieve the desired behaviour target identified. Goals are documented on a 'Workstation Tracker' [55], which is to be attached to the workstation clearly visible to the participant (for self-monitoring purposes). Following the coaching session, participants receive an email summary from the coach containing the key points discussed.

Support telephone calls

Each intervention group participant receives a total of four behaviour change support telephone calls following the coaching session, preferably from the same health coach. The telephone calls are delivered in staggered intervals (preferably at one, three, six, and ten weeks following the coaching session), offering more intense support during the initiation period and gradually less during the maintenance period of behaviour change. They serve as a general check-in on the participants' satisfaction with the study and their workstation, their goal achievement, barrier identification and problem solving, discussion of new strategies, and a potential adjustment of goals. During the second call, the health coach also discusses strategies to *Stand Up, Sit Less, and Move More* outside the workplace. On average, these calls should take around ten minutes.

Intervention feedback

At the end of the three-month intervention period, and again one year after baseline, the research team provides both individuals and the organisation with feedback on the sitting time reductions experienced by staff. This can be accompanied by a consultation on strategies that were considered to be most suited to the particular organisation and a discussion regarding potentially relevant future strategies and policy changes.

Discussion

Detailed reporting on intervention development is vital for the advancement of effective behaviour change interventions. This is the first paper to provide a thorough description of the development process of an intervention to reduce sitting time in office workers - *Stand Up Australia*.

Key strengths of this development process include: a systematic three-stage process guided by currently available evidence; strong theoretical grounding and translation of key constructs guided by the use of an intervention taxonomy; a participative approach to both the broader workplace and its staff; the targeting of multiple levels of influence on workplace sitting (organisational/managerial, environmental, and individual); as well as the integration of qualitative and quantitative data to inform subsequent uptake into practice.

However, when considering the potential for widespread translation of the *Stand Up Australia* intervention, it should be noted that, despite the strong input from workplaces into intervention development and the pragmatic design of the evaluation, the participatory process was limited by research funding constraints. The findings may therefore not generalise across the wider population of office workplace settings.

Stand Up Australia is currently being evaluated in the context of a cluster-randomised controlled trial at the Department of Human Services (DHS) in Melbourne, Australia (*Stand Up Victoria*; ACTRN12611000742976). This study is funded by the Australian National Health and Medical Research Council and the Victorian Health Promotion Foundation, and includes objective measurement of activity and posture via activPAL3 monitors, clinical assessment of anthropometric outcomes and cardio metabolic biomarkers, evaluation of work-related outcomes (including productivity, absenteeism and presenteeism), as well as cost-effectiveness analyses [56].

Conclusions

Stand Up Australia is an evidence-informed and systematically developed workplace intervention targeting reductions in office workers' sitting time. Feedback from participants and managers involved in the multiple phases of development suggests high acceptance and feasibility of all intervention components. Observations from the pilot

studies demonstrate the efficacy of *Stand Up Australia* to significantly reduce office workers' sitting time. Results of the currently implemented cluster-randomised controlled trial will inform its (cost-) effectiveness and feasibility on a larger scale.

Consent

Written informed consent was obtained from all participants for the publication of this report and any accompanying images.

Competing interests

Height-adjustable workstations were kindly provided by Ergotron (www.ergotron.com) for the *Stand Up Comcare* and *Stand Up UQ* pilot studies. The funding bodies had no influence on the conduct or the findings of the study.

Authors' contributions

All authors made substantial contributions to the conceptualisation and development of the *Stand Up Australia* intervention. All authors played a significant role in the drafting of this manuscript. All authors read and approved the final manuscript.

Acknowledgements

Neuhaus was supported by an Australian Postgraduate Award and UQ School of Population Health Top-Up Scholarship. Healy was supported by a National Health and Medical Research Council (NHMRC) [#569861] and Heart Foundation [PH 12B 7054] Fellowship. Dunstan was supported by an Australian Research Council Future Fellowship [#FT100100918], and by the Victorian Health Promotion Foundation and the Victorian Government's Operational Infrastructure Program. Owen was supported by a NHMRC Program Grant [#569940], a Senior Principal Research Fellowship [NHMRC #1003960], and by the Victorian Government's Operational Infrastructure Program. LaMontagne was supported by a Victorian Health Promotion Foundation Centre grant (grant #15732). Eakin was supported by a NHMRC Senior Research Fellowship [#511001].

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Received: 1 August 2013 Accepted: 17 February 2014
Published: 21 February 2014

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doi:10.1186/1479-5868-11-21
Cite this article as: Neuhaus *et al.*: Iterative development of Stand Up Australia: a multi-component intervention to reduce workplace sitting. *International Journal of Behavioral Nutrition and Physical Activity* 2014 **11**:21.

3.4 Discussion

As noted in the Discussion above, the *Stand Up Australia* intervention is currently being evaluated in a larger cluster-randomised controlled trial within the Department of Human Services in Melbourne, Australia (*Stand Up Victoria*) (147). This trial addresses some of the limitations in current evidence by including: objective and longer-term measurement of sedentary time (at baseline, 3 months [end-of-intervention] and 12 months); assessment of anthropometric outcomes and cardio metabolic biomarkers; evaluation of work-related outcomes; and, cost-effectiveness analyses. However, given the two-group design of the *Stand Up Victoria* trial, it will not be possible to determine if addressing the multiple levels of influence proposed by the *Healthy Workplace Framework* is more effective than the installation of activity-permissive workstations alone. Study 3 of this PhD research therefore comprised a 3-arm controlled trial, comparing the effectiveness of the multi-component *Stand Up Australia* intervention to reduce workplace sedentary time, to the installation of activity-permissive workstations only and to a (usual workplace practice) control condition.

CHAPTER 4. EFFECTIVENESS OF A MULTI-COMPONENT INTERVENTION VERSUS ACTIVITY-PERMISSIVE WORKSTATIONS ONLY

4.1 Introduction

This Chapter reports the findings of a 3-arm controlled field study conducted as part of this PhD over a 15-month period in Brisbane, Australia.

The findings from the systematic literature review presented in Chapter 2 showed that activity-permissive workstations can be an effective means to reducing workplace sedentary time. However, the way in which these workstations were implemented varied across the included studies and best-practice approaches to using such workstations could not be identified thus far. The workplace health promotion literature, such as the *Healthy Workplace Framework* described in the previous Chapters of this thesis, suggests that interventions should target the multiple interrelated workplace influences on health behaviour (109). Study 2 of this PhD research (Chapter 3) thus comprised the development of such a multi-component intervention. The efficacy of this intervention was first examined in a controlled pilot study, which reported workplace sedentary time reductions in the intervention group of more than two hours per 8-hour workday following intervention (99). Furthermore, as noted in the previous chapter of this thesis, it is currently being tested in a larger, cluster-randomised controlled study (147). However, the two-group design of these studies does not provide an opportunity to examine the relative benefit of the multi-component intervention compared to installation of activity-permissive workstations alone. This question has important practical implications given the additional resource costs associated with the multi-component intervention (versus the activity-permissive workstations alone). Therefore, the aim of Study 3 was to examine the effectiveness of the multi-component intervention to reduce workplace sedentary time and to compare it to the effectiveness of installing activity-permissive workstations only.

Between January 2012 and March 2013, a 3-arm controlled trial *Stand Up UQ* was conducted in a university setting in Brisbane, Australia. Study groups comprised three geographically separate groups of office workers: one intervention group received the multi-component *Stand Up Australia* intervention as described in Chapter 3 of this thesis; another group received sit-stand workstations only (the same workstations as used in the multi-component intervention); and, one group served as a (usual workplace-practice)

control group and participated in assessments only. Office workers' sedentary time was assessed using objective measurement methods (i.e. activPAL devices) at baseline and 3 months (end of the strategies targeting personal health resources and the psychosocial work environment) from all three study groups, and at 12 months from both intervention groups.

Results of the short-term (i.e. 3 months post baseline) outcomes of this trial have been published in the *American Journal of Preventive Medicine*. This was a highly cited paper. The *American Journal of Preventive Medicine has* an impact factor of 4.28 (5-yr IF = 5.09) and ranks within the top 9% of journals within the field of Public, Environmental & Occupational Health. With an Altmetric score of 71, the paper is amongst the highest ever scored in this journal (ranked #43 of 1020); and, it is currently in the 99th percentile of more than 2.6 million articles ever tracked by Altmetric. Following a media release of this paper in January 2014, the *Stand Up UQ* study has received substantial interest from media. This includes radio interviews with stations such as ABC National and ABC Sydney, online media such as www.MedicalResearch.com or www.ScienceAlert.com.au, as well as numerous print articles, and attention from social media such as twitter. A copy of the paper is provided in Section 4.2.

Additional methods are presented in Section 4.3 and additional outcomes are reported in Section 4.4. Immediately after completion of the 12-month assessment, qualitative interviews were conducted with both study participants and managers from the two intervention groups to inform the translation of intervention elements into practice and opportunities for further improvement. A brief summary of the findings from these qualitative interviews is presented in Section 4.4.4. Sixteen months following the end of the study, additional follow-up interviews were conducted with the managers of both intervention groups as well as the director of the university's OHS division. These results are presented in Section 4.4.5. The main findings from the *Stand Up UQ* study and their implications are then discussed. All materials related to the *Stand Up UQ* study are provided in Appendix B. These include:

- Stand Up UQ flowchart (Appendix B.1)
- Participant information sheet (Appendix B.2)
- Participant consent form (Appendix B.3)
- Information flyer – example from control group (Appendix B.4)
- Participant information presentation (Appendix B.5)

- Participant Information booklet (Appendix B.6)
- Workstation information sheet (Appendix B.7)
- Individual consultation script (Appendix B.8)
- Individual consultation checklist (Appendix B.9)
- Email template for individual consultation summary (Appendix B.10)
- Participant feedback report – Assessment 1 (Appendix B.11)
- Example protocol for telephone follow-up (Appendix B.12)
- Example template for management emails (Appendix B.13)
- Strategy list to stand up, sit less and move more outside of work (Appendix B.14)

4.2 Main outcomes

Neuhaus, M., Healy, G.N., Dunstan, D.W., Owen, N., Eakin, E.G. (2014). *Workplace Sitting and Height-Adjustable Workstations: A Randomized Controlled Trial.* American Journal of Preventive Medicine 46(1): 30–40.

Workplace Sitting and Height-Adjustable Workstations

A Randomized Controlled Trial

Maike Neuhaus, MPsych, Genevieve N. Healy, PhD, David W. Dunstan, PhD, Neville Owen, PhD, Elizabeth G. Eakin, PhD

Background: Desk-based office employees sit for most of their working day. To address excessive sitting as a newly identified health risk, best practice frameworks suggest a multi-component approach. However, these approaches are resource intensive and knowledge about their impact is limited.

Purpose: To compare the efficacy of a multi-component intervention to reduce workplace sitting time, to a height-adjustable workstations-only intervention, and to a comparison group (usual practice).

Design: Three-arm quasi-randomized controlled trial in three separate administrative units of the University of Queensland, Brisbane, Australia. Data were collected between January and June 2012 and analyzed the same year.

Setting/participants: Desk-based office workers aged 20–65 (multi-component intervention, n=16; workstations-only, n=14; comparison, n=14).

Intervention: The multi-component intervention comprised installation of height-adjustable workstations and organizational-level (management consultation, staff education, manager e-mails to staff) and individual-level (face-to-face coaching, telephone support) elements.

Main outcome measures: Workplace sitting time (minutes/8-hour workday) assessed objectively via activPAL3 devices worn for 7 days at baseline and 3 months (end-of-intervention).

Results: At baseline, the mean proportion of workplace sitting time was approximately 77% across all groups (multi-component group 366 minutes/8 hours [SD=49]; workstations-only group 373 minutes/8 hours [SD=36], comparison 365 minutes/8 hours [SD=54]). Following intervention and relative to the comparison group, workplace sitting time in the multi-component group was reduced by 89 minutes/8-hour workday (95% CI=−130, −47 minutes; $p<0.001$) and 33 minutes in the workstations-only group (95% CI=−74, 7 minutes, p=0.285).

Conclusions: A multi-component intervention was successful in reducing workplace sitting. These findings may have important practical and financial implications for workplaces targeting sitting time reductions.

Clinical Trial Registration: Australian New Zealand Clinical Trials Registry 00363297

(Am J Prev Med 2014;46(1):30–40)

From the Cancer Prevention Research Centre (Neuhaus, Healy, Dunstan, Owen, Eakin), School of Population Health, The University of Queensland, Herston, Queensland, Baker IDI Heart and Diabetes Institute (Healy, Dunstan, Owen, Eakin), Epidemiology and Preventive Medicine (Dunstan), Central Clinical School (Owen), Monash University, School of Population and Global Health (Owen), University of Melbourne, Melbourne, Victoria, and School of Sports Science, Exercise and Health (Dunstan), University of Western Australia, Perth, Western Australia, Australia

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0749-3797/$36.00
http://dx.doi.org/10.1016/j.amepre.2013.09.009

Background

Too much sitting is detrimentally associated with musculoskeletal symptoms[1] and several risk biomarkers of cardio-metabolic health,[2,3] particularly when accumulated in prolonged, unbroken bouts.[4] Desk-based office workers sit for an average of 6 hours during an 8-hour workday.[5–7] With much of this sitting time accrued in bouts of 30 minutes or more,[7–9] office workers are an important target for intervention.[10]

Height-adjustable workstations are a potentially feasible option to reduce workplace sitting. They offer the opportunity to complete desk-based/computer tasks while alternating between sitting and standing, without major disruption of work practices. Traditionally acquired for the prevention of musculoskeletal problems,[11,12] their utility in reducing sitting time for broader preventive-health benefits is increasingly being recognized.[13] Studies in the U.S., Europe, and Australia have reported reductions in workplace sitting between 0 and 143 minutes/workday following workstation installation in office environments.[5,14–19] However, preliminary indications suggest that installation of height-adjustable workstations alone may not be sufficient for sustained reductions in sitting time.[20] These findings support recommendations from the broader workplace health promotion literature[21,22] and ecologic models of sedentary behavior.[23] Both emphasize the importance of intervening on the multiple interrelated influences on individual behavior in the workplace, including the organizational structure, the physical and social/interpersonal environment, and intrapersonal factors.

A recent study that used such a multi-component approach achieved substantial reductions in workplace sitting time,[18] with intervention group participants reducing their workplace sitting by 2 hours relative to comparison group participants. However, given the two-group design, it was not possible to determine the contribution of the organizational- and individual-level elements, as distinct from the provision of height-adjustable workstations alone. Given that these elements are resource intensive, this issue has important practical and financial implications.

The aim of this study was to compare changes in objectively measured workplace sitting time following a multi-component intervention versus the installation of height-adjustable workstations alone, relative to a comparison condition, over 3 months.

Methods

Study Design

The study (Stand Up UQ) was conducted within three separate administrative units of the University of Queensland (UQ) in Brisbane, Australia, and included (1) a multi-component intervention group; (2) a (height-adjustable) workstations-only intervention group; and (3) a comparison group (usual practice; assessment-only). Because of one of the units being located ~90 km from the research center, the two local units were randomized to the intervention arms, with the distant unit allocated to the comparison group.

The study was approved by UQ's School of Population Health ethics committee. Data were collected January–June 2012, at baseline and 3 months thereafter. Research staff and participants were not blinded to group allocation.

Recruitment

The three units were identified by the University's Wellness Program Manager (who volunteered her own unit [HR/Payroll] for study participation) and located on three different campuses. Unit selection was based on the following criteria: all potential participants were to be located on the same office floor (to control for unit-specific norms; intervention groups only), and potential participants were to be employed in jobs primarily involving computer/administrative desk-based tasks with a designated desk within the workplace. Unit managers were given details of the study rationale and procedures, and all provided consent for their unit to participate.

A recruitment e-mail explaining the study purpose and procedures was sent to all staff from consenting units. Interested employees e-mailed the project manager and were interviewed via telephone to assess eligibility: aged 18–65 years; speaking English; ambulatory; not pregnant; working at least 0.5 full-time equivalent (FTE); without allergies to medical tape (used to attach the activity monitor); not experiencing any musculoskeletal discomfort or neck/back/shoulder strain; and not relocating to another worksite during the study period. A total of 44 participants (16 multi-component group, 14 workstations-only group, 14 comparison group) were recruited and underwent baseline assessment (Figure 1).

Multi-Component Intervention

The intervention was based on social cognitive theory, with emphasis on self-efficacy, outcome expectancies, and sociostructural factors.[24] The operationalization of theoretical constructs into intervention strategies was guided by an intervention taxonomy,[25,26] and focused on provision of normative feedback, goal-setting, self-monitoring and problem-solving. Strategies were applied at the organizational (e.g., through group-level normative feedback in comparison to the average sitting time among Australian office workers); environmental (e.g., normative cues from co-workers standing at height-adjustable desks); and individual level (e.g., through normative individual feedback at baseline in comparison to the group's sitting time).

The key intervention messages were *Stand Up*, *Sit Less*, and *Move More*. *Stand Up* was the main prompt to break up long bouts of sitting (≥30 minutes) by changing posture frequently (at least every 30 minutes). *Sit Less* communicated the importance of reducing overall sitting time. Participants were encouraged to substitute some sitting with standing or moving time, primarily by using the height-adjustable workstation. A sitting-to-standing ratio of approximately 50:50, accumulated through short bouts and regular postural transitions, was suggested. Both of these

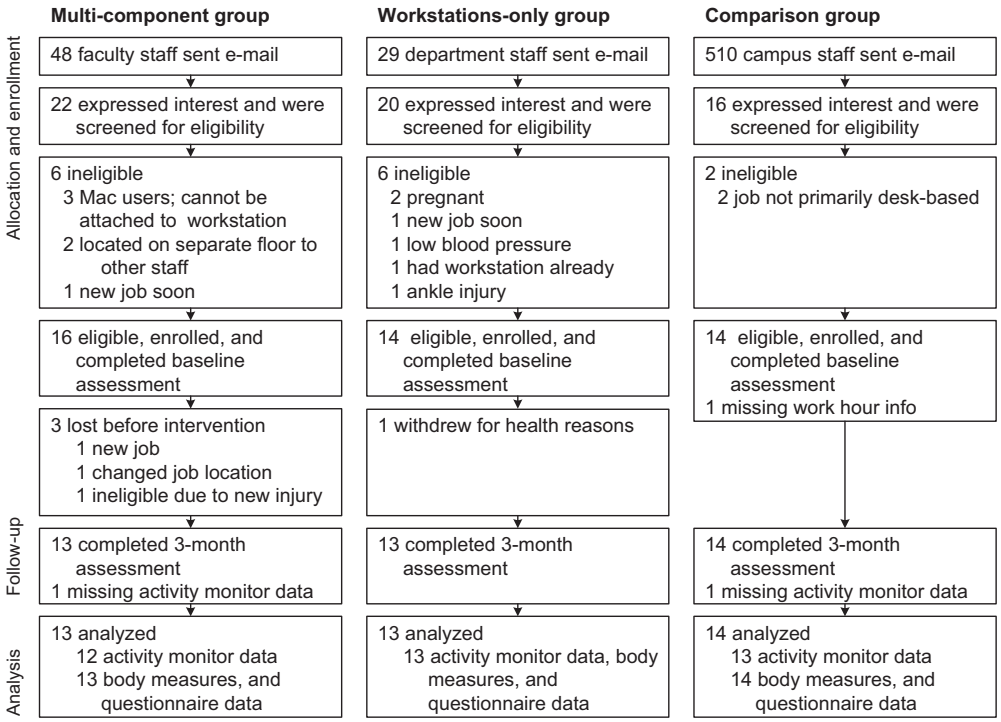

Figure 1. Flow diagram of enrolment, participation, and analyses

suggestions were guided by recommendations from the university's occupational health and safety (OHS) advisor that regular postural changes should be implemented every 30 minutes.[27] The principle of *Move More* targeted an increase in incidental, light-intensity physical activity throughout the workday (e.g., taking the stairs instead of the elevator).

Table 1. Intervention elements and timing of implementation

	Intervention level		
Timing	Organizational	Environmental	Individual
Week 1	Management consultation		
Week 2	Staff information and brainstorming session; manager e-mail 1		Information booklet
Week 3		Workstation provision	Coaching session and e-mail summary
Week 4	Manager e-mail 2		Phone call 1
Week 5			
Week 6	Manager e-mail 3		Phone call 2
Week 7			
Week 8	Manager e-mail 4		
Week 9			Phone call 3
Week 10	Manager e-mail 5		
Week 11			
Week 12	Manager e-mail 6		
Week 13	Manager e-mail 7		Phone call 4

Intervention Delivery

Multi-component intervention.

All intervention components were delivered and recorded by the same project manager (Table 1). Intervention fidelity was maintained through the use of detailed intervention scripts and checklists, and weekly meetings with senior study investigators.

The organizational intervention addressed some aspects of workplace culture and norms via inclusion of a consultation with the unit manager, an all-of-staff information session, and manager e-mails to employees. The manager consultation (~30 minutes) provided the rationale for the study, details of participation, and a discussion of approaches to stand up, sit less, and move more within their unit. The ensuing 30-minute staff information and brainstorming session addressed the study rationale and procedures, as well as feedback on the unit's baseline workplace sitting time. Over the course of the intervention, six fortnightly e-mails were sent from the

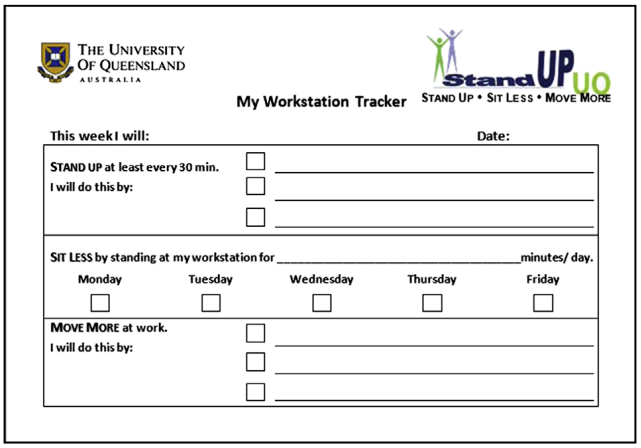

Figure 2. Self-monitoring sheet for participants in multi-component intervention group

manager to staff. They supported program participation, and included a study information booklet (provided by research staff). The remaining five e-mails encouraged staff to stand up, sit less, and move more and commented on strategies that appeared to be working well within the unit. E-mail templates were provided by research staff and tailored to the group by the manager.

The environmental intervention strategy modified the personal physical office environment through the provision of fully installed height-adjustable workstations (WorkFit-S) with an attached work surface tray (www.ergotron.com) for each intervention participant. Employees also received verbal (10-minute duration) and written instructions from the project manager on correct usage and how to alternate their working posture in line with OHS guidelines.

Individual intervention strategies included face-to-face coaching, a tailored e-mail, three telephone calls, an information booklet, and a self-monitoring tool. The initial 30-minute face-to-face coaching session was delivered at the worksite within 2 days following the workstation installation. This included a discussion of graphic feedback on the individual's baseline sitting, standing, and moving time (Figure 2) and collaborative goal-setting in relation to the three program messages. An e-mail summarizing the agreed-upon goals was sent to each participant on the same day. Three follow-up telephone calls (~10 minutes each) were delivered at 1, 3, and 7 weeks following the coaching session to assess goal achievement, problem-solve potential barriers, and reset goals as necessary. Participants also received a laminated self-monitoring tool (Figure 3). This Tracker was attached to the workstation, clearly visible to the participant and used during the coaching session and telephone calls for the participant to document and adjust specific goals and strategies used. Participants were able to contact the project manager at any time in the case of adverse events or problems with their workstation.

Workstations-only intervention. Participants in the workstations-only group received the same workstations and OHS instructions from the project manager as the multi-component intervention group. No further contact was scheduled.

Comparison group. No workspace modification was provided for comparison group participants. They were advised to maintain their usual day-to-day activity.

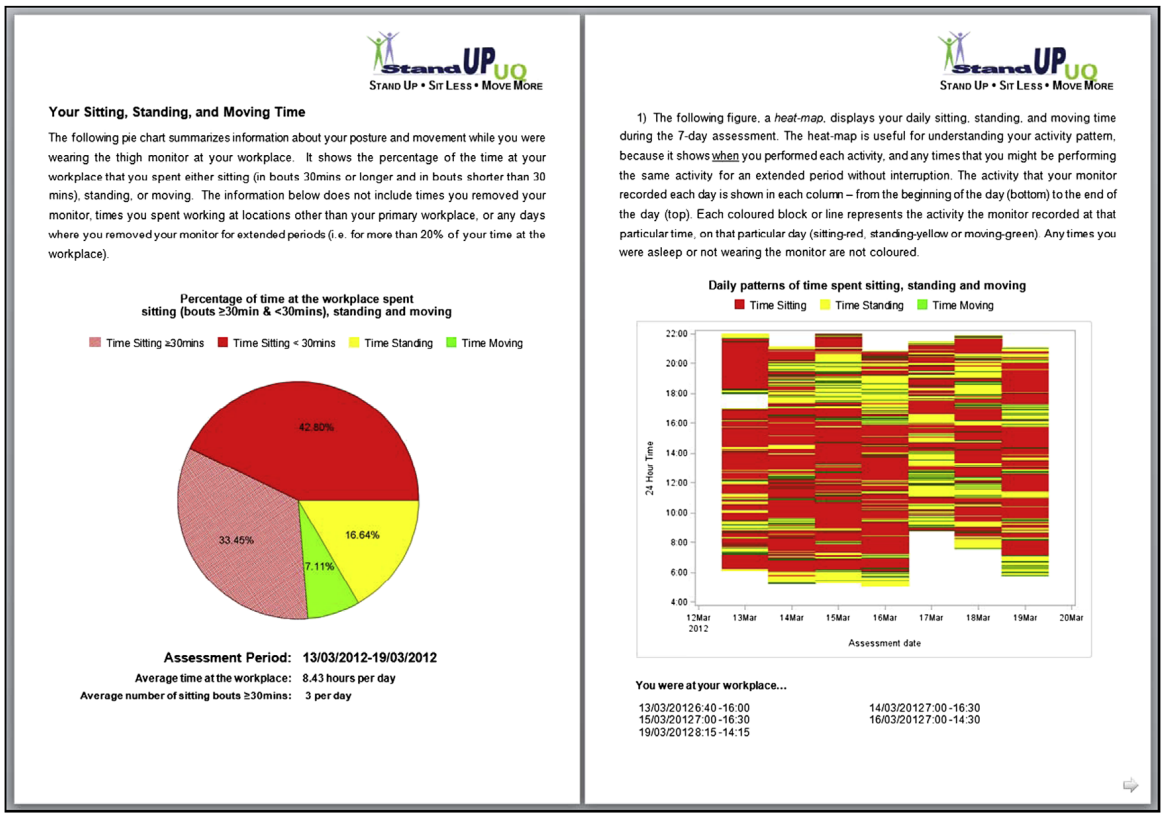

Figure 3. Extract from participant feedback sheet used in coaching sessions in multi-component intervention group

Data Collection

Individual assessments occurred at baseline and 3 months (follow-up) in a designated testing room at or near to the participating units. At each assessment, participants also wore an activity monitor (activPAL3; PAL Technologies Limited, Glasgow, United Kingdom) and self-completed an online questionnaire.

Measures

The activPAL3 monitor (53 × 35 × 7 mm; 15 g) was waterproofed and attached on the anterior midline of the right thigh using a breathable hypoallergenic adhesive patch. Participants were asked to wear the monitor for 7 consecutive days (24 hours per day). The monitor, a valid and responsive measure of posture and motion during everyday activities,[28,29] was initialized and downloaded (manufacturer-provided software, version 6.3.0) using the default settings. Participants recorded any monitor removal times and their wake/sleep and work hours in a diary.

Height (nearest 0.1 cm) was measured in duplicate without shoes using a stadiometer (Seca Ltd, Hanover, MD). Weight was measured using an electronic scale (Soehnle-Waagen GmbH & Co. KG, Backnang, Germany), with footwear and heavy clothing removed. BMI was then calculated as (average weight [kg]/average height [m^2]).

The online questionnaire was used to collect data on:

- demographics (age, gender, ethnicity, educational attainment, employment history, smoking history, medical history; baseline only);
- work-related elements (work-performance, e.g., *Rate your highest level of efficiency this week*; 10-item scale ranging from 1 to 10 with higher scores indicating better work-performance)[30];
- absenteeism[31] (*How many days in the LAST 3 MONTHS have you stayed away from your work for more than half the day because of health problems?*) and presenteeism[31] *(How many days in the LAST 3 MONTHS did you go to work while suffering from health problems?)*;
- musculoskeletal symptoms[32];
- and adverse events (open-question format).

Intervention-group participants also answered questions about the acceptability and feasibility of the intervention, including the acceptability of the height-adjustable workstations, which was rated on a 10-item scale (1=disagree strongly to 5=agree strongly), and via an open question. Participants in the multi-component group further evaluated (1=not useful at all to 5=very useful) the usefulness of all individual intervention components.

Information on intervention fidelity (i.e., completion of coaching sessions, calls, e-mails, and unscheduled contacts with participants) was systematically recorded.

Activity Monitor Data Processing

The activPAL3 records the beginning and ending of each bout of sitting or lying (referred to as sitting); standing; and moving at different speeds and the estimated METs (energy expended above the resting metabolic rate; 1 MET=1.0 kcal/kg/hour) expended during those bouts. Data were processed in SAS 9.3 using a customized program. For each of the outcomes, totals were calculated for each day at the workplace. Averages were calculated from valid days (i.e., activity monitor worn ≥80% of time spent at the workplace; 171 days at baseline, 147 days at follow-up). Outcomes were standardized to an 8-hour workday except for sit-to-stand transitions, which were divided by hours of workplace sitting.

In accordance with the key intervention messages, changes from baseline to follow-up in the following outcomes were assessed for time spent at the workplace: *Stand up*: standing time and prolonged sitting (time accumulated in prolonged sitting bouts ≥30 minutes); *Sit less*: sitting time (primary outcome) and the number of sit-to-stand transitions; *Move more*: stepping time, number of steps, and MET minutes of moderate-to-vigorous physical activity (MVPA) at ≥4 METs (≥120 steps per minute).

Statistical Analyses

Data were analyzed in 2012 using PASW Statistics, version 20.0.0, with statistical significance at $p<0.05$ (two-tailed). Within-group changes were assessed by paired *t*-tests (normal data) or Wilcoxon signed rank test (non-normal data). Multivariate analyses were by linear regression, using the Sidak method to control significance for multiple comparisons,[33] with adjustment for baseline values of the outcome. For each outcome, baseline values of the other outcomes and sociodemographic characteristics were considered as potential confounders, and were adjusted for in analyses if their inclusion changed the mean differences between groups in the outcome by more than 20%[34] and if significant at $p<0.2$.[35] Non-normally distributed outcomes (sit-to-stand transitions; MVPA MET minutes) were log-transformed, with their mean group differences expressed as rate ratios (RR, e.g., ratio of mean multi-component intervention group/comparison group).

Sample Size Calculation

The trial aimed to recruit 15 and retain 13 participants in each arm. A priori calculations in Stata (version 11.2) revealed this to be sufficient to achieve at least 80% power (5% significance, two-tailed), for the detection of differences between the multi-component group versus the comparison/workstations-only group of 70/90 minutes, respectively, per 8-hour workday for workplace sitting. This was based on expected SDs of change in workplace sitting of 70 minutes (intervention group) and 24 minutes (comparison group).[18] Minimum detectable differences for the other activity monitor outcomes were: 75/95 minutes (standing); 85/95 minutes (prolonged sitting); 15/15 minutes of stepping; 4/3 MET minutes of moderate-to-vigorous physical activity; 600/700 number of steps; and 2.1/3.0 sit-to-stand transitions between the multi-component group versus the comparison/workstations-only group, respectively.

Missing Data

Missing diary information was followed up with participants whenever possible. The online questionnaire structure did not permit missing values. Missing data on the activity monitor outcomes was low (*n*=6; 11.4%; Figure 1), occurring for three participants (multi-component group) due to becoming ineligible before (*n*=2) or during the intervention (*n*=1); one participant (workstations-only group) due to withdrawal; one (multi-component group) due to monitor malfunction; and one (comparison group) due to adverse reaction to the adhesive tape holding the

monitor in place. Accordingly, data were assumed to be missing completely at random and multivariate analyses conducted with completers.

Results

Participant Characteristics

The majority of participants were women (the multi-component condition had only women); Caucasian; nonsmokers; and general university staff in full-time employment (Table 2). On average (all groups combined) at baseline, 77% (±10%) of time at the workplace was spent sitting; 16% (±7%) standing; and 8% (±3%) stepping. Overall, 38% (±16%) of the total time at the workplace was spent in prolonged sitting bouts ≥30 minutes.

Changes in Sitting, Standing, and Moving

Following intervention, a significant overall effect of study group on workplace sitting time was observed (p=0.001; Table 3). For the multi-component group, the average reduction in daily workplace sitting time was 89 minutes (95% CI=−130, −47 minutes; $p<0.001$) relative to the comparison group and nearly an hour (–56 minutes, 95% CI=−107, −4 minutes; p=0.033) compared to the workstations-only group. There was no significant change in daily sitting time observed in the workstations-only group relative to the comparison group (–33 minutes, 95% CI=−84, 17 minutes; p=0.285). Within groups, mean sitting time reductions were 94 minutes (95% CI=−146, −43 minutes; p=0.002) and 52 minutes (95% CI=−79, −26 minutes; p=0.001) in the multi-component group and workstations-only group, respectively. No significant change was observed in workplace sitting time within the comparison group (−11 minutes, 95% CI=−22, 43 minutes; p=0.484).

A significant overall effect of intervention condition on workplace standing time ($p<0.001$) was observed. Relative to the comparison group, workplace standing time increased by 93 minutes (95% CI=45, 141 minutes; $p<0.001$) in the multi-component group—an hour greater (59 minutes, 95% CI=10, 107 minutes; p=0.014) when compared to workstations-only group participants. No significant changes were seen in any of the other secondary activity monitor outcomes. However, we were not adequately powered to detect these changes and 95% CIs could not rule out potentially meaningful intervention effects in prolonged sitting time (−31 minutes, 95% CI=−79, 17 minutes; p=0.296) in the multi-component group and in standing time (35 minutes, 95% CI=−12, 81 minutes; p=0.200) in the workstations-only group compared to the comparison group.

Changes in Work-Related Outcomes and Musculoskeletal Symptoms

No significant changes were observed in work-related or musculoskeletal outcomes. However, changes of ≥20%, indicating potentially meaningful intervention effects,[36] were observed in the following outcomes: increased absenteeism and presenteeism within the comparison group; musculoskeletal symptoms within the multi-component condition (shoulders increased; neck, knees, ankles/feet decreased) and the comparison group (hips/thighs/buttocks and knees increased; Appendix A, available at www.ajpmonline.org).

Adverse Events

Seven weeks following the provision of the height-adjustable workstation, one participant (workstations-only condition) withdrew from the study because of overall body pain. Although it cannot be ruled out that this was completely unrelated to the use of the workstation, this participant exclusively wore high-heels while standing at the workstation (which was not recommended per the intervention protocol). No other adverse events were reported.

Fidelity of Intervention Delivery

Overall, fidelity of intervention delivery in the multi-component condition was high. All participants received all intervention elements, with the exception of the staff information session, which was attended by 12/14 participants.

Study Feasibility and Acceptability

Acceptability of the height-adjustable workstations was high in both groups (mean score of 3.9/5 [SD=0.5] in the multi-component group and 3.7/5 [SD=0.6] in the workstations-only group). However, noted limitations included diminished desk-space, and not being able to adjust the distance from the computer screen to the eyes. All multi-component intervention group participants rated additional intervention components as either useful or very useful, and 12/13 rated the manager e-mails as either useful or very useful (minimum score=3).

Discussion

The multi-component intervention resulted in an approximate threefold greater reduction of office workers' sitting time during work hours relative to the provision of height-adjustable workstations alone. Likewise, the increase in standing time in the multi-component intervention group significantly exceeded that of the workstations-only intervention group. To our knowledge, this is the first study to evaluate the

Table 2. Baseline characteristics by study group, % (*n*) unless otherwise noted

	MC (*n*=16)	WO (*n*=14)	Comparison (*n*=14)	All (N=44)
Age (years, M [SD])	37.3 (10.7)	43.0 (10.2)	48 (11.6)	42.6 (11.5)
Males	0 (0)	21.4 (3)	29 (4)	16 (7)
Caucasian	94 (15)	93 (13)	93 (13)	93 (41)
Married/living together	81 (13)	71 (10)	64 (9)	73 (32)
Tertiary education	75 (12)	64 (9)	71 (10)	70 (31)
Tenure at workplace (years)				
≤1	6 (1)	21 (3)	36 (5)	20 (9)
1–3	50 (8)	21 (3)	7 (1)	27 (12)
≥3	44 (7)	57 (8)	57 (8)	52 (23)
1.0 full-time equivalent	75 (12)	79 (11)	93 (13)	82 (36)
Staff type				
Permanent	50 (8)	71 (10)	79 (11)	66 (29)
Contract	50 (8)	29 (4)	21 (3)	34 (15)
Job category				
Managers/professionals	38 (6)	71 (10)	57 (8)	55 (24)
Clerical/service/sales	63 (10)	29 (4)	43 (6)	46 (20)
Smoker	6 (1)	14 (2)	0 (0)	7 (3)
BMI (M [SD])	25 (5.0)	24 (3.7)	28 (5.7)	26 (5.1)
History of high cholesterol	31 (5)	21 (3)	21 (3)	25 (11)
History of diabetes	0 (0)	0 (0)	7 (1)	2 (1)
ACTIVITY MONITOR DATA (M [SD])	(n=16)	(n=14)	(n=13)[a]	(N=43)[a]
Time monitor worn at the workplace (hours/day)	8.1 (1.0)	8.0 (1.1)	7.9 (1.0)	8.0 (1.0)
Stand Up				
Standing time (minutes/8-hour workday)	81 (40)	68 (30)	76 (35)	75 (35)
Sit-to-stand transitions (*n*/hour sitting)[b]	5.1 (4.2, 6.3)	4.9 (3.4, 6.0)	4.2 (3.0, 5.2)	4.9 (3.6, 5.8)
Sit Less				
Sitting time (minutes/8-hour workday)	366 (49)	373 (36)	365 (54)	368 (46)
Time accrued in prolonged sitting ≥30 minutes (minutes/8-hour workday)	159 (63)	186 (67)	200 (96)	180 (76)
Move More				
Stepping time (minutes/8-hour workday)	34 (12)	39 (15)	40 (20)	37 (16)
MVPA MET minutes (minutes/8-hour workday)[b]	10 (4, 24)	9 (6, 20)	3 (2, 15)	7 (3, 22)
Steps (*n*/8-hour workday)	1548 (525)	1920 (568)	1789 (1015)	1742 (786)

Note: minutes/8-hour workday=minutes at the workplace standardized to 8 hours of work time
[a]Activity monitor data were missing for one participant
[b]Non-normal outcomes reported as median (25th percentile, 75th percentile)
MC, multi-component intervention group; MVPA, moderate-to-vigorous physical activity; WO, workstations-only intervention group

Table 3. Between-group differences at 3 months for sitting, standing and moving outcomes at the workplace

	MC (n=12) vs comparison (n=13)		WO (n=13) vs comparison (n=13)		MC (n=12) vs WO (n=13)		Overall-effect of arm
Measure	**Mean difference (95% CI)**	***p***	**Mean difference (95% CI)**	***p***	**Mean difference (95% CI)**	***p***	***p***
Stand Up							
Standing time (minutes/8-hour workday)	93 (45, 141)	<0.001	35 (−12, 81)	0.200	59 (10, 107)	0.014	<0.001
Sit-to-stand transitions (n/hour sitting)[a]	RR=1.11 (0.87, 1.40)	0.636	RR=1.15 (0.92, 1.45)	0.320	RR=0.96 (0.76, 1.22)	0.963	0.276
Sit Less							
Sitting time (minutes/8-hour workday, [primary outcome])	−89 (−140, −38)	<0.001	−33 (−84, 17)	0.285	−56 (−107, −4)	0.033	0.001
Time accrued in prolonged sitting ≥30 minutes (minutes/8-hour workday)[b]	−31 (−79, 17)	0.296	−15 (−59, 30)	0.799	−17 (−63, 29)	0.752	0.274
Move More							
Stepping time (minutes/8-hour workday)	−1 (−12, 10)	0.997	−1 (−12, 9)	0.988	1 (−10, 11)	0.999	0.956
MVPA (MET minutes/8-hour workday)[a]	RR=1.06 (0.60, 1.90)	0.991	RR=1.00 (0.57, 1.75)	>0.999	RR=1.06 (0.61, 1.85)	0.989	0.951
Steps (n/8-hour workday)	−12 (−535, 512)	>0.999	−74 (−584, 437)	0.978	62 (−461, 585)	0.988	0.928

Note: Mean change from baseline (95% CI), adjusted for baseline value of outcome (ANCOVA); ***p***-values and 95% CIs corrected for multiple comparisons (Sidak method); minutes/8-hour workday=minutes at the workplace standardized to 8 hours of work time (i.e., standardized minutes=minutes * 8/ observed hours at the workplace)

[a]Values reported are back-transformed from natural log scale; differences are interpreted as relative rates (RR), for example, the back-transformed mean for the multi-component group divided by the back-transformed mean for the comparison group.

[b]Adjusted for full-time employment

ANCOVA, analysis of covariance; MC, multi-component intervention group; RR, rate ratio; WO, workstations-only intervention group

benefit of adding individual- and organizational-level intervention elements to the installation of height-adjustable workstations.

Compared to the only other study (Stand Up Comcare) to have evaluated such a multi-component intervention to reduce sitting time including workstations, the reduction in workplace sitting time in the multi-component group of this study was less (125 minutes vs 94 minutes, respectively).[18] Although both of the studies used activPAL devices for the assessment of sitting time, it is unknown how the reductions in sitting time were accumulated (i.e., at the workstation, through organizational strategies such as standing meetings, or a mixture of both). A potential reason for the observed differences of intervention effects could be related to stronger organizational standing routines (i.e., standing meetings) in the better-performing sample of the Stand Up Comcare study. In fact, as the name indicates, that group consisted of office workers from Comcare, the Australian agency responsible for workplace safety, rehabilitation, and compensation in the Commonwealth jurisdiction, which likely has an increased awareness for healthy workplace practices and motivation for the implementation thereof.

The sitting time reduction in the workstations-only condition was not significant relative to the comparison group. The magnitude of change (−33 minutes) lies within the change reported by other studies that have installed height-adjustable workstations to reduce sitting time (0–66 minutes),[14–17] with the exception of one study that reported a reduction of 143 minutes/8-hour workday.[5] This difference might be related to the representativeness of the study sample, as the latter study was conducted within a group of public health researchers working in the area of sedentary behavior research in which sitting time–reducing strategies (e.g., standing meetings) were already part of the organizational culture. More studies including measures of when and how sitting time changes occur will be needed to put these differences into perspective.

Although no significant changes were observed for prolonged sitting, considering the benefits of even short breaks in sitting time on biomarkers of cardiovascular health is needed.[4,37,38] No significant changes were observed for prolonged sitting. Considering the benefits of even short breaks in prolonged sitting time on biomarkers of cardiovascular health,[4,37,38] stronger emphasis on the importance of regularly breaking up prolonged sitting may be needed, even when overall workplace sitting time is reduced. Although both intervention groups replaced some of their sitting time with standing, it is unknown how this increase in standing time was accumulated.

Consistent with previous studies,[5,18] no significant changes were observed in the number of steps, stepping time, or MVPA MET minutes during work hours. This may reflect the nature of desk-based office work, where the majority of time is spent at the desk to complete job tasks, and where time spent moving is minimal. Other workplace studies have successfully combined the installation of height-adjustable workstations with physical activity program strategies.[14,17] However, although the magnitude of sitting time reduction in these studies was significant, the magnitude of the changes (66 minutes and 58 minutes, respectively) was not as substantial as observed in the multi-component intervention group of the present study. Although yet to be evaluated, an optimal approach may be to use the multi-component approach to sitting time implemented in the current study in combination with successful exercise intervention strategies.

These results suggest that it is feasible to implement a multi-component intervention such as was used in Stand Up UQ with high fidelity, no perceived decrease in productivity, and few adverse outcomes. However, such study components are also resource intensive, including the installed workstations (currently retailing for approximately US$499, plus installation cost), and delivery of other intervention elements. Although the findings indicate that individual and organizational supports are important for reducing workplace sitting time, it is not possible to identify if any particular strategies were more important than others. As the individual-level intervention components are the most cost-intensive, future studies could evaluate the efficacy of the multi-component intervention in comparison to an intervention including only height-adjustable workstations and organizational strategies.

The three-arm design and objective measurement of sitting time are the key strengths of this study. However, there were a number of limitations. The sample size was small. However, the sociodemographic characteristics of the three groups involved are broadly comparable with office workers involved in previous sedentary behavior studies,[5,9,14,16,18] noting that the range of such characteristics has varied widely across the various studies. Likewise, the study was not powered for all outcomes examined, and it was not possible to fully randomize all intervention groups for reasons outlined in the Methods. Although all analyses controlled for baseline values and tested sociodemographic as well as workplace characteristics for potential confounding, the possibility that unmeasured confounders may have affected the results cannot be ruled out and true cause and effect cannot be claimed. Furthermore, with regard to the recruitment of study groups, the response rate in the

comparison group was low (3% in comparison to 46% and 69% in the multi-component and workstations-only group, respectively). However, although the two intervention groups were recruited from desk-based administrative staff groups only, the recruitment e-mail for the comparison group was sent to all staff working on this campus (i.e., including staff who are not desk-based, such as agricultural field workers).

Key reasons for the choice of the desk-mounts used in this study were their ability to retro-fit existing office furniture as well as their substantially lower cost in comparison to fully height-adjustable desks. However, some design flaws were apparent in this study (i.e., lost desk-space, non-adjustable computer screen distance to eyes). Considering the rapid advancements in design and increasing demand for height-adjustable furniture, fully height-adjustable desks are becoming increasingly more affordable; it is recommended that these newer models be used in future research. Finally, this study examined only short-term (3 months) results. Future studies should examine the sustainability (over 6 months or more) of reductions in workplace sitting time following intervention. Incorporating the increasing evidence base on successful strategies to reduce office-workers' sitting time (e.g., height-adjustable desks) into OHS policies may be crucial.

Conclusion

This is the first study to suggest that multi-component programs targeting workplace sitting may achieve more substantial reductions in office workers' sitting time than the provision of height-adjustable desks alone. These findings have important practical and financial implications for workplaces considering interventions to reduce sitting time among staff.

The authors would like to thank all participating UQ units, their management, and study participants. Further, we would like to acknowledge UQ's Deputy Director OH&S Division, Kris Fraser, who provided consultation on the use of the workstations in line with the university's OHS guidelines. Finally, the authors thank Dr Elisabeth Winkler for her support regarding data processing and statistical analyses.

MN was supported by an Australian Postgraduate Award Scholarship. GNH was supported by a National Health and Medical Research Council (NHMRC; No. 569861) and Heart Foundation (No. PH 12B 7054) Fellowship. DWD was supported by an Australian Research Council Future Fellowship (No. FT100100918). NO was supported by an NHMRC Program Grant (No. 569940) and a Senior Principal Research Fellowship (NHMRC; No. 1003960). EGE was supported by a NHMRC Senior Research Fellowship (No. 511001).

Funding source for the trial: Australian Postgraduate Award Scholarship, UQ School of Population Health Top-Up Scholarship and research student funding, Queensland Health Core Infrastructure Funding, and UQ Major Equipment and Infrastructure and NHMRC Equipment Grant.

Height-adjustable workstations were provided by Ergotron (www.ergotron.com). DWD presented at the Juststand Wellness Summit, a conference organized by Ergotron, in 2012 and GNH presented at the same summit in 2013. Ergotron covered travel and accommodation expenses for both DWD and GNH. No further honoraria or imbursements were received. The funding bodies had no influence on the conduct or the findings of the study.

No other financial disclosures were reported by the authors of this paper.

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Appendix

Supplementary data

Supplementary data associated with this article can be found at http://dx.doi.org/10.1016/j.amepre.2013.09.009.

Workplace Sitting and Height-Adjustable Workstations

A Randomized Controlled Trial

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Appendix A

Self-reported musculoskeletal symptoms and work-related outcomes in each group at baseline and 3-months follow-up

Measure	Multicomponent intervention (*n*=13)			Workstation-only intervention (*n*=13)			Comparison group (*n*=14)		
	Baseline, %	Follow-up, %	*p*	Baseline, %	Follow-up, %	*p*	Baseline, %	Follow-up, %	*p*
Work-related outcomes									
Work-performance	8.2 (1.2)	8.2 (1.4)	>0.999	7.3 (1.9)	8.1 (0.9)	0.201	7.9 (1.1)	8.1 (1.0)	0.189
>1 Sick days (last month)	62 (8)	62 (8)	>0.999	54 (7)	54 (7)	>0.999	**36 (5)**	**57 (8)**	**0.453**
>1 days worked while suffering health problems (last month)	54 (7)	69 (9)	0.625	62 (8)	69 (9)	>0.999	**43 (6)**	**64 (9)**	**0.250**
Musculoskeletal symptoms									
Neck	**100 (13)**	**77 (10)**	**N/A**	46 (6)	54 (7)	>0.999	71 (10)	57 (8)	0.500
Shoulders	**54 (7)**	**77 (10)**	**0.250**	46 (6)	54 (7)	>.999	50 (7)	57 (8)	>0.999
Elbows	8 (1)	15 (2)	>0.999	23 (3)	15 (2)	>0.999	7 (1)	14 (2)	>0.999
Wrist/hands	23 (3)	23 (3)	>0.999	46 (6)	39 (5)	>0.999	21 (3)	36 (5)	0.625
Upper back	**62 (8)**	**39 (5)**	**0.375**	46 (6)	31 (4)	0.500	43 (6)	43 (6)	>0.999
Lower back	62 (8)	77 (10)	0.625	77 (10)	62 (8)	0.500	43 (6)	50 (7)	>0.999
Hips/thighs/buttocks	23 (3)	31 (4)	>0.999	31 (4)	31 (4)	>0.999	**21 (3)**	**43 (6)**	**0.250**
Knees	**39 (5)**	**15 (2)**	**0.250**	**46 (6)**	**23 (3)**	**0.250**	**7 (1)**	**29 (4)**	**0.250**
Ankles/feet	**31 (4)**	**8 (1)**	**0.250**	15 (2)	15 (2)	>0.999	21 (3)	29 (4)	>0.999

Work-performance: *p*-values based on paired t-test; values represent means (SD) on 1-10 scale; all other outcomes: *p*-values based on McNemar test; absenteeism, presenteeism, and musculoskeletal symptoms are presented as % (*n*) of group who answered with 'yes'; within-group changes ≥20% are highlighted in bold

4.3 Methods not reported in the paper

The next three sections describe the methods used for the *Stand Up UQ* study that were not otherwise reported in the journal article. This includes the initial procedure for the approval of the sit-stand workstations by the university's OHS division; additional outcomes measured during the study assessments; the follow-up assessment at 12 months post-baseline; and, qualitative interviews conducted with both intervention group participants and managers immediately following the study and 16-months post-study end.

4.3.1 Initial meetings for the recruitment of study groups

In conjunction with the recruitment of the three study groups, the director of the UQ Wellness division consulted the university's OHS department about the compatibility of the sit-stand workstations that were to be used for the intervention with the university's OHS standards. A meeting was arranged during which OHS staff inspected the workstations, resulting in a detailed report being produced (Appendix C.1). While the workstations were not entirely aligned with the university's OHS guidelines, approval was given to use them for research purposes.

4.3.2 Additional outcomes measured

In addition to the activity-, health- and work-related outcomes described in the paper above, activity-related outcomes across all waking hours were examined at baseline and 3 months to explore the potential for compensation of sedentary reductions during work hours. Furthermore, the following outcomes were measured during the study assessments at baseline, 3 months and 12 months:

Body composition (percentage body fat and percentage body water) was measured with shoes, socks, and heavy clothing and jewellery removed using electronic bio-impedance scales (Soehnle-Waagen GmbH & Co.KG, Backnang, Germany).

Fasting blood profile (total cholesterol, high-density lipoprotein (HDL) cholesterol and triglycerides) and glucose were measured using a 35µL whole-blood sample via finger stick. Blood samples were analysed using a Cholestech LDX Analyzer, which have shown excellent validity compared with laboratory-based analysis (r=0.92) (148, 149).

4.3.3 Follow-up at 12 months

To examine if potential reductions in workplace sedentary time were maintained over time, an additional assessment was conducted with participants of both intervention groups 12

months post-baseline (i.e. 9 months after the final intervention contact in the multi-component intervention group). Both intervention groups kept the sit-stand workstations during the entire study period. However, no further intervention elements were implemented in either of the two groups. This third assessment followed the same procedure as the first two and included measurement of the additional outcomes described above (body composition and a fasting blood profile).

4.3.4 Qualitative feedback interviews

Following the end of the *Stand Up UQ* study in March 2013, semi-structured qualitative interviews were conducted with the managers (face-to-face) and remaining participants (via telephone) of both intervention groups. The aim of these interviews was to collect information regarding the experience with the study such as barriers to study implementation and the potential of long-term uptake of intervention strategies. The interview protocols are provided in Appendix D.1. In July 2014, 16 months after the end of the *Stand Up UQ* study, brief follow-up interviews were conducted with the managers from both intervention groups as well as the university's OHS director to examine if participation in this study had any longer-term impact on the routines and practices of these groups and/ or any wider implications within the university.

4.3.5 Sample size calculations

As stated in the associated journal article, the trial aimed to recruit 15 and retain at least 13 participants in each arm at the end of 3 month assessment. This was based on sample size calculations conducted in Stata (version 11.2), which revealed this to be sufficient to achieve at least 80% power (5% significance, two-tailed), for the detection of differences in the primary outcome (workplace sedentary time) between the multi-component intervention group and the comparison/ workstations-only group of 70/90 minutes per 8-hour workday, respectively. While it was anticipated that these group sizes were unlikely to be retained until the final 12-month assessment (and thus, the 12-month findings were likely to be underpowered), collecting these data was nevertheless considered informative given the infancy of research regarding the sustainability of sedentary time reductions as reported by Study 1 of this PhD research. Minimum detectable differences for the other activity monitor outcomes were: 75/95 minutes for standing; 85/95 minutes for prolonged sitting; and, 15/15 minutes for stepping between the multi-component group versus the comparison/workstations-only group, respectively. Furthermore, based on these sample size calculations, this study was a priori underpowered for the detection of changes

regarding secondary outcomes described in Section 4.3.2 at both assessments (99). However, collecting these data was considered important for informing further research about the potential improvements in cardio-metabolic outcomes. To inform whether effects on fasting blood profiles were potentially meaningful, clinically relevant changes encompassed within the confidence intervals were considered (150).

4.3.6 Data analyses

Follow-up data at 12 months were analysed in 2013 using PASW Statistics, version 20.0.0, with statistical significance at $p<0.05$ (two-tailed). Within-group changes were assessed by paired t-tests (normal data) or Wilcoxon signed rank test (non-normal data). To analyse potential differences between the two intervention groups, mixed models were calculated with adjustment for baseline values of the outcome. While statistical power was unlikely to be sufficient for the detection of statistically significant differences in workplace sedentary time (see previous section), any reduction of ≥ 30 minutes per 8-hour workday was considered as meaningful (see Section 3.2). Furthermore, an attenuation of sedentary time reductions >15 min from 3 to 12 months was considered meaningful (i.e. <1/2 of what was considered a meaningful reduction). Given the secondary focus of the qualitative interviews, formal qualitative methods were not applied, with data being presented as narrative.

4.3.7 Missing data

The flow of participants through the *Stand Up UQ* study and the reasons for withdrawal are displayed in Figure 4.1. From baseline to the 12-month assessment, seven participants were retained in each intervention group. While these attrition rates (44% in multi-component group; 50% for workstations-only group) are higher than what would usually be expected (151), three participants were lost in each group for reasons unrelated to study participation such as maternity leave or job relocation. Considering the small sample sizes, imputation of missing data was not feasible. Accordingly, quantitative data analyses were conducted with completers only (i.e. 7 per group at 12 months; see Figure 4.1 and Table 4.4). In recognition of the implications for results interpretation, the main focus of the 12-month results is on the trends observed in workplace sedentary time. While further analyses regarding health- and work-related outcomes were conducted, the small sample sizes per group at 12 months did not allow for interpretation of results. Therefore, only the results of additional outcomes measured at 3 months that were not presented in the published article (body composition and fasting blood profile) are presented below.

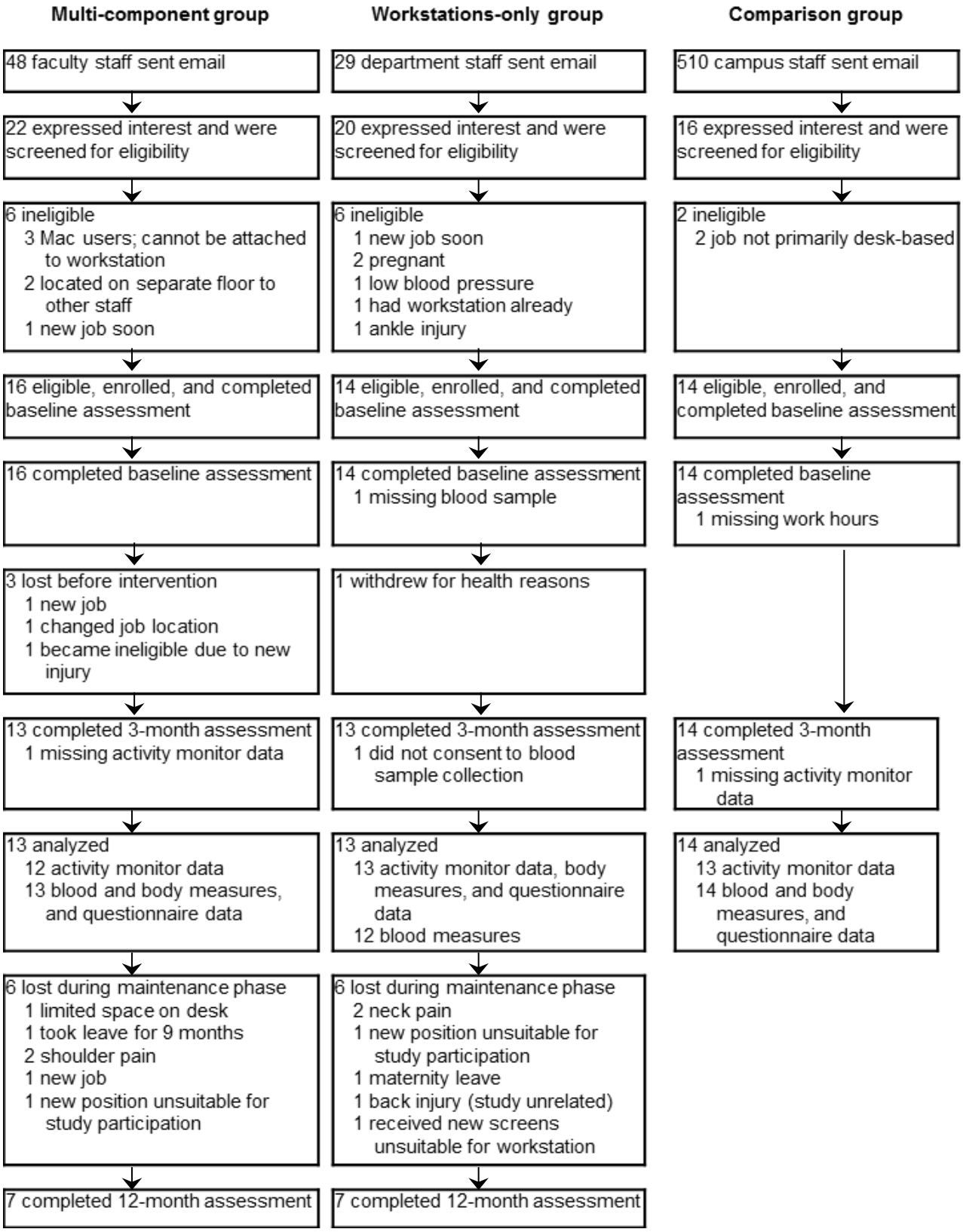

Figure 4.1. Participant flow through the *Stand Up UQ* study from baseline to 12 months.

4.4 Results not reported in the published paper

4.4.1 Activity-related outcomes during all waking hours at baseline and 3 months

The within group changes in activity-related outcomes during all waking hours from baseline to 3 months largely reflect the changes observed during work hours. Table 4.1 shows the within-group changes in these outcomes across the three study groups.

Table 4.1 Baseline and 3 month within-group changes in activity-related outcomes across study groups during all waking hours

Measure	Multi-component group mean (SD)			Workstations-only group mean (SD)			Control group mean (SD)		
	Baseline (n=14)	3 months (n=12)	p	Baseline (n=14)	3 months (n=13)	p	Baseline (n=14)	3 months (n=13)	p
Stand Up									
Standing time, mins/16hrs	229 (50)	308 (74)	.013	233 (40)	281 (54)	.001	229 (42)	255 (43)	.071
Sit-to-stand transitions, n/hour of sitting	6.0 (1.3)	7.2 (2.1)	.005	5.8 (1.0)	6.2 (0.9)	.011	5.6 (1.7)	6.1 (1.9)	.081
Sit Less									
Sitting time, mins/16hrs	630 (61)	553 (79)	.018	616 (50)	573 (55)	.001	606 (66)	586 (59)	.265
Time accrued in prolonged sitting ≥30 mins, mins/16hrs	280 (69)	260 (76)	.428	276 (75)	271 (69)	.792	309 (89)	285 (98)	.242
Move More									
Stepping mins/16hrs	100 (23)	99 (27)	.806	109 (24)	106 (21)	.381	123 (27)	119 (30)	.586
*MVPA MET mins/16hrs	15.4 (7.8, 27.1)	19.6 (8.4, 26.2)	.480	11.3 (6.1, 23.9)	14.3 (6.3, 29.7)	.861	10.3 (6.4, 23.9)	13.4 (4.0, 28.9)	.861
Steps, n/16hrs	2069 (517)	1901 (974)	.396	2347 (579)	2281 (560)	.461	2482 (607)	2410 (644)	.614

p-values are based on paired t-tests for normally distributed outcomes, with means (SD) reported; * p-values are based on Wilcoxon test for non-normally distributed outcomes with median (25^{th} percentile, 75^{th} percentile) reported; mins/16-hrs = minutes during all waking hours, standardized to 16 hours of waking time (i.e. standardized mins = mins * 16/ observed hours during the day)

4.4.2 Body composition and fasting blood profile outcomes

The baseline and 3-month changes in the body composition and fasting blood profile outcomes are presented in Tables 4.1 and 4.2, respectively. All blood values from all groups were within the healthy range (152). No statistically significant changes were observed. While meaningful changes could not be ruled out entirely, given the width of the confidence intervals the results are inconclusive (see Table 4.2).

Table 4.2 Baseline values of body composition and fasting blood profile

	MC (n=13)	**WO (n=12)**	**C (n=14)**
Body composition			
% Body fat	33.1 (5.5)	31.4 (7.6)	33.9 (10.8)
% Body water	48.8 (4.1)	49.0 (4.7)	47.8 (6.4)
Fasting blood profile			
Total cholesterol (mmol/L)	5.1 (0.8)	4.7 (1.0)	4.8 (0.9)
Triglycerides (mmol/L)	1.0 (0.7, 1.5)	1.0 (0.7, 1.3)	1.2 (0.8, 1.4)
HDL-cholesterol (mmol/L)	1.5 (0.3)	1.4 (0.5)	1.4 (0.4)
LDL-cholesterol (mmol/L)	3.0 (0.6)	2.5 (1.2)	2.7 (1.2)
Glucose (mmol/L)	4.8 (0.5)	4.8 (0.4)	5.3 (1.0)

Note: means (SD) are reported for normally distributed outcomes; median (25^{th} percentile, 75^{th} percentile) are reported for non-normally distributed outcomes; MC= Multi-component intervention group; WO= Workstations-only intervention group; C= Control group

Table 4.3 Baseline-adjusted between-group differences at 3 months for body composition and fasting blood profile

Measure	MC (n=13) vs. C (n=14)		WO (n=12) vs. C (n=14)		MC (n=13) vs. WO (n=12)		Overall-effect of arm
	Mean difference (95% CI)	*p*	Mean difference (95% CI)	*p*	Mean difference (95% CI)	*p*	*p*
Body composition							
% Body fat	-0.9 (-2.5, 0.8)	.296	-1.3 (-3.1, 0.4)	.123	0.5 (-1.2, 2.2)	.587	.285
% Body water	0.8 (-1.0, 2.5)	.393	0.5 (-1.3, 2.3)	.566	0.2 (-1.6, 2.0)	.790	.680
Fasting blood profile							
Cholesterol-total (mmol/L)	-0.1 (-0.5, 0.3)	.530	-0.1 (-0.5, 0.3)	.594	0.0 (-0.4, 0.4)	.933	.788
[a] Triglycerides (mmol/L)	RR=0.9 (0.7, 1.2)	.514	RR=0.9 (0.7, 1.2)	.625	RR=1.0 (0.8, 1.3)	.890	.791
HDL-cholesterol (mmol/L)	0.0 (-0.2, 0.1)	.866	0.0 (-0.2, 0.1)	.593	0.0 (-0.1, 0.2)	.719	.861
LDL-cholesterol (mmol/L)	-0.1 (-0.8, 0.6)	.742	-0.1 (-0.9, 0.6)	.714	0.0 (-0.8, 0.8)	.968	.919
Glucose (mmol/L)	0.2 (-0.2, 0.6)	.217	0.1 (-0.3, 0.5)	.602	0.1 (-0.1, 0.5)	.481	.457

* $p<0.05$ for change from baseline (paired t-test); [a] values reported are back-transformed from natural log scale; differences are interpreted as relative rates (RR), e.g. the back-transformed mean for the high-intensity intervention group divided by the back-transformed mean for the control group; MC= Multi-component intervention group; WO= Workstations-only intervention group; C= Control group

4.4.3 Activity-related outcomes at 12 months

The change in activity-related outcomes from baseline and 12 months in the two intervention groups is illustrated in Figure 4.2 and reported in Table 4.4. As Figure 4.2 shows, there was an overall decline in workplace sedentary time and standing time outcomes in the multi-component intervention group following the end of intervention at 3 months, while this decline was not observed in the workstations-only intervention group.

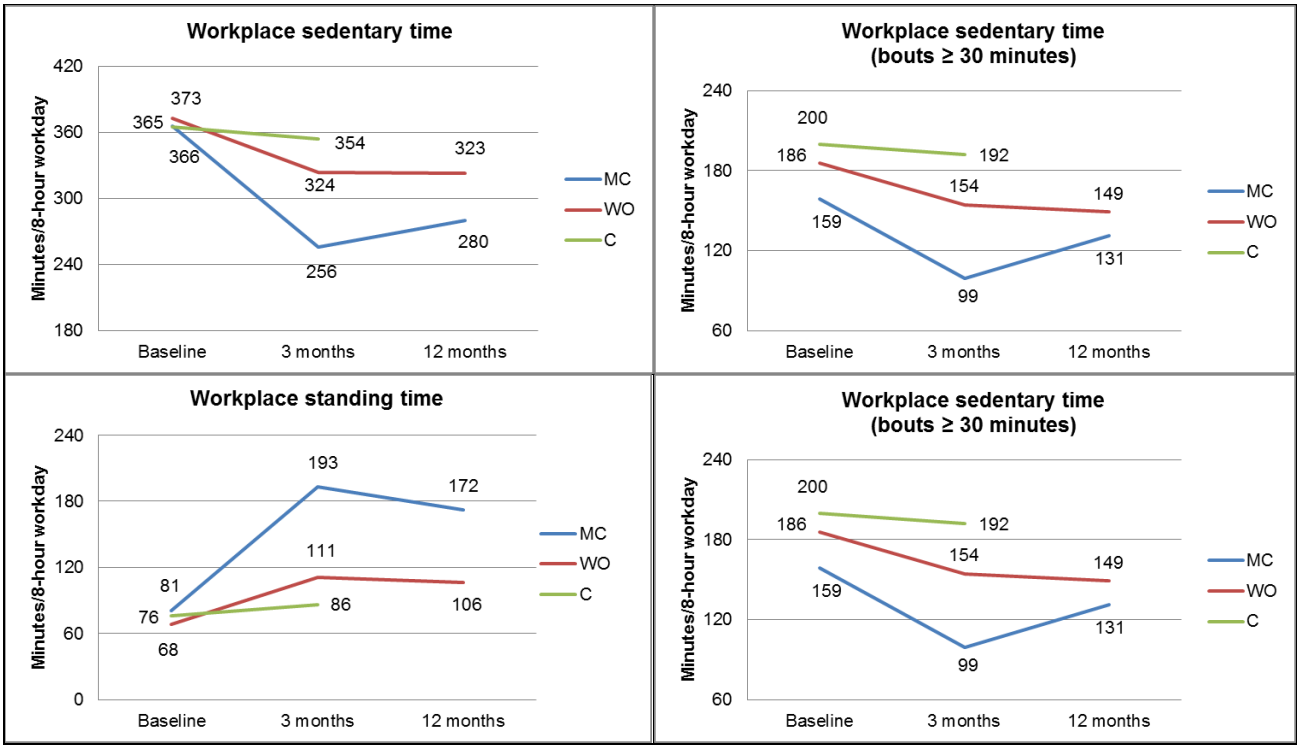

Figure 4.2. Within-group changes in activPAL outcomes of completers from baseline to 12 months; MC= Multi-component intervention group (n=7), WO= Workstations-only intervention group (n=7); C=Control group; note: no data was collected from control group participants at 12 months.

At 12 months, the difference in workplace sedentary time reduction between the two intervention groups was 36 minutes/ 8-hour workday (95% CI= -83, 11; p= .125). From 3 to 12 months, workplace sedentary time increased in multi-component intervention group participants by an average of 23 minutes/ 8-hour workday (95% CI= -55, 8; p= .138). In the workstations-only intervention group, sedentary time reductions were maintained (<15 minute change) from 3 to 12 months.

A similar pattern was observed regarding prolonged workplace sedentary time and workplace standing time in both groups. The between-groups difference in prolonged workplace sedentary time remained largely unchanged from 3 to 12, while an overall

increase of 32 minutes/ 8-hour workday (95% CI= -12, 75; p= .144) was observed in the multi-component intervention group. A change in workplace standing from 3 to 12 months was observed only in the multi-component intervention group (-20 minutes/ 8-hour workday (95% CI= -62, 21 p= .309). However, the difference in workplace standing time between the two intervention groups was still nearly an hour (54 minutes/ 8-hour workday; 95% CI= -3, 11; p= .063) at 12 months. Finally, in contrast to what would be expected, a significant between-groups difference was observed regarding workplace time spent stepping of 10 minutes/ 8-hour workday (95% CI= -18, 2; p= .015) in favour of the workstations-only group.

Table 4.4 Within and between-group changes in activPAL outcomes of completers

	12M Δ (95%CI) (n=14)	**p**	**3M Δ vs. 12M Δ (95%CI)(n=14)**	**p**
Standing minutes per 8-hour workday				
Multi-component	91 (52, 131)		-20 (-62, 21)	.309
Workstations-only	38 (-2, 77)		-6 (-47, 36)	.769
Difference	54 (-3, 111)	.063	-15 (-73, 44)	.601
Sitting minutes per 8-hour workday				
Multi-component	-86 (-120, -53)		23 (-55, 8)	.138
Workstations-only	-50 (-83, -17)		1 (-30, 30)	.933
Difference	-36 (-83, 11)	.125	25 (20, -69)	.258
Prolonged sitting minutes per 8-hour workday				
Multi-component	-28 (-66, 11)		32 (-12, 75)	.144
Workstations-only	-37 (-75, 2)		-5 (-47, 38)	.822
Difference	9 (-46, 63)	.753	36 (-24, 97)	.229
Stepping time minutes per 8-hour workday				
Multi-component	1 (-4, 6)		-1 (-6, 5)	.809
Workstations-only	11 (5, 16)		10 (-4, 15)	.003*
Difference	-10 (-17, -2)	.014*	-10 (-18, 2)	.015*

Note: values are based on mixed models analyses and presented as mean change (95% Confidence Interval; 3M Δ= change from baseline to 3 months; 12M Δ= change from baseline to 12 months; *values are significant at <0.5.

4.4.4 Qualitative feedback immediately post study completion

The following sections provide a summary of the qualitative feedback interviews with the study groups that occurred immediately following the final (12 month) assessment. First, the results from the interviews with the multi-component intervention group manager and participants are reported. This is followed by a summary of the interviews with the workstations-only group manager and participants.

Feedback from multi-component intervention group manager

Overall, the manager of the multi-component intervention group was very satisfied with the *Stand Up UQ* study - *"It ran very smoothly from start to finish. Even the roll-out of setting up the machines [i.e. sit-stand workstations] seems to have happened very seamlessly – no problems, no staff complaining about anything or worried. In fact, the number of staff that came up and wanted to be part of it increased after the workstations had already been set-up…I think it was very well organised".*

In particular, this manager appreciated the opportunity of participating in the study to show her staff that she cared about their health and wellbeing – *"I can't tell you enough that as a manager and especially here where there are a lot of people in our office, it is extremely powerful for the manager of an organisation to be able to say 'You are really important to me and therefore I want you to participate in this because there is a chance that you might gain something personally out of this. Not just me workwise in terms of productivity or something, but you personally… And this is a way to say that I care and I want you to come to a workplace that can offer you something of benefit'".*

When asked if the organisational routines or norms around sitting and standing at work had changed in her workplace, she replied: *"The feedback I got from staff is that they really welcomed it and that they really enjoyed it – standing up and sitting down and it is very odd now that they* [the sit-stand workstations] *have been taken away. And it's odd to see because whenever I'm approaching I think 'What's different? That's right – you're sitting!' So that's different. They were really standing all the time and clearly enjoying it.* [Staff name] *actually also as a result does the standing thing in meetings quite often. She will stand up and then she'll say 'feel free to stand up if you need to".*

However, this manager also mentioned barriers to standing in meetings outside of her own team, where the culture around standing and sitting had not changed – *"I certainly now*

choose to stand up at all-staff meetings and it was because you came to two or three of them right? And so I stood up and now I stand up. But other meetings I go to, senior faculty meetings etc. – no, I sit down. Yeah I don't know but a lot of those meetings are with senior staff that may only know about the basics around what we've done here".

She did not perceive any loss (or increase) regarding productivity among her staff through any of the intervention elements (including walking over to colleagues instead of emailing them) – *"It's hard for me to work out whether it's good, right, because I don't have the metrics to measure that. I can't say that I think without them I would have gotten less work or productivity. I just think that it was good for them. And what's good for them becomes good for me".*

In this manager's opinion, all of her staff would benefit from having a sit-stand workstation. When asked about whether she thinks that her staff would benefit from additional strategies such as coaching sessions and/ or management emails to reduce workplace sedentary time, she said: *"'I think everyone to start. At least to start they will need additional support. And again, it's just a reminder until it becomes a habit. I think we all need that support in the beginning and then the reminders".*

At the time of this interview, this manager's group was preparing to move into new office spaces within the next year. While budget constraints were a barrier for the purchase of sit-stand workstations for all of her staff, she was trying to fit out the new offices with as many sit-stand desks as possible. When asked whether she had any additional future strategies in place for reducing sedentary time in her workplace, she replied that she plans to revise the induction training to include instructions on the appropriate use of the new sit-stand workstations. As she perceives staff education and continuous reminders from management to reduce sedentary time as key factors for intervention success, she also plans to show ongoing support of less sitting and other health behaviours via continued manager emails three to four times per year.

Feedback from multi-component intervention group participants

Of the seven participants who were retained in the multi-component intervention group until the end of the *Stand Up UQ* study, six completed the qualitative feedback interview. Overall, these participants were very satisfied with the study, reflecting the positive feedback of their manager. When asked about perceived advantages and disadvantages

of more standing at work, participants listed a number of advantages including improved health, in particular improvements in lower back pain, energy and productivity – *'Just having the option to sit or stand was great. I felt more energised and my back wasn't as sore as usual'.*

The most commonly mentioned disadvantage was related to the design flaws of the sit-stand desk-mount used in the study, such as reduced desk space, limited space for the mouse, not being sturdy enough and non-adjustable computer screen distance – *'The desk took up a lot of room which was a bit annoying at times.' 'It took me a few months to get used to it, but then I really got into it and I really miss it now'.* Another mentioned disadvantage was the need to consider appropriate shoe wear (i.e. flat shoes). Participants mentioned an increased awareness of excessive sedentary time as well as higher acceptability of standing in the workplace as a consequence of the study. Interestingly, they also noted a steady decline in standing during meetings once the sit-stand workstations (located in individual office spaces) were de-installed at the end of the study – *'When everyone still had their desks, there was quite a lot of standing in our meetings. But once they had lost their desks they also went back to sitting in meetings'.*

All participants thought that the workstations and other intervention strategies had a neutral or beneficial impact on their productivity. *'Even though the desk was not perfect I felt like I achieved more throughout the working day'.* They also perceived great support from their manager. In particular, they appreciated the emails she sent out in support of the study's key messages (i.e. the manager emails sent as part of the intervention protocol) – *'We got emails from her, which was great. They brought everyone onto the same page and encouraged you to try things. I reckon if she would do that again it would help me to get into better habits again'.* Finally, when asked about what strategies they are likely to continue, participants expressed the motivation to keep standing in meetings; however, while standing in smaller team meetings still seemed to be common practice at present, they also expressed a need for a higher-level staff or chair-person to initiate and/ or publically welcome standing during larger team meetings to overcome a 'hierarchy issue'. Among other strategies participants said they were likely to continue were: taking the stairs instead of the lift; walking over to colleagues instead of emailing them; and, standing up to answer the phone.

Feedback from the workstations-only intervention group manager

Similar to the manager of the multi-component intervention group, the manager of the workstations-only intervention group was very satisfied with the study – '*It was a very participative process 'Is this going to work or is that going to work or might this work better for you…?' etc., sending people out times to have their monitors and their checks and working like that even outside of normal work hours… I thought all of that was perfect. Not a single piece of negative feedback'.* However, this manager perceived a relatively negative attitude in her group regarding the sit-stand workstations. She noted that while staff loved having the option to sit or stand, they continuously complained about the design flaws of the workstations and that they were impeding on work performance when used in standing position – *'They just did not like them. They loved having the opportunity to be able to stand up, but they couldn't work with the particular type of workstation…They couldn't get through all their paperwork when standing, they weren't comfortable using their phone because they were aware of noise disruptions, …they had trouble with the mouse etc…So they tended to have it down and sitting'.*
Furthermore, she did not perceive any change regarding organisational culture or practices around sitting and standing such as standing meetings – *'People would probably go 'What are you doing?' But they certainly would never feel ostracised in any way because they were doing it'.* However, she mentioned that those who used the workstations regularly became 'more approachable' altogether, thus having a positive impact on the social culture in the workplace.

This manager has a sit-stand desk herself now with a fully height-adjustable desk surface (as opposed to the desk mounts used in this study) and wind-up mechanism. Notably, she does not use it to change her posture regularly as finds it too tedious to wind it up or down – *"It's 37 iterations to get it up or down, so I'm just not going to do it."* Since the end of the *Stand Up UQ* study, this manager has acquired funds for the purchase of ten electronic sit-stand workstations with a fully height-adjustable desk surface.

Feedback from workstations-only intervention group participants

Of the seven participants who were retained in the workstations-only intervention group until the end of the *Stand Up UQ* study, five completed the qualitative feedback interview. Overall, the participants were very satisfied with the study and perceived many

advantages to increased standing at work – *'Just health wise - it made you feel better and I didn't feel as tired'*. However, in line with the feedback from the manager, lots of negative feedback was noted regarding the design of the workstations. When asked about whether the workstations had any impact on their work performance, most participants mentioned either a neutral or negative impact due to the design flaws of the workstations – *'I don't think it had any impact except that you had to work around the flaws of the workstation design'.* All participants perceived their manager to be supportive of the workers to reduce their sitting time. When asked about whether the organisational culture/ norms had changed around sitting and standing, mixed answers were given: while some thought standing was more accepted and practiced in their workplace, others said that no one stands in meetings and is unlikely to do so in the future *'It is more accepted to stand now' 'No, I can't see our group having a standing meeting - too many people just like to sit".*

As mentioned above, following the de-installation of sit-stand workstations at the end of the study, the manager of this group purchased ten sit-stand workstations (with a fully height-adjustable desk surface as opposed to the desk mounts used in the study) that were given to most of the study participants. These participants said that they continuously use the workstations to sit less. Those who did not receive a workstation said that they tried to remember to stand up regularly.

Summary of qualitative interviews

In summary, managers and participants from both intervention groups expressed positive feelings about their experiences with the study overall. Participants in both groups appreciated having the option to sit or stand at their desks. However, despite both groups having received the same workstations, a greater positive attitude was evident among multi-component intervention group participants. A noted commonality between the feedback from the managers included the opinion that all of their staff would benefit from working at sit-stand workstations. However, they also both reported that budget constraints posed a major barrier to refurbishing their offices accordingly. Finally, they both perceived additional strategies to reduce workplace sedentary time (including education about the health impacts of sedentary time, role modelling and continuous reminders) as key to successful and sustained sedentary time reductions among their staff.

4.4.5 *Stand Up UQ*: Longer-term follow-up

Sixteen months following the end of the *Stand Up UQ* study, both intervention group managers as well as the univerit's OHS director participated in a brief follow-up interview conducted by the PhD candidate.

As mentioned above, the multi-component intervention group was planning to move into a newly built office building. When asked if participation in the *Stand Up UQ* study had any impact on this move, this manager explained that she was able to mobilise funding for the purchase of electronically-adjustable sit-stand workstations (with fully height-adjustable desk surfaces) for 35 of her staff. However, this manager also mentioned significant difficulties during the approval process due to scepticism of more senior staff. Furthermore, this manager is currently discussing other options to continue encouraging her staff to stand up, sit less and move more. This includes a note on meeting agenda templates that 'standing is welcome', modification of staff induction trainings to include appropriate use of the sit-stand workstations and educational seminars around sedentary behaviour to her staff.

A brief interview with the manager of the workstations-only intervention group revealed that no further changes have occurred regarding workplace sedentary behaviour in this workplace since the end of the *Stand Up UQ* study. Apart from those ten staff who received the new sit-stand workstations, she has not observed any other changes such as standing in meetings or other efforts to reduce workplace sedentary time.

Finally, the university's OHS Director participated in a brief follow-up interview. She explained that the message that prolonged sedentary behaviour can pose a health risk has been received by staff across the university over the last few months, mainly through the increase in media reports. In particular, she noticed that those workers who are employed in occupations with generally lower occupational health risk such as desk-based office workers have a much stronger awareness of this health risk behaviour. Accordingly, a shift in their expectations regarding work style choices has occurred. These include the availability of activity-permissive furniture and/ or routines such as standing-friendly meetings. Accordingly, budgetary and office furniture design requirements are now being made by an increasing number of departments in order to adopt activity-permissive work environments in the near future.

4.5 Discussion of the *Stand Up UQ* study

The *Stand Up UQ* study examined the effectiveness of a 3-month multi-component intervention to reduce workplace sedentary time in line with the workplace health-promotion literature (including activity-permissive workstations and strategies targeting personal health resources and the psychosocial work environment). Additionally, it compared the effectiveness of this intervention to an intervention comprising installation of activity-permissive workstations only and a comparison group in a 3-arm trial.

Results showed that the multi-component intervention resulted in an approximately 3-fold greater reduction in workplace sedentary time at 3 months (89 minutes/ 8-hour workday) when compared to installation of activity-permissive (sit-stand) workstations only (33 minutes/ 8-hour workday), though both sedentary time reductions were considered meaningful. The results of this study further suggest that the sedentary time reductions during work hours do not impact on sedentary time across the whole day. Furthermore, the sustainability of these changes was assessed 9 months after completion of the strategies targeting personal health resources and the psychosocial work environment (12 months post baseline). Here, the sedentary time reductions in the workstations-only group were maintained, whereas an increase of 23 minutes/ 8-hour workday was observed in the multi-component intervention group. While this was considered a meaningful drop-off (i.e. >15 minutes; see Section 4.3.6), there was still a substantial difference of 36 minutes/ 8-hour workday between the two intervention groups at 12 months. These findings suggest that strategies targeting personal health resources and/ or the psychosocial work environment in addition to activity-permissive workstations may be needed to achieve more substantial reductions in workplace sedentary time than what may be achieved through the installation of activity-permissive workstations only. However, provision of the additional strategies may be needed on a longer-term or ongoing basis to facilitate sustained sedentary time reductions of that magnitude.

A major limitation of this study was the small sample size, in particular at the 12-month follow-up, leading to significant caveats regarding the interpretation of the activity-, health- and work-related outcomes. Accounting for approximately half of the attrition rate were reasons such as maternity leave and job relocation, both factors commonly reported in longer-term workplace studies (153, 154). This further emphasises the need for longer duration and larger-scale studies in this field, as already highlighted in Chapter 2. However, other reasons for study dropout included shoulder and/ or neck pain and limited

desk space, all of which were related to working at the sit-stand workstations. This is an important finding regarding the feasibility of the sit-stand desk mounts used in this study. In particular, it suggests that there needs to be careful consideration of the numerous workstations types available in accordance with the requirements and work-tasks of the end-user. Further implications of these findings for research, policy and practice are discussed in the next chapter.

The qualitative feedback from both participants and managers at the end of the study showed high acceptability of the study overall and of the multiple intervention components specifically. There was high appreciation of participants for having the option to sit or stand at work, which has been reported in other studies using such workstations (155, 156). However, while participants from both groups made some suggestions regarding improvement of the workstation design, a noticeable negative attitude was evident among participants from the workstations-only intervention group because of the design flaws of the workstations. While the reason for this is not known, it may be attributable to the lack of managerial support and encouragement as well as the lack of individual coaching on how to overcome barriers experienced throughout the study.

CHAPTER 5. Discussion

5.1 Overview

This PhD research has taken place in the context of a rapidly evolving field of research aiming to reduce sedentary time across multiple settings. It is embedded within the broader *Stand Up Australia* program of research, which examines the benefits of reducing sedentary behaviour in the workplace. The primary aim of this PhD research was to examine the effectiveness of strategies to reduce workplace sedentary time in desk-based office workers.

Throughout this thesis research, the *Healthy Workplace Framework* (109) was used as a guiding model. This model provides structure for the development of workplace health behaviour interventions and addresses four key dimensions of health behaviour influence in the workplace: the physical work environment; the psychosocial work environment; personal health resources; and, enterprise community involvement. In the context of reducing workplace sedentary time, approaches integrating these dimensions are not well researched. Furthermore, there are potentially significant resource implications associated with intervening on these various dimensions. Given that sitting is a habitual behaviour that is strongly influenced by the environments and settings it occurs in, it has been suggested that modifications of the physical work environment, such as through installation of activity-permissive workstations, may be particularly important in order to reduce sedentary time in office-based workplaces (115). However, the evidence to date regarding the effectiveness of such workstations to reduce office workers' sedentary time is limited.

This PhD research addressed these gaps in the current evidence through three studies: a systematic review; the development and detailed description of a multi-component intervention; and, a 3-arm intervention trial. This chapter provides a brief summary of the main findings from these three studies, followed by an integrated discussion of their implications for interventions comprising activity-permissive workstations only as well as multi-component approaches. This is followed by a discussion of the limitations of this PhD research and the current state of evidence in this field, including recommendations for future research studies. Based on these findings, recommendations for future policy and practice are provided.

5.2 Summary of findings across PhD studies

Study 1 was a systematic literature review examining the effectiveness of activity-permissive workstations to reduce office workers' sedentary time. Thirty-eight studies were included in the review, with sample sizes ranging from n = 2 to 66. This review found that activity-permissive workstations are generally an effective, feasible and functional means to reducing workplace sedentary time. However, the current evidence base is limited with regard to guidance on how to implement such workstations. In particular, there were few studies that evaluated the importance of addressing other key dimensions for behaviour change in addition to the physical environment, such as the psychosocial work environment or personal health resources. This research gap was addressed by Studies 2 and 3.

Study 2 comprised the evidence-guided and systematic development of the *Stand Up Australia* intervention. This intervention included activity-permissive workstations as well as strategies targeting personal health resources (e.g. through individual health coaching) and the psychosocial work environment (e.g. through presentations to staff) consistent with workplace health promotion frameworks.

Study 3 examined, in a 3-arm controlled field study, the effectiveness of the multi-component intervention developed in Study 2 and compared it to the effectiveness of installing activity-permissive workstations only and to a control group. In this study, the multi-component intervention resulted in a 3-fold greater reduction in workplace sedentary time at the 3-month assessment compared to the intervention comprising installation of activity-permissive workstations only (~90 min vs. ~30 min reduction per 8-hour workday). At the 12-month assessment, sedentary time reductions remained unchanged in the workstations-only group, while multi-component intervention participants regained workplace sedentary time by an average of 23 minutes per 8-hour workday. However, the difference in workplace sedentary time between the two intervention groups was still substantial, favouring the multi-component group.

These findings have a number of implications regarding the use of activity-permissive workstations only vs. targeting workplace sedentary time using multi-component approaches.

5.3 Implications regarding interventions using activity-permissive workstations alone

5.3.1 Interventions comprising installation of activity-permissive workstations only can be an effective means to reduce workplace sedentary time

In the systematic review of this PhD research (Study 1), which also included results of the field study (Study 3), sedentary time was reduced by an average of 77 minutes per 8-hour working day following installation of activity-permissive workstations. This is notably higher than what has been reported in studies not having used such workstations (118, 121, 157), where reductions have ranged from −21 minutes/ 8-hour workday ($p = 0.084$) (118) to −48 minutes/16-hour waking day ($p < 0.05$) (121). Furthermore, an extrapolation from the existing epidemiological evidence suggests that the magnitude of this change (i.e. -77 minutes) may be associated with a significantly reduced risk of all-cause mortality. Specifically, a recently published meta-analysis reported that the risk of all-cause mortality increased by 5% for each 1-hour increment in daily sedentary time for adults who sit 7 hours or more per day (12). In the field study of this PhD research (Study 3), participants in the workstations-only intervention group reduced their sedentary time by 33 minutes/ 8-hour workday on average. However, findings of this study also suggest that additional strategies targeting the psychosocial work environment and personal resources produce even greater reductions in sedentary time. This key finding is discussed in Section 5.4.

5.3.2 The use of activity-permissive workstations has a neutral or beneficial impact on health-related outcomes in office workers

The majority of studies included in the systematic review of this PhD research (Study 1) reported that activity-permissive workstations do not pose an OHS hazard in the workplace. Adverse events were reported in relation to 4/984 participants only (97, 131). Neutral or beneficial impacts were observed with regard to the majority of health-related outcomes, while most of the waist circumference and psychological wellbeing outcomes improved following installation of activity-permissive workstations. However, to examine potential concomitant benefits in relation to cardio-metabolic health biomarkers as observed in recent laboratory-experimental studies (64-66, 74) or other health-related outcomes such as musculoskeletal symptoms, larger-scale studies with sufficient statistical power and longer-term follow-up assessments are needed (99).

5.3.3 Activity-permissive workstations have a predominantly neutral impact on work-related outcomes

Across the studies included in the systematic literature review (Study 1), no negative impacts were reported on work-related outcomes such as absenteeism, presenteeism and cultural-organisational factors, while a predominantly neutral impact was observed on work performance indicators. These results are further in line with another recent workplace study reporting a neutral impact on performance indicators following installation of sit-stand workstations (74) - a finding that is particularly important when considering the potential for a broader adoption of such workstations by industry workplaces.

5.3.4 Activity-permissive workstations are an accepted alternative to conventional desks among office workers

This finding was evident across all the studies forming part of this PhD. Overwhelmingly positive feedback was received from study participants completing the two pilot studies forming part of the intervention development in Study 2, as well as from participants of the field study (Study 3). However, it was also evident that the workstation type and design need to be carefully selected and suited to individual needs and job tasks. This is very similar to the participant feedback reported by other recent qualitative studies on office workers' perspectives on sit-stand desks (155, 156). This key finding is discussed in detail in Section 5.6.2.

5.4 Implications regarding multi-component interventions

5.4.1 Strategies targeting other levels of influence in the workplace may be needed in addition to activity-permissive workstations to achieve substantial changes in workplace sedentary time

The multi-component intervention developed in Study 2 of this PhD research included strategies targeting the psychosocial work environment and personal health resources in addition to the installation of activity-permissive workstations. Throughout these PhD studies, the importance of addressing these additional strategies was evident, in particular when considering the outcomes of the 3-arm field study (Study 3). Here, the multi-component intervention resulted in a 3-fold greater reduction in workplace sedentary time than the installation of sit-stand workstations alone. A similar finding was reported in a study that compared the acceptability and use of sit-stand workstations across four

companies, where the highest use was reported in the company having provided the most educational and motivational support in addition to the workstations (158).

This finding could also explain the significant heterogeneity in the magnitude of intervention effects found across studies included in the meta-analysis of Study 1. The reason for this heterogeneity cannot be determined in the absence of a meta-regression analysis. However, it may be attributable to the widely varying intervention approaches that were taken across the included studies. Specifically, a difference was evident in the way activity-permissive workstations were integrated in workplaces and whether additional strategies (e.g. such as at the psychosocial work environment or targeting personal resources) were applied. This finding reflects the call for integrated approaches by the workplace health promotion literature as outlined in Section 1.5 (159).

5.4.2 Ongoing additional support may be needed for sustained sedentary time reductions

In the systematic review of this PhD research (Study 1), two studies measured maintenance of sedentary time reductions at least 3 months after the end of the intervention (160, 161). These studies reported a meaningful sedentary time reduction from baseline to the final follow-up. However, they also observed a substantial increase in sedentary time since the end of the intervention (160, 161). A similar outcome was observed in the field study of this PhD research (Study 3), where sedentary time increased by an average of 23 minutes (i.e. by 21% of the reduction observed at 3 months) after the additional intervention components (i.e. strategies targeting personal health resources and the psychosocial work environment) finished in the multi-component intervention group. The challenge of achieving sustained health behaviour change is a commonly reported problem in the context of health behaviour change initiatives (162). Avenues to address this challenge are discussed in Section 5.6.2.

5.5 Limitations & recommendations for future research

This section highlights the limitations of this PhD research in the context of the current evidence in this field, and provides recommendations to address these gaps in future studies.

5.5.1 Evaluation of individual intervention components

Limitation: While the findings of this PhD research speak to the importance of multi-component approaches to reducing workplace sedentary time, it could not be determined

which of the applied intervention strategies, or combination of strategies, were more effective than others.

Recommendations: The inability to isolate (the most) effective intervention elements is a common problem in the evaluation of complex interventions (163). An important next research step is to evaluate the effectiveness of the various *Stand Up Australia* intervention components. Methods for such analyses are now increasingly being applied (164). These include the application of a 'Multiphase Optimization Strategy Trial' (165) and the 'Sequential Multiple Assignment Randomized Trial' (166), both of which could be applied in the *Stand Up Australia* intervention context. The former is used to identify one of the best possible combinations of multiple intervention components via multi-arm randomised controlled trials (165), while the latter facilitates the identification of optimal intervention elements and their dosage tailored to the responsiveness of participants (166).

5.5.2 Evaluation of the cost-effectiveness of the *Stand Up Australia* intervention

Limitation: Related to the point above is the limitation that the field study of this PhD research did not collect data informing the cost-effectiveness of the intervention.

Recommendation: While critical measures to inform the cost-effectiveness of the *Stand Up Australia* intervention are currently assessed as part of the *Stand Up Victoria* study (147), the effectiveness of alternative, more affordable intervention modalities could be examined in future studies. This applies particularly to intervention elements targeting personal health resources such as the coaching sessions. Here, future studies may examine the effectiveness of group-based coaching sessions or of delivering the individual coaching sessions exclusively via telephone, which has been shown to be a cost-effective and feasible alternative to face-to-face contact in physical activity and diet interventions (167). Furthermore, the use of (smartphone) applications, text messaging and use of self-quantification devices has become increasingly researched in recent years in the context of health education, goal-setting and self-monitoring. While research has shown their usefulness in preventive health care contexts (168, 169), studies are needed to examine the effectiveness of such technology for the reduction of sedentary time. Here, they might be particularly well-suited given their ability to prompt breaks in sitting time, provide real-

time feedback about sedentary time and gather data about contexts of prolonged sitting bouts.

5.5.3 Sustainability of sedentary time reductions

Limitation: The current evidence base regarding the sustainability of sedentary time reductions is limited. In the systematic literature review (Study 1), it was observed that of the 13 studies, only three reported an additional assessment of sedentary time beyond the end of the intervention. Furthermore, the field study of this PhD research (Study 3) was largely underpowered to detect statistically significant changes in workplace sedentary time at the 12-month assessment.

Recommendation: Longer-term and sufficiently powered trials with additional follow-up assessments following end-of-intervention are necessary to examine sustainability of sedentary time reductions over time.

5.5.4 Understanding and targeting sedentary time during work and non-work hours

Limitation: These PhD studies focussed predominantly on workplace sedentary time and therefore provide limited insight into sedentary behaviour across different settings. Furthermore, while some aspects (the second management email and follow up telephone call) of the *Stand Up Australia* intervention developed in Study 2 of this PhD research address the importance of additionally reducing sedentary time outside of work hours, targeting both workplace and leisure time sedentary behaviour equally was beyond the scope of these PhD studies.

Recommendation: Understanding potential compensation or generalisation effects of reducing workplace sedentary time is a key future research area. Studies should therefore collect data across the entire day to enable understanding of setting-specific interventions on sedentary behaviour and physical activity across the day and other settings. Moreover, combining multi-component interventions to reduce sedentary time at work and during non-work hours comprises an opportune next step in this field.

5.5.5 Long-term impacts on health- and work-related outcomes

Limitation: These PhD studies provide a limited contribution to the understanding of the impact of sedentary behaviour interventions on health- and work-related outcomes.

The systematic literature review (Study 1) identified limitations of current studies with regard to understanding health and work-related outcomes due to inadequate sample sizes and typically short-term follow-up assessments. Furthermore, some decrements were observed regarding health- and work-related outcomes: In the systematic literature review, some negative impacts were observed in relation to musculoskeletal complaints (16/239 outcomes) (38, 131, 141, 170, 171) and foot swelling (1/239 outcomes) (171). In contrast and as noted in section 5.3.2, psychological wellbeing was found to be positively impacted on throughout these PhD studies: In the systematic review of Study 1, the majority of psychological wellbeing outcomes improved following workstation installation; and, the majority of participants from the field study in Study 3 expressed relief and happiness about being able to choose between sitting and standing at work. Regarding work performance, decrements were reported in relation to fine motor skills such as typing performance (131, 172-174) and operation of the mouse (131, 175, 176) in studies using treadmill desks and cycle ergometers. Notably, all of these negative impacts were exclusively reported by studies of short duration (i.e. <12 weeks).

As noted in Chapter 4, while the field study (Study 3) showed no impacts on health- and work-related outcomes, it was underpowered to detect changes in these outcomes.

Recommendation: Larger trials of sufficient statistical power and longer (i.e. >12 weeks) follow-ups are necessary to examine the potential benefits of reducing sedentary time on cardio-metabolic health biomarkers such as those that have been observed in laboratory-experimental studies, and other health indicators. More specifically, it is important to establish the extent of health benefits gained from replacing sedentary time with standing and moving, respectively. And, in line with the positive impacts on psychological wellbeing identified throughout these PhD studies, future studies are needed to further examine the mental wellbeing benefits of sedentary time reductions. Regarding work-performance indicators, larger and longer-term studies are needed to examine the role of practice when working at treadmill desks and cycle ergometers.

5.5.6 Examining the context and determinants of change

Limitation: These PhD studies did not contribute to the currently limited evidence regarding the context or determinants of reductions in workplace sedentary time (see Section 1.5). To elaborate, this means that it cannot be determined whether the sedentary time reductions at work occurred predominantly at the desk, in meetings or other contexts.

Furthermore, the evidence regarding the role of social-cognitive factors (such as intentions or self-efficacy), social influences (e.g. collegial or managerial support) and physical environmental elements (such as activity-permissive workstations) to reducing sedentary time remains limited.

Recommendation: A key future research area is to examine the context and determinants of sedentary behaviour change in workplaces such as pointed to in social ecologic models and workplace health promotion frameworks. This includes the characteristics of individuals achieving greater reductions in sedentary time, the context of sedentary time reductions (e.g. at the desk vs. during meetings), patterns (few prolonged vs. several short bouts) and replacement behaviours (standing vs. moving or a combination).

5.5.7 Targeting other high-risk groups and involving workplace communities

Limitation: For reasons outlined throughout Chapter 1, the focus throughout this PhD research is limited to addressing workplace sedentary time in healthy office-based workers. Given the infancy of the field, this research did not address office workers with chronic health conditions (e.g. such as musculoskeletal issues or mental illness) or other groups accumulating high volumes of workplace sedentary time (e.g. such as pilots and construction and transport vehicle drivers (177)) or other key target groups outside the workplace domain (e.g. school children (178) or older adults (179)). Furthermore, the *Stand Up Australia* intervention did not address the enterprise community involvement dimension of the *Healthy Workplace Model* (highlighted in Figure 5.1) (109). As described in Chapter 1, the enterprise community involvement dimension represents the mutual influences between enterprises and their local communities and involves activities, expertise and social and physical resources. Strategies targeting this dimension have the potential to facilitate dissemination of health behaviour intervention elements beyond the workplace setting.

Figure 5.1. Enterprise Community Involvement dimension of the *Healthy Workplace Framework* (109).

Recommendation: Studies are needed that examine the impact of sedentary behaviour interventions in office workers with existing conditions such as musculoskeletal or mental health symptoms, as well as targeting other groups at high risk of accumulating high volumes of daily sedentary time. As shown in Chapter 1, the determinants of sedentary time in these groups are likely to be context-specific and the intervention messages and strategies may differ accordingly. For example, in the context of construction and transport vehicle drivers, high volumes of sitting times are likely inevitable. Here, interventions can focus on reducing prolonged bouts of sedentary time via regular standing/moving breaks from driving as is done in a current intervention trial (180). In contrast, the influences on sedentary behaviour in school settings are more similar to those observed in workplace contexts. Here, intervention strategies to reduce and break up sedentary time are more feasible and can target similar levels of determinants as in the workplace such as the physical school environment and organisational support. Studies have now begun to examine such interventions, including the effectiveness of standing desks in classrooms (181, 182).

Furthermore, studies are needed to examine strategies to disseminate the message to reduce sedentary time beyond the workplace setting. This enterprise community involvement includes the resources and expertise a workplace provides for the wellbeing of a community (109). In the context of sedentary behaviour interventions, such

engagement could be realised through the facilitation of free screening services to assess sedentary time or provision of educational material on sedentary behaviour (including tips on how to reduce it) for the families and other peers of workers. Direct engagement of workplaces with the broader community to promote less sitting and a more active lifestyle could be accomplished in the context of events at local schools, aged care homes or sporting clubs, media campaigns or partnerships with local gyms.

5.5.8 Targeting additional health behaviours

Limitation: The key message of the *Stand Up Australia* intervention was to reduce sedentary time and increase time spent standing and moving *(Stand Up, Sit Less, and Move More;* see Section 3.2). In the field study of this PhD research (Study 3), substantial intervention effects were observed regarding workplace sedentary and standing time. However, minimal changes were observed regarding time spent moving. While this is consistent with the idea that the sit-stand workstations would be the primary driver of the sedentary time reductions in this intervention study, it points to the need for a reinforcement of the message to increase movement.

Recommendation: Studies have consistently shown greater health behaviour change effects resulting from interventions targeting multiple health behaviours (109). Other health behaviours may be targeted in combination with strategies to reduce workplace sedentary time. One such opportunity in the context of the *Stand Up Australia* intervention is to target increases in physical activity across the entire intensity spectrum more strongly. In fact, participant feedback from the *Stand Up Australia* pilot study suggested that providing instant feedback regarding physical activity levels (e.g. via pedometers) or coordinating group exercise programs (e.g. walking groups during lunch breaks or boot camps before work) may help participants to increase their moderate- to vigorous physical activity levels.

5.6 Recommendations for future policy & practice

Based on the findings of these PhD studies, the following recommendations are provided for future policy and practice:

5.6.1 Recommendations for policy

Integrating sedentary behaviour reduction into workplace policies

In order to facilitate the adoption of less sedentary routines in workplaces, integrating a focus on reducing sedentary time into OHS policies is likely to be needed. In the field study of this PhD research (Study 3), qualitative interviews revealed that both participants and managers often felt awkward when standing up or moving more at work. For participants, this pertained particularly to standing during meetings and to moving more in the office, as they feared to be perceived as being unproductive. For managers, this mostly pertained to standing during higher management-level meetings involving staff who were not otherwise involved in the study and were potentially unsupportive of less sedentary working habits. These observations reflect the importance of changing the workplace culture and OHS policies around sedentary behaviour as highlighted in a recently published article (183). Examples of how such policy changes could be realised include the integration of the ascertainment of high/ prolonged sedentary time into OHS risk assessments and induction trainings or revising policies regarding replacement of conventional sitting desks with activity-permissive alternatives. However, it is important to acknowledge that findings from this PhD research do not provide a guiding framework for the re-design of job tasks and postural execution of desk-based occupations.

Inter-disciplinary collaboration

The integration of sedentary behaviour into workplace policy is likely to involve numerous stakeholders. These include wellness officers, OHS staff, ergonomists, union delegates, management and team leaders. Inter-disciplinary collaboration between these stakeholders is important to identify a target behaviour and message in line with current practices across these disciplines. In Study 2 of this PhD research, collaboration with the university's OHS staff was essential to develop the intervention messages in the absence of more specific guidelines (see Section 3.2).

Inter-disciplinary collaboration is further needed when considering implementation of activity-permissive workstations and/ or other strategies to adopt more active routines in workplaces. In the field study of this PhD research, the sit-stand workstations were approved by the OHS department for the study purposes. However, the broader roll-out of

these workstations at the university was not permitted due to the lack of alignment with existing OHS policies. It is thus important to identify workplace-specific opportunities and barriers in the early adoption process of such practices and to ensure compatibility of such strategies with existing OHS policies. Appropriately qualified study champions, such as trained as part of the *Stand Up Australia* intervention, are likely needed to guide the implementation of such change processes.

5.6.2 Recommendations for practice

Creating a culture of change

As noted in Section 5.2, findings of these PhD studies consistently point to the importance of combining installation of activity-permissive workstations with additional strategies to achieve more substantial reductions in sedentary time and foster a positive culture of change. This includes strategies targeting the psychosocial work environment such as staff emails supporting workers to sit less, educational materials or encouraging standing in meetings. Such strategies are also likely to increase the use of physical environmental opportunities to reduce sedentary time such as working at activity-permissive workstations. Provision of support strategies may be needed on an ongoing basis to maintain a positive organisational culture around reducing sedentary time in the long term.

Choice of activity-permissive workstation

The findings across these PhD studies consistently highlight the importance of carefully selecting the design and mechanism of the activity-permissive workstation in relation to individual job tasks and preferences.

In the systematic review forming Study 1, a number of issues with certain types of activity-permissive workstations were noted with regard to health- and work-related outcomes. Increases in musculoskeletal symptoms were predominantly observed in studies using fixed-height standing desks (without availability of height-adjustable chairs) (38, 131, 141, 170, 171); and, decrements in work performance were exclusively reported by studies using treadmill desks (131, 172, 174-176) or cycle ergometers (131, 173).

Across the *Stand Up Australia* intervention studies (including the field study forming Study 3), sit-stand desk mounts were used. In the field study (Study 3), 1/44 participants dropped

out after the baseline assessment due to body pain, and 4/26 participants dropped out after the 3-month assessment due to experiencing shoulder and/or neck pain. Furthermore, despite the high appreciation by participants for the option to sit or stand during work, there was considerable negative feedback from participants regarding workstation-specific design issues. This is a common finding across other studies that have used these desk mounts (96, 155, 156). Notably, newer models of this sit-stand workstation have overcome many of these issues.

Based on these findings, the use of height-adjustable desks with a fully adjustable desk surface can be recommended when targeting reductions in sedentary time. Furthermore, treadmill desks and cycle ergometers have the potential increase energy expenditure, and can thus play an important role in the context of weight loss and/or weight management interventions (125). However, more research is needed to examine the role of familiarisation with regard to the potential negative impacts on work performance.

Impacts of activity-permissive workstations on the broader workspace

Increased standing, such as facilitated by sit-stand workstations, can lead to reductions in privacy in open-plan offices. Furthermore, if partitions between desk cubicles are not raised accordingly, noise levels may be elevated. In the qualitative interviews following the workstations pilot study in Study 2, some participants expressed concerns regarding visual and noise distractions as well as compromised privacy when using sit-stand workstations in open-plan office spaces. Furthermore, some participants of the field study (Study 3), as well as in another study that installed sit-stand desks (155), suggested that re-arrangement of other office furniture, shelving and/or stationary may be useful to ensure practicality and ergonomic suitability when standing. It is therefore important to consider the potential impacts on surrounding colleagues and the broader workspace, when considering installation of activity-permissive workstations in open-plan offices.

Activity-permissive changes to the broader workspace

While the modifications to the physical work environment addressed in these PhD studies were limited to installation of activity-permissive workstations, there are numerous other opportunities to modify the broader workplace environment to encourage less sitting and more movement. This includes signage in meeting rooms that standing is welcome,

provision of standing desks in meeting rooms or communal areas such as kitchens, or access to stair wells. Activity-based workplace designs, such as mentioned in Section 1.6.3, are increasingly gaining popularity for multiple reasons, including enhanced collaboration between colleagues (184).

Partnerships between industry workplaces and researchers

Finally, and related to the above note, is that the growing interest from industry workplaces in reducing sedentary behaviour provides an opportunity for collaboration between such workplaces and public health researchers. Monitoring the impact of activity-based workplace designs such as mentioned above on key outcomes such as activity levels, productivity and workplace culture through natural experiments is an important area of future research. Workplaces play an important role in the examination of intervention elements in real-world settings. They provide opportunity to recruit potentially large groups of workers and are often willing to provide resources that are often limited in research context (e.g. through facilitation of activity-permissive workstations). Simultaneously, information that is typically collected by workplaces (e.g. work performance indicators) can provide a valuable contribution to program evaluations of research studies.

5.7 Summary and conclusions

This PhD thesis addressed a rapidly evolving public health issue: high volumes of sedentary time in office workers. The primary aim of this PhD research was to contribute to the currently limited evidence informing interventions using activity-permissive workstations to reduce workplace sedentary time in office workers. Results showed that installation of activity-permissive workstations can be a feasible, effective and acceptable approach to reduce workplace sedentary time in office workers. However, multi-component interventions may lead to significantly higher reductions in workplace sedentary time than the installation of activity-permissive workstations alone. Provision of these additional intervention components may be needed for sustained sedentary time reductions. These findings have important implications for occupational policy and practice.

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Appendix A. *Stand Up Australia* pilot studies

Appendix A.1. Post-pilot study interview protocol

Baker IDI
HEART & DIABETES INSTITUTE

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AUSTRALIA

Stand Up Comcare – Follow-up interviews

Hi [*participant's name]*, it's Maike calling from the Stand Up Comcare study. We scheduled this time for our 20-minute phone interview. Are we fine to go ahead?

We really appreciated your participation in our pilot study. I would like to ask you some questions about each of the parts of the program so that we can improve on it for the future. For training purposes, I would like to record our conversation. However everything we say will be kept anonymous and confidential. Are you okay with that?

1) WORKSTATION AND BEHAVIOUR CHANGE

- **I would like to start with some questions about the sit-stand workstation. How did you go with your workstation?**

[Use following questions as prompts, but only if they haven't already addressed the question in their answer to the opening question.]

- What did you like about it? Any particular benefits that you noticed from using it?
- Did you experience any physical discomfort or other problems from using the workstation?
  - If yes: What sort of problems? How often did you experience this? What did you do about it if anything?
- Was there anything that you did not like about the workstation?
  - If yes: What exactly? What would you tell the manufacturers to change about it?
- Did the use of workstations by others around you cause any disruption to you?
  - If yes: In what way? What could be done to minimize this?
- How would you rate the workstation on a 5-point scale (where 1=didn't like using it at all and 5= thought it was great)?
- If you had the choice, would you have liked to keep it?

2) CONSULTATION

- **I am now going to ask you about your experience with the consultation session that you had right in the beginning of the study. This is where either Kirsten or Jenny went through your feedback, discussed strategies for standing up, sitting less, and moving more, and helped you to set goals to reach these targets.**

[Use the following questions as prompts.]

- Was the feedback you received about your sitting/ standing/ moving, and your body measures easy to understand? All the tables and graphs?

1

- If no: which ones were difficult to understand? Which ones would you change? How?

- Do you think the 3 program recommendations (stand up/sit less/move more) were easy to understand?
  - If no: Which one did you find easier / more difficult?
- During the month-long study, did you focus equally on all of them or was there one or two that you focussed on most?
- Which strategies did you find most useful for standing up regularly? Sitting less? Moving more? (*would see if they can id strategies for each)*
- Did you find the goal setting useful to help you stand up, sit less, move more?
  - If no: Why not? What could be changed?
- Did you use the Tracker?
  - If yes: How often?
  - If no: Why not?
- Overall, how was your experience with this consultation session?
  - What did you like about the session?
  - What did you not like?
  - Other than what has been discussed, would you change anything about it?
    - If yes: What would you change?
  - How would you rate it overall on a 5-point scale (1=very bad 5=very good)

3) SUPPORT PHONE CALLS AND EMAILS

- **Ok. Let's have a chat about the phone calls and emails. How was your experience with the 3 support phone calls you received?**

[Use the following questions as prompts.]

- Did you find them long enough or even too long?
- On a 5 point scale (1=not useful and 5= very useful) how useful were the chats for changing your work activity patterns?

- **How was your experience with the Email Summaries you received from us?**

[Use the following questions as prompts.]

- Did you read the summaries?
  - If yes: every one? Most? Some?
- How would you rate the content of the emails? Too much info or not enough?
- On a 5-point scale with 1=not useful at all and 5= very useful, how would you rate the emails overall for changing your activity patterns?

4) ORGANISATIONAL SUPPORT

- **I am also interested in how much support you received from Comcare to stand up/sit less and move more at work during the study period?**

[Use the following questions as prompts.]

- What in particular did the Comcare management do to support you standing and moving more at work?
- What could Comcare management have done to be more supportive?
- Did you (and potentially your colleagues) do any standing other than at the workstation (e.g. in meetings)?
- What did you think about the weekly email tips you received from the Comcare management? Did you read them?
- And on a 5-point scale with 1= did not feel supported from Comcare at all and 5= the support from Comcare was great, how would you rate it?

5) OVERALL EXPERIENCE

I would like to finish this interview off with some questions about your overall experience with the Stand Up Comcare study.

- Overall, how helpful did you find the Stand Up Comcare program in helping you to stand up, sit less, and move more at work? (1-5 scale)
- Would you say that you now sit less outside of work, too?
- Can you think of anything else that would improve the program?
- Any other comments/ questions?

That was it. I hope you have enjoyed our program. Thanks again for your participation. You will receive the feedback from your last assessment around the end of November.

Appendix A.2. Post-pilot study interview summary

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THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Stand Up Comcare – Interview summary report

Overall Findings

Of the 21 intervention group participants who completed the study, 18 were satisfied with the overall study and the study staff, as well as the individual intervention components (i.e. the consultation session, the feedback reports, support phone calls and emails).

Some participants thought that the sit-stand workstations had negative aspects in regards to the design (details below), but for most participants having the opportunity to stand while working on the computer outweighed these negatives: 12/18 employees would have liked to keep their workstation (3 others had a height-adjustable desk already; otherwise they would have liked to keep it, too). The workstations were widely perceived as being easy to use and no-one thought they were causing disruption to anyone else in the (open-plan) office. In fact, some participants thought standing up while working and seeing others do the same made them feel more like belonging to a team and that it improved the organisational culture. Also walking to colleagues instead of emailing them was perceived as enhancing the organisational culture as it improved awareness of workloads.

Most participants felt supported by Comcare to change their work patterns because they knew that the study was approved by the management. Other features that made participants feel supported were: signs around in the office with standing/moving tips; signs in meeting rooms that 'standing meetings are welcome'; no complaints from management about employees talking/moving/ imailing too much.

Suggestions for the Main Study

Assessments

- When booking appointments with participants for assessments/ consultation/ phone-calls, send them an invitation to their outlook calendar → higher convenience and adherence
- Provide a broader referral for the blood tests (i.e. including also other blood labs especially include those pathologies who work by appointment to take up less participant time)

1

Individual Intervention Components

- Take more time to set up the correct ergonomic posture for participants immediately following workstation set-up (e.g. use stickers as discussed)
- Emphasize the importance of regular postural changes (also when standing!)
- Help participants with set-up of online stopwatch.
- Suggest use of cordless headsets and re-arranging workspace for standing and sitting
- Stronger emphasis on less sitting at home (only 8/18 reported reduced sitting outside of work)
- Allow number of support phone calls and email summaries to be determined by participant
- Incorporate initiatives like group walks in program
- Refine recommendations (?) (difficulty to distinguish SU and SL)
- Include a pedometer (some participants report using one as 'MM strategy')

Organisational Support

- Encourage management to check-in with employees on how they are going with the workstations/program/ behaviour change (potentially via email)
- Management to encourage staff to have more frequent breaks
- Encourage management to initiate standing meetings; also: less chairs in meeting rooms; signs in meeting rooms that standing meetings are welcome
- Brainstorm healthy ideas beyond program (e.g. group walks)
- Purchase workstations for permanent use (12/possible 15 employees would have liked to keep their workstation)
- Provision of cordless headsets, potentially document holders, pedometers etc.

2

Intervention Component Ratings

Satisfaction ratings	Rating (1-5): average	Rating (1-5): range
Overall study	4.86	4-5
Workstation	4.18	1-5
Support from Comcare management	4.1	3-5
Face-to-face consultation	4.6	4-5
Support phone-calls	4.1	2.5-5
Email summaries	4	1.5-5
Usefulness ratings (yes/no)		**Number 'yes'**
Individual Feedback (including tables and graphs) was easy to understand		17/18
Goal setting was useful to achieve behaviour change		13/18
Tracker was useful to achieve behaviour change		14/18
Weekly standing tips/ emails from Comcare were useful		6/18

Specific Comments on Workstations

Positive	Negative
• enjoying being able to work while standing	• no flexibility to move WS back and forth on desk
• being less stiff	• no flexibility to move keyboard back and forth relative to monitor
• significant reductions in back/ neck/ shoulder discomfort	• takes a while to get used to (workstation/ standing), sore feet/legs in beginning
• feeling less tired and lethargic	• keyboard/mouse shelf too small
• feeling better/ more energetic	• workstation shelf too small
• improved concentration	• takes up too much room on desk
	• monitor does not swivel sidewards

3

Favourite Behaviour Change Strategies

Recommendation	Strategy
Stand Up	
	❖ Set a timer (online, through outlook, etc)
	❖ Stand up when the phone rings or when someone enters the office
	❖ Stand up when someone else does
	❖ Fill water bottle more often
	❖ Pick up printing more often rather than in bulk
Sit Less	
	❖ Determine certain 'standing times', i.e. every morning and after lunch
	❖ Stand up when someone else does
	❖ Stand during meetings
Move More	
	❖ Use the stairs instead of the lift
	❖ Walking laps
	❖ More active lunch breaks (e.g. walking around the block)
	❖ Fill water bottle/ pick up printing more often
	❖ iMails

4

Appendix A.3. Post-workstation pilot study interview protocol

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StandUP UQ

Stand Up UQ workstation pilot – interview protocol

Hi *[participant's name]*, it's Maike calling from the Stand Up UQ study. We scheduled this time for our 10-minute phone interview. Are we fine to go ahead?

We really appreciated your participation in our workstation pilot study. I would like to ask you some questions about your experience with the sit-stand workstations. For training purposes, I would like to record our conversation. However everything we say will be kept anonymous and confidential. Are you okay with that?

- How many workstations were installed in your office?
- During the time that the workstation(s) was (were) installed – on how many days were you at your workplace?
- What % of the time in or around your desk?
- How did you find having the workstation(s) in use around you?
- What do you see as beneficial about the workstations?
- Did you at any time feel disturbed because of the workstation(s)?
    - What exactly was it that disturbed you? (Noise from moving up and down/ Noise from people talking while standing/ visual disturbance (privacy issues)/ …)
    - About what percentage of your workday were you disturbed?
    - Do you think you would have felt less or more disturbed if you or everyone else would have had a sit-stand workstation as well?
- Do you have any suggestions for making the sit-stand workstations work better in your work area?

When we start the larger study, would you be willing to take part and have a workstation installed at your desk?

Appendix A.4. Post-workstation pilot study interview summary

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Stand UP UQ

Stand Up UQ Workstation pilot study summary report

In August/September 2011, a mini pilot study was conducted to test the impact and acceptability of Ergotron Sit-stand workstations in the open-plan offices of the UQ Human Resources Division.

With support from Vicki McNabb, five employees were identified to trial the workstation for 2 weeks. The workstations were installed in the morning of Monday, 22nd August and de-installed on Monday, 5th September. Following the trial period, all participants (workstation group), as well as another seven employees (peer group), who are sharing the same office and sitting nearby the installed workstations, underwent a brief (5-minute) feedback interview on their experience.

Workstation Group Feedback

Among the five employees trialling the workstations, the overall impression of the workstations was 100% positive. Everyone liked having the option to sit or stand while working at their computer and to change their posture to their own liking. On a 5-point scale from 1='did not like it at all' to 5='found it great', participants rated the workstations from 3 to 5 with an average of 3.9 points. Standing proportions of 30-40% throughout the working day were reported, with standing bouts of 30-60 minutes in length. None of the participants perceived any disturbance for others working around them.

Characteristics of the workstations that were perceived as open for improvement were: more mouse or wrist space; reduction in desk space should be compensated by more document holders; possibility to turn the computer screen sidewards; workstation sits a little too far forward on desk.

Among the five participants, four are keen to have the workstations re-installed and to take part in the larger study. In fact, one participant felt such a great positive impact on her lower back issues that she has had, that it was arranged to leave the workstation installed at her desk. One participant would 'probably' not take part because of the negative characteristics as listed above.

Peer Group Feedback

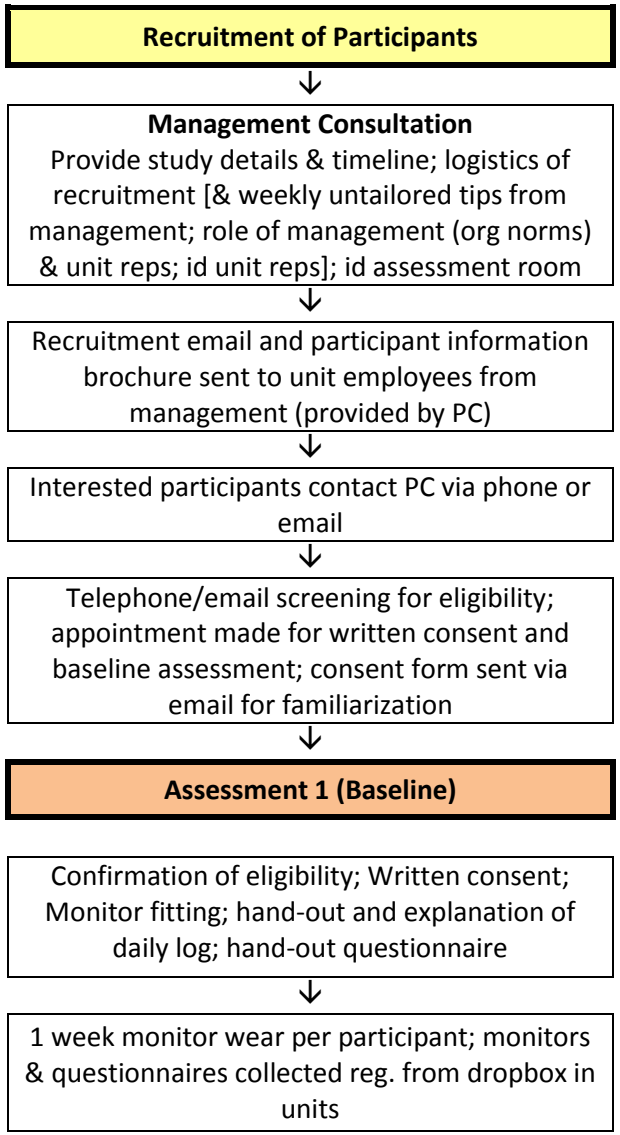
Among the seven employees working in the immediate environment of the workstations, six perceived benefits in being able to sit less and change the posture more frequently by working at a height-adjustable workstation. One peer group participant was explicitly jealous not to have had such a workstation herself.

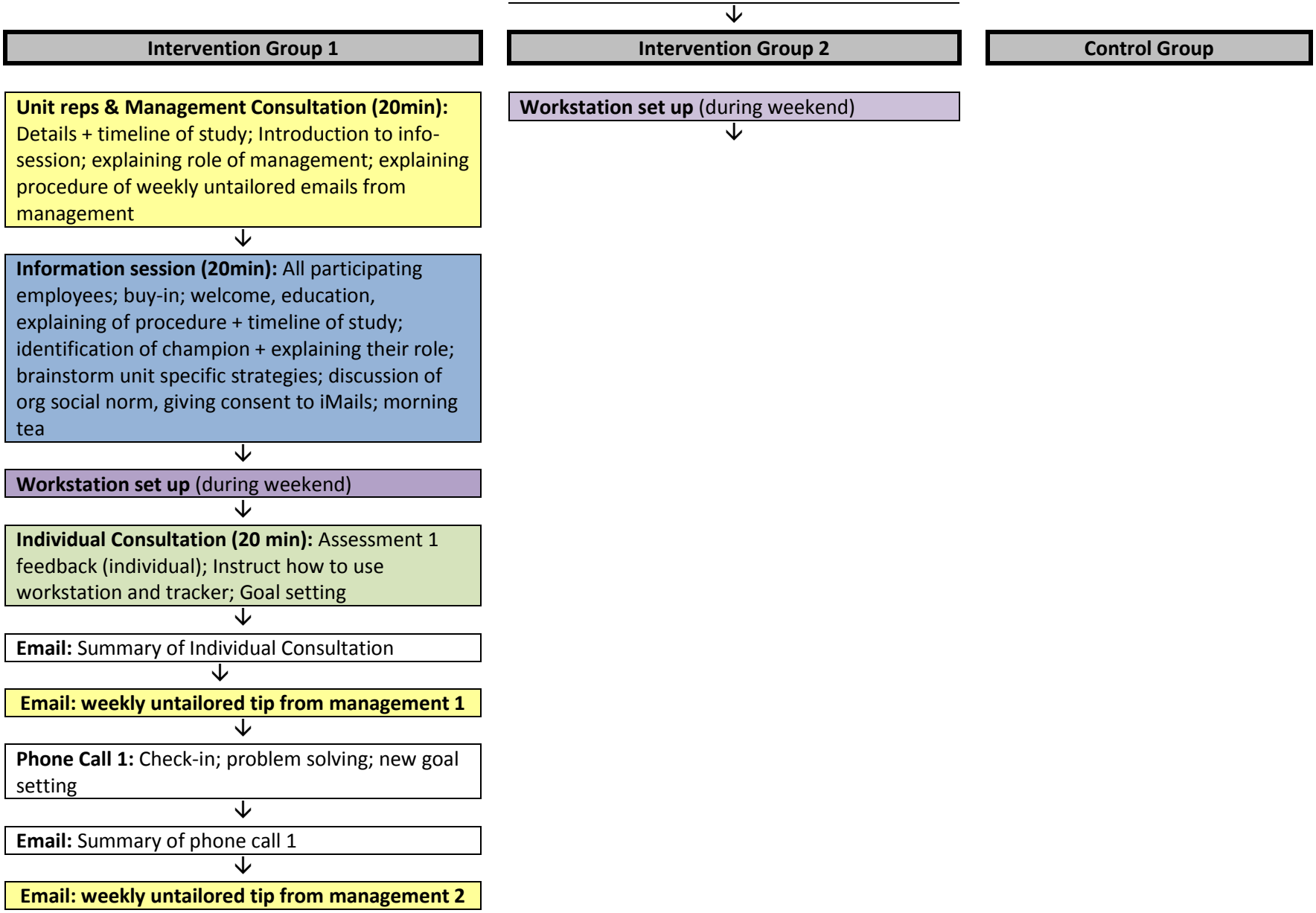
1

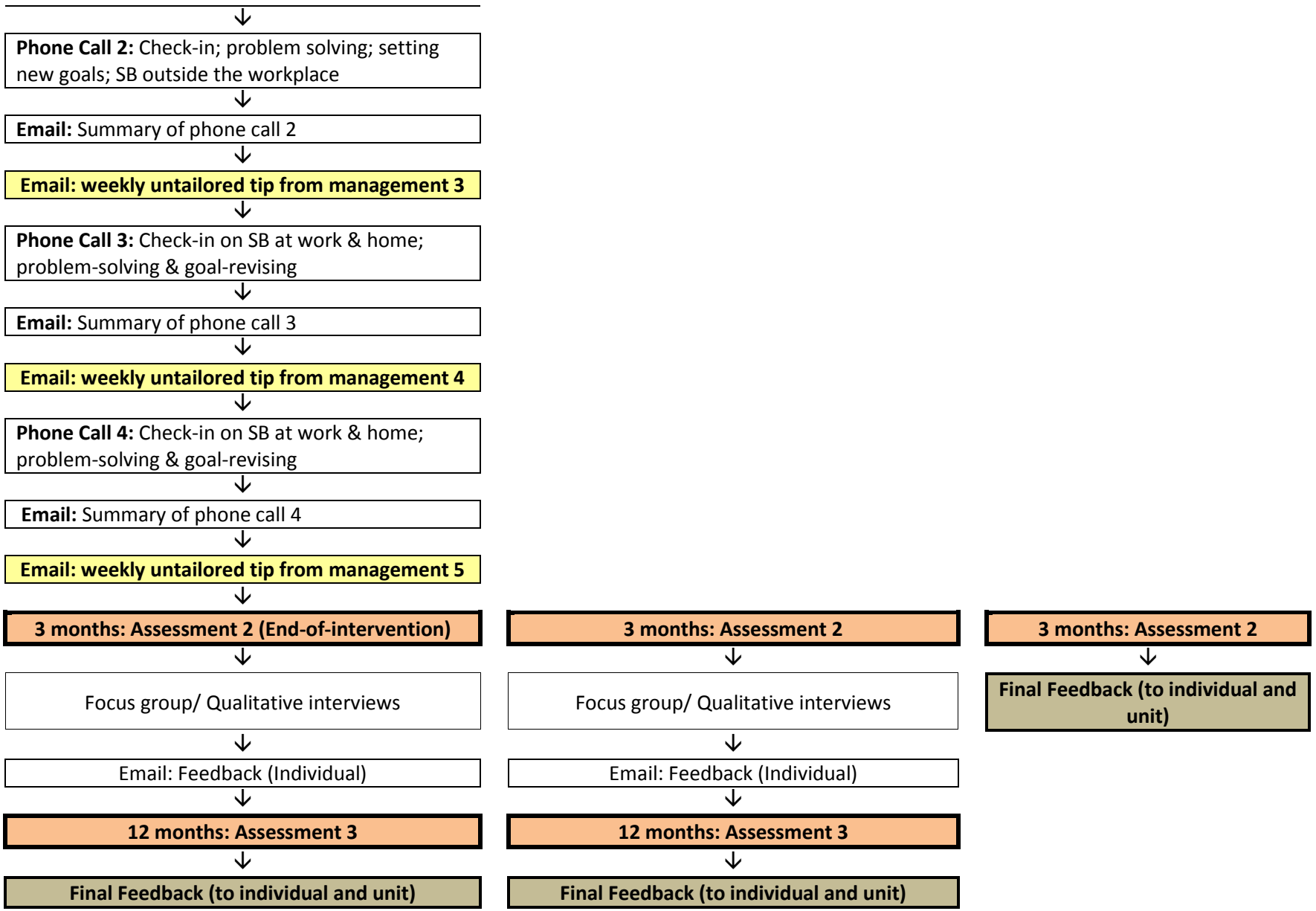
Six peer group participants did not feel disturbed in any way by others using the workstations. One participant however felt distracted by the increase noise level and the fact that the 'workstation user' was able to look over the partition while standing up. It was suggested by two employees that the partitions could be raised to avoid such issues.
Of the seven peer group participants, three are keen to have a workstation installed and take part in the larger study themselves; one would not opt for such a workstation because she usually talks a lot on the phone and has to write down a lot which she would find difficult when having a workstation installed; one participant would prefer the usual desk set-up because the sit-stand workstations take up too much space on the desk; one participant simply prefers to sit; one participant has not responded yet.

Appendix B. *Stand Up UQ* study materials

Appendix B.1. Stand Up UQ flowchart




Intervention Group 1
Intervention Group 2
Control Group
Unit reps & Management Consultation (20min): Details + timeline of study; Introduction to info-session; explaining role of management; explaining procedure of weekly untailored emails from management
Information session (20min): All participating employees; buy-in; welcome, education, explaining of procedure + timeline of study; identification of champion + explaining their role; brainstorm unit specific strategies; discussion of org social norm, giving consent to iMails; morning tea
Workstation set up (during weekend)
Individual Consultation (20 min): Assessment 1 feedback (individual); Instruct how to use workstation and tracker; Goal setting
Email: Summary of Individual Consultation
Email: weekly untailored tip from management 1
Phone Call 1: Check-in; problem solving; new goal setting
Email: Summary of phone call 1
Email: weekly untailored tip from management 2
Workstation set up (during weekend)


Phone Call 2: Check-in; problem solving; setting new goals; SB outside the workplace
Email: Summary of phone call 2
Email: weekly untailored tip from management 3
Phone Call 3: Check-in on SB at work & home; problem-solving & goal-revising
Email: Summary of phone call 3
Email: weekly untailored tip from management 4
Phone Call 4: Check-in on SB at work & home; problem-solving & goal-revising
Email: Summary of phone call 4
Email: weekly untailored tip from management 5
3 months: Assessment 2 (End-of-intervention)
Focus group/ Qualitative interviews
Email: Feedback (Individual)
12 months: Assessment 3
Final Feedback (to individual and unit)
3 months: Assessment 2
Focus group/ Qualitative interviews
Email: Feedback (Individual)
12 months: Assessment 3
Final Feedback (to individual and unit)
3 months: Assessment 2
Final Feedback (to individual and unit)

Appendix B.2. Participant information sheet – example from multi-component intervention group

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Stand UP UQ

Stand Up UQ

Participant Information Sheet

Investigators: Maike Neuhaus, PhD Candidate, & Prof Elizabeth Eakin, Director,
Cancer Prevention Research Centre, School of Population Health, The University of Queensland

1. What is the 'Stand Up UQ' study?

The Stand Up UQ Study is conducted by researchers at The University of Queensland. Scientific data over the last decade has shown that less sitting throughout the day is associated with a decreased risk of many chronic conditions such as type 2 diabetes, heart disease, and some cancers. While at work, office workers report high levels of sitting time, mostly due to the nature of their computer and desk based jobs. Height-adjustable workstations may provide a means of reducing sitting time at work. However, the most effective way to introduce such workstations to organisations is yet to be established. That is what this study is all about.

If you decide to take part in 'Stand Up UQ', we will install a new Ergotron sit-stand workstation at your desk that allows you to easily move your computer up and down and thus alter your posture from sitting to standing (and vice versa) whenever you like, while being able to keep doing the desk-based tasks you usually would.

Over the 12-month study, you will complete three study assessments (described below) after which you will receive a detailed report on your movement patterns at work and how these may have changed during the course of the study. The workstation is provided free of charge and you will have it installed at your desk for the duration of the study. Your participation in this research will help to develop workplace health promotion programs.

2. What will happen if I decide to take part?

If you decide to take part in this study, you will undergo a total of three 30-minute **assessments** (described below) over 12 months and have an Ergotron sit-stand **workstation** installed on your desk.

The **total time** commitment for the study will be approximately **2.5 hours** over 12 months.

Assessments

If you take part in the Stand Up UQ Study, you will undergo three assessments: before the study starts, after three months, and after another nine months.

All three assessments will take about 30 minutes each and are fairly similar: In a designated testing room within your workplace, you will be asked to

- fast the morning of your assessment
- complete a fingerstick test to measure your cardio-metabolic biomarkers
- have your height, waist and hip circumference taken, as well as body weight and composition using bio-impedance scales
- wear a small activity monitor and complete a daily log during the following seven days. The activity monitor will be secured to your thigh using non-allergenic patches (*Tegaderm*), which may involve shaving a small area of skin on your thigh (so your hair does not stick to it when you remove it). The monitor will be made waterproof, so there is no need to remove it, but additional patches will be provided to change the dressings as required. You will also be requested to complete a daily log to record your sleep and work times. At the completion of seven days of wear, the researcher will collect the monitor and daily log.

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AUSTRALIA

Stand UP UQ

- You will also be asked to fill in a 30-minute **online questionnaires** (with questions about your health, diet, activity, and work performance)

Workstation Installation

After Assessment 1 (i.e. after you have worn the activity monitor for seven days), your desk will be fitted with a sit-stand workstation and you will receive written and verbal instructions on how to use it.

Individual Consultation Session

Once the workstation has been installed to your desk, one of our team members will schedule an appointment for a face-to-face session with you. During this session, you will receive feedback from your first visit and strategies to get the most out of your new workstation will be discussed.

3. What are the benefits to me if I take part?

We cannot guarantee that you will receive any personal benefit from participating in the study. However, we know that sitting time is linked to poor health, so reductions in sitting time may lead to improved health and well-being. If you do take part, you will receive feedback on your sitting time and your body measures from each time point, and how these may have changed since the start of the study. Your participation will provide valuable information to develop and improve workplace health promotion programs.

4. What are the risks in taking part?

You may experience physical changes as a result of standing more often. However, the risks of involvement are not expected to exceed those faced by office workers as part of their day-to-day working conditions.

You will be asked to complete a blood sample collection. Blood will be collected at the workplace using a finger stick procedure (35µl whole blood collected). The finger stick should cause minimal discomfort.

The activity monitor will be attached to your upper thigh using non-allergenic patches (Tegaderm). However we cannot fully exclude the possibility that you will experience skin irritation. In that case you will be asked to take the monitor off and contact the project coordinator.

5. Participation is voluntary

Taking part in this program is voluntary, and if you do not wish to take part you are not obliged to. If you decide to take part and at a later stage change your mind, you are free to withdraw from the program at any time. Withdrawing from the program will not affect your job security in any way. If you do decide to withdraw, we would appreciate you notifying a member of the research team, so that the workstation can be removed.

6. Privacy & confidentiality

All information will be treated with the strictest confidence by the research team. You will be allocated an identification (ID) number so that your information can be stored in computer files without your name. Identifiable information (e.g., consent forms) will be stored in a locked filing cabinet accessible only by the investigators named above. All other data (both paper and electronic) will only be identifiable by your study ID number and electronic files will be password-protected. You will not be identified in any reports or presentations that arise from the research.

7. Results of project

At the completion of the study, you will receive printed feedback summarising your results and the overall results of the study. Each participant will also receive an individual letter thanking them for participating in the study and a summary of the research findings will be included with this letter.

8. Who can I speak to if I have questions?

This study has been cleared by the School of Population Health Research Ethics Committee of the University of Queensland in accordance with the National Health and Medical Research Council's guidelines. You are welcome to discuss your participation in this study with the project coordinator

Maike Neuhaus Ph: 3365 5350 M: 0424 494 363, E: m.neuhaus@uq.edu.au

Appendix B.3. Participant consent form – example from multi-component intervention group

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Stand UP UQ

Stand Up UQ
Participant Consent Form

Investigators: Maike Neuhaus, PhD Candidate, & Prof Elizabeth Eakin, Director,
Cancer Prevention Research Centre, School of Population Health, The University of Queensland

I have read, or have had read to me, and I understand the Participant Information Sheet, V3 dated 16 Jan 2012. I understand that my participation in this study involves:

- having the opportunity to attend a 20-minute **study information session** at my worksite
- having an Ergotron sit-stand **workstation** installed on my desk
- receiving a 30-minute **individual consultation session** at my workplace as well as
- receiving four 10-minute **support phone-calls**
- undergoing a total of three 45-minute **assessments** over 12 months, which include:
  - fasting the morning of the assessment to complete a fingerstick test
  - having my height, weight, and hip and waist circumference taken, as well as my body composition using bio-impedance scales
  - filling in a questionnaire (with questions about my health, diet, activity, and work performance) and
  - wearing a small activity monitor and complete a daily log during the following seven days.

I freely agree to participate in this project according to the conditions in the Participant Information Sheet. I understand that there are no foreseeable risks associated with my involvement in this study. I understand that my participation is voluntary and I am free to withdraw from this study at any time without penalty. I understand that all data will be treated confidentially and the researcher has agreed not to reveal my identity and personal details if information about this project is published or presented in any public forum.

Participant's Name (please print): _____

Participant's Signature: _____ Date: _____

Work address (Room, department, building): _____

_____

Contact phone: _____ Mobile: _____

Email: _____

Appendix B.4. Information flyer – example from control group

Am I eligible for the study?

To be eligible you need to be:

- Employed at least 0.6 FTE
- Aged 18-65 years
- Not currently pregnant
- Be able to stand at your desk for periods of 10 minutes or longer

How do I participate in the study?

Please contact the Project Coordinator Maike Neuhaus to let her know of your interest.

Maike Neuhaus
Ph: 3365 5412
Mobile: 0424 494 363
Email: m.neuhaus@uq.edu.au

Maike will check if you are eligible for the program and book you in for your first assessment. She will also provide you with more comprehensive details of the study.

What if I have questions about the program?

Feel free to contact Maike at any time if you have any questions and would like to know more about the program.

THANK YOU ☺

Where can I obtain more information about the research?

For more information, of if you have any concerns, please do not hesitate to contact the

Project Coordinator

Maike Neuhaus
School of Population Health
The University of Queensland
Level 3, Public Health Building
Herston QLD
Ph: 3365 5412
Mobile: 0424 494 363
Email: m.neuhaus@uq.edu.au

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AUSTRALIA

StandUP UQ

STUDY INFORMATION

Investigators

Ms Maike Neuhaus, PhD Candidate[1]
Prof Elizabeth Eakin, Director[1]
Dr Genevieve Healy, Research Fellow[1]
A/Prof David Dunstan[2]
Prof Neville Owen[2]

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[2]Baker IDI, Melbourne

This study has been approved by The School of Population Health Research Ethics Committee

What is the Stand Up UQ Study about?

Research over the last decade has shown that overall activity levels throughout the day are linked to many chronic conditions such as type 2 diabetes, heart disease, and some cancers. We know that while at work, office workers report low levels of physical activity, mostly due to the nature of their jobs.

We are a group of researchers from the School of Population Health, UQ, who are developing programs to optimise activity patterns in office workers. As part of a study, we would like to take detailed measurements of the patterns of daily physical activity and evaluate how these may be linked to some body measures in employees from your department of UQ.

Your participation in this research will help to develop effective workplace health promotion programs to reduce prolonged sitting. The study will run for 3 months.

What will I be asked to do if I participate?

If you volunteer for the study, you will undergo two assessments: one before the program starts, and another one three months later. Assessments include:

- wearing a small monitor for one week to measure your activity patterns at work
- filling in a questionnaire
- having your height, body composition, and weight and waist circumference taken
- completing a finger-prick test to assess your blood lipid levels.

The **total time commitment** for the program will be **1.5 hours** over the course of 3 months.

Are there any risks for me if I participate?

You will be asked to complete a blood sample collection. Blood will be collected at the workplace using a finger stick procedure. The finger stick should cause minimal discomfort.

The activity monitor will be attached to your upper thigh using non-allergenic patches (Tegaderm). However we cannot fully exclude the possibility that you will experience skin irritation. In that case you will be asked to take the monitor off and contact the project coordinator.

The OH&S Ergonomics and Rehabilitation Adviser at UQ has approved the workstations for use in the study and will act as a consultant throughout the trial.

Identifiable information will be kept in a securely locked cabinet, and only the UQ researchers will have access to these files. Project findings will be included in research publications, but no worksite or individual identifying information will be disclosed.

Can I decide not to participate in the study?

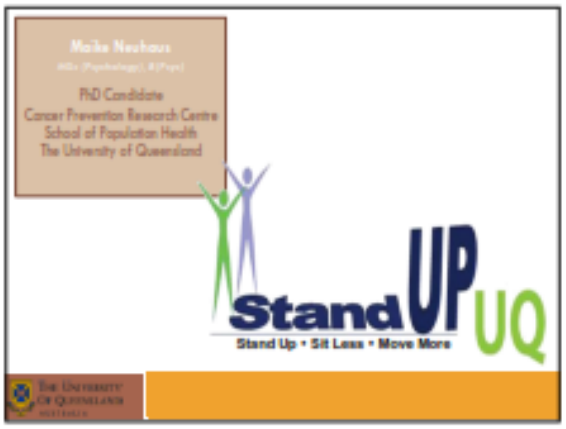
Your participation in this study is **completely voluntary**.

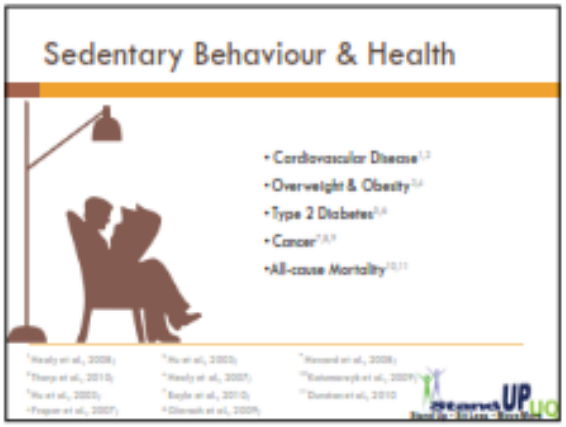
Are there benefits for me if I participate?

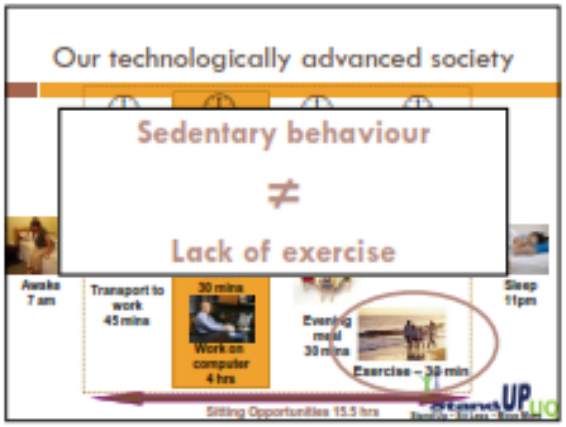
If you decide to participate, you will receive feedback on your activity levels while you are at work, your body measures, and your productivity from both assessments, and how these may have changed since the start of the study. This study will provide us with valuable information to develop and improve workplace health promotion programs. Therefore, your participation may help improve the health of office workers in the future.

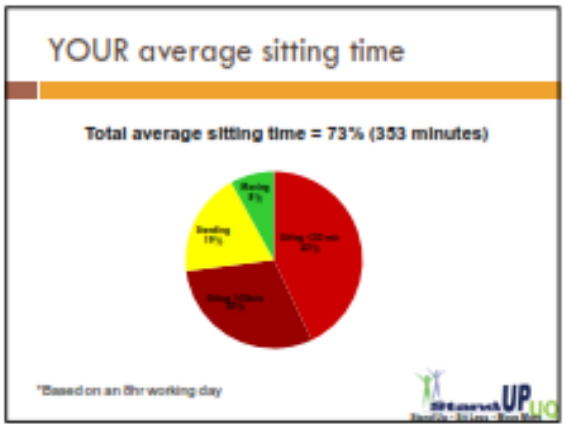
Your participation in the study will be during paid work time, as your workplace is supporting this study.

Appendix B.5. Participant information presentation







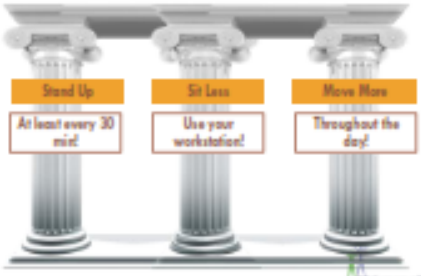


Stand Up UQ Purpose

To determine (in office workers) the effectiveness and feasibility of a 3-month workplace intervention that integrates organisational, individual, and environmental elements on:

- Workplace sitting time
- Non-workplace sitting time
- Body composition and biological biomarkers of health

We recommend that you...



The Workplace 'Package'

Strategies to Stand Up, Sit Less, Move More HERE

- Standing (in) meetings/ during presentations
- Stand up to greet someone
- Stand up when someone else does
- Stairs instead of lift
- Eat lunch away from your desk
- ...
- ...

What's next...

Thank you ☺

Appendix B.6. Participant information booklet

StandUP UQ

STAND UP • SIT LESS • MOVE MORE

Workplace Sitting and Health

The health benefits of regular exercise have been well known for several decades. However, new research has shown that less sitting is related to a lower risk of developing type 2 diabetes, lower risk of premature death from heart disease and a decreased risk of developing some cancers. Sitting less is also known to positively influence risk factors which contribute to diabetes and heart disease such as body size and blood sugar levels. Changes in the types of jobs we do, the way we travel and how we spend our leisure time mean that we are sitting throughout the day more now than ever before. Importantly, the negative impacts on health of too much sitting have been found **even in people who regularly exercise.**

These scientific findings do not mean that everybody who sits for long periods at work will develop these diseases. We are all different, and our health is determined by our family history, our lifestyle, and by a wide range of other influences. Nevertheless, reducing sitting time at work will have a range of benefits for your health and well-being.

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important thing is to listen to your body and to alter you posture regularly. Try to stand up every 30 min, even if it is just standing up and sitting directly back down AND, when you can, try standing at your workstation for as long as you are comfortable, but probably not for more than half an hour, at least to start.

At first, you may find it challenging to change the way you're used to working, but I will assist you to develop new habits that suit you and your work patterns. By replacing your sitting with standing up, you are making your muscles work harder, which can lead to better heart health.

3) Move More

The third recommendation is about *moving more* at work. This strategy will aim to not only get you to stand up but to *move around your work space more*. There are lots of strategies that I will show you to help you move more. By moving more you will increase your daily energy expenditure, which can help improve your health.

STAND UP • SIT LESS • MOVE MORE

Next Steps

I thank you for taking part in the "Stand Up UQ" Study and hope you enjoy your new workstation and being more active at your workplace. I will install your new sit-stand workstation over the weekend and am looking forward to working with you in your Health Coaching Session next week. On the next page you can see an overview of the different times that I will be in contact with you.

In the mean time if you have any questions please don't hesitate to contact me.

Maike Neuhaus

Project Coordinator

E: m.neuhaus@uq.edu.au

Ph: 3365 5350

M: 0424 494 363

STAND UP • SIT LESS • MOVE MORE

Stand Up UQ - Study Timeline

Study phase	Date	Activity
Assessment 1 (Baseline)	27 Feb '12	Blood & Body Measures, Questionnaires, Monitor & Diary
Week 1	19 Mar '12	Management Consultation
		Group Information Session & Email summary
		Workstation Installation and check-in by Maike
Week 2	26 Mar '12	Individual Consultation & Email summary
Week 3	2 April '12	Telephone check-in 1; Management email
Week 5	16 April '12	Telephone check-in 2; Management email
Week 7	30 April '12	Management email
Week 9	14 May '12	Telephone check-in 3; Management email
Week 11	28 May '12	Management email
Week 13	11 June '12	Telephone check-in 4; Management email
Assessment 2 (3 months)	18 June '12	Blood & Body Measures, Questionnaires, Monitor & Diary
Assessment 3 (12 months)	11 Mar '13	Blood & Body Measures, Questionnaires, Monitor & Diary
Feedback	May 2013	Feedback to Individuals and Organisation

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StandUP UQ
STAND UP • SIT LESS • MOVE MORE

Strategies to STAND UP more often

- ☐ Set timer (e.g. online: www.online-stopwatch.com or through MS Outlook)
- ☐ When your phone rings/ every time you call someone (put phone upon a shelf or wear a headset); you may want to sit back down soon after, so no-one else gets distracted by the noise level
- ☐ After completing a task
- ☐ When you get tired
- ☐ When you feel discomfort in your back/neck/ shoulders
- ☐ When someone enters your office/ workspace
- ☐ During meetings/ presentations
- ☐ When you see a colleague standing up

StandUP UQ
STAND UP • SIT LESS • MOVE MORE

Strategies to Move More

- iMails (walk over and talk) instead of eMails to colleagues (again, working in an open-plan office, please be aware of the increased noise levels)
- Remove bins/printers from your office and use a central one
- Dispose of waste/ collect printing more frequently
- Drink more water so you have to go to the water cooler (and bathroom!) more often
- Use a bathroom that is further away
- Step outside for fresh air
- Use the stairs instead of the lift
- Use an active way of commuting to work (walk or ride your bike; stand up in train; stand up to wait for your train/bus; ...)
- Park your car further away from your workplace and have a short walk or park in short term parking
- Have lunch away from your desk
- Have walking meetings (in particular when the meetings are short and you do not need to use the computer)

Appendix B.7. Workstation information sheet

StandUP UQ

STAND UP • SIT LESS • MOVE MORE

Top 10 Tips for Using your Workstation

1. Position the screen height to be within 15-50 degrees below your horizontal line of vision. It is preferable to use reading glasses or progressive lenses that enable you to view the screen through the mid range of the lense. If using bifocals, you may need to lower the monitor further and turn screen upward in order to attain neutral head and neck position.
2. Tilt your monitor back 10° to 20° to keep the same focal length as your eyes scan from the top to bottom of screen. If using bifocals, use a 30° to 40° angle.
3. Position the screen at a comfortable viewing distance.
4. The top of your keyboard should be approximately level with the height of your elbow.
5. Avoid elevating the back aspect of the keyboard as this will result in upward bending of the wrists. You may wish to use a soft gel wrist rest to provide wrist support in the case that there is adequate space.
6. Arrange the materials and equipment used at your workstation, in a way that enables you to stand periodically during computer use.
7. Prolonged periods of standing and sitting can result in muscle fatigue and accordingly you are encouraged to change between seated and standing postures by adjusting the overall height of the workstation. The height difference between the screen and the keyboard is likely to remain constant. Remember that when seated in the chair and when standing, the height of your elbow should approximate the height of the keyboard. The seat height may require adjustment to achieve this.
8. You are encouraged to change between seated and standing postures at the computer workstation, on a half-hourly basis. In the case that you experience discomfort or pain you should change your posture.
9. If you cannot stand for 30 minutes at a time, try to stand in shorter bouts (e.g. 10-minute bouts throughout the day).
10. You are changing a habit which you have probably had for many years (i.e. sitting down for most of your time at work) – make small changes, and always listen to your body and change posture or sit down if you need to.

The images below depict optimal computer workstation adjustment between sitting and standing:

Source: http://www.ergotron.com/Products/tabid/65/PRDID/379/language/en-AU/Default.aspx

If you experience any problems or have any concerns, please contact

Maike Neuhaus: Ph: 3365 5350 Mobile: 0424 494 363 Email: m.neuhaus@uq.edu.au

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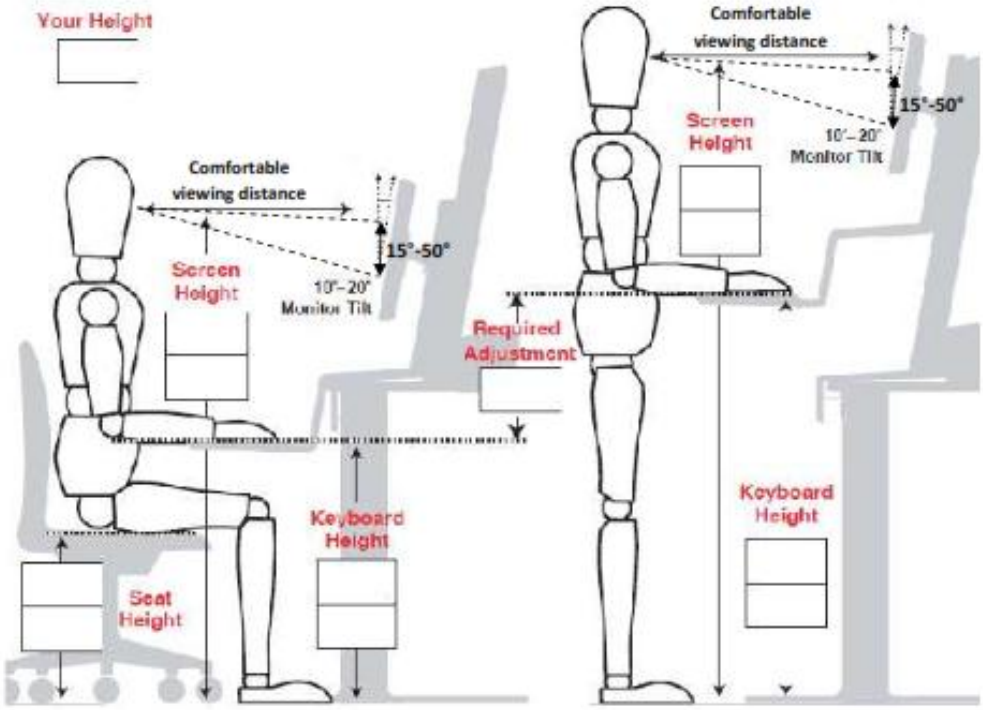
STAND UP • SIT LESS • MOVE MORE

Workstation Information Sheet

To determine the appropriate values below for an optimal workstation adjustment, simply enter your height on: http://www.ergotron.com/tabid/305/language/en-AU/Default.aspx

The UQ Computer Workstation Design and Adjustment Guideline and Checklist can be used as supplementary information regarding optimal workstation adjustment. They are found at: http://www.uq.edu.au/ohs/computer-workstations

Requirements for seating at UQ are specified in the Selection and Purchase of Seating and Furniture Policy that is found at http://www.uq.edu.au/ohs/pdfs/ERGO-SelectionandPurchaseofSeatingandFurniture.pdf



Source: http://www.ergotron.com/tabid/305/language/en-AU/Default.aspx

Note: The values represent average dimensions for people of your stature and do not account for variations due to gender, age or body type. Refer to the values as a starting point, rather than the final mounting height of your computer equipment. Values are derived without clothing allowances. Always add shoe height to figure proper measurement. Additional factors may apply. Consult with an ergonomist for more detailed information. Values are based on the 1988 Anthropocentric Survey of the U.S. Army Personnel database.

For more product information, please refer to the manufacturer website at: http://www.ergotron.com

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Appendix B.8. Individual consultation script

STAND UP • SIT LESS • MOVE MORE

Individual Consultation Script

- Will be scheduled in advance by the Project Coordinator with this info communicated to the Consultant; Takes about 30min
- To be conducted in a private room (except workstation/posture check at the end)
- Materials required: *SUUQ Participant Record*; *SUUQ Feedback Report*; *SUUQ Tracker* (laminated copy, non-permanent marker, blu tack); *SUUQ Individual Consultation Checklist*; Laminated *SUUQ Master Strategy Sheet*, 4 stickers (2 red, 2 yellow)
- Note: The red highlighted paragraphs reflect the notes/hints on the checklist

Introduction

- **Introduce self; Ok to go ahead w/consult?; Brief check-in on workstation**

Hi_____, I am Maike from the Stand Up UQ study. How are you today? We scheduled this time for your 20 min consultation. Are we okay to go ahead?

It looks like your workstation has been successfully installed. How have you gone with it so far?

[They would have likely been using it, so have a brief conversation about how they've found it. Did they use it? Like it? Did they get their workstation information sheet? Did they enter their height on the Ergotron website? Note that the reason for today's consultation is to talk about how they can get the most out of using it. Note: The longer the participant has already had the workstation prior to the consultation, the more important it is to get into a little more detail about how they went as this will be helpful for goal-setting later in the consult.

- **We are going to work together towards SUUQ Study Goals (Based on what we know…); info session attended?; email summary received?; participant check-in**

We are going to work together over the next month to help you use the workstation and change your work patterns in line with the 3 goals of the Stand Up UQ Study: **Stand Up, Sit Less, and Move More.**

Based on what we know about the negative ways that too much sitting impacts our health, we recommend that you **Stand Up regularly and at least every 30 minutes; Sit Less throughout the whole day by working at your new workstation while standing; and that you generally Move More around your workplace.**

You would have seen these recommendations already in our Stand Up UQ study materials. And if you went to the Study Information Session, you would have heard lots more about this. May I ask you if you attended any of the sessions? Which one? *[Note on participant record sheet.]* Any questions so far?

1

- **Today: Feedback & Plan; 4 phone calls; Taking notes for email summary**

In the time that we have today, I am going to give you some feedback from your first assessment (mainly on the thigh monitor that you so kindly wore!), and then I'd like us to come up with a plan for you to Stand Up, Sit Less and Move More when you're at work, with a focus on how you can get the most out of your new workstation. Over the next 3 months, I will give you a total of 4 phone calls for a 5-10 minute check-in to see how you're going. I will also take some notes throughout our conversation, so I can keep track of what we discuss and send you an email summary. This will also help jog my memory when we have our phone call next week.

Feedback

- **Feedback from monitor → pie chart; explain colours; Is this what you expected?; compare to average office worker (75% ST; 6/8hrs); other pie chart with overall awake hours**

Here are your results from the activity monitor you wore during your assessment period of ____ *[name the assessment dates]*. This pie chart shows the amount of time you spent sitting, standing, and moving at your workplace during that time. The yellow represents the time you spent standing, the green represents 'moving', red is for sitting, and the 'striped red' shows you the amount of time you have been sitting in bouts of 30 minutes or longer.

As you can see, you have been standing for an average of ___% of your workday and moving for ___%. You spent ___% of your work hours sitting and another ___% sitting for 30 minutes or longer in one bout. That means that altogether you spent ___% *[add up both sitting proportions]* of your work hours sitting. Does this make sense to you? Is this what you expected?

[At this point, the consultant and/or the participant might make some general comments about the participant's sitting/standing time, potentially in comparison to the average Australian office worker, who sits about 2/3 of the working day (e.g., "Your sitting time is pretty much in line with what we see in Australian office workers who sit about 66% of the working day.").

As you can see, there is another pie chart displaying your activity pattern during the day from 6am to 10pm, not only work hours and you can see that *[point out second pie chart and summarize briefly]*.

- **Compare to recommendations:**
  1. **STAND UP → definition; pie chart & heat map; typical work hours? Can you remember what you were doing during that time? Goal: Get rid of the long bouts (striped red) completely!**

Let's look at your results now in relation to our Stand Up UQ recommendations.

STAND UP regularly and at least every 30 minutes. What is important here is the regularity – so that you try to break up those long periods of sitting. And this can be as brief as getting off your chair, having a little stretch, and sitting back down again (if you do not feel like standing for a bit longer).

So we already know that during your first assessment week, you spent ___% of your work hours sitting in long bouts of 30 minutes or more. And here it says that you accumulated that that time through an average number of ___ long sitting bouts each day.

Let's have a look at this heat map *[point to heat map]*. Here you can see your activity patterns from 6am to 10pm for each day of your assessment week. And here you can see your work hours during your assessment week *[underneath heat map]*. Again, the red is 'sitting', the yellow 'standing', and

the green 'moving'. What we are looking for specifically is the number of times you have been sitting for 30 minutes or longer. As you can see, there are a few pretty big red blocks here and there *[point out]*, which indicates that you have been sitting during those times without any interruptions *[point out on heat map]*. Can you remember what you were doing then? *[write down]*

Now let's look for some more time periods where you have been a bit more active *[point out colourful parts in heat map]*. These time periods look much better, with lots of yellow and green stripes throughout the red indicating more frequent postural changes, about equal proportions of sitting and standing, and some moving *[point out on heat map]*.

So the goal is to get rid of those long red sitting bouts altogether *[point out the striped red on pie chart]* and today we'll talk about some strategies to help you reach this recommendation. Ok, let's move on to our second recommendation.

2. SIT LESS by replacing some of your sitting by standing at your workstation. So the aim is to reduce the red and increase the yellow instead. So once you get into the habit of getting off your chair more frequently, you could every now and then just keep standing for a little while. → Look at pie chart and heat map; workstation & other strategies

SIT LESS by replacing some of your sitting by standing at your workstation. So the aim is to reduce the red and increase the yellow instead. So once you get into the habit of getting off your chair more frequently, you could every now and then just keep standing for a little while.

As we saw, you stand for about ___% of your work hours and spend much more time sitting. We know that as an office worker, you are basically bound to sitting at your desk and computer for most of the day. So this is where you new workstation comes into play, as it allows you to keep working at your computer, but it gives you the choice to sit or stand while you are doing that. And there are also some other strategies that we will talk about later.

3. MOVE MORE → Heat map showing 'no green' → Today we'll find strategies to increase green

Our final recommendation is to MOVE MORE at work. So looking at this heat map again, that would mean having lots of green stripes throughout the working day. So as you can see, there are times here that contain more green than others, where there is hardly any moving [point out on heat map accordingly]. So one of the things we'll talk about today will be how you can increase your steps and move more at work to increase these green sections.

This is for you to keep *[hand over feedback sheet]*.

Outcome Expectancies and Readiness Check

- What do you think about this focus on standing up more at work?

We've covered quite a bit already. What do you think about this focus on standing up more at work? *[It is very important here to get a sense of the participant's level of interest and motivation. Are they taking part simply because they have to? Are they actually keen?]*

- On a scale of 1-10 how would you rate your readiness/confidence to change your habits towards more standing?

And on a scale of 1 to 10 how would you rate your readiness/confidence to change your habits towards more standing? *[Make sure to reflect/ paraphrase what participant answers here. If 5 or less, need to explore why they're taking part. If 6-7, what is keeping them from feeling more strongly*

ready? Any particular barriers/negative things they are expecting to happen? They might answer that they are happy to give it a go, but as they have never tried to work at a workstation like this; they simply have no idea how they will go and hence are sceptical. In this case the consultant could normalize, e.g. 'Yes, that is absolutely normal/understandable, in fact a lot of participants feel like that in the beginning etc'; If 8 – 10, 'great, sounds like you're ready to give it a go'.]

Tracker

- **I'd like to make sure that you've got a good plan in mind.**
- **We'll come up with some specific goals and write them down in your Tracker, which you can attach to your workstation.**
- **The idea is that it reminds you of your goals, the strategies, and that you by the end of each day think about whether you have achieved/tried them; if yes: give yourself a tick!**
- **Let's start with the first recommendation.**

I'd like to make sure that you've got in mind a good plan for using your workstation as well as some ideas about other ways that you can stand up more at work, and I'd like us to end up with a plan which suits you and your work patterns best. Basically, we will come up with some specific goals and write them down on this Tracker. You can attach it to the shelf of your workstation, and the idea is that whenever you are at your workstation, it reminds you of the goals you have, and the strategies you can use to achieve these. At the end of each day you can use the Tracker to reflect on whether you have achieved those goals and if you have, you give yourself a tick in the box. Let's start with the first recommendation.

1. **Stand Up regularly and at least every 30 minutes to get rid of those long bouts of sitting**
   - **Do you think you could do this? How?**
   - **To give you some (more) ideas, I have brought a list of strategies...**
   - **PICK 2-3 AND WRITE IN BOTH TRACKERS!**

So as we have discussed in the beginning, the first goal in this study is for you to get rid of those long bouts of sitting by standing up regularly and at least once every 30minutes. Do you think this sounds possible? How would you remind or prompt yourself to do this?

[Consultant can reflect back to time of day/task that they identified the blocks of red in the heat map.]

To give you some ideas, I have brought a list of strategies. You could for example... *[Briefly read out the strategies]* These are some strategies that your managers/site representatives find particularly easy to incorporate at your workplace...

OK, so let's pick 2-3 strategies you like most and write them into your tracking sheet. *[Consultant takes notes on his/her sheet, gives marker to participant and shows him/her where to write it down on Tracker]* I would encourage you to try all of these strategies at least once in the next week, and tick them off on here when you try them.

2. **Sit Less by replacing with standing time; up to equal amounts with sitting;**
   - **Workstation comes into play; importance to get up regularly AND if you can move your workstation up and keep standing for a while and up to 30 min**
   - **Obviously big step; important to take small steps, have realistic goals**

4

- What do you think? What could work for you? 2 ways of thinking about increasing standing time: time-based vs. task-based...
- WRITE IN BOTH TRACKERS!

Our second recommendation is to SIT LESS by replacing some of your sitting time with standing time. Now, as a general guideline, we recommend you to sit and stand at your workstation in equal proportions throughout the day.

This is where your new workstation comes into play. To start, you probably do not want to stand for more than half an hour at a time. But this will vary for each person, with some doing more and some doing less. And for most people, it will take some time to build up to standing more. The most important thing is to listen to your body and to alter you posture regularly.

Now this may sounds like quite a big change in your current work pattern, and I would rather like to make sure that the goals we set for you are realistic and that you think they are achievable. So I am happy if we started you off a little lower and you build up your standing time over this next month that we are working together. What do you think? Can you see yourself work at your computer in a standing position for a few times throughout the day? *[Note that 10 minute bouts are a reasonable way to start for anyone uncertain about standing for 30 min.]*

There are two ways you could think about increasing your standing time – linked to specific times throughout the day (e.g. the first hour in the morning, then again after lunch and maybe the last hour before you go home), or linked to specific tasks (e.g. every time you check a bulk of emails, or whenever you have to work on specific documents etc). Obviously, you could also stand during presentation, meetings or some other occasions away from your workstation. Are there any regular meetings you attend during which you could d some standing? What length and number of bouts could work for you for standing at your workstation?

All right, let's write this down. *[Consultant takes notes on his/her sheet and encourages participant to write it down on Tracker]*

3. Move More
   - **Note: If running out of time, could save this for the first phone call.**
   - Finally, let's see how you could move more. You could for example...
   - PICK 2-3 AND WRITE IN BOTH TRACKERS!

Finally, let's see how you think you could move more around your workplace. What do you think you could do to help you move more at work? You could for example...

OK, so how about if you pick 2-3 strategies you like most and write them into your tracking sheet. Again, it would be great if you would try all of these strategies at least once in the next week, and tick them off on here when you try them.

So **STAND UP** regularly and at least every 30 minutes.

SIT LESS by replacing some of your sitting time with standing time at your new workstation.

And **MOVE MORE** and as much as you can throughout the day.

Finishing Up the Consult

- Looking at these goals on your tracking sheet - how do you feel about them?
- Potentially refer back to 1-10 readiness scale; potentially re-adjust goals

Great. I hope these goals will help you to get started on standing more at work. Looking at these goals on your tracking sheet - how do you feel about them? Are they realistic changes you can make over the next week at work? And if I asked you about your confidence to stand up more and change your posture more often again, on a scale from 1-10...? *[Potentially need to clarify barriers and/or reset goals which they are confident they can achieve.]*

- Try to stick to your goals but listen to your body!

Over the next week, try to stand and break up your sitting time as much as you can. It is best to change your posture regularly, at least every 30 min – from sitting to standing to moving. But remember that you are about to change a sitting habit you have probably had for quite some time. So listen to your body – if you feel you are getting stiff or feel uncomfortable or extremely tired (a little in the beginning is normal), change your posture or sit back down for a little while.

- Email summary and Appointment for phone call 1 *[WRITE DOWN BELOW & ON TRACKER]*

I will send you an email soon summarising your personal goals and strategies. I will also give you a total of 4 brief phone calls over the next 3 months to see how you are going with all of this. It would be really helpful if you could complete the tracker each day, so that when we talk, we can focus on what has worked well and not so well. This will help us to keep tweaking the way you use the workstation to get the most out of it.

I would like to give you the first phone call next week. What day/time would suit for me to call you next week? It will take about 10 minutes. *[Note appointment]* Great. I can send you an invitation through outlook. If you have questions in the meantime, please do not hesitate to call or email me.

Workstation Check

- Before finishing off, I'd like to make sure your WS is adjusted correctly for your height *[walk to participant's desk].*
- OK. *[Paraphrase what they told you in the beginning about their use of the workstation to this point (e.g., Sounds like you've given it a bit of go already," or "Sounds like you haven't used it much yet.")]* Have you had any problems or concerns? *[If yes – write down on checklist]*
- Let's have a look at your standing posture: right angle of upper to lower arms; even wrists (keyboard flat?); monitor 15-50 degrees below viewing line (head straight); body straight but cruisy and comfortable! Listen to your body and change posture whenever necessary
- Stickers: 2 yellow ones for standing, 2 red ones for sitting; attach yellow ones
- Now look at sitting posture; repeat same body posture rules; attach red stickers
- That's it for today. Thanks once again. I will email you a summary and give you a call next week. Bye.

Now before we finish off I would like to briefly make sure that your workstation is adjusted correctly for your height. Would you mind if we had a quick look at it together? *[walk to participant's desk]*

OK. *[Paraphrase what they told you in the beginning about their use of the workstation to this point (e.g., Sounds like you've given it a bit of go already," or "Sounds like you haven't used it much yet.")]* Have you had any problems or concerns? *[If yes – write down on checklist]*

Now let's have a look at your standing posture: It is important that your upper and lower arms are in a right angle to each other. Your wrists should be nice and even *[make sure their keyboard is not lifted at the back; if it is, ask them if they would be happy to lower it]*; the monitor is supposed to be at a comfortable viewing distance, with the middle of the screen – and this is going to sound very precise, but this is the ergonomically correct instruction - between 15-50 degrees below the horizontal line of vision *[illustrate this line with arm]*, basically it is important that the head is not overly tilted. Most importantly, it is important to sit/stand straight, but make sure your posture feels relaxed and 'cruisy' as opposed to overly straight and stiff. Listen to your body and change your posture accordingly! *[Consultant may need to make small adjustments to workstation set-up]*I have brought some stickers that we can attach to your workstation on the bar behind the monitor mount and the shelf, so that you know exactly where they are meant to go next time you adjust your workstation up and down. Again, red is for 'sitting' and yellow is for 'standing' *[attach yellow stickers]*. Alright, how about if you sit down for a moment and we check your workstation set-up once again? *[instructions are the same for as for standing posture: wrists, elbows, head, viewing distance, straight but cruisy, listen to your body; this time, attach red stickers]*.

That's it for today. Thanks once again. I will email you a summary and give you a call next week. Bye.

STAND UP at least every 30 min. **I will do this by:**	☐ _____ ☐ _____ ☐ _____
SIT LESS by standing at my workstation for _____minutes/ day.	
Monday ☐ **Tuesday** ☐ **Wednesday** ☐ **Thursday** ☐ **Friday** ☐	
MOVE MORE at work. **I will do this by:**	☐ _____ ☐ _____ ☐ _____

7

Appendix B.9. Individual consultation checklist

STAND UP • SIT LESS • MOVE MORE

Individual Consultation Checklist

- Will be scheduled in advance by the Project Coordinator with this info communicated to the Consultant; Takes about 30min
- To be conducted in a private room (except workstation/posture check at the end)
- Materials required: *SUUQ Participant Record; SUUQ Feedback Report; SUUQ Tracker* (laminated copy, non-permanent marker, blu tack); *SUUQ Individual Consultation Checklist*; Laminated *SUUQ Master Strategy Sheet*, 4 stickers (2 red, 2 yellow)

Introduction

- Introduce self; Ok to go ahead w/consult?; Brief check-in on workstation
- We are going to work together towards SUUQ Study Goals (Based on what we know…); info session attended?; email summary received?; participant check-in
- Today: Feedback & Plan; 4 phone calls; Taking notes for email summary

Participant Feedback

- Feedback from monitor → pie chart; explain colours; Is this what you expected?; compare to average office worker (75% ST; 6/8hrs); other pie chart with overall awake hours
- Compare to recommendations:

1. **STAND UP** → definition; pie chart & heat map; typical work hours? Can you remember what you were doing during that time? Goal: Get rid of the long bouts (striped red) completely!
2. **SIT LESS** by replacing some of your sitting by standing at your workstation. So the aim is to reduce the red and increase the yellow instead. So once you get into the habit of getting off your chair more frequently, you could every now and then just keep standing for a little while. → Look at pie chart and heat map; workstation & other strategies
3. **MOVE MORE**→ Heat map showing 'no green'→Today we'll find strategies to increase green

HAND OVER FEEDBACK SHEET

Outcome Expectancies and Readiness Check

- What do you think about this focus on standing up more at work?
- On a scale of 1-10 how would you rate your readiness/confidence to change your habits towards more standing?

Tracker

- I'd like to work together now to come up with a good plan for you that suits you and your work patterns for using your workstation and move more at work.
- We'll come up with specific goals, which you can write on your Tracker & attach to your workstation.
- The idea is that it reminds you of your goals & strategies, and that you tick at the end of each day if you have achieved/tried them.
- Let's start with the first recommendation.

1. **STAND UP** regularly and at least every 30 minutes to get rid of those long bouts of sitting

1

- Do you think you could do this? How?
- To give you some (more) ideas, I have brought a list of strategies...
- PICK 2-3 AND WRITE IN BOTH TRACKERS!

2. **SIT LESS** by replacing some sitting with standing time; up to equal amounts with sitting
   - Workstation comes into play; importance to get up regularly AND if you can move your workstation up and keep standing for a while and up to 30 min
   - Obviously big step; important to take small steps, have realistic goals
   - What do you think? What could work for you? 2 ways of thinking about increasing standing time: time-based vs. task-based...
   - WRITE IN BOTH TRACKERS!

3. **MOVE MORE**
   - [Note: If running out of time, could save this for the first phone call.]
   - Finally, let's see how you could move more. You could for example...
   - PICK 2-3 AND WRITE IN BOTH TRACKERS (Get participant to write in his own!)

It would be great if you could try all of these strategies at least once during the next week, and make sure that by the end of each day you reflect on whether you have achieved your goal of standing and give yourself a tick in the box if you have. I will ask you how you went over the phone next week.

So STAND UP regularly and at least every 30 minutes.
SIT LESS by replacing some of your sitting time with standing time at your new workstation.
And MOVE MORE and as much as you can throughout the day.

ATTACH TRACKER TO WORKSTATION

Finishing Up the Consult

- Looking at these goals on your tracking sheet - how do you feel about them?
- Potentially refer back to 1-10 readiness scale; potentially re-adjust goals
- Try to stick to your goals but listen to your body
- Email summary and Appointment for phone call 1 [write down below & on tracker]
- Thank you.

Workstation Check (refer to tip sheet)

- Before finishing off, I'd like to make sure your WS is adjusted correctly for your height [walk to participant's desk].
- OK. [*Paraphrase what they told you in the beginning about their use of the workstation to this point (e.g., Sounds like you've given it a bit of go already," or "Sounds like you haven't used it much yet.")*] Have you had any problems or concerns? [*If yes – write down below]*
- **Problems/ concerns:** _____
- Let's have a look at your standing posture: right angle of upper to lower arms; even wrists (keyboard flat?); monitor 15-50 degrees below viewing line (head straight); body straight but cruisy and comfortable! Listen to your body and change posture whenever necessary
- Stickers: 2 yellow ones for standing, 2 red ones for sitting; attach yellow ones
- Now look at sitting posture; repeat same body posture rules; attach red stickers
- That's it for today. Thanks once again. I will email you a summary and give you a call next week. Bye.

Appendix B.10. Email template for individual consultation summary

STAND UP • SIT LESS • MOVE MORE

Summary of your consultation session

Dear _____ ,

I hope you had a good start with your new workstation.

As promised, here are some important points for you to remember from our discussion yesterday that will help you achieve your goals for standing up, sitting less, and moving more.

EITHER: Overall, you are doing quite well. Keep it up and try to gradually increase the time you spend standing and using your workstation.

OR: The results from the activity monitors showed that you are sitting a fair bit. I am sure that your new workstation and the strategies we spoke about will help you stand more while working.

As noted on your tracking sheet, you are aiming to... *[mention goals as on Tracker]*

STAND UP at least once every 30 minutes

To make sure you change your posture and get off your chair regularly, you are going to... *[paraphrase strategies from Tracker]*

SIT LESS by replacing some of your sitting time with standing time at your new workstation for at least ____minutes/day:

You were going to do this by standing for ____minutes _____ (e.g. in the morning), _____minutes _____(e.g. immediately before lunch) and _____....

Move more at work

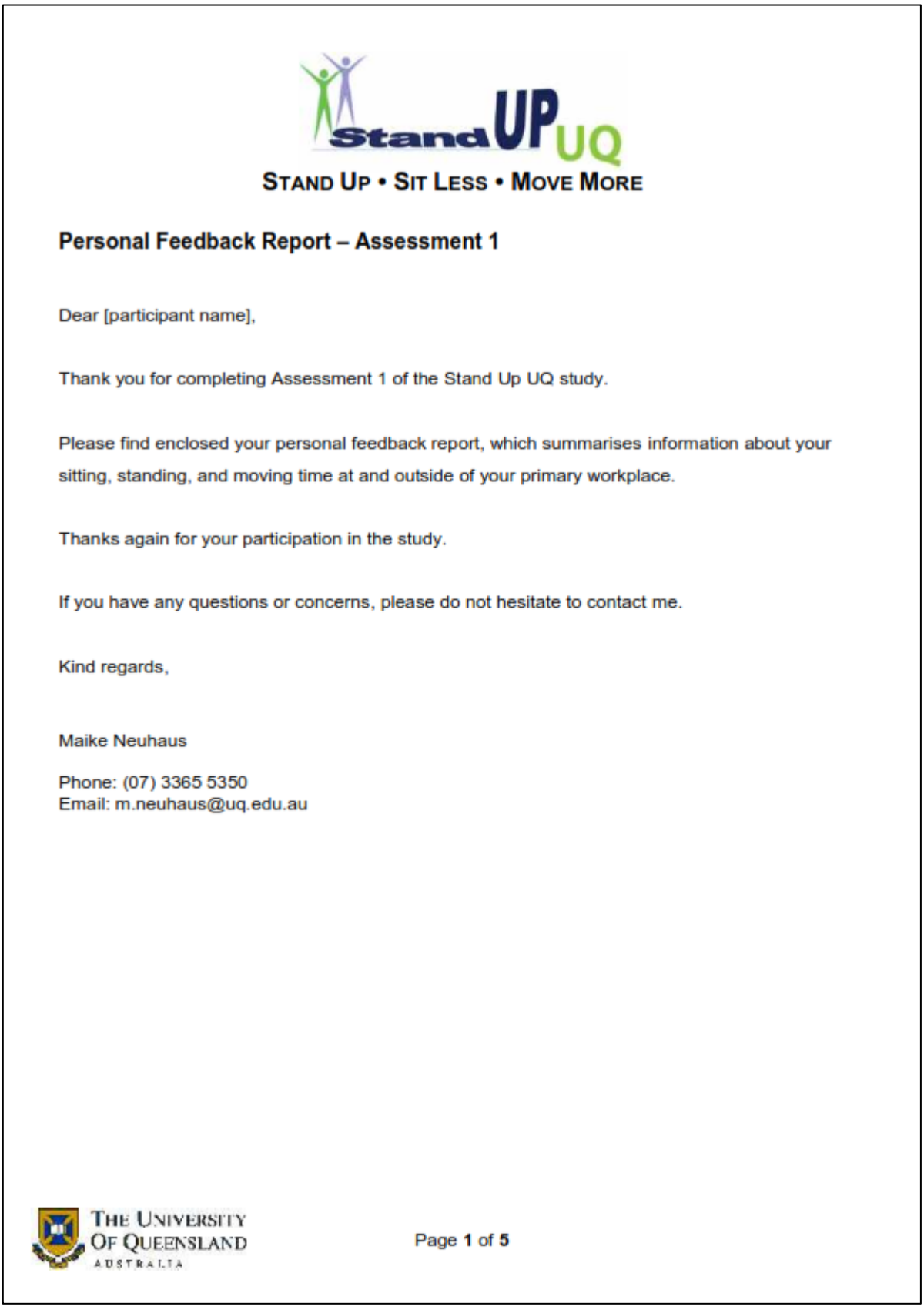
Finally, you have chosen to do the following to become more active throughout your whole working day: *[paraphrase strategies from Tracker]*

As we agreed, I will give you a call on _____ to check-in on how you are going and how these strategies are working for you. Please remember to try all of these strategies and give yourself a tick in the box each day if you have tried a strategy and achieved your goals.

I hope you enjoy your new workstation. Call or email me if you have any questions or concerns.

Kind regards,
Maike

Appendix B.11. Participant feedback report example - Assessment 1



STAND UP • SIT LESS • MOVE MORE

Personal Feedback Report – Assessment 1

Dear [participant name],

Thank you for completing Assessment 1 of the Stand Up UQ study.

Please find enclosed your personal feedback report, which summarises information about your sitting, standing, and moving time at and outside of your primary workplace.

Thanks again for your participation in the study.

If you have any questions or concerns, please do not hesitate to contact me.

Kind regards,

Maike Neuhaus

Phone: (07) 3365 5350
Email: m.neuhaus@uq.edu.au

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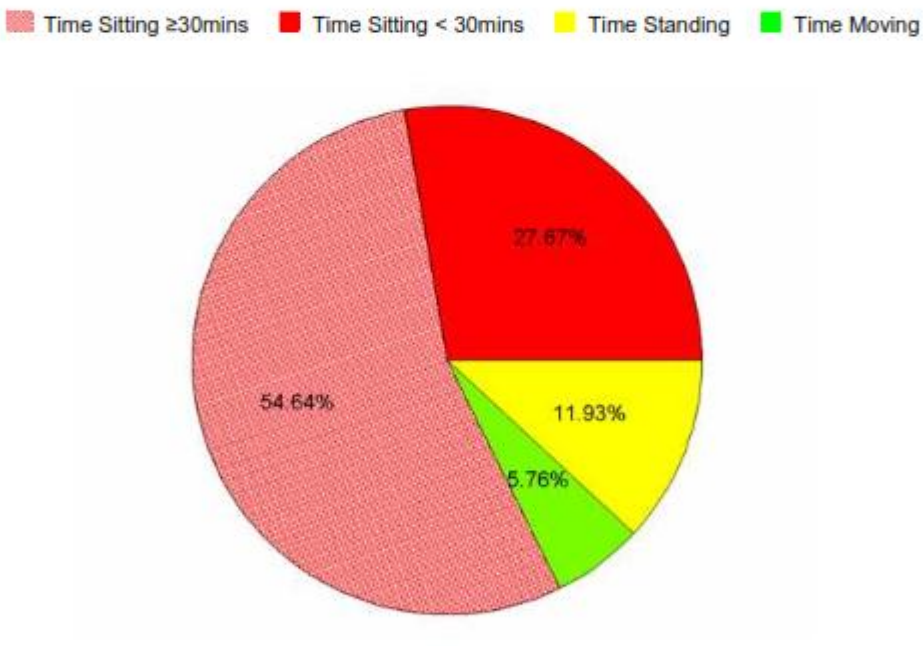
Page **1** of **5**

STAND UP • SIT LESS • MOVE MORE

Your Sitting, Standing, and Moving Time at Work

The following pie chart summarizes information about your posture and movement while you were wearing the thigh monitor at your workplace. It shows the percentage of the time at your workplace that you spent either sitting (in bouts 30mins or longer and in bouts shorter than 30 mins), standing, or moving. The information below does not include times you removed your monitor, times you spent working at locations other than your primary workplace, or any days where you removed your monitor for extended periods (i.e. for more than 20% of your time at the workplace).

Percentage of time at the workplace spent sitting (bouts ≥30min & <30mins), standing and moving



Assessment Period: 29/02/2012-08/03/2012

Average time at the workplace: 8.51 hours per day

Average number of sitting bouts ≥30mins: 5 per day

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Page **2** of **5**

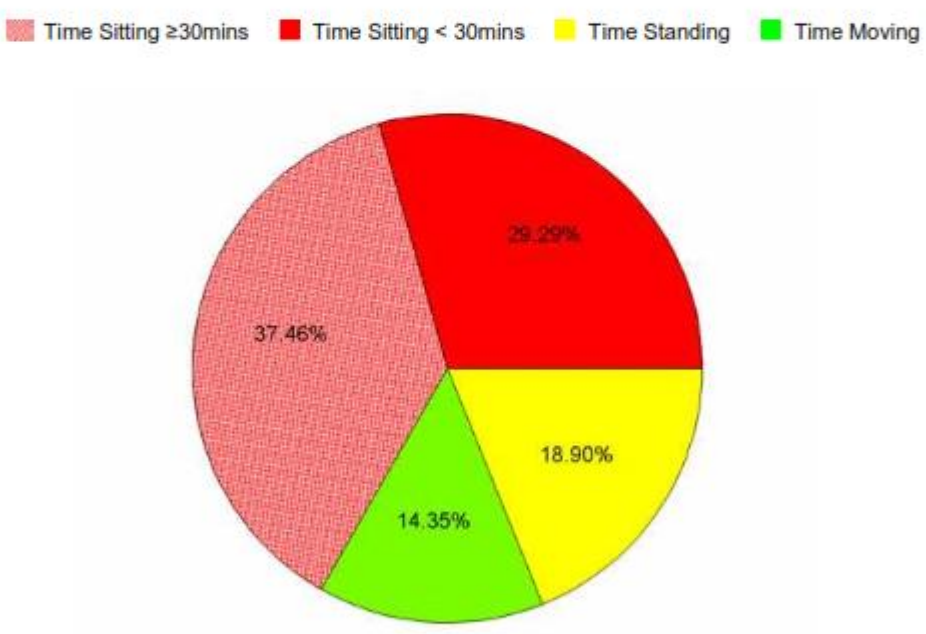
STAND UP • SIT LESS • MOVE MORE

Your Sitting, Standing, and Moving Time during Overall Awake Time

The following figures summarize information about your posture and movement during your overall awake time in the assessment period.

1) The pie chart shows the percentage of your waking hours that you spent either sitting (in long bouts of 30 mins or longer, or in bouts shorter than 30 mins), standing, or moving. The information excludes any times you were not wearing the monitor, any times you were asleep, and any days the monitor could not capture enough of your waking hours (i.e. your monitor was worn for less than 10 waking hours, or was removed more than 20% your waking hours).

Proportion of waking hours spent sitting (bouts ≥30min & <30mins), standing and moving



Assessment Period: 29/02/2012-08/03/2012

Average waking time: 16.12 per day

Average number of sitting bouts ≥30mins: 6 per day

STAND UP • SIT LESS • MOVE MORE

2) The following figure, a *heat-map*, displays your daily sitting, standing, and moving time during the 7-day assessment. The heat-map is useful for understanding your activity pattern, because it shows when you performed each activity, and any times that you might be performing the same activity for an extended period without interruption. The activity that your monitor recorded each day is shown in each column – from the beginning of the day (bottom) to the end of the day (top). Each coloured block or line represents the activity the monitor recorded at that particular time, on that particular day (sitting-red, standing-yellow or moving-green). Any times you were asleep or not wearing the monitor are not coloured.

Daily patterns of time spent sitting, standing and moving

You were at your workplace…

01/03/2012 8:55 -17:35	06/03/2012 9:30 -17:40
07/03/2012 8:50 -17:15	08/03/2012 8:45 -17:30

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StandUP UQ
STAND UP • SIT LESS • MOVE MORE

Your Body and Blood Measures

These are your body and blood measures taken during Assessment 1. The desirable level refers to your specific gender and/or age group. If any of your levels are outside the desirable levels, it is recommended that you visit your doctor.

	Your Level at Assessment 1	Desirable Level
Body Measures		
Height (cm)	167.0	N/A
Weight (kg)	75.3	N/A
Body Mass Index (kg/m^2)	27.0	18.5 – 24.9
Waist Circumference (cm)	89.9	< 80
Hip Circumference (cm)	114.5	N/A
Waist-to-hip ratio	0.79	< 0.80
Blood Measures		
Fasting blood glucose (mmol/L)	5.11	< 5.55
Total Cholesterol (mmol/L)	5.02	< 5.18
LDL Cholesterol (mmol/L)	3.12	< 2.59
HDL Cholesterol (mmol/L)	1.57	≥ 1.03
Triglycerides (mmol/L)	0.73	< 1.69

Appendix B.12. Example protocol for telephone follow-up

ID: ☐-☐☐☐

STAND UP – SIT LESS – MOVE MORE

Phone Call 1 – Week 2

- Have participant's consultation checklist and record at hand

Hi _____,

This is Maike from the Stand Up UQ Study. How are you today?

As promised, I am calling you to see how the workstation is going for you. Do you have a few minutes to chat now?

How did you go with your workstation?

_____

_____

Did you manage to **stand for _____ minutes each day**? Did you give yourself a tick on the tracking sheet every day that you did that? *[get participant to refer to their tracker while you talk about this]*

☐ Yes ☐ No

Difficulties/ Problems with reaching goal:

_____

_____

Solution for coming week: *[try to get the participant to come up with these]*

_____

_____

Do you think you need to increase/decrease your goal for the coming week? *[if yes, direct to re-write the goal on the Tracker with the non-permanent marker provided]*

☐ Yes ☐ No

_____

_____

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What about **standing up regularly and at least once every 30 minutes** – do you think you have achieved that goal? How did you go with those strategies you wrote down on your tracking sheet? Which strategies did you find helpful?

Difficulties/ Problems with reaching goal:

_____

_____

New strategies for coming week: [*suggest writing these on the tracker]*

_____

_____

You also chose some strategies to help you **move more throughout your working day**. How did you go with those?

Difficulties/ Problems with reaching goal:

_____

_____

New strategies for coming week: [*suggest writing these on the tracker]*

_____

_____

Thank you for your time. I hope this helps to keep you on track.

I would also like to make an appointment for our next phone call which will be due in two weeks. How about...?

Next phone call: _____ Thanks again, bye.

- **Note appointment on participant's record.**

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Appendix B.13. Example template for management emails

STAND UP – SIT LESS – MOVE MORE

Dear [Org name] Team,

This is **Week 2** of the Stand Up UQ study. I hope you are finding your new workstation helpful to stand more and are enjoying a healthier way to work!

[E.g.: During my walk through the office this morning I have noticed that...

We have also initiated a walking group every [day/time]...]

Here is your STAND UP – SIT LESS – MOVE MORE TIP OF THE WEEK:

Keep standing,

Management Signature

Appendix B.14. Strategy list to stand up, sit less and move more outside of work

STAND UP – SIT LESS – MOVE MORE

You are now familiar with your new workstation and are familiar with some other practical ways to Stand Up, Sit Less, and Move More in your office. You may also want to use these strategies outside of your workplace. Here are some tips that people have found useful to reduce and break up their sitting time in their every day routine at home or other places than the office. Feel free to add to it!

- ☐ While watching TV, get off the couch and walk around the house or do household chores such as folding clothes, washing dishes, or ironing during commercial breaks
- ☐ Choose more active ways of commuting: cycle or walk all the way or use public transport so you have to cycle/walk to the next transport stop
- ☐ Stand up to wait for the bus/train and stand up in the train instead of sitting down
- ☐ Park your car further away from your destination and walk a bit instead
- ☐ Stand up and walk around while talking on the phone (why not get a headset?)
- ☐ When sitting down while reading a book, get up every few pages.
- ☐ Stand up while reading the morning newspaper, mail, or email

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- ☐ Walk to visit neighbours instead of calling them
- ☐ Move around the house when hacking text messages or email on your phone
- ☐ Wash your car by hand instead of using a drive-through car wash
- ☐ Break up sitting time with little jobs, instead of working straight for longer periods then sitting for longer periods
- ☐ _____
- ☐ _____
- ☐ _____

STAND UP – SIT LESS – MOVE MORE

Take every opportunity to be more active and move those muscles!

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Appendix C. Workstation report from UQ OHS department

Executive Summary: Workstation Options for the Workstation Study

1. Background

Professor Elizabeth Eakin (Director Cancer Prevention Research Centre) and Vicki McNabb (UQ Wellness Coordinator) invited Kris Fraser (UQ Ergonomics Adviser) to review ergonomics design factors of the 'Ergotron' workstation.
It is understood that Professor Eakin and Maike Neuhaus (PhD Candidate) are conducting a 'Workstation Study' that is examining UQ staff working in standing and sitting postures at computer workstations, and it is proposed that the Ergotron workstation is used for this purpose. The workstation study is valuable research and is well positioned to be conducted in UQ workplaces.

The UQ Ergonomics Adviser has taken an enabling and problem solving approach to the assessment of the Ergotron workstation, with the aims of:

- Specifying conditions under which the Ergotron may be used in UQ office environments for the purpose of the workstation study.
- Assisting the UQ Researchers to optimise working postures and movements of the study participants and to ensure the health and safety of the study participants.

The ergonomics review findings of three additional standing/sitting workstation options are also detailed in this report. The three workstations are as follows:

- Actiforce electric height adjustable workstation
- Body Language electric height adjustable workstation
- A fixed height workstation that enables work sitting on a high chair or in a standing posture.

2. Workstation Options

2.1. Use of Ergotron workstations

Main comments

- Relatively inexpensive at $500 per unit when compared with the electric height adjustable desks.
- Readily enables alternation between seated and standing postures
- Design features can result in awkward and unsupported postures and movements during performance of computer, reading, writing and file handling tasks.
- Not certified by BIFMA/AFRDI and does not meet the AS/NZS:1997 Office Desks or the SafeWork Australia design specifications for office desks.
- Testing for strength, stability and durability performed and documented by the manufacturer (see Ergotron Test Plan attached)

Conditions for use for the Workstation Study:

- Staff with a history or current symptoms of musculoskeletal strain to the neck, shoulders, mid back and lower back are excluded from the study. This strategy can contribute to the health and safety of the study participants and can assist to minimise any risk of injury throughout the course of the study.
- Study participants be required to make an early report of musculoskeletal strain/pain or limited standing tolerances that may arise during the course of the study. Its is UQ policy for all injuries and incidents to be reported on the Online Injury, Illness and Incident database. It is found at https://www.risk.admin.uq.edu.au/uq-injury/forms/default_content.asp

1

- A shortened keyboard without a numerical keypad should be used with a mouse on the keyboard tray. (The links to suitably designed keyboards are included in the Ergonomics Review Report section 1.1 Design Constraints.)
- Appropriate seating from the UQ office chair range should be used at the workstation. http://www.pf.uq.edu.au/Cat_furn/chairs/office.html
- User acceptance and experience of the Ergotron would be helpful feedback, as this can add value and perspective to the overall ergonomics evaluation.

At this point in time, it is preferred that the use of the Ergotron by UQ staff is limited to the Workstation Study.

2.2. Use of the Body Language electric height adjustable desk

Main comments

- Readily enables alternation between sitting and standing postures
- Design features facilitate neutral and well supported postures
- Higher cost at $1055 per unit
- Australian Furniture Research and Design Institute (AFRDI) accreditation with a 10 year warranty.
- Meets the AS/NZS:1997 Office Desks and the SafeWork Australian design specifications for office desks

Conditions for use for the Workstation Study:

- Appropriate seating from the UQ office chair range should be used at the workstation. http://www.pf.uq.edu.au/Cat_furn/chairs/office.html
- User acceptance and experience of the Body Language desk would be helpful feedback, as this can add value and perspective to the overall ergonomics evaluation.
- Study participants be required to make an early report of musculoskeletal strain/pain or limited standing tolerances that may arise during the course of the study. Its is UQ policy for all injuries and incidents to be reported on the Online Injury, Illness and Incident database. It is found at https://www.risk.admin.uq.edu.au/uq-injury/forms/default_content.asp

2.3 Use of the Actiforce electric height adjustable desk

Main comments

- Readily enables alternation between sitting and standing postures
- Design features facilitate neutral and well supported postures
- Higher cost at $999 per unit
- BIFMA accreditation (AFRDI equivalent)
- Meets the AS/NZS:1997 Office Desks and the SafeWork Australian design specifications for office desks

Conditions for use for the Workstation Study:

- Appropriate seating from the UQ office chair range should be used at the workstation. http://www.pf.uq.edu.au/Cat_furn/chairs/office.html
- User acceptance and experience of the Actiforce desk would be helpful feedback, as this can add value and perspective to the overall ergonomics evaluation.
- Study participants be required to make an early report of musculoskeletal strain/pain or limited standing tolerances that may arise during the course of the study. Its is UQ policy for all injuries and incidents to be reported on the Online Injury, Illness and Incident database. It is found at https://www.risk.admin.uq.edu.au/uq-injury/forms/default_content.asp

2.4 Use of the fixed height standing/sitting workstation

Main comments

- Enables alternation between sitting and standing postures
- Must be used with a high chair; this can present safety issues for some users when getting on and off the chair
- Desk height suited to the individual only and use by other staff may be unsuitable.
- Cost of $600 - $700 per desk, $500 per chair. Total cost $1200
- Meets UQ Design Standards for Construction Projects

Conditions for use for the Workstation Study:

- Staff who have significant medical conditions of the lower back, hip, knee, ankle or foot, and staff who have limited mobility / balance are excluded from the study. This strategy can contribute to the health and safety of the study participants and can assist to minimise any risk of injury throughout the course of the study.
- User acceptance and experience of the fixed height desk would be helpful feedback, as this can add value and perspective to the overall ergonomics evaluation.
- Study participants be required to make an early report of musculoskeletal strain/pain or limited standing tolerances that may arise during the course of the study. Its is UQ policy for all injuries and incidents to be reported on the Online Injury, Illness and Incident database. It is found at https://www.risk.admin.uq.edu.au/uq-injury/forms/default_content.asp

3. General comment regarding standing workstations in open plan offices

The use of a standing workstation in an open plan office that has seated height acoustic screens, is likely to increase annoyance noise produced by speech.
Where open plan office acoustic screens have not been designed to accommodate standing workstations, it is preferable for the standing workstations to be used in areas where there is less conversation, *or* where speaking would not be considered an annoyance noise issue. For example where there is minimal telephone work, or where team members welcome continuous conversation or discussion.

4. Workstation Planner Sheet and Information Sheet

The illustration and check points are useful tools for the guidance of the Ergotron workstation adjustment.
There are some changes required to ensure that correct information regarding posture and movement is provided to UQ staff
The UQ Computer Workstation Design & Adjustment Guideline will be the basis for the changes to the Workstation Planner Sheet and Information Sheet.
http://www.uq.edu.au/ohs/pdfs/computerworkstations.pdf

Ergonomics Review

1. Ergotron

Design Benefits

- Enables a seated or standing posture for work tasks
- Low force requirements to move the workstation upward and downward
- The computer screen height is adjustable throughout a range that is considered appropriate for most people; it can be positioned between 15-50 degrees below the horizontal line of vision for most people.

- There is a tray directly above the keyboard that could be used to place hard copy documents on; for reading only.
- There is independent height adjustability between the computer screen and keyboard tray.

Design constraints

- The distance from the keyboard to the computer screen is fixed at 760mm. The preferred viewing distance from the person to the computer screen varies between individuals in the range of 610-930mm.People who require a shorter viewing distance may lean forward (forward flexion of the spine) and those requiring a longer viewing distance may move away from the computer screen and keyboard surface resulting in awkward postures of the shoulder and elbow.
- The tray that is used to support hard copy documents may require repetitive reaching above shoulder height when writing on documents whether in a seated or standing position. When there is a combination of keyboard and writing tasks being performed in a standing position (ie when files/documents are stored on a desk surface) forward bending may occur. When there is a combination of keyboard and writing tasks being performed in a seated position, extended forward reaching and forward bending may occur.
- Forearm support reduces high static loads on postural muscles and reduces compressive forces on the lower back by 40%, and is recommended in the ergonomics literature. The limited depth of the keyboard platform means that forearm support is limited.
- The awkward postures and movements that are described above are considered to be risk factors for musculoskeletal disorders under the Manual Tasks Code of Practice 2010.
- The keyboard/mouse tray has limited width for use of a standard size keyboard and mouse; it is 630mm wide whereas the comfortable width is closer to 650-670 mm wide.

  A shortened keyboard without a numerical keypad and a mouse can be comfortably used on the surface. The shortened keyboard also enables neutral right shoulder posture during right hand mouse use and either of 2 models can be purchased via:

  http://www.ergonomicoffice.com.au/catalogue_view.asp?catID=15&prodID=149&nav=

  http://www.ergonomicoffice.com.au/catalogue_view.asp?catID=15&prodID=508&nav=

- The Australian/New Zealand Standard 4442:1997 Office Desks recommends that:

  Single task operations (eg keyboard work) have minimum desk dimensions of 1200mm x 800 mm

  Mixed tasks (eg keyboard and clerical work) have minimum desk dimensions of 1600 mm x 800 mm

  The reason for this specification is to ensure adequate space for materials and equipment, flexibility and adaptability, and provision for optimal postures and movements.

  The minimal work surface requirements specified by the standard is not met by the Ergotron.

  The standards for specified for worksurfaces by the Ergonomic Principles and Checklists for the Selection of Office Furniture and Equipment are not met by the Ergotron.

Certifications

- The Ergotron manufacturer has self-tested the strength, durability and stability of the equipment and the findings are in the attached spreadsheet.
- Not certified by BIFMA (The International equivalent to the Australian Furniture Research Design Institute).
- Does not meet the AS/NZS 4442:1997 Office Desks nor the standards for specified for worksurfaces by the Ergonomic Principles and Checklists for the Selection of Office Furniture and Equipment.

Cost: Approximately $500 per unit

2. Actiforce height adjustable desk

Design benefits:

- Enables a seated or standing posture for work tasks
- No force requirements to move the workstation up and down
- Meets the Australian/New Zealand 4442:1997 Office Desks
- Meets the Ergonomics Principles and Checklists for the Selection of Office Furniture and Equipment (SafeWork Australia publication)

Design constraints

- None observed from written description, specifications and illustration obtained from supplier.

Certifications

- ANSI/BIFMA x 5.5 - 1998
- BIFMA - Business & Institutional Furniture Manufacturers Association. [An international standard and is the American equivalent to the Australian Furniture Research and Design Institute (AFRDI/Furntech) accreditation.]

Cost (40 units): $999 per unit

3. Body Language height adjustable desk

Design Benefits

- Enables a seated or standing posture for work tasks
- No force requirements to move upward and downward
- Meets the AS/NZS 4442:1997 Office Desks
- Meets the Ergonomics Principles and Checklists for the Selection of Office Furniture and Equipment (SafeWork Australia publication)

Design constraints

- None observed from written description, specifications and illustration obtained from supplie

Certifications:

- Australian Furniture Research and Design Institute (Furntech) accreditation with a 10 year warranty.

Cost: (40 units): $1055 per unit

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4. Fixed height standing/sitting workstation

Design benefits

- Enables a seated or standing posture for work tasks
- Meets the AS/NZS 4442: 1997 Office Desks
- Meets the Ergonomics Principles and Checklists for the Selection of Office Furniture and Equipment (SafeWork Australia publication)

Design constraints

- Must be used with a high gas lift chair and high footrest. The high chair cannot be used by people who have limited mobility/balance or who have significant hip, knee or lower back conditions owing to potential difficulties getting on the off the chair and the risk of falling.
- The desk height must be designed to suit the body dimensions of the individual person and may not be suitable for use by people with different body dimensions (eg standing elbow height)
- The desk height may not be suitable for use in offices where it is used for meetings with other staff who prefer to be seated. This would require the meeting to be conducted in standing or with several high gas lift chairs.

Certifications

- Meets UQ Design Standards for Construction Projects

Cost: approximately $600 - $700 per unit.

References

- Manual Tasks Code of Practice 2010 - Workplace Health & Safety Act Qld
- HumanScale - Niels Diffrien et al
- Fitting the Task to the Man : A textbook of Occupational Ergonomics – Etienne Grandjean
- AS/NZS 4442:1997 Office Desks – Standards Australia
- Ergonomics Principles and Checklists for the Selection of Office Furniture and Equipment- SafeWork Australia publication

UQ Selection and Purchase of Seating and Furniture Guidelines

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Appendix D. *Stand Up UQ* feedback interview protocol

Stand Up UQ – feedback interview protocols

Individual face-to-face interviews with managers; telephone-delivered interviews with participants before the presentation of study results *(Aim: To get their feedback on the various aspects of the intervention; likes/dislikes; likelihood of continuing any aspects)*

Managers

Multi-component intervention group:

- How was your overall experience with the Stand Up UQ study?
- How did you find your role as "champion" of efforts to reduce sitting time among your staff? What did you do? What worked? What didn't? What, if anything, will you continue to champion? Are there any things you might do differently post-study?
- As a result of the study, has your group changed any of its norms or organisational routines around sitting/standing/moving? What has changed? What do you see as advantages to more standing at work? What are the chances that you will continue this change? Any negatives about this change? What is it going to take for these changes to become sustainable in your group in the long-term?
- What did you think about the impact of the stations on your team's productivity? What did you think about the impact of any of the other SU SL MM practices on their productivity?
- What proportion of your staff do you think would benefit from having height-adjustable desks? What proportion of your staff do you think would benefit from additional support (coaching etc) to reduce their sitting time?
- What would you be willing to pay for such desks/ coaching etc.? How many desks will you be able to afford in the near future? What strategy can you think of that would help you accumulate more desks over time?
- Are you considering changing your current office furniture for height-adjustable workstations or something similar?

Workstations-only intervention group:

- How was your overall experience with the Stand Up UQ study?
- As a result of the study, has your group changed any of its norms or organisational routines around sitting/standing/moving? What has changed? What do you see as advantages to more standing at work? Any negatives about this change? What are the chances that you

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will continue to change? What is it going to take for these changes to become sustainable in your group in the long-term?

- What did you think about the impact of the stations on your team's productivity?
- What proportion of your staff do you think would benefit from having height-adjustable desks? What proportion of your staff do you think would benefit from additional support (coaching etc.) to reduce their sitting time?
- What would you be willing to pay for such desks/ coaching etc.? How many desks will you be able to afford in the near future? What strategy can you think of that would help you accumulate more desks over time?
- Are you considering changing your current office furniture for height-adjustable workstations or something similar?

Participants

- How was your overall experience with the Stand Up UQ study?
- What do you see as advantages and disadvantages to more standing at work?
- Would you say that the organisational norms and/or culture around sitting/standing have changed within your work group since participating in the Stand Up UQ study? What do you find positive/negative about this change?
- What things are you likely to continue? Could you see your workplace taking on any other changes after the study?
- What did you think about the impact of the stations on your productivity? (Multi-component intervention group only: What did you think about the impact of any of the other SU SL MM practices on your productivity)?
- How would you rate the support from your manager to reduce your sitting time?
- Any other comments/feedback/questions?
- Is there anything that would have made study participation better for you, esp. in relation to increasing standing and postural changes?