MONASH University

Understanding and Influencing Workplace Sedentary Behaviour

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ABSTRACT

Background: Technological advances and automation of everyday tasks have resulted in sedentary behaviour, or sitting, becoming highly prevalent in daily life. This is concerning as accumulating epidemiological evidence links high levels of sitting with increased risk of chronic disease. For many adults, the majority of daily sedentary behaviour occurs in the workplace, making it a target setting for interventions. However, while strategies to reduce workplace sedentary behaviour have become increasingly common, little is known about the correlates, or factors associated with workplace sitting. To design effective and targeted strategies for reducing workplace sedentary behaviour, there is a need to identify the correlates of workplace sitting time, barriers and facilitators to change, and the feasibility and acceptability of intervention strategies.

Aims: This thesis aimed to further understanding of the factors influencing workplace sitting time through three primary research aims:

1. To identify socio-demographic, health-related, work-related and social-cognitive correlates of workplace sitting time. (Chapters 2 and 3)
2. To determine key barriers and facilitators for reducing high levels of sitting in the workplace, and the feasibility of change. (Chapters 4 and 6)
3. To understand the mechanisms through which a workplace sedentary behaviour intervention leads to successful behaviour change. (Chapter 5)

Methods: Three main data sources were used. Cross-sectional analysis of data from the *Australian Diabetes, Obesity and Lifestyle study* (AusDiab 3, conducted in 2011-12, n=1,235) addressed the first research aim (Chapter 2). An original qualitative study designed and conducted by the candidate across three organisations (n=20) in Melbourne, Australia during 2015-16, addressed the second research aim (Chapter 4). Secondary analyses of quantitative and qualitative data from the *Stand Up Victoria* (SUV) cluster randomised controlled trial, a 12-month workplace intervention study (n=231 at baseline) conducted in Victoria, Australia during 2012-14, addressed all three research aims (Chapters 3, 5, and 6).

Key findings:

- Factors associated with higher levels of occupational sitting among Australian workers were: higher household income; and, for men only, higher educational attainment, and having a professional/managerial occupation.
- At baseline, SUV participants spent the majority (79%) of their working hours sitting. However, there was significant worksite-level variation in objectively measured total and prolonged workplace sitting time, which remained after adjustment for individual-level factors.
- Changes in social-cognitive factors (perceived behavioural control, barrier self-efficacy) only partially explained SUV intervention effects on workplace sitting reduction.
- Perceived barriers to reducing workplace sitting for office-based workers included: the nature of desk-based work; organisational social norms around the appropriateness of moving more and sitting less; and office furniture and layout (e.g. the limited availability of furniture facilitating postural shifts). Conversely, social support and the availability of sit-stand workstations were considered key facilitators during the SUV intervention.

Conclusions: These findings suggest that factors operating at the individual, social and environmental-levels influence workplace sedentary behaviour, and the perceived feasibility of reducing sitting. In particular, social and physical environment characteristics were identified as perceived barriers and/or facilitators to reducing workplace sitting, highlighting the need for multi-component workplace interventions. Further research should extend beyond individual-level correlates and examine associations between these suggestive influences with objectively measured workplace sitting time. To improve generalisability, these findings should be examined in larger population-based studies with representation from diverse occupational sectors and industries.

PUBLICATIONS, PRESENTATIONS AND AWARDS

Published works by the candidate incorporated into the thesis

Hadgraft NT, Lynch BM, Clark BK, Healy GN, Owen N, Dunstan DW. Excessive sitting at work and at home: Correlates of occupational sitting and TV viewing time in working adults. BMC Public Health. 2015;15:899.

Hadgraft NT, Healy GN, Owen N, Winkler EA, Lynch BM, Sethi P, et al. Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations. Prev Med Rep. 2016;4:184-191.

Hadgraft NT, Brakenridge CL, LaMontagne AD, Fjeldsoe BS, Lynch BM, Dunstan DW, et al. Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers. BMC Public Health. 2016;16:933.

Hadgraft NT, Winkler EA, Healy GN, Lynch BM, Neuhaus M, Eakin EG, et al. Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial. Int J Behav Nutr Phys Act. 2017;14:27.

Hadgraft NT, Willenberg L, LaMontagne AD, Malkoski K, Dunstan DW, Healy GN, et al. Reducing occupational sitting: Workers' perspectives on participation in a multi-component intervention. Int J Behav Nutr Phys Act. 2017;14:73.

Additional published works by the candidate produced during candidature relevant to the thesis but not forming part of it

Koohsari MJ, Sugiyama T, Sahlqvist S, Mavoa S, **Hadgraft N**, Owen N. Neighborhood environmental attributes and adults' sedentary behaviors: Review and research agenda. Prev Med. 2015;77:141-9.

Hadgraft N, Owen N. Sedentary behavior and health: Broadening the knowledge base and strengthening the science. Res Q Exerc Sport. 2017;88(2):123-9.

Brakenridge CL, Healy GN, **Hadgraft N**, Young DC, Fjeldsoe BS. Employee perceptions of an organisational-level intervention to reduce workplace sitting. Health Promot Int. Forthcoming 2017.

Additional published works by the candidate produced during candidature

Nguyen NH, **Hadgraft NT**, Moore MM, Rosenberg DE, Lynch C, Reeves MM, Lynch BM. A qualitative evaluation of breast cancer survivors' acceptance of and preferences for consumer wearable technology activity trackers. Support Care Cancer. 2017. doi:10.1007/s00520-017-3756-y.

Conference presentations during candidature

International

Hadgraft N, Dunstan D, Healy G, Lynch B, Owen, N. Desk bound: socio-demographic, work-related, health and social-cognitive correlates of objectively measured workplace sitting time. Short oral presentation at the International Society for Behavioral Nutrition and Physical Activity Annual Meeting, Edinburgh, UK, June 2015.

Hadgraft N, Lynch B, Owen N, Fjeldsoe B, Lawler S, Healy G, LaMontagne A, Dunstan D. Reducing sitting in the office workplace: exploring barriers to change and feasibility of strategies. Oral presentation at the 6th ISPAH Congress on Physical Activity and Public Health, Bangkok, Thailand, November 2016.

Hadgraft N, Lynch B, Owen N, Fjeldsoe B, Lawler S, Healy G, LaMontagne A, Dunstan D. Social and environmental influences on office workers' sitting time: a qualitative study. Poster presentation at International Congress of Behavioral Medicine 2016, Melbourne, December 2016.

National

Hadgraft N, Dunstan D, Lynch B, Owen, N. From the office chair to the couch: correlates of high workplace sitting plus high non-work screen-time. Oral presentation at 'be active 2014' National Physical Activity Conference, Canberra, October, 2014. (Short-listed for award).

Hadgraft N, Dunstan D, Lynch B, Owen, N. From the office chair to the couch: correlates of high workplace sitting plus high non-work screen-time. Poster presentation at Australian Heath & Medical Research Congress, Melbourne, November, 2014.

Local

Hadgraft N, Dunstan D, Lynch B, Owen, N. From the office chair to the couch: correlates of high workplace sitting plus high non-work screen-time. Poster presentation at AMREP Conference, Melbourne, September, 2014.

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THESIS INCLUDING PUBLISHED WORKS DECLARATION

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes five original papers published in peer reviewed journals. The core theme of the thesis is factors influencing workplace sedentary behaviour and sedentary behaviour change. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Physical Activity laboratory at Baker Heart and Diabetes Institute under the supervision of Prof David Dunstan, Prof Neville Owen, Dr Brigid Lynch (Cancer Council Victoria) and A/Prof Genevieve Healy (The University of Queensland).

The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.

In the case of Chapters 2-6 my contribution to the work involved the following:

Thesis Chapter	Publication Title and Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-author, Monash student Y/N*
2	Excessive sitting at work and at home: Correlates of occupational sitting and TV viewing time in working adults *Published*	70% Contributed to the conception and design of the study, undertook statistical analyses and interpreted the data. Drafted and critically reviewed the manuscript. Corresponding author.	1) Brigid Lynch: 8% Contributed to the conception and design of the study; contributed to manuscript development and critical review. 2) Bronwyn Clark: 3% Contributed to manuscript development and critical review. 3) Genevieve Healy: 3% Contributed to manuscript development and critical review. 4) Neville Owen: 8% Contributed to the development of the overall survey and the measures used; contributed to the conception and design of the study; contributed to manuscript development and critical review. 5) David Dunstan: 8% Contributed to the development of the overall survey and the measures used; contributed to the conception and design of the study; contributed to manuscript development and critical review.	N/A

3	Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations *Published*	75% Contributed to the conception and design of the study. Conducted statistical analyses and interpreted the data. Drafted and critically reviewed the manuscript. Corresponding author.	1) Genevieve Healy: 4% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement. Contributed to the conceptualisation and design of this secondary analysis, manuscript revision and critical review. 2) Neville Owen: 4% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement tools. Contributed to the conceptualisation and design of this secondary analysis, manuscript revision and critical review. 3) Elisabeth Winkler: 4% Participated in the design and coordination of SUV methodology and measurement tools. Contributed to the design of this secondary analysis. Provided advice on statistical analyses and interpretation. Contributed to manuscript revision and critical review. 4) Brigid Lynch: 2% Contributed to the conceptualisation and design of this secondary analysis, manuscript revision and critical review. 5) Parneet Sethi: 2% Provided advice on statistical analyses and interpretation. Contributed to manuscript revision and critical review. 6) Elizabeth Eakin: 1% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement. Contributed to manuscript development and critical review. 7) Marj Moodie: 1% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement. Contributed to manuscript development and critical review. 8) Anthony LaMontagne: 1% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement. Contributed to manuscript development and critical review. 9) Glen Wiesner: 1% Project managed SUV trial. Participated in the design and coordination of SUV methodology and measurement tools. Contributed to manuscript revision and critical review. 10) Lisa Willenberg: 1% Project managed SUV trial. Participated in the design and coordination of SUV methodology and measurement tools. Contributed to manuscript revision and critical review. 11) David Dunstan: 4% Conceptualised broader SUV trial, participated in the design and coordination of	N/A

Thesis Chapter	Publication Title and Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-author, Monash student Y/N*
			SUV methodology and measurement tools. Contributed to the conceptualisation and design of this secondary analysis, manuscript revision and critical review.	
4	Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers *Published*	80% Conceptualised and designed the study, wrote the ethics application, recruited participants, undertook data collection, analysed and interpreted the data. Drafted and critically reviewed the manuscript. Corresponding author.	1) Charlotte Brakenridge: 4% Analysed the data, assisted with interpretation of the findings. Contributed to manuscript development and critical review. 2) Anthony LaMontagne: 2% Contributed to the conception and design of the study. Contributed to manuscript development and critical review. 3) Brianna Fjeldsoe: 2% Contributed to the conception and design of the study. Assisted with analysis of the data and interpretation of the findings. Contributed to manuscript development and critical review. 4) Brigid Lynch: 2% Contributed to the conception and design of the study. Contributed to manuscript development and critical review. 5) David Dunstan: 2% Contributed to the conception and design of the study. Contributed to manuscript development and critical review. 6) Neville Owen: 2% Contributed to the conception and design of the study. Contributed to manuscript development and critical review. 7) Genevieve Healy: 2% Contributed to the conception and design of the study. Contributed to manuscript development and critical review. 8) Sheleigh Lawler: 4% Contributed to the conception and design of the study. Assisted with analysis of the data and interpretation of the findings. Contributed to manuscript development and critical review.	N/A
5	Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial *Published*	70% Contributed to the design and conceptualisation of this study, conducted statistical analyses. Drafted and critically reviewed the manuscript. Corresponding author.	1) Elisabeth Winkler: 9% Participated in the design and coordination of SUV methodology and measurement tools. Contributed to the design of this secondary analysis. Provided expert advice on statistical analyses. Contributed to manuscript revision and critical review. 2) Genevieve Healy: 3% Conceptualised broader SUV trial, participated in the design and coordination of SUV methodology and measurement. Contributed to the design and conceptualisation of this secondary analysis, manuscript revision and critical review.	N/A

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6	Reducing occupational sitting: Workers' perspectives on participation in a multi-component intervention *Published*	60% Analysed and interpreted the data, drafted the manuscript, critically reviewed the manuscript.	1) Lisa Willenberg: 14% Project managed SUV trial. Participated in the design and coordination of the study and development of the interview guides. Conducted the interviews and focus groups, analysed the data. Contributed to manuscript revision and critical review. 2) Anthony LaMontagne: 4% Conceptualised broader SUV trial, participated in the design and coordination of the study and development of the interview guides. Contributed to manuscript revision and critical review. 3) Keti Malkoski: 1% Participated in the design and coordination of the study and development of the interview guides. Contributed to manuscript revision and critical review.	N/A

Thesis Chapter	Publication Title and Status	Nature and % of student contribution	Co-author name(s) Nature and % of Co-author's contribution*	Co-author, Monash student Y/N*
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I have not renumbered sections of submitted or published papers in order to generate a consistent presentation within the thesis.

Student signature: [redacted] **Date**: 30 May 2017

The undersigned hereby certify that the above declaration correctly reflects the nature and extent of the student and co-authors' contributions to this work. In instances where I am not the responsible author I have consulted with the responsible author to agree on the respective contributions of the authors.

Main Supervisor signature: [redacted] **Date**: 30 May 2017

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LIST OF ABBREVIATIONS

AusDiab	Australian Diabetes, Obesity and Lifestyle Study
BLUP	Best Linear Unbiased Prediction
BMI	Body mass index
CI	Confidence interval
FTE	Full time equivalent
ICC	Intracluster Correlation Coefficient
IPAQ	International Physical Activity Questionnaire
LIPA	Light intensity physical activity
LTPA	Leisure-time physical activity
MDI	Minimum difference of interest
MVPA	Moderate and vigorous physical activity
NHANES	National Health and Nutrition Examination Survey
OHS	Occupational health and safety
OR	Odds ratio
RCT	Randomised controlled trial
RRR	Relative risk ratio
SD	Standard deviation
SE	Standard error
SUV	Stand Up Victoria
TV	Television
WHO	World Health Organization

PREFACE

The workplace has a considerable influence on the health and well-being of working adults. Over the past several decades, developed countries such as Australia have seen a declining manufacturing sector, and a rise in service-related jobs and computer-based work (1, 2). The implications of these economic and technological shifts are fewer jobs that are physically demanding and a greater proportion that are largely sedentary (3). While modern workplaces have become safer in many other aspects—through control or elimination of significant hazards—emerging evidence suggests that the high levels of sitting characteristic of many jobs may also pose a significant public health risk.

Office workers have been found to spend upwards of two thirds of their work day sitting, accumulating close to six hours of sitting in the workplace alone (4, 5). As the epidemiological evidence linking high levels of sitting time with adverse health outcomes has strengthened (6, 7) there has been increasing interest in interventions targeting workplace sedentary behaviour (8). However, this has occurred despite limited knowledge about the correlates, or factors influencing workplace sedentary behaviour. To design more effective interventions to reduce workplace sitting time it is important to understand what elements need to be changed in order to change behaviour, and the specific groups such strategies should target to have the greatest overall public health impact.

To address this knowledge gap, this thesis aimed to examine the correlates of workplace sitting time, using self-report and objective measures of sitting time. It also aimed to understand the feasibility and acceptability of reducing workplace sitting time among office-based workers, including identifying potential barriers and facilitators to behaviour change. Finally, some of the potential mechanisms through which an intervention leads to successful reductions in workplace sitting time were also examined.

This thesis, including published works, contains seven chapters across two parts. Part 1 addresses the context of workplace sitting (Chapters 1, 2, 3), while Part 2 addresses potential influences on workplace sedentary behaviour change (Chapters 4, 5, 6).

Chapter 1 comprises an introduction and narrative literature review, followed by the primary research aims. This chapter provides context to the thesis, positions the proposed research within the existing evidence base, and outlines the rationale for the focus on the workplace as a target setting for addressing sedentary behaviour.

Chapter 2 includes a paper published in *BMC Public Health* that examined the correlates of self-reported workplace sitting time through a secondary analysis of quantitative data from the third

phase of the *Australian Diabetes, Obesity and Lifestyle study* (AusDiab 3). AusDiab is an Australian longitudinal population-based study that began in 1999-2000, with data collection for AusDiab3 occurring in 2011-12.

Chapter 3 includes a paper published in *Preventive Medicine Reports* which examined the correlates of objectively measured total and prolonged workplace sitting time using data from the Stand Up Victoria (SUV) study. Variation in workplace sitting time across the 14 participating worksites was also examined. SUV was a cluster randomised controlled trial of a multi-component intervention to reduce workplace sitting time, conducted in Victoria, Australia in 2012-14.

Chapter 4 reports the findings of an original qualitative study, conducted across three organisations in Melbourne, Australia during 2015-16. The study aimed to explore office workers' perceptions of the feasibility and acceptability of reducing workplace sitting time, among a group of workers that were not currently exposed to a workplace intervention. The paper included in this chapter was published in *BMC Public Health*.

Chapter 5 includes a paper published in *International Journal of Behavioral Nutrition and Physical Activity*, which examined the potential social-cognitive mechanisms through which the SUV multi-component intervention led to significant reductions in workplace sitting time.

Chapter 6 includes an analysis of data from the qualitative component of SUV, which aimed to explore participants' experience of the SUV intervention, including factors perceived to act as barriers and facilitators to workplace sitting change, the acceptability of the intervention, and any potential effects on health and work-related outcomes. This chapter includes a paper published in *International Journal of Behavioral Nutrition and Physical Activity*.

Chapter 7 summarises the main findings from the preceding chapters, reports strengths and limitations, and suggested avenues for further research. This chapter also discusses the potential implications of the thesis findings for research, policy and practice.

Accompanying each publication or manuscript within the chapter are brief introduction and discussion sections, designed to link chapters together and provide a coherent narrative for the reader. These summary sections are also designed to highlight the main findings and implications of each publication as they relate to the overall thesis.

Three of the five studies used data from the same dataset (SUV). The methods section of each of these published papers was tailored to the specific aims of the study. To provide readers with a comprehensive overview of the study methods and procedures a detailed description of the SUV methods is provided at the start of Chapter 3. However, the nature of each published paper being

written as a standalone piece of work has resulted in some unavoidable repetition in the methods sections of the publications. Further details of the methods of the two other datasets used are also provided at the start of the relevant chapters. Citations for the publications are contained within those papers while citations for the other parts of the thesis (Introduction, Chapter summary sections, Discussion) are contained in the References section at the end of the thesis.

PART 1: THE CONTEXT OF WORKPLACE SEDENTARY BEHAVIOUR

CHAPTER 1

INTRODUCTION AND AIMS OF THE THESIS

Technological advances over recent decades have changed the ways in which people work, travel and spend their leisure time. While this has arguably led to many economic and social improvements in quality of life, the rise in automation and computerisation may also have come at a cost. The propensity of adults in developed countries to spend large amounts of time in sedentary behaviours (often referred to simply as 'sitting'), may be contributing to chronic disease incidence and premature mortality.

The importance of undertaking regular moderate or vigorous physical activity (MVPA) is generally well recognised. The World Health Organization (WHO) advocates that adults should perform at least 150 minutes per week of moderate intensity physical activity, or at least 75 minutes per week of vigorous intensity physical activity (9). These recommendations and guidelines are based on consistent epidemiological evidence that regular MVPA is associated with reduced risk of premature mortality and the incidence of chronic diseases such as type 2 diabetes, cardiovascular disease and certain cancers (10, 11).

However, despite the strong evidence that MVPA is beneficial for health, most Australians do not achieve the levels recommended in national and international guidelines (12). The majority of adults' waking hours are instead spent sedentary (13), in behaviours such as watching television [TV], using a computer for work or pleasure, or driving a car. The workplace, in particular, can make a significant contribution; for those in sedentary, desk-based jobs, sitting at work can comprise over half of total daily sitting time (14-16). It is becoming increasingly evident that sedentary time, and the manner in which it is accrued, has impacts on health that are distinct from the time spent in MVPA (17, 18).

This chapter will provide an overview on sedentary behaviour and public health, including how it is defined and measured, models for understanding sedentary behaviour, evidence linking high levels of sitting with adverse health outcomes, and a review of the literature on the correlates of sedentary behaviour. The chapter will then focus specifically on the workplace setting, providing an overview of the evidence relating to correlates of occupational sitting time, and evidence relating to the effectiveness and feasibility of interventions to reduce sedentary behaviour in the workplace.

1.1 Sedentary behaviour concepts and measurement

1.1.1 Definition of sedentary behaviour

In the context of physical activity research, the term "sedentary" was historically used to describe a person who did not undertake the minimal recommended amount, or in some cases, any MVPA (18, 19). However, as sedentary behaviour began to be studied distinctly from MVPA, the need for standardised terms and a consistent definition of sedentary behaviour was recognised (20). Sedentary behaviour has been defined by the Sedentary Behaviour Research Network as *"any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture"* (20), where 1.0 MET is equivalent to a resting state. Thus, this definition of sedentary behaviour comprises a postural and energy expenditure element. It was also suggested that those not performing sufficient levels of MVPA should be defined as "inactive" rather than sedentary (20). This distinction recognises that it is possible for someone to be both highly active and highly sedentary, sometimes referred to as an "active couch potato" (21).

As this thesis focuses on sitting in the workplace where the predominant sedentary posture is sitting, not reclining, the terms "sedentary behaviour" and "sitting" will be used interchangeably throughout. In the context of studies using objective measures of behaviour (see section 1.1.2) "sedentary time" will be used when referring to studies using accelerometers that do not measure posture directly. The terms "workplace" and "occupational" will also generally be used interchangeably when referring to sedentary behaviour/sitting, although "workplace sitting" will be used preferentially for sitting that is known to occur at the place of work.

1.1.2 Measurement of sedentary behaviour

Sedentary behaviour can be measured using either self-report or objective measures. Self-report measures include questionnaires, where participants are asked to recall the amount of time spent sitting across the entire day (total sitting time) or in specific domains (e.g. work or leisure) or for activities (e.g. TV viewing). Reference periods for this recall vary. The International Physical Activity Questionnaire (IPAQ), asks participants to estimate the total time they usually spent sitting on weekdays and weekends during the past seven days (22). Other questionnaires such as the SIT-Q, ask participants to recall habitual behaviour over the past 12 months (23) while the Past-day Adults' Sedentary Time (PAST) uses the previous day as the reference period (24). Some questionnaires, such as the IPAQ (22) are limited to asking participants about total or overall sitting across the day, while others (such as the SIT-Q) ask participants to report on

specific domains or activities, such as time spent sitting at work or study, watching TV or sitting for transportation (23). Of these domain-specific activities, TV viewing time has been the most frequently measured (25).

The strengths of self-report measures are that they are relatively inexpensive, facilitating use in large population-based studies, and that they enable quantification of sedentary time in specific settings or activities, such as desk-based work or TV viewing (26). However, their accuracy and precision has been questioned, particularly at the individual level. When compared to objective measures, self-reported estimates of total sitting time are often underreported (27, 28). For example, the IPAQ has been found to underestimate total sitting time by 2.2 h/day across the whole week when compared to the activPAL (27), with underestimations found to be higher when assessing leisure time (29) and weekend days (27). The level of agreement between the two sources of measurement has also been shown to be quite variable, with increased bias observed at the lower and higher amounts of sitting time (27, 29). It has been suggested that the ubiquitous nature of sedentary behaviour throughout the day may be an important contributor to these inaccuracies (17, 26). However, another possibility is that the underreporting could reflect a social desirability bias, where participants wish to present their behaviour more positively (27).

Noting the limitations of self-reported measures, objective measures of sedentary or sitting time, such as accelerometers, have become more common in epidemiological and intervention studies. To date, the majority of large cohort studies ($n \geq 400$) have used accelerometers worn on either the hip or the wrist (30). Activity is often represented as “counts”; the number of counts over a period of time (e.g. one minute) can be used to determine the intensity of activity. Sedentary time has been frequently operationalised as less than 100 counts/min for adults (26), providing an indirect measure of sitting time. Accelerometers are useful for distinguishing time spent in various intensities of physical activity, such as light, moderate and vigorous. However, as hip- or wrist-worn accelerometers are not specifically designed to detect posture, some activities performed at low intensities, such as standing still (which typically falls under the 100 counts/min threshold), can be misclassified as sitting (31).

Increasingly, thigh-worn monitors, such as the activPAL, are being used (32-34). Such monitors are able to directly measure posture based on thigh angle and acceleration (32), providing an accurate and reliable measure of total sitting time (35, 36) and breaks from sitting (37).

A limitation of objective measures of sedentary behaviour/sitting is the lack of information on the settings or activities through which it occurs (38). To obtain this information, these devices generally need to be used in conjunction with behavioural logs or diaries (e.g. participants reporting work hours to measure occupational sitting time). In addition, there are a number of

subjective decisions to be made in relation to data processing that can influence the findings, for example, epoch length and the minimum amount of wear time required for valid data (26, 38, 39).

1.2 Sedentary behaviour: implications for public health

1.2.1 Descriptive epidemiology of sitting

The amount of time that adults report sitting per day appears to vary between populations and whether self-report or objective measures of sitting/sedentary time are used. One large 20-country epidemiological study with over 49,000 participants reported a median self-reported sitting time of five hours/day across all participants (40). Country-specific medians ranged from 2.5 hours in Portugal through to seven hours/day in Japan and Saudi Arabia (40). Findings from a study involving 28 European Union countries in 2013 revealed similar findings, with a median five hours of self-reported sitting per day, ranging from three hours/day in Portugal to six hours/day in the Netherlands and Denmark (41). In the 2011–12 Australian Health Survey, adults reported sitting on average 39 hours/week, or 5.6 hours/day, which included nearly 13 hours/week watching TV (12).

When limited to working adults, estimates of total self-reported sitting time are often higher. A sample of 794 Australian office workers self-reported sitting, on average, for nine hours/day, with five of those hours spent sitting for work (15). Civil servants in the United Kingdom have reported sitting, on average, for 10.4 hours on workdays with sitting for work also comprising more than half of this time (16).

However, studies using objective measures suggest that these self-reported findings may be underestimates of true levels of sitting time. Accelerometer-derived measures in population-based studies in Australia, Canada, the United States and the United Kingdom report average sedentary times of between seven and 10 hours/day (13, 42-45), which can be more than half of waking hours (13, 42, 43, 45).

1.2.2 Sitting time and health outcomes

Some of the earliest evidence suggesting a link between too much sitting and adverse health outcomes arose from the seminal studies conducted by Jeremy Morris and colleagues in the 1950s. Comparing bus, tram and trolleybus drivers with conductors in London’s transport system, Morris et al. found that the drivers—who spent their working hours seated—had a higher

incidence of coronary heart disease and developed it at a younger age than the conductors, whose tasks were mostly performed standing (46). These findings were largely attributed to the comparative physical inactivity of the drivers relative to the conductors (46). More recent evidence from prospective cohort studies extends upon these initial findings by specifically implicating sitting time as a potential risk factor for chronic disease and premature mortality. An overview of these findings is provided below.

Evidence from prospective cohort studies from multiple countries suggests that exposure to high levels of sitting, measured as TV/screen viewing time (47-49), leisure-time sitting (50), self-reported total sitting time (49, 51, 52) or objectively measured sedentary time (53) is associated with increased risk of all-cause mortality. A 2013 meta-analysis of six prospective cohort studies (54) concluded that every additional hour of sitting per day beyond seven hours was associated with a 5% increased risk of mortality, even after adjusting for physical activity. For TV viewing time in particular, mortality risk may increase significantly beyond three hours (55) or four hours (56) of TV viewing per day.

A number of systematic reviews and meta-analyses have also found evidence to support associations of high levels of sitting time with chronic disease incidence, and cause-specific mortality. A 2015 meta-analysis reported significantly increased risk of type 2 diabetes incidence (Hazard Ratio [HR]: 1.91 (95% confidence interval: 1.64–2.22)), cardiovascular disease incidence (HR: 1.14 (1.00–1.30)), and cardiovascular mortality (HR: 1.18 (1.11–1.24)) when comparing the highest to the lowest category of sedentary behaviour, after adjusting for physical activity (6). Sedentary behaviour also appears to increase the risk of developing some cancers, with the most consistent evidence for colorectal, endometrial, and lung cancers (57-60), and some evidence supporting an association with breast cancer (58, 60, 61).

Cross-sectional associations have been observed between high levels of sedentary time and high body mass index (BMI) or overweight/obesity (14, 62-64) and the metabolic syndrome (65), however prospective studies have been mixed in their findings (7, 66-68). High levels of sitting have also been shown to be associated with poorer mental health outcomes. Specifically, higher occupational sitting time, self-reported total sitting, and objectively measured sedentary time have been associated with increased psychological distress (69, 70). Higher TV viewing time, computer/Internet use and total sitting time appear to be associated with increased risk of depression (71), and higher levels of total sitting time also appear to be associated with increased risk of anxiety symptoms (72). Findings of associations between higher levels of sitting time and increased risk of psychological distress and depression have been observed even after adjustment for MVPA (69-71).

Sedentary behaviour may also have adverse effects on certain cardiometabolic biomarkers. In particular, high levels of sedentary time have been found to be associated with lower insulin sensitivity (73, 74) and higher levels of triglycerides (74-76). More recent studies using isotemporal substitution analyses have been able to model the expected effects on biomarkers if sitting were to be replaced with activities of an upright posture and/or higher intensity. Replacing two hours of sitting per day with standing has been found to be associated with lower fasting glucose, triglycerides and higher HDL cholesterol (13). Similarly, others have shown potential benefits for insulin sensitivity, β-cell function and triglycerides if 30 minutes of sitting is replaced with standing (74). The beneficial effects of reallocating time away from sitting have typically been observed to be greater the higher the intensity of the activity it is replaced with (13, 74).

Although associations with all-cause mortality have been demonstrated even in studies adjusting for time spent in physical activity (6, 54), participation in MVPA may have at least a partially protective role against the health hazards of prolonged sitting. A recent harmonised meta-analysis of 13 prospective cohort studies assessed the joint associations between sitting time and physical activity with all-cause mortality. While dose-response relationships were found between sitting time category and risk of mortality for the three lowest categories of physical activity, the association was attenuated for those in the highest quartile of physical activity (77). It is worth noting however, that the amount of physical activity undertaken by this group was high—60–75 min/day of moderate intensity activity (77)—which exceeds typical population levels (12, 45, 78) and this attenuation was less pronounced for associations between TV viewing time and mortality (77).

1.2.3 Sedentary time accumulation patterns and health

As described above, the total *volume* of sitting time accumulated across the day is associated with a number of adverse health outcomes. However, the pattern in which it is accumulated also appears to be an important contributor to health risk. More frequent interruptions (or breaks) in sedentary time, measured by hip-worn accelerometer, have been shown to be associated cross-sectionally with lower waist circumference (73, 75, 79, 80) and body mass index (75, 79). Some studies have also found more frequent breaks to be beneficially associated with 2-h plasma glucose (79) and C-reactive protein – an inflammatory marker (73). There is less evidence to support associations between sitting breaks and blood lipid levels (81).

Following on from these cross-sectional, observational findings, acute experimental studies have manipulated the length and timing of sitting breaks and assessed the impact on metabolic biomarkers. A crossover study comparing three conditions (each performed for five hours): i) uninterrupted sitting; or sitting broken up every 20 mins with two minutes of ii) light or iii) moderate intensity physical activity, found reductions in postprandial glucose, insulin (82) and blood pressure (83) under both physical activity conditions. Other acute experimental studies have also shown that, compared with prolonged sitting, breaking up sitting with regular light or moderate intensity activities has beneficial effects on plasma glucose (84, 85) and insulin sensitivity (84, 86).

1.2.4 Mechanisms of adverse health effects associated with high sitting time

The specific mechanisms through which high levels of sitting time contribute to chronic disease are still being determined. However, insight from experimental studies and animal models suggests some potential pathways through which this may occur.

Sitting is generally a static body position, characterised by low levels of dynamic contractile activity in postural skeletal muscles and consequently, a low level of energy expenditure (87). Both the postural aspect and the low energy expenditure of sitting have been suggested as potential contributors to the metabolic and vascular effects associated with prolonged sitting. Although standing is also a low energy expenditure posture (88), sitting is associated with lower levels of activity in the lower body postural muscles relative to standing and other light intensity activities (89, 90). Muscle inactivity may alter metabolic pathways involved in glucose and lipid metabolism. Evidence from bed rest studies suggest that prolonged inactivity leads to reduced glucose uptake and insulin sensitivity in skeletal muscle, demonstrated by lower concentration of the GLUT-4 transporter (91). Bed rest is, however, an extreme form of inactivity and may not be directly applicable to sitting in the free-living setting, which is generally broken up periodically with standing or other light activity. Muscle inactivity has also been shown to be directly associated with higher levels of triglycerides and lower levels of HDL cholesterol (90). One possible mechanism suggested from animal studies is that reduced skeletal muscle contractile activity is associated with a reduction in lipoprotein lipase activity, which is important for triglyceride uptake into skeletal muscle and the production of HDL cholesterol (87, 92). However, this has not been specifically tested in humans.

More recent work has implicated differential gene expression as a contributing factor to the development of cardiometabolic dysfunction. The acute experimental study described in section

1.2.3 comparing prolonged sitting with sitting broken up at regular intervals with light or moderate intensity physical activity (82), found changes in the expression of genes associated with carbohydrate and lipid metabolism in the activity conditions, relative to the prolonged sitting condition (93).

Micro- and macro-vasculature changes have also been associated with prolonged sitting, which could have implications for the development of cardiovascular disease. Two acute experimental studies have observed a reduction in blood flow and sheer stress in lower leg and forearm arteries (94) and impairment of endothelial function (95) during acute periods of prolonged sitting. In contrast, changing posture from sitting to walking appears to restore lower limb vascular function (94).

In summary, high levels of sedentary behaviour have been identified as a risk factor for chronic disease and premature mortality, which may be additional to the risk associated with insufficient levels of MVPA. Although the specific mechanisms through which this occurs are yet to be fully elucidated, epidemiological findings suggest that exposure to high levels of sitting time is common, and as such, sedentary behaviour should be considered a significant contributor to chronic disease risk and a public health concern.

1.3 Frameworks for understanding sedentary behaviour

With increasing evidence linking high levels of sitting with adverse health outcomes, further research is required to understand factors influencing this behaviour and in turn, how best to intervene. As with research involving other health behaviours, conceptual frameworks—models and theories—can assist in explaining and predicting sedentary behaviour, and can provide strong guidance for developing interventions. Figure 1.1 outlines the Behavioural Epidemiology framework for understanding sedentary behaviour (96, 97). This framework proposes six main phases of research, moving from disease aetiology through to policy translation. As indicated by the arrows, the phases are interconnected, whereby research in one phase can inform research in the other phases. The shading indicates the current strength of the evidence base.

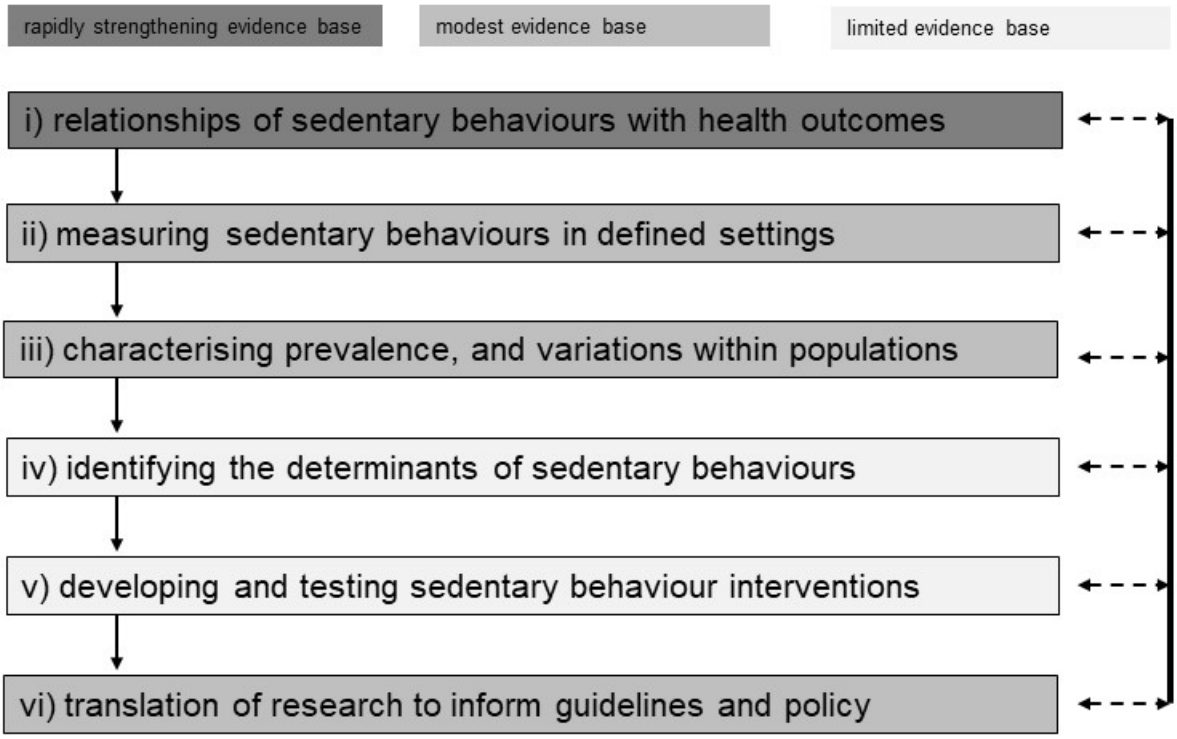

Figure 1.1: Behavioural Epidemiology framework for understanding sedentary behaviours (98)

As indicated in the brief review in the previous two sections, the evidence base relating to the first three phases of the Behavioural Epidemiology framework is consolidating. This thesis will focus predominantly on generating knowledge relating to Phase IV of the Behavioural Epidemiology framework, where the evidence base is more limited. An ecological model of

sedentary behaviour will be used to guide this research, as described further in section 1.3.1. In the second part of this thesis the emphasis will be on how the knowledge relating to the factors influencing sedentary behaviour can inform the design and targeting of interventions (Phase V), and the development of relevant policies (Phase VI).

1.3.1 Ecological model of sedentary behaviour

Ecological models have been used to assist with understanding a number of different health behaviours, including physical activity, nutrition and tobacco smoking (99). Ecological models aim to recognise the complexity of health behaviours, acknowledging that there is unlikely to be a single cause and effect pathway. In line with approaches used to address some of these other health risk factors, the application of an ecological model to sedentary behaviour may also assist in guiding future research and identifying novel intervention targets.

Ecological perspectives of health behaviour have five key principles (99):

1. There are multiple levels of influence on health behaviours
2. Environmental contexts are significant determinants of health behaviours
3. Influences on behaviours interact across levels
4. Ecological models should be behaviour specific
5. Multi-level interventions should be most effective in changing behaviours

While individual-level models often emphasise the importance of psychosocial attributes (e.g. self-efficacy and motivation) as influences on individual behavioural choices, ecologic models have a greater focus on individuals' interactions with their physical and social environments (100). According to this notion, the impact of motivating or educating a person to change their behaviour is expected to be limited if the surrounding environment is not also supportive of behaviour change. However, while supportive environments are considered necessary for healthy behaviours, the idea that there are multiple levels of influence on behaviour means that altering the environment on its own may not be sufficient for behavioural change (101). As such, multi-component, or multi-level, interventions that aim to address a range of potential influences on behaviour are considered more likely to be effective at changing behaviour than single component interventions.

The ecological model depicted in Figure 1.2 identifies four domains in which sedentary behaviour typically takes place—*leisure, household, transport* and *occupation*—and the main levels of influence proposed (102). The types of factors that influence sedentary behaviour, and their relative importance, is considered to differ in each of these domains (102). For example, the factors influencing time spent sitting at home will not necessarily be the same as those that influence sitting at work. The relative importance of each of these settings is also likely to differ across population groups. For working adults in sedentary jobs, intervening in the workplace setting may have the largest impact on total daily sitting time (14, 16), whereas this setting will not be relevant for those not in the labour force. As such, different intervention responses may be needed depending on the setting in which sedentary behaviour takes place.

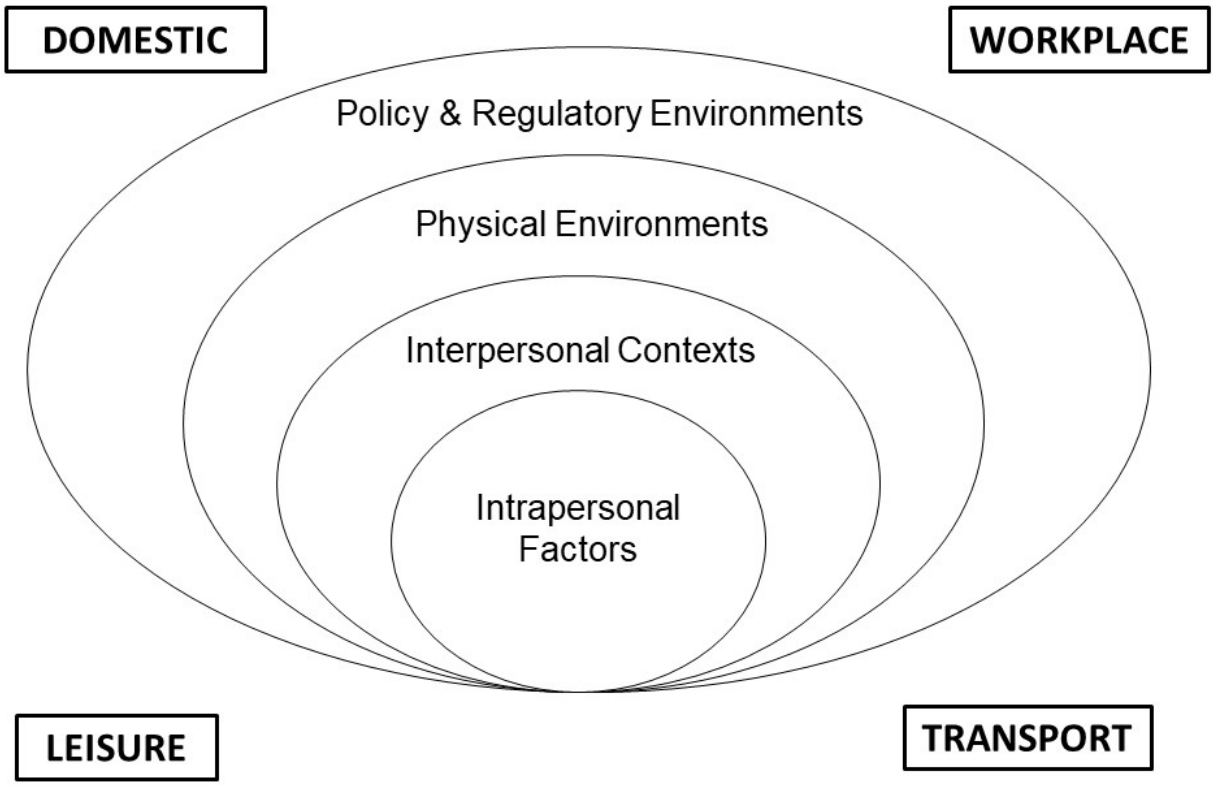

Figure 1.2: A simplified Ecological Model of Health Behaviour (98)

Further details on the role that ecological models can play in understanding sedentary behaviour can be found in a book chapter submitted for publication, *Models for Understanding Sedentary*

Behaviour, included as Appendix A. As noted above, some of the preceding material in this section of the thesis has been drawn from that chapter.

1.4 The workplace as a target setting for sitting reduction

In line with an ecological model of sedentary behaviour (99, 102), it is important to identify and understand the 'behaviour settings' (103), or contexts, in which sedentary behaviour takes place. The 'behaviour settings' principle of the ecological model underpins this thesis. Specifically, this infers that developing effective interventions to reduce sedentary behaviour requires a context-specific approach, informed by an understanding of the correlates and determinants in that particular setting.

The workplace has been identified as a key setting for reducing high levels of sitting due to the volumes of time that adults spend in the workplace and the increasingly sedentary nature of jobs. Over the past 50 years, industrial change in countries such as Australia and the USA has seen a reduction in blue collar sectors, such as manufacturing, and a rise in service-related industries (3, 104). Accompanying this shift has been a decreasing trend in the average occupation-related energy expenditure and an increasing prevalence of sedentary jobs (3).

Office-based work, in particular, is highly sedentary. For this group of workers, sitting at work can comprise the majority of total sitting time accumulated across the day (14-16). When measured objectively, office-based workers spend between 65 and 80% of their working hours sitting (4, 5, 105-109), equivalent to 5.5 to 7 hours sitting per 8-h workday. As such, there is an opportunity to reduce total levels of sitting time in a large segment of the population by addressing exposure in the workplace.

Workplace sedentary behaviour also takes place within a context that is subject to formal regulation – where employers have legal responsibilities for the health and safety of their employees. This may make it more amenable to change, relative to sedentary behaviour that occurs in other settings, such as the home environment. While occupational health and safety has traditionally focused on the hazards associated with excessive physical loads, there is now starting to be increased interest in the potential hazards of excessive occupational sitting (110). Within Australia, occupational sedentary behaviour has been identified as an emerging work health and safety issue by Safe Work Australia (111), the federal government agency responsible for coordinating policy and strategy relating to occupational health and safety.

1.4.1 Occupational sitting and health outcomes – evidence to underpin the rationale for targeting the workplace setting

As reviewed in section 1.3.2, while there is now a sizeable body of evidence supporting associations of overall sitting time and TV viewing time with health outcomes, a relatively smaller number of studies have specifically assessed workplace sitting as an exposure. A 2010 systematic review of the evidence linking workplace sitting with health outcomes revealed mixed findings, with few high quality studies (112). The strongest evidence supported associations between high levels of occupational sitting with type 2 diabetes and mortality (112). Since this review was undertaken, additional prospective studies have been published assessing associations between workplace sitting and mortality. In a 12–14 year follow-up of over 45,000 participants in the Norwegian HUNT2 cohort, participants with jobs requiring walking and/or lifting or heavy physical labour had a lower risk of all-cause and cardiovascular mortality than participants in mostly sitting jobs (113). A study involving over 10,000 participants from multiple British cohorts found increased risk of all-cause and cancer-related mortality amongst women in sitting occupations compared with women in standing or walking occupations, however, no association was found for men (114). In contrast, no evidence for an association of occupational sitting with all-cause mortality was found in two large cohort studies involving Danish (115) and Spanish populations (116).

The 2010 review concluded that there was suggestive, but not definitive evidence for an association between occupational sitting time and some forms of cancer (112). More recent meta-analyses suggest that occupational sitting is associated with increased risk of breast cancer amongst women (61) and colon cancer (60). Two other meta-analyses have concluded that there is a decreased risk of prostate cancer (117) and endometrial cancer (118) among those with the highest levels of occupational physical activity compared with the lowest levels. However, some of the studies included in these reviews assessed occupational physical activity, rather than specifically measuring sedentary behaviour.

There have been conflicting findings as to whether sedentary occupations are associated with increased risk of cardiovascular outcomes (112, 119-121). In terms of other cardiometabolic health risk markers, there is some evidence from cross-sectional studies to suggest that occupational sitting or low occupational activity is associated with markers of overweight/obesity (122-126). However, the small number of prospective studies have generally failed to find an association between baseline sitting and incident cases of obesity (127) or increases in BMI at follow-up (128, 129).

There are a few possible explanations for the equivocal findings in the literature relating to associations between occupational sitting and health outcomes. The majority of studies have used categorical measures of occupational physical activity, rather than specifically measuring occupational sitting. Analyses have often involved the comparison of occupations classified as mostly sitting compared with mostly standing, or mostly walking, or compared light physical activity to moderate or heavy. This has led to imprecise estimates of workplace sitting time that do not quantify the amount of time spent sitting or frequency of sitting breaks (130). Some studies have also used job type as a proxy for occupational activity, rather than obtaining a direct measure. These methods are likely to have led to some misclassification of the exposure (131).

Another consideration is that high levels of occupational physical activity (such as heavy or manual labour) have also been shown to be associated with adverse health outcomes such as cardiovascular disease and mortality (132-134), particularly for those with low cardiorespiratory fitness (134, 135). For this reason, the reference category used in analyses and the types of occupational physical activity represented in the cohort are highly relevant. The choice of statistical analytical techniques has also been suggested as an explanation for conflicting findings about the possible detrimental health effects of occupational physical activity (132).

The amount of workplace sitting time considered to be detrimental to health is therefore not yet clear from the epidemiological evidence. As such, there are few specific recommendations for employers and workers about appropriate levels of exposure to workplace sitting time. The most specific guidelines that have been released were contained within an expert position statement released in 2015. This suggested that desk-based workers should initially aim to accumulate 2 h/day of standing or light intensity activity during working hours, with a goal of progressing to 4 h/day (136). The authors also noted the need for additional research to improve the certainty and precision regarding the recommendations (136).

To inform recommendations for sedentary behaviour in the workplace, more explicit evidence is needed on the amount of workplace sitting time that is deleterious to health. To assess possible associations between workplace sitting and health outcomes with more rigour, there is a need for high quality prospective studies that are better able to quantify workplace sitting time exposure, with objective measures used where possible.

1.5 Correlates of sedentary behaviour: at work and at home

The next two sections present an overview of the existing literature relating to Phases IV and V of the behavioural epidemiological framework. This section reviews the correlates of sedentary

behaviour, with a focus on the correlates of workplace sitting. Section 1.6 describes the recent research into the effectiveness and feasibility of interventions to reduce workplace sitting time.

Relative to evidence pertaining to associations between sedentary behaviour and health outcomes, comparatively fewer studies have sought to identify the correlates of sedentary behaviour in adults – the factors that might influence or predict differing levels of sedentary behaviour within the population (102). Research identifying the correlates of high levels of sitting is essential for informing the design of strategies, interventions, and ultimately policy aimed at reducing sedentary behaviour. While the terms correlates and determinants are sometimes used interchangeably, a "determinant" infers the factor is causally associated with the outcome, whereas the term "correlate" is considered to be more appropriate to describe factors where associations, but not causal relationships, have been demonstrated (137). Prospective study designs are therefore required to provide evidence for temporality as a pre-requisite for causation. Current knowledge about the factors that influence sedentary behaviour is largely limited to correlates, with few prospective studies. This section will provide a brief narrative review of the evidence for correlates of overall sitting and leisure-time sitting (specifically, TV/screen viewing time) as this has been the focus of the majority of studies in this area. The smaller evidence base relating specifically to workplace sitting time will then be addressed. Table 1.1 presents a brief summary of the information presented in sections 1.5.1-1.5.3, detailing the main correlates that have been identified through a narrative review of the literature and the direction of their association with sedentary behaviour. References are provided in the following sections.

Table 1.1: Key correlates of overall sedentary behaviour, work-related sitting, TV viewing time and computer use among adults

	Overall sedentary behaviour/ sedentary time	Work-related sitting	TV viewing	Computer use
Demographic factors				
Age	Mixed	−	+	−
Male gender	Mixed	Mixed	Mixed	*
Married/de facto marital status	−	*	−	−
Caring responsibilities	−	*	*	*
Children in household	−	*	*	*
Socio-economic and work-related				
Higher income	Mixed	+	−	+
Higher educational attainment	+	+	−	+
Employed	*	+	−	*
Employed full-time	+	*	*	*
Blue-collar or physically demanding occupation	*	−	*	*
White collar or professional occupation	*	+	*	*
Health-related				
Higher BMI	+	*	+	+
Unhealthy dietary patterns	*	*	+	*
Social-cognitive				
Higher perceived behavioural control	*	−	*	*
Environmental				
Neighbourhood environmental attributes	Mixed	*	*	*

+ denotes positive association; − denotes negative association; mixed denotes conflicting findings; * indicates limited evidence.

1.5.1 Correlates of overall sedentary behaviour

Identifying the correlates of domain-specific sedentary behaviour is important for understanding how best to intervene in particular settings. Furthermore, identifying factors associated with higher levels of overall sitting time, i.e. the total time spent in all sedentary behaviours across the day, may also be important for identifying population sub-groups at higher risk of associated health outcomes (102). Socio-demographic attributes, health-related factors, and work-related factors have been the most frequently assessed as potential correlates of total sitting time (138).

Demographic factors

A number of studies have reported men to have higher levels of total sitting or sedentary time than women (14, 41, 64, 139-145). While a 2012 systematic review concluded that, on balance, gender did not appear to be related to the amount of time spent in sedentary behaviour (138), population differences between studies may explain these discrepancies. An analysis of self-reported sitting time from 20 countries found no overall differences according to gender, however country-specific data revealed higher levels of sitting for men in seven countries, higher levels amongst women in five countries and no difference in eight countries (40).

The association between sitting time and age has also been frequently assessed. Older adults (>65 years) appear to be more likely to have high levels of total sitting (42, 142, 143, 145) and prolonged sitting time (146) compared with young or middle-aged adults. However, some studies have also reported high levels of sitting in late adolescence (147) and early adulthood (15, 16), suggesting that sitting may vary across the lifespan, and/or potentially, between generations. The relative contribution of different sedentary behaviours, such as work and leisure-time sitting, to overall sitting time has been shown to differ between age groups (145). It has been suggested that education and employment status may partially explain differences between age groups in sedentary behaviour levels (41, 42).

Living arrangements, family and caring responsibilities may also influence the amount of time spent in sedentary behaviours. Being single or unmarried (16, 62, 63, 143, 148, 149) or widowed/separated/divorced (143, 150) has been associated with higher levels of self-reported and objectively measured sitting time compared to being married or in a de facto relationship. Women with home duties or caring responsibilities have also been found to have lower levels of sitting time compared to women without these responsibilities (151), while childless adults may have higher levels of sedentary time compared to adults with children (139, 141, 152).

Socio-economic and work-related factors

Higher levels of educational attainment have generally been found to be associated with higher levels of both self-reported sitting (40, 63, 139, 140) and accelerometer-assessed sedentary time (139, 141), relative to those with lower levels of education. Findings relating to income are mixed: some have found income to be positively associated with self-reported sitting time (63) or objectively measured sedentary time (141), while others have found that participants on higher incomes have higher workday sitting, but lower sitting on non-work days compared to people with lower incomes (16). Similarly, adults in higher income households have been found to be less likely to have high leisure-time sitting (153, 154), suggesting that workplace sitting time may be a large contributor to total sitting time for this group. In line with this, Stamatakis et al. (155) found that associations between socioeconomic factors and total sedentary behaviour were weaker within a population not employed.

Supporting the important contribution of workplace sitting to total sitting time, working full-time has been associated with increased risk of high total sitting time compared to those working part-time or not in the labour force (63, 151, 154). Having a white collar job (139), or a job involving mostly sitting is also associated with higher overall sitting time (64).

Environmental factors

A small number of studies have assessed whether built environment features found to be associated with physical activity are also associated with the amount of time that individuals spend sitting. A systematic review published in 2015 (156) identified 17 studies that assessed associations between adults' sitting time with a variety of neighbourhood attributes, including walkability, access to destinations, aesthetics, and social/crime-related features. Overall, the authors concluded that there was generally mixed or insufficient evidence to support an association between neighbourhood environmental attributes and sitting time. The most consistent evidence was for lower levels of sedentary behaviour to be associated with living in urban areas and having access to local destinations. The authors suggested that the measure of sedentary behaviour used, and the lack of direct correspondence with features of the built environment could potentially explain the results. For example, measures of total sedentary behaviour will include activities that occur in other settings, such as in the workplace, which are less likely to be influenced by aspects of the neighbourhood environment around the home.

1.5.2 Correlates of leisure-time sitting

The most common leisure-time sedentary behaviour in Australia, the United Kingdom and the United States is TV viewing (157-159). TV viewing time has been more frequently assessed in population-based studies relative to other sedentary behaviours (25), resulting in greater knowledge about potential correlates. This section will focus on the evidence examining the correlates of TV viewing time and also computer use as there is minimal evidence on correlates of other leisure-time sedentary behaviours.

While TV viewing is highly prevalent, it may not be an accurate marker of overall sitting time, particularly in men (160) and for employed adults (161). Consistent with this, the correlates of TV viewing time differ to some extent from those identified for total sitting time. Socio-demographic factors associated with higher levels of TV viewing time include older age (138, 143, 161-163), being unemployed or retired (164-167), having lower levels of income (143, 155, 168-170) and educational attainment (141, 143, 155, 162, 164, 166-172), and being unmarried (relative to married or de facto) (143, 169, 173). High TV viewing time has also been associated with unhealthy diet patterns, including lower consumption of fruit and vegetables (143, 174), and higher consumption of sugar-sweetened beverages and fast food (174). There are mixed findings as to whether TV viewing time differs according to gender (160, 170, 175).

Social-cognitive and environmental factors that have been found to be associated with higher levels of TV viewing include having larger sized TVs (162), eating in front of the TV (176), higher levels of partner TV viewing time (172), and enjoyment of TV viewing (172, 177).

The other most commonly assessed leisure-time sedentary behaviour is computer use. In contrast to TV viewing time, which has been associated with older age and indicators of lower socioeconomic status, high levels of computer/Internet use appear to be more common amongst those of younger age (26, 141, 143, 167, 170, 171), with higher levels of educational attainment (141, 143, 155, 162, 167, 170, 171) and higher individual (143, 155) and neighbourhood-level (141) income. Certain attributes have, however, been found to be common to both TV viewing and computer use, specifically being unmarried (143, 173) and having a higher BMI (167, 178).

1.5.3 Correlates of workplace sitting

This section summarises the modest evidence base relating to correlates of high levels of workplace sitting and highlights gaps in the literature.

The most consistent factor found to be associated with workplace sitting time is occupation or job category. In particular, workers in physically demanding and blue-collar occupations have

been found to sit less at work than those in professional or white-collar, physically undemanding jobs (122, 123, 172, 179-183).

Evidence pertaining to socio-demographic correlates of workplace sitting time is mixed or less than definitive. While some have observed self-reported occupational sitting time to be higher amongst men (123, 181), others have found no gender difference (15, 184), or higher occupational sitting time amongst women (16). Four studies have reported occupational sitting time to be higher amongst younger employees compared with older employees (15, 181, 184, 185); although one found this association only amongst women (184) and another observed that this association was stronger for men (185). Similar to correlates of overall sedentary behaviour, higher income (181, 184) and education (172, 181, 184) have also been associated with higher levels of work-related sitting time; these factors may be a proxy for sedentary, office-based jobs.

There is emerging evidence relating to possible psychological, or social-cognitive correlates of workplace sitting. In one of the first studies to assess a broad range of potential correlates of workplace sitting, De Cocker et al. (181) identified two potential psychosocial correlates in a sample of Australian workers. Lower levels of perceived control to reduce workplace sitting were associated with higher levels of sitting amongst full-time and part-time workers, but not casual workers (181). In addition, higher awareness of the advantages of reduced sitting time was associated with higher levels of workplace sitting, the opposite direction to that expected (181). Others have also found higher levels of perceived behavioural control to be associated with lower workplace sitting time (186, 187). Additional social-cognitive factors suggested to be associated with high levels of workplace sitting or infrequency of sitting breaks, include perceived lack of time (188), a lack of concern about sitting for long periods (184), and having insufficient information about taking breaks (188). Work engagement may also be related to workplace sitting time. One study also found that higher levels of ‘vigour’ (mental resilience and energy) were associated with lower levels of work sitting, while being immersed in work correlated with high workplace sitting for women only (185).

Only one study has specifically investigated the potential influence of spatial features of the office environment. Comparing workers in open-plan, shared offices and private offices, Duncan et al. (189) found that greater visibility of co-workers was associated with more frequent breaks from sitting across all participants, while the connectivity of the local environment (e.g. availability of different paths to access locations within the building) was associated with frequent breaks for those in shared and open-plan offices, but not private offices (189).

Overall, there is an emerging body of evidence that points to potential correlates of workplace sitting. The most consistent correlate appears to be occupation, with those in white

collar/professional occupations likely to have higher levels of occupational sitting compared to those in blue collar or physically demanding occupations. There is currently inconsistent or relatively modest evidence about whether other socio-demographic, health-related, social-cognitive, or environmental factors are related to higher levels of workplace sitting time. As social-cognitive and environmental factors (particularly at the micro level) may be more amenable to modification in an intervention than socio-demographic attributes, further investigation of their role is likely to be informative for intervention design. It is also worth noting that the studies reported in this section all used self-reported measures of workplace sitting time.

1.5.4 Summary – correlates of sedentary behaviour

As suggested by this narrative review, evidence relating to the correlates of total sitting time and TV viewing time is growing, although the majority of studies have been cross-sectional in design and the focus has predominately been on individual-level factors. In comparison, there is only suggestive evidence about likely correlates of occupational or workplace sitting time beyond occupation category. Only a small number of studies have assessed correlates of overall sitting time or sedentary time using objective measures of sitting, and no studies have employed objective measures to identify correlates of workplace sitting. As noted previously, activity monitors, such as accelerometers and inclinometers, have advantages of providing more accurate and precise information on sitting time than self-report measures (27, 29). Devices such as the activPAL can also assess patterns of sitting, including bout duration (38). For the workplace setting, where a large proportion of sitting time can be accumulated in prolonged, unbroken bouts (105, 106), it may also be useful to identify factors associated with this potentially harmful pattern.

Some of the conflicting findings relating to correlates of total or overall sitting time highlight the need for domain or settings-specific measures of sedentary behaviour. Limitations of composite measures of total sitting time are that they mask potential differences between individuals and populations in the relative contribution of work, and leisure-related sitting time, and thus, important contextual information about where to intervene. To understand who to target and how best to intervene, further knowledge is required about the factors or attributes associated with high levels of workplace sitting time.

1.6 Intervening to reduce workplace sedentary behaviour

As evidence of the adverse health effects associated with total sedentary behaviour has strengthened, there has been growing interest in workplace interventions to reduce sitting time. The development of interventions has largely outpaced knowledge of the correlates or factors influencing workplace sitting time, as outlined in the previous section.

In contrast to traditional workplace physical activity interventions that have typically focused on promoting discrete bouts of MVPA (190), interventions targeting workplace sitting generally encourage workers to break up their prolonged sitting with more frequent bouts of light intensity activity across the working day. Evidence relating to the effectiveness and feasibility of some of the more common forms of interventions for reducing workplace sitting are reviewed in this section. Most of the evidence relates to environmental-based interventions; with some emerging evidence for multi-component interventions that incorporate aspects of individual, organisational and environmental-level strategies.

1.6.1 Environmental-based interventions

The physical environment is considered to be a key influence on activity levels within the workplace (191, 192). As such, many workplace sitting interventions have involved modifications to the immediate physical environment around workers—particularly, the workstation—as a strategy to facilitate reductions in sitting time. Different types of activity-permissive workstations have been trialled, which aim to facilitate standing or light movement while allowing users to concurrently perform their regular work tasks. Sit-stand workstations are the most common example (8). Provided in isolation they have been shown to reduce objectively assessed (106, 193-195) and self-reported (196, 197) sitting time in the range of 33 to 137 minutes relative to control conditions, at 3-12 week follow-ups. Sit-stand workstations are generally acceptable to users, with no negative effects reported on work performance or productivity (196-198). Other forms of activity-permissive workstations, including desks incorporating treadmills or cycle/pedal mechanisms, have also been evaluated, with modest evidence suggesting they can lead to reductions in sitting time (199, 200).

A small number of natural experiments have also been conducted of activity-permissive or activity based working environments, where physical modifications have been made to floors or buildings to encourage greater physical activity, such as open and visually appealing stairs, centrally located amenities and facilities (e.g., printing), and standing height options in shared spaces. Effects on objectively measured sitting or sedentary time in pre-post studies have

generally been minimal to modest when workers do not have access to individual sit-stand workstations (201, 202), although participants have self-reported sitting less (201, 203).

1.6.2 Individual and organisational-level interventions

A meta-analysis of workplace interventions targeting reductions in sitting time, published in 2016, found that individual-level behavioural or education-based strategies delivered in isolation led to smaller effects on workplace sitting time than environmental or multi-component approaches (204). These interventions have typically involved the use of strategies such as behavioural prompts, goal setting and self-monitoring of behaviour (204).

Only one study has evaluated the effectiveness of organisational-level strategies aimed at reducing workplace sitting time. Low cost strategies delivered by a workplace champion (including regular emails with tips for reducing sitting, senior management support and participation), led to reductions in workplace sitting time of 35–40 minutes at 12 month follow-up in a group of office-based workers without access to sit-stand workstations. Interestingly, no significant effect was observed at three months, with the authors suggesting that a longer period of time may be needed to achieve changes in workplace culture (205).

1.6.3 Multi-component interventions

More recent interventions targeting workplace sitting have aimed to address the multiple levels of influence on workplace sitting time in line with the principles of an ecological model and best practice workplace health promotion models (206). Studies from the Stand Up Australia body of research (207) have demonstrated the effectiveness of a multi-component workplace intervention incorporating an environmental component (sit-stand workstation with OHS guidance), individual-level strategies (including face-to-face and telephone-based health coaching, and a self-monitoring tool) and organisational-level strategies (staff information sessions, manager consultation and emails). In a pilot study, Healy et al. (5) demonstrated reductions of sitting time of over two hours, favouring the intervention group, after a four-week non-randomised trial. Neuhaus et al. (106) compared the effects on sitting time of a similar multi-component intervention, to a group provided with a sit-stand workstation only, and a comparison group. Relative to the comparison group, participants in the multi-component group reduced their sitting time by 89 minutes/8-h day. The reduction in sitting time achieved by the workstation-only group was not significantly different from the comparison group (106). To address some of the limitations of these smaller-scale studies, a large cluster randomised controlled trial (Stand Up

Victoria [SUV]) was conducted to provide higher quality evidence of the effectiveness of this multi-component intervention, and assess the potential impact over a long-term period (12 months). Intervention sites achieved significant average reductions in sitting time of 99 and 45 minutes/8-h day at three and 12 months, respectively, relative to control sites (208).

Others (209) have also evaluated the efficacy of a multi-component intervention to reduce workplace sitting, through a cluster randomised controlled trial within workplaces in Denmark and Greenland. This intervention, provided to workers who already had sit-stand workstations, also comprised strategies acting at the individual-level (educational lecture, emails and text messages) organisational-level (social and managerial support; workshop to select strategies and determine common goals), and environmental-level (high meeting tables). In the intervention group, workplace sitting time was reduced by 48 minutes/8-h work day at 3 months, relative to control participants.

The results of these two cluster randomised controlled trials suggest that multi-component interventions can effectively reduce workplace sitting in a real world setting, and these reductions can be at least partially sustained over a long-term period. However, there are still evidence gaps in understanding of the mechanisms through which these changes occurred, and potential barriers and facilitators to change experienced by participants.

1.6.4 Workers' perspectives on reducing workplace sitting

When evaluating interventions aimed at reducing workplace sitting, useful insight can be gained through qualitative research that seeks to understand workers' perspectives on different approaches. This may assist with understanding why interventions may or may not have worked, and factors that may facilitate, or act as barriers to change.

There is a growing evidence base related to the perceived feasibility and acceptability of reducing workplace sitting, mostly in the context of interventions. Factors perceived by workers to act as barriers to reducing workplace sedentary behaviour include the habitual nature of sitting (210, 211), time and work pressures (191, 211-213), jobs that require predominately computer-based tasks (213, 214), concern about being perceived to be less productive (210, 211, 213), and the limitations of the physical workplace environment in facilitating movement (191, 213).

In contrast, perceived facilitators to reducing workplace sitting include having role models promoting change (191), evidence of supportive management or leadership (191, 213) and perceiving individual benefits from breaks in sitting (such as improved concentration, well-being or reduced back pain) (191, 213, 215).

A number of qualitative studies have specifically examined participants' experiences with sit-stand workstations. These suggest that sit-stand workstations are generally well accepted and are perceived as being a feasible solution to reducing sedentary behaviour (215, 216). Workers have reported being attracted by the novelty of the workstations, and appreciating the opportunity to change their posture during working hours (198, 215). Positive reported outcomes following use of the workstations include increased focus and alertness (197, 215-217). However, barriers to their use have also been noted. Dissatisfaction with the design of certain sit-stand workstations used in intervention trials has been reported, particularly relating to the size of the desk portion of the height-adjustable workstation (197, 215, 216), and the overall stability (193, 197, 215, 217). Other potential barriers include issues relating to the open-plan environment, such as noise issues, and feeling self-conscious while standing (215). The need to wear different footwear to accommodate standing has also been reported as a potential barrier (193).

1.6.5 Employer representatives' perspectives on reducing workplace sitting

When considering the implementation of possible strategies or interventions to address workplace sitting, it is also important to consider the views of senior staff or occupational health and safety (OHS) representatives who will be actively involved in implementing policies and programs relating to OHS and well-being. Only a few studies have sought the views of these stakeholders.

In one study, supervisors of participants who received sit-stand workstations were interviewed about their perspectives on the intervention (217). Similar to feedback from participants, supervisors reported that the workstations had the potential to increase health and well-being and also perceived that the employees had had increased engagement with work after the workstation installation (217).

Interestingly, in another study employees and managers appeared to have differing views about the perceived factors influencing the take up of intervention strategies. While employees considered that mandatory strategies were likely to be most effective, management reported that employees should take responsibility and initiative for reducing their sitting time. Similarly, while employees perceived that taking more frequent breaks from sitting would be viewed as unproductive, this view was not necessarily shared by management staff (210). In addition to those in senior leadership, another key stakeholder group that are likely to be involved with designing and implementing sedentary behaviour reduction initiatives are OHS practitioners. Gilson et al. (218) conducted interviews to explore practitioners' knowledge of sedentary

behaviour as a health risk factor and their perspectives on the feasibility of strategies to reduce sitting. OHS practitioners appeared to have greater awareness of the broad range of the cardiometabolic health risks associated with sedentary behaviour than employees and managers, who in a previous study were more likely to relate high levels of sitting with musculoskeletal conditions (191). When asked to identify possible strategies that may assist with efforts to reduce sitting in the workplace, participants suggested aligning strategies with job tasks, using workplace champions or leaders to promote strategies, and presenting a business case to management outlining the economic benefits (218).

Overall, while there is emerging insight into the views of senior staff or OHS representatives in addressing workplace sitting, it is clear that further research is required. Understanding the perspectives of all key stakeholders involved in implementing, overseeing or participating in strategies designed to reduce workplace sedentary behaviour will assist in identifying the most feasible and acceptable approaches.

1.6.6 Summary – effectiveness and feasibility of workplace sedentary behaviour interventions

The available evidence suggests that workplace sitting time can be reduced through targeted interventions, with multi-component approaches demonstrated to result in the largest reductions, followed by environmental-only approaches (204). Similarly, a review of specific behaviour change techniques and strategies used in sedentary behaviour interventions concluded that environmental restructuring was a particularly promising technique, along with education and persuasion (219).

Many of the studies reviewed were small-scale pilot studies and short-term in duration. Recent reviews of workplace interventions targeting sedentary behaviour have noted the need for higher quality studies to be conducted, specifically with larger sample sizes, objective measures of behaviour and longer follow-up periods (8, 204, 220, 221). All of these reviews were conducted prior to the publication of the main outcomes of the two cluster randomised controlled trials discussed in section 1.6.3 (208, 209), which addressed many of these previous limitations.

Emerging qualitative research suggests that sit-stand workstations are an acceptable solution for reducing workplace sitting, however there appear to be some barriers to their use. Work-related factors such as the predominance of computer-based tasks and concerns about productivity loss may be additional barriers to breaking up sitting time more frequently. In contrast, there is some initial evidence to suggest that supportive social environments may assist to facilitate change.

Additional research examining the correlates of workplace sitting time, and factors impacting on intervention feasibility and effectiveness, is required to support the refinement and development of these workplace sedentary behaviour interventions. Identifying potential high risk groups and barriers and facilitators to change will assist with targeting interventions to those most at need and improving intervention feasibility and effectiveness.

1.7 Research aims

Broadly, this thesis aims to improve understanding of factors influencing workplace sitting time, including the correlates of high levels of workplace sitting time, potential barriers or facilitators to reducing this behaviour, and the mechanisms through which reductions in sedentary behaviour may occur.

The three research aims outlined below will be addressed through the five empirical studies presented in subsequent chapters.

1. To identify socio-demographic, health-related, work-related and social-cognitive correlates of workplace sitting time. (Chapters 2 and 3)
2. To determine key barriers and facilitators for reducing high levels of sitting in the workplace, and the feasibility of change. (Chapters 4 and 6)
3. To understand the mechanisms through which a workplace sedentary behaviour intervention leads to successful behaviour change. (Chapter 5)

CHAPTER 2

CORRELATES OF SELF-REPORTED OCCUPATIONAL SITTING TIME AND TV VIEWING TIME

The literature review in Chapter 1 identified that there is only a modest body of evidence relating to the correlates of workplace or occupational sitting time, with limited knowledge about factors other than occupation that may be important influences on behaviour. Studies that specifically aim to assess the correlates of occupational sitting time are needed to further our understanding of the predominant influences of sedentary behaviour in this setting and inform intervention design and targeting.

As noted in Chapter 1, sitting for work comprises a large proportion of total daily sitting time for many adults (14, 108); those in sedentary occupations can accumulate over six hours of sitting during working hours alone (106, 222). From a public health perspective, intervening in the setting where the majority of adult sedentary behaviour is accumulated provides the potential to reduce exposure to this health risk factor for a large segment of the population.

Other than sitting for work, the other activity likely to comprise the largest proportion of total sitting time is TV viewing (14); the most common leisure activity for Australian adults (157). High levels of TV viewing time specifically have been associated with increased risk of premature mortality and chronic disease incidence (55, 77).

As described in Chapter 1, it appears that the correlates of these two sedentary behaviours may differ. For example, markers of high socio-economic status (such as higher education and income) have been shown to be associated with higher levels of work-related sitting time, but lower levels of TV viewing (223). However, while these findings reflect average associations in the population, it is possible that there may be a sub-group of workers with high levels of both of these activities. When considering who to target within the workplace setting, this group may be important to identify as the amount of sitting time accumulated from these two settings alone may be at a sufficient level to increase risk of premature mortality and chronic disease.

This chapter aimed to explore the socio-demographic and health-related correlates of occupational sitting time, and occupational sitting time and TV viewing time in combination, in an Australian adult population. To address these aims, data from the third wave of the Australian Diabetes, Obesity and Lifestyle study (AusDiab 3) was used. Further details of methodology and

participant recruitment for AusDiab is provided below. The peer reviewed paper, published in BMC Public Health, is presented in section 2.2.

2.1 AusDiab methods

AusDiab is a national, longitudinal population-based study originally designed to examine the prevalence and natural history of diabetes, obesity, kidney disease and hypertension in Australia. The methodology and response rates have been described in detail previously (224). Briefly, the original recruitment occurred between May 1999 and December 2000 through a stratified cluster sampling design. The six Australian states and the Northern Territory formed the strata. Six census collector districts (CD, a unit of measurement defined by the Australian Bureau of Statistics, comprising 225 dwellings on average) were randomly selected in each strata to form the sample, with the aim of obtaining a cluster size of 250 participants. As single CDs did not provide the required cluster size in most cases, adjoining CDs were added to the original randomly selected CD until the cluster size was reached. Three clusters consisted of single CDs, 22 two CDs, 16 three CDs and one four CDs.

Within the 42 clusters, 25,984 households were approached, contact was made with 19,215 and 17,129 were eligible to participate. Interviews were successfully conducted at 11,479 households with 20,347 eligible adults. All household members aged 25 years and over at the participating households were invited to a testing site to complete a biomedical examination, which involved physical measurements, blood sampling, and urine testing. 11,247 participants completed the biomedical examination. Data on demographic characteristics, medical history, physical activity, alcohol and tobacco, health knowledge and service utilisation were collected through an interviewer-administered questionnaire. Questionnaires relating to general health and well-being (SF-36) and diet were self-administered. Data from AusDiab1 were weighted to match the age and gender distribution of the Australian residential population in 1998.

Follow-up studies, AusDiab2 and AusDiab3, were conducted in 2004-05 and 2011-12, respectively. The present study incorporates data from AusDiab3. Of the original 11,247 participants, 4,614 participants attended an assessment centre for AusDiab3 and completed an interviewer-administered questionnaire that assessed socio-demographic and health-related attributes and sitting time.

While TV viewing time was collected at all three time points, questions on other domains of sitting time, including occupational sitting, were only asked in AusDiab3. The questions for occupational sitting and TV viewing are detailed below. Both questions asked participants to

estimate the amount of time (in hours and minutes) in these activities during the past week, for Monday to Friday and Saturday and Sunday separately.

Sitting for work in the last week

Please estimate the total time during the last week that you spent sitting down as part of your job while at work, or working from home, including meal and snack breaks, sitting to do work such as at desk or in meetings, sitting to use computer at work, and sitting for travel as part of work such as being a taxi driver?

TV viewing in the last week

Please estimate the total time during the last week that you spent watching TV or videos/DVDs. This is when it was the main activity that you were doing; for example you would not include time when the television was switched on and you were preparing a meal.

Participants were also asked to report how many hours they had worked in the past week. For the study reported in section 2.2, inclusion criteria was having reported working or volunteering the equivalent of full-time hours (≥35 h/week) across weekdays (n=1,378). The rationale for only including participants who worked the equivalent of full-time was that no data was available for the number of days that participants worked. As such, it was determined that calculating part-time workers' average exposure to sitting time per workday would involve substantial error without information about the number of days they worked. An assumption was therefore made of a traditional, Monday to Friday working week. Work hours and work sitting on weekends were not included in this study as the majority of participants did not report working during the weekend, or reported very few hours on these days. This decision was made for similar reasons as to the exclusion of part-time workers – to avoid diluting average daily sitting time by including a denominator of seven workdays rather than five. Participants were also excluded if they were pregnant or missing data on the covariates of interest, resulting in a final sample size of 1,235 for the fully adjusted models (women: n=466, men: n=769). A reduced sample size (n=437) was used in the univariate analysis between occupational category and occupational sitting time for women, reported in Table 2, due to the exclusion of the small number of women in blue collar occupations.

2.2 Excessive sitting at work and at home: Correlates of occupational sitting and TV viewing time in working adults

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Excessive sitting at work and at home: Correlates of occupational sitting and TV viewing time in working adults

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Abstract

Background: Recent evidence links sedentary behaviour (or too much sitting) with poorer health outcomes; many adults accumulate the majority of their daily sitting time through occupational sitting and TV viewing. To further the development and targeting of evidence-based strategies there is a need for identification of the factors associated with higher levels of these behaviours. This study examined socio-demographic and health-related correlates of occupational sitting and of combined high levels of occupational sitting/TV viewing time amongst working adults.

Methods: Participants were attendees of the third wave (2011/12) of the Australian Diabetes, Obesity and Lifestyle (AusDiab) study who worked full-time (≥35 h/week; n = 1,235; 38 % women; mean ± SD age 53 ± 7 years). Logistic and multinomial logistic regression analyses were conducted (separately for women and men) to assess cross-sectional associations of self-reported occupational sitting time (categorised as high/low based on the median) and also the combination of occupational sitting time/TV viewing time (high/low for each outcome), with a number of potential socio-demographic and health-related correlates.

Results: Higher levels of occupational sitting (>6 h/day) were associated with higher household income for both genders. Lower levels of occupational sitting were associated with being older (women only); and, for men only, having a blue collar occupation, having a technical/vocational educational attainment, and undertaking more leisure-time physical activity (LTPA). Attributes associated with high levels of both occupational sitting and TV viewing time included white collar occupation (men only), lower levels of LTPA (both genders), higher BMI (men), and higher energy consumption (women).

Conclusions: Higher household income (both genders) and professional/managerial occupations (men only) were correlates of high occupational sitting time, relative to low occupational sitting time, while health-related factors (lower LTPA, higher BMI – men, and higher energy consumption – women) were associated with high levels of both occupational sitting and TV viewing time, relative to low occupational sitting and low TV viewing time. These findings suggest possible high-risk groups that may benefit from targeted interventions. Further research is needed on potentially modifiable environmental and social correlates of occupational sitting time, in order to inform workplace initiatives.

Keywords: Sedentary behaviour, Correlates, Occupational sitting, Television viewing

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Background

Evidence is accumulating on the detrimental health consequences of sedentary behaviour, or too much sitting. Amongst adults, studies have observed increased risk of cardiovascular and all-cause mortality, some cancers, type 2 diabetes and the metabolic syndrome with higher levels of sedentary behaviour [1–4]. Importantly, these detrimental associations have persisted in studies that have controlled for moderate-vigorous or leisure-time physical activity [3], suggesting the need for a dedicated public health focus on too much sitting.

In order to effectively intervene and reduce overall levels of sedentary behaviour, it is important to understand the settings in which it occurs, and the specific factors influencing high levels of sedentary behaviour in these particular settings. For many adults, the occupational setting is where a large proportion of daily sedentary time is accrued [5]. Recent studies using objective monitoring have indicated that office-based workers spend at least two-thirds of their working hours sedentary [6, 7]. With technological advances automating many previously manual tasks, sitting has become the normative posture in many workplaces [8]. This, coupled with the increasing recognition of the adverse health impacts, has led some to propose that occupational sitting should be identified as a potential hazard and treated accordingly under work health and safety laws [9].

In this context, there is the need to identify the relevant attributes of those working adults who are most sedentary, in order to strengthen the evidence base required to inform future workplace guidelines, programs and policies. Of the few studies that have examined the attributes associated with sedentary behaviour in the work environment, employment characteristics and socio-demographic attributes have been identified as individual-level correlates [10]. In particular, evidence suggests that workers in physically demanding and blue-collar occupations have been found to have lower levels of occupational sitting than those in physically undemanding and white collar jobs [11, 12]. Higher educational attainment and income [10, 13], being male, younger and having a higher BMI also appear to be attributes linked with higher levels of occupational sitting [10].

When considering working adults' opportunities to be sedentary, occupational sitting time combined with television viewing time account for the greatest proportion of sedentary waking hours on work days [14, 15]. TV viewing is the most common leisure-time sedentary behaviour in Australia, the UK and the USA [16–18] and there is consistent evidence linking high levels of TV viewing time with adverse health outcomes including the metabolic syndrome, cardiovascular disease and premature mortality [1, 2, 19]. A recent meta-analysis found mortality risk to increase by 5 % for each additional hour spent sitting beyond seven hours per day [20]. Working adults who combine high levels of occupational sitting and high levels of TV viewing time are likely to accumulate at least seven hours of sitting across the day, suggesting a potential increased health risk for these workers. In addition, there is evidence to suggest that the adverse health effects of occupational sitting and leisure-time sitting combined may be greater than those associated with each behaviour separately [21].

Occupational sitting and TV viewing time may therefore be key areas to target in order to have the greatest impact in reducing overall levels of sedentary behaviour in working adults. Identifying attributes associated with high occupational sitting and also the combination of high occupational sitting with high TV viewing time is therefore likely to be important for informing intervention strategies, by determining which groups within working populations may benefit from targeted approaches to reduce both of these behaviours. Whether the factors influencing sitting time in these areas differ for women and men is also of interest, as gender differences have been reported in the correlates of both occupational sitting [13] and TV viewing time [22]. Notably, few studies have explored these potential variations, which may be important for understanding why some studies have found higher levels of occupational sitting amongst men compared with women [10, 12]. Further research in this area is warranted.

We first examined the socio-demographic and health-related correlates of high occupational sitting time compared to low occupational sitting time for women and men; and second, identified the correlates of having high occupational sitting time and high TV viewing time compared to low occupational sitting time and low TV viewing time, in a large sample of Australian women and men.

Methods

Participants & procedures

The Australian Diabetes, Obesity and Lifestyle study (AusDiab) is a national longitudinal study, designed originally to examine the prevalence and incidence of diabetes and its precursors in a population-based sample of Australian adults. Details of the data collection methods and response rates have been described previously [23]. Briefly, 11,247 adults participated in the baseline survey in 1999–2000. Follow-up studies were conducted in 2004–05 (AusDiab2) and 2011–12 (AusDiab3) with 6,400 and 4,614 participants completing follow-up (including biomedical examination) for AusDiab2 and AusDiab3 respectively [24]. The present study uses data from AusDiab3 and includes those participants who reported working or volunteering ≥ 35 h/week across weekdays (n = 1,378). Participants were excluded if

they were pregnant (n = 2) or were missing data on any of the covariates of interest (n = 141). The final sample comprised 1,235 participants (466 women and 769 men). The Alfred Hospital Ethics Committee approved the study and written informed consent was obtained from all participants.

Measures

Occupational sitting time and television (TV) viewing time

Occupational sitting time on weekdays and weekends was assessed by the question *"Please estimate the total time during the last week that you spent sitting down as part of your job while at work or working from home, including meal and snack breaks, sitting to do work such as at desk or in meetings, sitting to use the computer at work, and sitting for travel as part of work such as being a taxi driver?"*. Participants were asked to estimate the total time sitting first for Monday to Friday, and then for Saturday and Sunday. A similar question has previously been validated in a working adult population [25]. Modifications were made to this question to align with the AusDiab study format, including adding examples of occupational sitting behaviour. For this study, only weekday occupational sitting time was considered in analyses, as the majority of participants reported working zero hours across the weekend and only 6 % reported working for 15 h or more across the two weekend days. The average weekday occupational sitting time (hours/day) was calculated by dividing the reported hours participants sat for work on Monday-Friday by five. Participants were classified as having either high (>6 h/day) or low (≤6 h/day) weekday occupational sitting time based on a median split.

Television viewing time was collected from the question, *"Please estimate the total time during the last week that you spent watching TV or videos/DVDs. This is when it was the main activity that you were doing; for example you would not include time when the television was switched on and you were preparing a meal"*. This question has been shown to have established reliability and validity [26]. Average daily TV viewing time (hours/day) was calculated by adding weekday and weekend hours and dividing by seven. Participants were classified as having either high (≥1.5 h/day) or low (<1.5 h/day) TV viewing time based on a median split.

Socio-demographic attributes

Socio-demographic attributes, including gender and age, were determined from interviewer-administered questionnaires. Educational attainment (collected at baseline in 1999/2000) was categorised as high school or lower; technical/vocational (including trade or technician's certificate, associate or undergraduate diploma, or nursing or teaching qualification); and, bachelor's degree or higher. Occupation was collapsed from eight categories to three: *professional/managerial* (professionals, managers,); *white collar/administrative* (community & personal service workers, clerical & administrative workers, sales workers); *blue collar* (technicians & trades workers, machinery operators & drivers, labourers). Marital status was categorised as *married/de facto; separated/divorced/widowed; never married*. Presence of children in the household was categorised as yes or no. Annual gross household income was categorised into four categories: *less than $60,000*; *$60,000-$125,000*; *$125,000+*; *don't know/preferred not to say*. Participants reported the number of hours and minutes they worked during the previous week on Monday to Friday. The average hours worked per weekday was calculated by dividing the total reported time by five.

Health-related attributes

Leisure-time physical activity (LTPA) was assessed using the Active Australia Survey Questionnaire, which assesses walking for recreation or transport, other moderate-intensity activity and vigorous-intensity activity [27]. LTPA was measured in minutes per week and participants were classified as either meeting (≥150 min/week), or not meeting (<150 min/week), adult physical activity guidelines [28]. Smoking status was categorised as current smoker, ex-smoker or non-smoker. Daily energy and alcohol intake were assessed through a self-administered food-frequency questionnaire [29]. Participants reported frequency of consumption of various food items, with the last 12 months as a reference. Gender-specific standard portion sizes were derived from weighed food records and the reported frequencies were converted to daily equivalents. NUTTAB95 food composition data was used to calculate the intake of energy [30]. Alcohol intake was measured in grams, and categorised as ≤10 g/day; >10- ≤ 20 g/day and >20 g/day, based on Australian National Health and Medical Research Council (NHMRC) guidelines [31] that suggest that adults drink no more than two standard drinks (20 g alcohol) on any day to limit long-term risk of alcohol-related harm.

Height and weight measurements were taken by trained AusDiab personnel at designated testing sites. BMI was calculated using the formula: weight (kg)/height $(m)^2$ and categorised as underweight (<18.5), normal (18.5- < 25), overweight (25- < 30) or obese (≥30) [32]. Due to the small number of participants (<1 %) in the underweight category, the underweight and normal categories were combined.

Statistical analyses

Dichotomous high/low categories of occupational sitting time and TV viewing time were used as the outcome

variables in analyses. An *a priori* decision was made to stratify all regression analyses by gender. For the first aim, logistic regression analyses were conducted to identify socio-demographic and health-related correlates of high occupational sitting time. Univariate logistic regression models were first conducted to examine relationships between socio-demographic and health-related factors with the outcome variable (high vs low occupational sitting time). All available socio-demographic and health-related factors were then entered into the second set of logistic regression models. As these analyses were exploratory in nature, a backward regression approach was then applied, removing variables until only those significant at $p < 0.20$ remained, to achieve a parsimonious model. Age, average hours worked/day and LTPA were forced into all models. As there were only a small number of women in blue collar occupations who reported high occupational sitting, occupational status was changed to missing for these participants in the regression analyses, with comparisons made between the other two occupational groupings (white collar/administrative and professional/managerial).

To address the second aim, participants were grouped into one of four categories based on combinations of high or low for occupational sitting and TV viewing time. Multinomial logistic regression analyses, stratified by gender, were conducted to identify the socio-demographic and health-related correlates of being in each of the groupings with at least one 'high' category (low occupational sitting/high TV; high occupational sitting/low TV; high occupational sitting/high TV), compared with the category considered to be the lowest risk – the low occupational sitting/low TV viewing grouping (reference group). The same backward, stepwise regression approach described above was applied to achieve a parsimonious model. Analyses were conducted using Stata 12 for Windows (StataCorp, College Station, TX). Statistical significance was set at $p < 0.05$.

Results

Participant characteristics

The mean (SD) age of participants was 53 (7) years and 38 % were women (Table 1). There were significant differences between women and men in a number of socio-demographic and health-related attributes. Of note, a higher proportion of men had a technical/vocational level of educational attainment (48 % vs 35 %) and more were in blue collar occupations (31 % vs 6 %). A higher proportion of women were separated, divorced or widowed (20 % vs 7 %), worked in white collar/administrative occupations (40 % vs 11 %) and reported household incomes < $60,000 (21 % vs 13 %) compared with men. Men reported an additional one hour of LTPA per week, and higher energy intake and alcohol consumption than women.

Correlates of high occupational sitting time

The socio-demographic and health-related correlates of high occupational sitting time (reference: low occupational sitting time), stratified by gender, are shown in Table 2. In the fully adjusted models for women (adjusted for age, hours worked, TV viewing time, LTPA and all other remaining covariates), higher household income remained the strongest correlate: the odds of being in the high occupational sitting group increased over twofold for women with household incomes of $60,000-$125,000 and $125,000+ respectively, compared with those on less than $60,000. Women who were separated, divorced or widowed (compared with being de facto or married) were nearly twice as likely to have high levels of occupational sitting. In addition, the odds of being in the high occupational sitting group decreased slightly with age.

In the fully adjusted models for men, educational attainment, occupation and household income remained significant, although the association of household income with high occupational sitting was diminished. Being in a blue collar occupation and having a technical or vocational education were associated with lower odds of being in the high occupational sitting group, compared with their respective comparison categories. Each one hour increase in work hours was associated with 26 % higher odds of being in the high occupational sitting group, while each 30 min increase in leisure-time physical activity per week was associated with a small, but significant decrease in the odds of men being in the high occupational sitting group.

Correlates of high occupational sitting and high TV viewing time

The results of the multinomial logistic regression analyses are shown in Table 3 (women) and Table 4 (men). Age, hours worked and leisure-time physical activity were adjusted for in both models and the low occupational sitting/low TV viewing category was the reference category for all comparisons.

For women (Table 3), socio-demographic attributes associated with being in the high occupational sitting/high TV viewing group included marital status and income. Single women, relative to de facto/married women, had a higher risk of being in the high occupational sitting/high TV group than the low occupational sitting/low TV viewing group, although the wide confidence interval suggests some degree of uncertainty with this finding. Having a household income of $60,000-$125,000 (ref < $60,000) was associated with a nearly three times higher relative risk ratio of being in the high occupational

Table 1 Participant characteristics by gender (mean (SD), % or median (IQR))

	Total sample ($n = 1,235$)	Women ($n = 466$)	Men ($n = 769$)	p
Socio-demographic attributes				
Age (years)	53.3 (7.2)	52.9 (6.8)	53.6 (7.4)	0.076
Education				$p < 0.001$
High school or less	24.4	30.5	20.7	
Technical/vocational	43.1	34.6	48.2	
Bachelor's degree or higher	32.6	35.0	31.1	
Marital status				$p < 0.001$
De facto/married	81.9	72.5	87.7	
Separated/divorced/widowed	11.9	20.2	6.9	
Single	6.2	7.3	5.5	
Child(ren) in the household				
Yes, %	48.1	45.3	49.8	0.123
Occupation				$p < 0.001$
Professional/managerial	56.6	53.7	58.4	
White collar/administrative	21.9	40.1	10.9	
Blue collar	21.5	6.2	30.7	
Annual gross household income				$p < 0.001$
Less than $60,000	16.0	21.2	12.9	
$60,000-$125,000	40.4	37.8	42.0	
$125,000+	39.9	36.3	42.1	
Don't know/Preferred not to say	3.6	4.7	3.0	
Average weekday hours worked	8.0 (8.0, 10.0)	8.0 (7.6, 9.0)	8.4 (8.0, 10.0)	$p < 0.001$
Health-related factors				
Leisure-time physical activity (min/week) - median (IQR)	240 (90, 500)	210 (60, 420)	270 (95, 540)	0.004
Physical activity guidelines				0.068
Sufficiently active, %	64.8	61.6	66.7	
Insufficiently active, %	35.2	38.4	33.3	
Smoking status				0.055
Current smoker, %	6.2	4.3	7.3	
Ex-smoker, %	32.4	31.1	33.2	
Non-smoker, %	61.5	64.6	59.6	
BMI (kg/m^2)	27.9 (5.0)	27.5 (5.7)	28.2 (4.4)	0.034
Normal, %	29.4	39.1	23.5	$p < 0.001$
Overweight, %	43.6	32.4	50.3	
Obese, %	27.0	28.5	26.1	
Energy intake (kJ/day)	7036.5 (5367.8, 9091.6)	5661.3 (4552.1, 7014.3)	8083.1 (6370.9, 9989.7)	$p < 0.001$
Alcohol consumption (g/day)	9.7 (2.1, 23.6)	5.3 (1.2, 15.1)	13.7 (3.2, 30.0)	$p < 0.001$
≤10	50.9	64.8	42.4	
>10- ≤ 20	18.0	16.7	18.7	
>20	31.2	18.5	38.9	
Sitting time				
Weekday work sitting time (hours/day)	6.0 (3.0, 7.6)	6.0 (2.8, 7.5)	6.0 (3.0, 7.6)	0.924
TV viewing time (hours/day)	1.4 (0.7, 2.1)	1.3 (0.7, 2.0)	1.6 (0.9, 2.3)	$p < 0.001$

Table 2 Socio-demographic attributes and health-related factors associated with high occupational sitting time compared with low occupational sitting time: stratified by gender

	Women				Men			
Correlates	Unadjusted odds ratio (95 % CI)	*p*	Fully adjusted odds ratio (95 % CI)[ab]	*p*	Unadjusted odds ratio (95 % CI)	*p*	Fully adjusted odds ratio (95 % CI)[ab]	*p*
Socio-demographic attributes								
Age (years)	0.96 (0.93, 0.99)**	0.003	0.96 (0.94, 0.99)*	0.021	0.98 (0.96, 1.00)	0.096	0.99 (0.97, 1.02)	0.578
Educational attainment								
High school or less	1.00		-		1.00		1.00	
Technical/vocational	0.96 (0.60, 1.52)	0.858	-		0.54 (0.36, 0.79)**	0.002	0.58 (0.38, 0.88)*	0.011
Bachelor's degree or higher	1.51 (0.96, 2.38)	0.076	-		1.77 (1.18, 2.65)**	0.006	1.10 (0.68, 1.78)	0.711
Marital status								
De facto/married	1.00		1.00		1.00		-	
Separated/divorced/ widowed	1.19 (0.75, 1.89)	0.453	1.99 (1.15, 3.46)*	0.014	0.55 (0.29, 1.01)	0.054	-	
Single	1.79 (0.88, 3.65)	0.108	2.01 (0.92, 4.43)	0.082	0.55 (0.28, 1.10)	0.091	-	
Child(ren) in the household	0.98 (0.68, 1.42)	0.931	-		1.67 (1.25, 2.23)**	0.001	1.31 (0.93, 1.83)	0.124
Occupation								
Professional/ managerial	1.00		-		1.00		1.00	
White collar/ administrative	0.99 (0.68, 1.45)	0.976	-		0.74 (0.46, 1.18)	0.201	1.12 (0.66, 1.90)	0.683
Blue collar	[c]		-		0.20 (0.13, 0.29)***	$p < 0.001$	0.28 (0.18, 0.45)***	$p < 0.001$
Annual gross household income								
Less than $60,000	1.00		1.00		1.00		1.00	
$60,000-$125,000	2.30 (1.37, 3.87)**	0.002	2.71 (1.53, 4.79)**	0.001	2.49 (1.44, 4.31)**	0.001	1.62 (0.89, 2.93)	0.113
$125,000+	2.02 (1.19, 3.41) **	0.009	2.61 (1.38, 4.95)**	0.003	4.37 (2.53, 7.54)***	$p < 0.001$	1.86 (1.00, 3.45)*[f]	0.049
Don't know/ Preferred not to say	0.68 (0.23, 2.00)	0.480	1.04 (0.33, 3.31)	0.944	1.49 (0.52, 4.27)	0.462	0.77 (0.25, 2.41)	0.656
Average weekday hours worked	1.10 (0.97, 1.25)	0.130	1.11 (0.98, 1.27)	0.107	1.28 (1.17, 1.40)***	$p < 0.001$	1.26 (1.14, 1.39)***	$p < 0.001$
Health-related factors								
Leisure-time physical activity (mins/week)[d]	0.99 (0.98, 1.01)	0.442	0.99 (0.97, 1.01)	0.269	0.99 (0.98, 1.00)	0.123	0.98 (0.97, 1.00)*[f]	0.014
Smoking status								
Current smoker	1.00		-		1.00		-	
Ex-smoker	1.03 (0.40, 2.67)	0.953	-		2.07 (1.07, 3.98)*	0.030	-	
Non-smoker	1.22 (0.48, 3.07)	0.673	-		2.17 (1.15, 4.08)*	0.017	-	
BMI (kg/m^2)	1.01 (0.98, 1.04)	0.586	-		1.02 (0.99, 1.05)	0.208	-	
Energy intake (kJ/day)[e]	1.00 (0.99, 1.01)	0.414	-		0.99 (0.99, 1.00)* [f]	0.028	-	
Alcohol consumption (g/day)								
≤10	1.00		1.00		1.00		-	
>10- ≤ 20	1.63 (0.99, 2.70)	0.054	1.53 (0.91, 2.57)	0.108	0.86 (0.58, 1.29)	0.474	-	
>20	1.22 (0.76, 1.98)	0.411	1.11 (0.67, 1.83)	0.693	0.92 (0.67, 1.27)	0.626	-	

Table 2 Socio-demographic attributes and health-related factors associated with high occupational sitting time compared with low occupational sitting time: stratified by gender *(Continued)*

Sitting time								
TV viewing time (average hours/day)	0.99 (0.82, 1.20)	0.937	1.06 (0.86, 1.29)	0.601	0.87 (0.76, 1.00)	0.052	1.00 (0.86, 1.17)	0.958

Women: low work sitting category ($n = 264$); high work sitting category ($n = 202$). Men: low work sitting category ($n = 459$); high work sitting category ($n = 310$)
*$p < 0.05$ **$p < 0.01$ ***$p < 0.001$
[a]Logistic regression model for women adjusted for age, marital status, household income, average weekday hours worked, alcohol consumption, leisure-time physical activity and TV viewing time
[b]Logistic regression model for men adjusted for age, educational attainment, children in the household, occupation, household income, average weekday hours worked, leisure-time physical activity and TV viewing time
[c]Women in blue collar occupations were excluded from this analysis due to the small number of blue collar workers in the high occupational sitting group
[d]OR corresponds to each additional 30 min/week of leisure-time physical activity
[e]OR corresponds to each additional 100 kJ of energy consumed per day
[f]Significant confidence intervals include the value of 1.00 due to rounding

sitting/high TV group compared to the low occupational sitting/low TV group. Of the health-related factors, energy consumption was positively associated, while leisure-time physical activity was negatively associated, with being in the high occupational sitting/high TV viewing time group relative to the low occupational sitting/low TV viewing group, although effect sizes were small.

The factors identified above, apart from household income, were associated with the high occupational sitting/high TV viewing category only and not either of the other two occupational sitting/TV viewing categories. In contrast, higher household income was also associated with higher risk of being in the high occupational sitting/low TV viewing category compared to the low occupational sitting/low TV viewing group. Age was positively associated with being in the low occupational sitting and high TV viewing, relative to the low occupational sitting/low TV viewing group, but no significant association was observed between age and the high occupational sitting groups.

Table 3 Associations of socio-demographic and health-related factors with occupational sitting/TV viewing time categories – women

	Low occupational sitting/High TV viewing time ($n = 111$)		High occupational sitting/Low TV viewing time ($n = 127$)		High occupational sitting/High TV viewing time ($n = 75$)	
Correlates	RRR (95 % CI)	*p*	RRR (95 % CI)	*p*	RRR (95 % CI)	*p*
Socio-demographic						
Age	1.07 (1.03, 1.12)**	0.001	0.97 (0.94, 1.01)	0.190	1.02 (0.97, 1.07)	0.430
Marital status						
De-facto/married	1.00		1.00		1.00	
Separated/divorced/ widowed	0.47 (0.22, 0.99)*	0.048	1.35 (0.68, 2.70)	0.393	1.58 (0.72, 3.47)	0.252
Single	1.87 (0.59, 5.95)	0.288	1.92 (0.63, 5.85)	0.253	3.89 (1.23, 12.26)*	0.021
Annual gross household income						
Less than $60,000	1.00		1.00		1.00	
$60,000-$125,000	0.85 (0.42, 1.70)	0.648	2.52 (1.19, 5.33)*	0.015	2.85 (1.26, 6.49)*	0.012
$125,000+	1.04 (0.48, 2.22)	0.924	2.83 (1.24, 6.49)*	0.014	2.51 (0.96, 6.56)	0.062
Don't know/ Preferred not to say	0.83 (0.26, 2.68)	0.759	0.86 (0.19, 3.87)	0.842	1.22 (0.21, 6.99)	0.821
Average weekday hours worked	0.91 (0.76, 1.10)	0.346	1.15 (0.99, 1.35)	0.075	0.91 (0.72, 1.14)	0.416
Health-related						
BMI	1.03 (0.99, 1.08)	0.141	1.00 (0.96, 1.05)	0.965	1.04 (0.99, 1.09)	0.107
Leisure-time physical activity (mins/week)[a]	0.98 (0.96, 1.00)	0.073	0.99 (0.97, 1.01)	0.297	0.97 (0.94, 1.00)*[c]	0.040
Energy consumption (kJ/day)[b]	1.01 (1.00, 1.02)	0.108	1.00 (0.99, 1.02)	0.696	1.02 (1.00, 1.03)*[c]	0.024

Multinomial logistic regression model: reference group is low occupational sitting time, low TV viewing time ($n = 153$)
Multinomial logistic regression model results presented are adjusted for all other variables included in the table
RRR: Relative risk ratio; CI: confidence interval
*$p < 0.05$ **$p < 0.01$
[a]RRR corresponds to each additional 30 min/week of leisure-time physical activity
[b]RRR corresponds to each additional 100 kJ of energy consumed per day
[c]Significant confidence intervals include the value of 1.00 due to rounding

Table 4 Associations of socio-demographic and health-related factors with occupational sitting/TV viewing time categories – men

	Low occupational sitting/ High TV viewing time (n = 256)		High occupational sitting/ Low TV viewing time (n = 162)		High occupational sitting/ High TV viewing time (n = 148)	
Correlates	RRR (95 % CI)	*p*	RRR (95 % CI)	*p*	RRR (95 % CI)	*p*
Socio-demographic						
Age	1.04 (1.01, 1.07)**	0.004	1.02 (0.99, 1.05)	0.262	1.01 (0.98, 1.04)	0.472
Educational attainment						
High school or less	1.00		1.00		1.00	
Technical/vocational	1.06 (0.64, 1.77)	0.812	0.68 (0.36, 1.26)	0.218	0.55 (0.30, 0.99)*	0.045
Bachelor's degree or higher	0.58 (0.30, 1.12)	0.103	1.06 (0.54, 2.09)	0.869	0.72 (0.37, 1.41)	0.341
Child at home	1.41 (0.92, 2.16)	0.110	2.20 (1.36, 3.55)**	0.001	1.17 (0.73, 1.89)	0.519
Occupation						
Professional/managerial	1.00		1.00		1.00	
White collar/ administrative	2.69 (1.29, 5.60)**	0.008	1.74 (0.75, 4.06)	0.198	2.31 (1.05, 5.07)*	0.037
Blue collar	1.76 (1.08, 2.86)*	0.022	0.36 (0.18, 0.69)**	0.002	0.42 (0.23, 0.80)**	0.008
Annual gross household income						
Less than $60,000	1.00		1.00		1.00	
$60,000-$125,000	1.12 (0.63, 1.98)	0.694	3.30 (1.17, 9.32)*	0.024	1.21 (0.57, 2.57)	0.618
$125,000+	1.57 (0.83, 2.98)	0.162	3.76 (1.30, 10.88)*	0.015	1.90 (0.86, 4.19)	0.114
Don't know/Preferred not to say	2.57 (0.76, 8.66)	0.127	2.29 (0.39, 13.58)	0.363	1.09 (0.22, 5.46)	0.916
Average weekday hours worked	0.82 (0.72, 0.94)**	0.005	1.27 (1.12, 1.45)***	$p < 0.001$	1.00 (0.87, 1.15)	0.991
Health-related						
BMI	1.05 (1.01, 1.10)*	0.024	1.03 (0.98, 1.09)	0.252	1.05 (1.00, 1.11)*[c]	0.045
Leisure-time physical activity (mins/week)[a]	0.98 (0.97, 1.00)*[c]	0.022	0.98 (0.96, 1.00)* [c]	0.014	0.97 (0.96, 0.99)**	0.003
Energy consumption (kJ/day)[b]	1.01 (1.00, 1.01)	0.106	0.99 (0.99, 1.00)	0.220	1.01 (1.00, 1.01)	0.209

Multinomial logistic regression model: reference group is low occupational sitting time, low TV viewing time ($n = 203$)
Multinomial logistic regression model results presented are adjusted for all other variables included in the table
RRR: Relative Risk Ratio; CI: confidence interval
*$p < 0.05$ **$p < 0.01$ ***$p < 0.001$
[a]RRR corresponds to each additional 30 min/week of leisure time physical activity
[b]RRR corresponds to each additional 100 kJ of energy consumed per day
[c]Significant confidence intervals include the value of 1.00 due to rounding

For men (Table 4), occupation was a significant correlate of combined high levels of occupational sitting and TV viewing time. Compared to men in managerial/professional occupations, men in blue collar occupations were less likely to be in the high occupational sitting/high TV viewing group than the low occupational sitting/low TV viewing group, while men in white collar/administrative jobs were more likely. Having a technical/vocational level of educational attainment (ref: high school or less) was associated with a lower relative risk of being in the high occupational sitting/high TV viewing group compared to the low occupational sitting/low TV viewing group. Of the health-related factors, higher levels of LTPA were associated with reduced risk of high occupational sitting/high TV viewing, and a lower risk of being in each of the other two high sitting groups (low occupational sitting/high TV, high occupational sitting/low TV), compared to the low occupational sitting/low TV viewing group. As BMI increased, there was a corresponding increase in the relative risk of being in the high occupational sitting/high TV group, as well as the other high TV category (low occupational sitting/high TV group) compared to the low occupational sitting/low TV viewing group

Attributes associated with the other two occupational sitting/TV viewing categories for men included occupation, income, hours worked and having a child at home. Compared with men in managerial/professional occupations, blue collar workers were also less likely to be in the other high occupational sitting group (high occupational sitting/low TV viewing) while white collar workers were more likely to be in the other high TV viewing group (low occupational sitting/high TV viewing), compared to the low occupational sitting/low TV viewing group. Income had a positive association with being in the high occupational sitting/low TV group only (although confidence intervals were wide), while having a child at home was also associated with increased likelihood of

being in this group, compared to the low occupational sitting/low TV viewing group. An increase in hours worked per day was associated with a lower risk of being in the low occupational sitting/high TV viewing group and a higher risk of being in the high occupational sitting/low TV viewing group, compared to the low occupational sitting/low TV viewing group.

Discussion

Research on the correlates of occupational sedentary behaviour is still in its infancy, despite growing interest in workplace-based initiatives to address excessive sitting time. In this sample of full-time Australian workers, we observed variations between women and men in the attributes associated with high occupational sitting, and high occupational sitting and TV viewing time in combination.

Correlates of high occupational sitting time

Of the socio-demographic attributes, household income was the strongest correlate of high occupational sitting in both women and men. This is consistent with other studies [10, 13] and is likely to reflect the tendency for many higher paid jobs to be office-based. For women, the only other significant correlates were age and marital status. Separated/divorced or widowed participants were found to be more likely to be in the high occupational sitting category than married/de facto women and the odds of having high occupational sitting decreased with age. Others have also reported a similar finding of lower levels of occupational sitting with increasing age [13, 33], although the reasons for this association are unclear. As our models controlled for the number of hours worked it appears unlikely that this is due to older people working fewer hours.

Other factors were identified as correlates amongst men only. Similar to previous findings [11, 12], men employed in white collar or managerial/professional occupations were more likely to have higher levels of occupational sitting than blue collar workers. Considering the tasks and roles performed by these occupational groups – which are likely to be office-based – this is not overly surprising. The small number of women employed in blue collar occupations precluded exploration of whether this association also holds for women in our sample, but others have confirmed this association amongst women in an Australian population [12].

Correlates of high occupational sitting and high TV viewing time

In line with the identified correlates of high occupational sitting on its own, higher household income was associated with an increased likelihood of being in each of the two high occupational sitting groups for women, relative to the low occupational sitting, low TV viewing group. Interestingly, single women were more likely to have high levels of both occupational sitting and TV viewing time than married/de facto women, which may be due to fewer domestic responsibilities. Few studies have explored the association between marital status and sedentary behaviours by gender. One previous study found support for higher levels of TV viewing amongst single women compared to women who were married or in de facto relationships [34], however another [22] found no significant differences by marital status. In a sample of working adults of both genders Clemes et al. [35] found higher daily sitting times on workdays for those who were single, divorced or widowed, compared with those who were married/de facto, including higher levels of sedentary leisure activities. However, no differences were observed for sitting time at work.

Amongst men, blue collar workers (compared with managerial/professional workers) were more likely to be in the high TV viewing categories and less likely to be in the high occupational sitting/low TV viewing category. Workers in manual jobs tend to have higher levels of occupational physical activity than white collar or professional workers [36, 37] which could suggest a compensatory effect. However, previous studies have generally found no difference in leisure-time sitting between those with high and low occupational sitting time [11, 38, 39] and Chau et al. [40] found that workers in physically demanding/heavy labour occupations were less likely to have high levels of leisure-time sitting. Alternatively, occupational category may be a proxy measure for socioeconomic position in this sample; people in lower socioeconomic groupings have been found to spend more time watching TV [41].

Certain health-related factors were also associated with higher levels of occupational sitting and TV viewing time, which is broadly consistent with what has been reported by previous studies [42, 43] suggesting that high levels of sitting may occur alongside other unhealthy behaviours. For women, energy intake was positively associated with being in the "high risk", high occupational sitting/high TV group compared with the low occupational sitting/low TV viewing group. For men BMI was positively associated with being in both high TV viewing groups (combined with both low and high occupational sitting), suggesting that this association may be more of a reflection of the levels of TV viewing than the high occupational sitting. Higher levels of TV viewing time have previously been found to be associated with higher consumption of high energy snack foods [44] and increased risk of obesity [19, 45]. It is of interest however, that no association was observed between high sitting time and BMI for women, in light of the higher energy intake for those in the high occupational sitting, high TV viewing group.

Leisure-time physical activity (LTPA) appeared to be more strongly associated with occupational sitting time amongst men than women. For men, higher levels of LTPA were associated with a lower likelihood of high occupational sitting, and being in each of the three high categories of occupational sitting/TV viewing. For women, higher physical activity levels were significantly associated with a lower risk of being in the high occupational sitting/high TV category, but the magnitude of the association was small. We found no evidence to support a 'compensation' effect– whereby participants with high levels of workplace sitting undertake more physical activity in their leisure time [40]. In contrast, it appears that those who were engaged in the lowest levels of sitting during the day, particularly for work, were also more likely to be active during leisure time and this association was observed to be stronger for men than women. Studies using both objective and self-report measures of sitting time have reported weak correlations between LTPA and sedentary behaviour [5, 46]; however these generally have not been stratified by gender. Further research is needed to explore potential associations between occupational and leisure sitting time with LTPA, including separately for women and men.

The observation that a number of health-related correlates were associated with being in the group with high occupational sitting and high TV viewing suggests that an intervention that also includes elements targeting other health behaviours (e.g. healthy eating; promotion of leisure-time physical activity) in conjunction with efforts to reduce sedentary behaviour may be of benefit to those with high levels of occupational sitting time and low levels of occupational physical activity. The workplace has previously been identified as a key target setting for implementing health promotion interventions more generally, with workplace interventions found to be beneficial for increasing physical activity, improving fitness levels and reducing diabetes risk [47, 48]. Knowledge gained from previous successful programs that have targeted, for example, physical activity and healthy food choices, may be useful for the design of workplace interventions to reduce sedentary behaviour. To ensure maximum impact, it will be important to ensure that such programs capture those most at risk (e.g. high levels of occupational sitting and high TV viewing time with low levels of leisure-time physical activity and poor diet quality).

Further research is needed to identify potentially modifiable environmental and social correlates of occupational sitting. Our findings were in line with previous research [10–13] indicating that work-related factors – occupation and income levels – were correlates of high levels of occupational sitting time. As such, exploration of the relative influence of the workplace environment and broader workplace culture is likely to be beneficial, as they may be key drivers of sedentary behaviour [49]. This could include studying organisational strategies common in some office-based organisations such as job rotation, hot-desk arrangements and flexible working patterns. In the context of increasing interest in the effectiveness and feasibility of implementing activity-permissive work practices in the office environment [50], there is a need for high quality evidence on the multiple individual and interacting influences on occupational sedentary behaviour.

Strengths of this study include the large sample of workers from a range of backgrounds, located across urban and regional areas of Australia. The analysis of a range of potential socio-demographic and health-related correlates of both occupational sitting and TV viewing time is also an important contribution. However, there are some limitations. While participants in AusDiab were originally recruited as a population-based sample, those who participated in the 2011/12 follow-up were younger, less likely to live in a socioeconomically disadvantaged area, had a higher level of education and lower BMI than those who didn't participate [51]. This is similar to factors relating to attrition in another large Australian longitudinal survey [52] and may have introduced bias into our results. As this was a 12 year follow up, participants were also generally older (median age 53), with limited representation of younger workers. These factors should be taken into consideration when interpreting our findings. Investigating whether patterns of sedentary behaviour differ in younger (i.e. less than 35 years) and older workers would be beneficial as their experiences with technology and work environments are likely to differ.

Another potential limitation is that occupational sitting time and TV viewing time were self-reported. Self-report measures permit investigation of sitting in particular domains (e.g. work, leisure), which was of interest to this study. However, the reliance on self-report may have introduced recall error, including possible misclassification of the outcome measure. While a number of self-report questions on occupational sitting time and TV viewing time, such as the ones used in the present study, have previously been validated and considered to be acceptable for use in population-level studies [15, 25], it has been suggested that they may not be highly accurate on an individual level, particularly for low and high levels of sitting [15, 25, 53]. However, as these measures were used in this study to categorise participants into dichotomous low/high categories, misclassification of the outcome is expected to be minimal. The nature of the occupational sitting time question used in this cohort study also precluded examination of patterns of sitting amongst adults who work non-standard weeks, for example, shift workers

or casual workers. Consequently, assumptions were made that participants worked a similar number of hours across each weekday. Further studies should seek to explore correlates of sitting amongst workers from a range of different working patterns. Objective measurement of sitting time combined with the use of self-report diaries or location sensors could enable more accurate measurement of occupational sitting time, including capturing the time of day for both work hours and sitting time and the length of time spent in prolonged bouts of sitting. Furthermore, the cross-sectional design of this study precludes inferences regarding causality, restricting analysis to correlates, rather than determinants of sitting time.

Conclusions

Socio-demographic attributes (higher household income; being separated, divorced or widowed; and younger age amongst women; professional/managerial occupation and higher educational attainment amongst men), were identified as correlates of high occupational sitting time, while certain health-related factors (lower leisure-time physical activity; higher BMI amongst men, higher energy consumption amongst women) were also associated with high levels of occupational sitting and TV viewing in combination. As some of the attributes associated with high occupational sitting, and high occupational sitting/high TV viewing time differed between women and men, targeted sitting time reduction strategies according to gender may need to be considered. Building this evidence base on occupational sedentary behaviour will assist in the development of approaches needed to address an emerging work health and safety issue.

Availability of data and materials

Not applicable

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

DD and NO contributed to the development of the overall survey and the measures used. NH, BL, DD and NO contributed to the conception and design of the study. NH undertook data analysis and interpretation and drafted the manuscript. All authors were involved in manuscript development and critical review for important intellectual content. All authors read and approved the final manuscript.

Authors' information

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2.3 Summary and implications of the findings

Key findings from this study were that high levels of occupational sitting time (defined as > 6 h/day) were associated with higher household income, older age (amongst women only), higher educational attainment and professional/managerial occupations (men only). Correlates of high occupational sitting time and TV viewing time in combination also differed between genders. For women, increased risk of being in the high sitting group for both of these behaviours (relative to the low sitting group for both) was associated with being single (relative to de facto/married), having higher energy consumption and lower levels of LTPA. For men, increased risk of being in the high occupational sitting, high TV viewing group was associated with higher BMI and having lower levels of LTPA. In addition, men in white collar/administrative roles were more likely to be in this group, and men in blue collar occupations less likely, than men in professional/managerial roles.

These findings support other research conducted just prior to the present study (181, 184) suggesting that characteristics indicative of a higher socio-economic position (higher education and income) are associated with spending more time sitting at work, but not necessarily more time watching TV. People with higher educational attainment and income may be more likely to work in roles that require seated, computer-based work – for example, knowledge-intensive jobs (225). Men in blue collar occupations were less likely to be in the high occupational sitting group compared to men in professional/managerial roles, also confirming previous research (123, 179-181). Overall, this suggests that male workers in manual roles are less likely to be exposed to high levels of sitting and therefore may have less need for specific workplace interventions. Due to a small number of women reporting working in blue collar occupations in this sample, it was not possible to assess whether this association existed for both genders.

This study adds to the knowledge base relating to correlates of workplace sitting time, supporting some previous evidence and suggesting avenues for further confirmatory research. However, it also adds a unique element by examining factors that might be associated with high levels of workplace sitting time and TV viewing in combination. One of the key findings was that high levels of sitting at work and TV viewing may cluster with other health risk factors, including low levels of LTPA, higher BMI and increased energy consumption. When considering these findings in conjunction with the available evidence linking TV viewing time with health outcomes, those identified as being in this highly sedentary group may be an important group to target within the workplace setting.

As noted in the paper, these findings suggest that comprehensive, multi-faceted workplace health or chronic disease prevention programs may be of benefit for those with multiple health risk

factors. These could incorporate education and preventive strategies relating to physical inactivity and nutrition alongside strategies to reduce sedentary behaviour (both at work and at home). Knowledge gained from previous successful workplace interventions targeting these other risk factors may be beneficial for informing the more recent field of workplace sedentary behaviour interventions.

The strengths and limitations of this study are detailed in the paper. While AusDiab was originally representative of the Australian population, AusDiab3 was a 12 year follow-up and participants in the present study represented an older cohort (mean age 53 years), with a greater proportion of men than women. This limits the generalisability of these findings, particularly in relation to younger workers. Another potential limitation was the use of self-reported sitting time, which has been found to be less accurate than objective measures (226) and can potentially introduce recall error or social desirability bias. However, as this data was used for categorising participants into dichotomous categories, the risk of bias is considered to be minimal (226).

The absence of information on the number of hours participants worked per day may also have contributed to errors in the calculation of average sitting time. Assumptions made that participants' reported work hours were accumulated across five days, meant that our measure of average occupational sitting time is unlikely to have reflected actual behaviour for those with non-standard working weeks, including casual and shift workers. In addition, by categorising participants' sitting time into low or high categories, information was lost about the specific amount of sitting time accumulated, affecting power and the ability to examine possible linear associations between potential correlates and sitting time. A specific issue with the categorisation of occupational sitting time and TV viewing time was that it resulted in small cell sizes in Tables 3 and 4. As indicated by the wide confidence intervals surrounding some of the estimates, it is unlikely that these analyses were sufficiently powered. Caution should therefore be taken in the interpretation of these estimates, ensuring consideration of the size of the confidence intervals. There is a need for replication of the present findings within larger studies. Addressing some of these measurement limitations, Chapter 3 aimed to assess the correlates of workplace sitting time in a group of office-based workers, using an objective, postural-based measure of sitting time.

CHAPTER 3

CORRELATES OF OBJECTIVELY MEASURED WORKPLACE SITTING TIME

Chapter 2 identified certain socio-demographic and work-related attributes to be correlates of occupational sitting time. As noted in section 2.3, a limitation of this study was the use of a self-report measure to assess occupational sitting time. While self-report measures of sitting time are practical and cost-effective for large cohort studies such as AusDiab (26), the correlation with objective measures has often been found to be low-moderate, with wide variation between individuals (29, 226). In particular, Clark et al. (226) found that differences between self-reported workplace sitting and accelerometer-derived workplace sedentary time were greatest at the lowest and highest levels of sitting, which has implications for accurately identifying the amount of workplace sitting time accrued by those at the high end. Previous studies that have specifically aimed to examine the potential correlates of workplace sitting time have also been based on self-report measures (181, 184). To reduce the potential for bias, and gain a more comprehensive understanding of the potential correlates of workplace sitting time, studies using objective measures of sitting are needed.

Another advantage of objective measures of workplace sitting time, such as the activPAL, is the ability to provide insights into accumulation patterns of sitting time (32). Previous research suggests that office workers accumulate approximately half of their workplace sitting time in prolonged bouts of 30 minutes or more (5, 105); a pattern which may be associated with a poor cardiometabolic risk profile (73, 79, 81). Understanding the correlates of high levels of workplace sitting time accumulated in prolonged bouts may assist with designing strategies to encourage more frequent breaks in sitting. Only one study (188) has investigated potential correlates of patterns of sitting accumulation, using a self-reported measure of break frequency. Two factors were significantly associated with break frequency, specifically, less frequent breaks: a perceived lack of time amongst men, and a lack of information about taking short physical activity breaks amongst women (188). The main limitation was the self-report measure, which only assessed typical break frequency during working hours and did not provide an indication of the duration of sitting periods.

The ecological model of sedentary behaviour proposes that the factors influencing sedentary behaviour are likely to operate at multiple levels including individual, interpersonal, environmental and policy-levels (102). As discussed in section 1.7.3, studies assessing the correlates of workplace sitting have predominately focused on individual-level factors, such as

socio-demographic and work-related attributes (181, 183, 184, 227). However, within the workplace environment, factors acting at the broader organisational-level may also influence the amount of sitting time workers accumulate across the day. Determining the relative influence of individual-level versus organisational-level factors on workplace sitting may provide important insight to inform the design and targeting of intervention strategies.

To address the limitations of the study reported in Chapter 2 and prior research, this chapter includes a peer-reviewed paper published in *Preventive Medicine Reports* which aimed to examine the worksite-level variation, and the socio-demographic, health-related, work-related, and social-cognitive correlates of objectively-assessed total and prolonged workplace sitting time in Australian office-based workers participating in the Stand Up Victoria (SUV) cluster randomised controlled trial. The methodology of SUV is presented firstly in section 3.1 to provide context, followed by the peer-reviewed publication in section 3.2. This chapter uses data from the baseline assessment prior to initiation of the intervention. Chapter 5 uses data from all three time points (baseline, 3 months and 12 months) of SUV, while Chapter 6 uses data from the qualitative component of SUV that occurred after the 12 month assessment.

3.1 Stand Up Victoria methods

3.1.1 Study design and participant recruitment

SUV was a two-arm, cluster randomised controlled trial assessing the efficacy of a multi-component workplace intervention on reducing workplace sitting time in office workers. The full intervention was delivered for three months, with sit-stand workstations retained for 12 months. Assessments were conducted at baseline, three months and 12 months for control and intervention participants.

Study participants were drawn from 14 geographically separate (≥ 1 kilometre apart) worksites (clusters) from the Department of Human Services (DHS), a federal government department in Victoria, Australia. Worksites were selected as potentially eligible if they were not currently delivering a physical activity intervention to employees. At each worksite a team (i.e., a distinct group with dedicated team leader(s) and regular group meetings) was identified for participation. A second team was added if the original team size was less than 10 employees. Randomisation to control or intervention conditions occurred at the worksite level through a simple cluster randomisation process, performed by a research staff member not involved in data collection or recruitment.

Participants were recruited between April 2012 and October 2013 through a rolling recruitment process by worksite. Inclusion criteria for participation included: working ≥0.6 full time equivalent hours (FTE), aged 18–65 years, speaking English, and having designated access to a telephone, internet and desk within the workplace. Exclusion criteria were: pregnancy, being non-ambulatory, having a pre-existing musculoskeletal complaint, and/or having a planned absence from work for >2 weeks or a planned relocation to another workplace during the first three months of the intervention.

3.1.2 Intervention

SUV was a multi-component intervention, with individual, organisational and environmental-level components. In brief, the key intervention messages were to *Stand Up* (breaking up prolonged bouts of sitting), *Sit Less* (reduce overall sitting time across the day) and *Move More* (increase overall physical activity across the workday). The intervention was developed through extensive formative research (5, 106) and was informed by social cognitive theory (228) and an ecological model of sedentary behaviour (99, 102). The intervention development has been described in detail previously (207).

Individual-level components: Health coaching was provided to participants for the first three months to support individual-level behavioural change. An initial face-to-face session was held shortly after the workstation was installed, with follow-up telephone calls at weeks 2, 4, 8 and 12. The initial session was used to explain the key intervention messages, provide participants with feedback on their activity from the baseline assessment, and to identify individual goals and behaviour change strategies to achieve the intervention messages. Participants were encouraged to record goals and strategies on a laminated "workstation tracker" and place this within eyesight. Follow-up phone calls were used to assess progress towards goal attainment, including problem solving any issues that had arisen.

Organisational-level components: Organisational level support for the SUV intervention was facilitated through initial consultation with senior management to gain permission for the trial, and a consultation workshop with DHS staff representatives (from multiple levels of seniority), to provide information and brainstorm strategies that could be implemented. A further information and brainstorming session took place with all participants to provide details about the trial, discuss strategies identified in the representatives' consultation and brainstorm other potential worksite-level strategies that could be implemented. This ensured a participatory approach to selection of intervention strategies at each worksite. Ongoing organisational support

was provided by team champions (typically team leaders) at each worksite who promoted participation in the study and were responsible for sending out tailored emails to their team (templates designed by the researchers that could be modified to suit the needs of each team). These emails were sent out every two weeks for the first three months to convey management support for the intervention.

Environmental-level component: Intervention participants were provided with a dual-screen sit-stand workstation (Ergotron WorkFit-S) for 12 months, which was retrofitted to existing desks. This model allowed participants to easily change postures between sitting and standing by raising or lowering the platform. Participants were also provided written information about correct ergonomic posture when using the workstations.

3.1.3 Procedures

Participants at control sites continued with their normal work practices but underwent the same assessments as intervention participants. Assessments to collect data on the anthropometric measures and cardiometabolic markers were undertaken at each worksite by project staff at baseline (prior to installation of the sit-stand workstation), three months (after cessation of health coaching) and at 12 months. At the assessments, participants were provided with activPAL3 and ActiGraph GT3X activity monitors and instructed to wear these for the seven days following the assessment. The ActiGraph was worn during waking hours only (apart from water-based activities), while participants were instructed to wear the activPAL continuously. Participants were asked to record work hours, wake and sleep times, and device removals greater than 15 minutes in a diary. Written feedback on activity and biomarker outcomes was provided for intervention participants after each assessment, while for control participants this was only provided at three months (for baseline and three month data) and 12 months. Following each assessment participants were also emailed a unique link to complete an online survey (229). Details of the survey measures are provided below.

3.1.4 Outcome measures

Details on the outcome measures of interest for this thesis are provided below. Comprehensive information about all other variables measured in SUV, including cardiometabolic biomarkers, is provided elsewhere (230).

Activity outcomes

Data on workplace sitting, standing and stepping time were obtained from the activPAL activity monitor, using a customised SAS program (SAS Institute Inc. Cary, NC). This included total time spent sitting at work and prolonged sitting time, defined as sitting time accrued in bouts of 30 minutes or more in length. Total workplace sitting time and prolonged workplace sitting time were standardised to an 8-h day using the formula: standardised minutes = minutes of sitting time x 480/observed minutes at the workplace). Data from the GT3X was used to determine time spent in MVPA.

Anthropometric

Waist circumference and hip circumference (to the nearest 1cm) were measured by trained research staff at each assessment. Waist circumference was taken at the midpoint between the lowest rib and the iliac crest. Hip circumference was taken as the maximum circumference in the horizontal plane over the buttocks. Two measurements were taken, with a third taken if these two differed by more than 1cm. Weight to the nearest 0.1kg, fat mass, fat-free mass and percent body mass were measured using a bioelectrical impedance analysis scale. Height was measured to the nearest 0.1cm using a portable stadiometer, with two measurements taken (or a third if the first two differed by 0.5cm or more). Body mass index (kg/m^2) was calculated from height and weight measures.

Survey measures

Socio-demographic: Socio-demographic characteristics were obtained at baseline only. Participants reported their date of birth; gender; ethnicity (Caucasian or white; Aboriginal or Torres Strait Islander; Middle Eastern; Asian; Pacific Islander; Hispanic/Latino; Other); marital status (married or living together; married but separated; divorced; widowed; never married); and highest level of education (never attended school; some primary school; completed primary school; some high school; completed high school; TAFE or trade certificate or diploma; University; CAE or some other tertiary institute including post university).

Work-related: Participants were asked to report their tenure at the current workplace (less than 3 months; between 3 and 12 months; between 1 and 3 years; between 3 and 5 years, more than 5 years); occupation (managers and administrators, professionals, associate professionals, tradespersons and related workers, clerical and service workers, clerical sales and service

workers, intermediate production and transport workers, labourers and related workers); and full-time equivalent (FTE).

Health-related: The Nordic Musculoskeletal Questionnaire (231), modified to include references to the preceding seven days and three months, was used to assess musculoskeletal health. The frequency of experiencing a number of health problems associated with stress over the past month (such as migraines, digestive problems and poor sleep quality) was assessed. The survey also included questions on smoking status (in general and at work), self-reported history of diabetes and hyperlipidaemia. Quality of Life was assessed using the Australian Quality of Life Survey (AQoL-8D) which enables the calculation of eight separately scored dimensions that can be combined to form two "super dimensions" – physical and mental (232).

Social-cognitive factors: Knowledge, barrier self-efficacy, perceived behavioural control and perceived organisational social norms were assessed on 5-point Likert scales (strongly disagree to strongly agree). As no pre-existing social-cognitive measures relating to workplace sitting existed, these scales were adapted from the physical literature, or developed specifically for the study, and had been previously pilot-tested (5). Further details of these measures, including the internal consistency and individual items comprising the scales are provided in Chapter 5. Participants were also asked their preference for sitting and standing at work (5-point scale ranging from none of the time to 80-100% of the time). Two items from the Health and Work Questionnaire assessed job control and overall stress on 10-point scales (1 = no control, 10 = total control; 1 = not stressed at all, 10 = very stressed) (233).

3.1.5 Qualitative component of Stand Up Victoria

At the 12 month assessment, participants in the intervention group were asked through a question in the online survey tool whether they wished to participate in qualitative research aimed at understanding the feasibility and acceptability of the SUV intervention. From those who expressed interest (n=56), a sample were chosen to participate in interviews and focus groups. Face-to-face and telephone-based interviews (n=21), and two focus groups (n=7), were conducted with a mix of employees and team leaders across the seven intervention sites. Interview guides were developed based on the following themes: intervention acceptability, overall impact, barriers and facilitators to reducing workplace sitting, and perceived impact on productivity and workplace culture. Further details of the methodology of this component are provided in Chapter 6, which reports the study findings.

3.2 Office workers' objectively assessed total and prolonged sitting time: individual-level correlates and worksite variations

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Office workers' objectively assessed total and prolonged sitting time: Individual-level correlates and worksite variations

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ABSTRACT

Sedentary behavior is highly prevalent in office-based workplaces; however, few studies have assessed the attributes associated with this health risk factor in the workplace setting. This study aimed to identify the correlates of office workers' objectively-assessed total and prolonged (≥30 min bouts) workplace sitting time. Participants were 231 Australian office workers recruited from 14 sites of a single government employer in 2012–13. Potential socio-demographic, work-related, health-related and cognitive-social correlates were measured through a self-administered survey and anthropometric measurements. Associations with total and prolonged workplace sitting time (measured with the activPAL3) were tested using linear mixed models. Worksites varied significantly in total workplace sitting time (overall mean [SD]: 79% [10%] of work hours) and prolonged workplace sitting time (42% [19%]), after adjusting for socio-demographic and work-related characteristics. Organisational tenure of 3–5 years (compared to tenure >5 years) was associated with more time spent in total and prolonged workplace sitting time, while having a BMI categorised as obese (compared to a healthy BMI) was associated with less time spent in total and prolonged workplace sitting time. Significant variations in sitting time were observed across different worksites of the same employer and the variation remained after adjusting for individual-level factors. Only BMI and organisational tenure were identified as correlates of total and prolonged workplace sitting time. Additional studies are needed to confirm the present findings across diverse organisations and occupations.

1. Introduction

Exposure to high levels of workplace sedentary (sitting) time has become common, particularly in office environments (Healy et al., 2012). Office-based workers have been reported to spend between two-thirds and three-quarters of their working hours sitting (Thorp et al., 2012; Parry and Straker, 2013; Clemes et al., 2014; Ryan et al., 2011), with a high proportion accrued in prolonged, unbroken bouts of 30 min or more (Parry and Straker, 2013; Ryan et al., 2011). Consistent evidence has linked high levels of sitting with chronic diseases and premature mortality (Biswas et al., 2015; de Rezende et al., 2014) and prolonged sitting with cardio-metabolic risk (Healy et al., 2008). Thus, exposure to excessive workplace sitting is an emerging workplace health and safety issue (Straker et al., 2014).

Despite a growing interest in workplace interventions (Neuhaus et al., 2014a), relatively little is known about factors influencing workplace sitting time; knowledge which could improve targeting of

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strategies. While factors relating to work have been identified as potential correlates (Hadgraft et al., 2015; Mummery et al., 2005; Wallmann-Sperlich et al., 2014; De Cocker et al., 2014), only two studies (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) have assessed cognitive-social factors that may influence sitting time. Both studies noted the need for confirmatory and additional research (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014). Also, no previous studies have analysed potential correlates of prolonged sitting time (i.e. unbroken bouts) to assess whether these attributes differ from those associated with total workplace sitting time.

Existing studies have also used self-report questionnaires to measure sitting time (Hadgraft et al., 2015; Wallmann-Sperlich et al., 2014; De Cocker et al., 2014). Relative to self-report, objective-measurement devices—such as inclinometers—can determine the volumes and accumulation patterns of sitting time with better validity and accuracy (Clark et al., 2011). The use of objective-measures of workplace sitting in studies assessing correlates reduces the potential for measurement error.

The factors influencing workplace sitting are likely to operate at multiple levels – including individual, cognitive-social, environmental, and policy levels (Owen et al., 2011). The extent to which workplace sitting is influenced by factors acting at the individual-level, compared with at the organisational-level, is of interest when considering how interventions should be designed and targeted. This may include whether strategies should be individually-driven and targeted at "high risk" groups and/or aimed at influencing the organisational-level through policy and cultural change. Assessing the variation in sitting time between worksites, before and after accounting for individual-level factors, provides the opportunity to explore such issues.

The aim of this study was to examine the worksite-level variation, and the socio-demographic, health-related, work-related, and cognitive-social correlates of objectively-assessed total and prolonged workplace sitting time in Australian office-based workers. Given limited evidence relating to the correlates of workplace sitting time, including prolonged workplace sitting, this study employed an exploratory, data-driven approach.

2. Methods

2.1. Study design and participants

Participants were recruited for a cluster randomized controlled trial of a multi-component workplace intervention aimed at reducing workplace sitting (the Stand Up Victoria [SUV] trial). They were informed that the study aimed to "investigate the effectiveness of an intervention to increase overall physical activity levels at the workplace". The intervention, detailed elsewhere (Dunstan et al., 2013; Neuhaus et al., 2014b; Healy et al., 2016), comprised organisational-, environmental-(sit-stand workstation), and individual-level strategies. Here, we report findings derived from baseline measurements. In brief, recruitment and randomization occurred at the worksite-level. Fourteen geographically separate worksites were recruited from a single government department (Victoria, Australia). At each site, a work team (i.e., a distinct group with dedicated team leader(s) and regular group meetings) was selected (if team size was <10, two teams were combined). Eligibility criteria included: aged 18–65 years, English-speaking, worked ≥0.6 full time equivalent (FTE) and had designated access to a telephone, internet, and desk within the workplace. Participants did not have height-adjustable desks at baseline. Participants' roles mostly involved telephone-based and clerical/administrative tasks.

Of the 278 who originally expressed interest, 33 were ineligible and 14 were no longer eligible and/or willing to participate at the intervention commencement, leaving 231 participants. Ethics approval was granted by Alfred Health Human Ethics Committee (Melbourne, Australia). The SUV trial was prospectively registered with the Australian New Zealand Clinical Trials Registry (ACTRN12611000742976).

2.2. Data collection

At baseline, trained staff conducted onsite assessments to collect anthropometric measurements, provide participants with activity monitors and logbooks, and give instructions on activity monitor use (see below). Thereafter, participants completed a self-administered online questionnaire (LimeService), containing questions relating to socio-demographic, work, health-related and cognitive-social characteristics.

2.3. Measures

2.3.1. Objectively measured sitting time and moderate-vigorous physical activity (MVPA)

Sitting time was measured objectively using the activPAL3 activity monitor (PAL Technologies Limited, Glasgow, UK) which provides highly accurate measures of sitting time and sitting accumulation (Lyden et al., 2012). Participants were asked to wear the activPAL for seven consecutive days (24 h/day) following the onsite assessment. The monitor was waterproofed and secured to the anterior mid-line of the right thigh, about one third down from the hip, using hypoallergenic adhesive material. During waking hours (apart from water-based activities) participants also wore the tri-axial Actigraph GT3X+ activity monitor (ActiGraph, Pensacola, Florida) on an elastic belt over their right hip. Participants were asked to record sleep and waking times, work hours and any device removals >15 min in a logbook.

Activity monitor data were processed in SAS 9.3 (SAS Institute Inc., Cary NC), with reference to participant logbooks. Quality controls were conducted before (e.g. diary entry errors) and after processing (visual checking). For activPAL data, events were coded as: awake, non-wear, or at work when they were mostly (≥50%) within these periods. Non-wear time and sleep were excluded. Workplace time was taken as all work hours for this employer from any location. Days were considered valid for workplace time when the device was worn for ≥80% of work hours (see Edwardson et al., 2016 for details of compliance). Times spent sitting, sitting for ≥30 min continuously (prolonged sitting), standing and stepping during work hours were averaged from the totals for valid days and standardised to an 8-h day. Time, rather than the number of prolonged bouts, was used as the outcome as it provides a more informative measure of the extent or duration of exposure to this potential health risk.

The GT3X+ data (extracted as 60-s epochs) were used to identify MVPA(Harrington et al., 2011) based on all minutes with ≥1952 vertical acceleration counts (Freedson et al., 1998) on valid days (≥10 h waking wear time). The activPAL estimation of MVPA, using a cadence-based equation, does not have high agreement with referent methods (Harrington et al., 2011). Non-wear time (≥60 min of 0 counts, allowing for up to 2 min with 1–49 counts) (Winkler et al., 2012) was excluded, as was sleep (McVeigh et al., 2015). Non-work time excluded work for any employer, and days the participant reported working but did not indicate work times. Non-work MVPA (min/day) was calculated using a weighted daily average (average non-work day MVPA × 2/7 + non-work time MVPA on work days × 5/7) to account for differences in non-work time on such days and the number of work and non-work days during the monitoring period.

2.3.2. Socio-demographic and health-related variables

Participants reported their age, gender, ethnicity (Caucasian; Asian; other), marital status (married/de facto; separated/divorced/widowed; never married), educational attainment (high school or lower; trade/vocational; university level) and smoking status at work (yes; no). Non-work MVPA was calculated as above. Body mass index (BMI) was calculated from height, measured using a portable stadiometer (average of two measures; third if the difference was ≥0.5 cm), and mass,

measured to the nearest 0.1 kg using bioelectrical impedance analysis scales. BMI was categorised as underweight (BMI < 18.5 kg/m^2), healthy (18.5 — <25 kg/m^2), overweight (25 — <30 kg/m^2) and obese (≥30 kg/m^2). Given only one underweight participant, the underweight and healthy weight categories were combined.

2.3.3. Work-related variables

Individual-level work-related variables included: a measure of working hours – 1.0 FTE (yes; no), tenure at the current workplace (<3 years; 3–5 years; >5 years), and occupational skill level (managers; professionals/associate professionals; clerical/sales/services workers).

2.3.4. Cognitive-social variables

Six cognitive-social constructs were assessed: workspace satisfaction (average of four items); knowledge (five items); barrier self-efficacy (nine items); perceived behavioral control (five items); perceived organisational social norms (eight items); and, frequency of use of self-regulation strategies (10 items). These were adapted from physical activity literature or developed for the trial to be specific to workplace sitting (Dunstan et al., 2013), for example, barrier self-efficacy related to barriers to reducing workplace sitting; perceived organisational social norms related to norms about workplace sitting/standing. Items were measured on 1–5 Likert scales (strongly disagree–strongly agree; not at all confident–very confident; never–very often). Item questions and construct internal consistency are provided in Supplementary Table 1. Cronbach's alpha coefficients ranged from 0.50 (knowledge) to 0.92 (barrier self-efficacy). Two items from the Health Work Questionnaire (Shikiar et al., 2003) assessed job control (*How much control did you feel you had over how you did your job this week*?) and overall stress (*Overall, how stressed have you felt this week*?) on 10-point scales (1 = no control, 10 = total control; 1 = not stressed at all, 10 = very stressed). Participants also self-reported their desired proportion of the day spent sitting at work (categorised as <50%; ≥50%).

2.4. Statistical analyses

Descriptive statistics were calculated for the whole sample and by worksite. To assess the correlates of total and prolonged sitting time (min/8-h workday), linear mixed models were used, with worksite cluster specified as a random effect. Models were limited to participants with complete data for outcomes and covariates (n = 214). Potential correlates were entered in three blocks: (i) socio-demographic and health-related variables; (ii) work-related variables; and (iii) cognitive-social variables. As this study was exploratory in nature, the final adjusted models were obtained using backwards elimination. All potential correlates were forced into the model and variables with the highest p-value removed one-by-one until only those with $p < 0.20$ remained (Faraway, 2002). Age and gender were retained in all models. Likelihood ratio tests were used to assess goodness of fit after variable removal and Akaike's Information Criterion and Bayesian Information Criterion were calculated to compare models. Retained variables from previous blocks were included for successive blocks. Variance Inflation Factors (VIFs) were <2.5 in all models. The minimum difference of interest for total and prolonged sitting time was 45 min (Dunstan et al., 2013).

To assess worksite variation in the outcome variables, the random intercept for worksite was tested by likelihood ratio test. The difference between each worksite-specific mean and the overall mean was estimated using Best Linear Unbiased Predictions. Worksite variation was considered unadjusted, and correcting for compositional effects (i.e., individual attributes not pertaining to work).

Data were analysed in Stata 12.1 (StataCorp LP, College Station, TX); $p < 0.05$ was considered statistically significant.

3. Results

3.1. Participant characteristics

Participant characteristics are presented in Table 1. The majority (69%) were women and 67% were aged 35–55 years, which was broadly typical of all departmental employees (72% women; 59% aged 35-< 55 years) (Department of Human Services, 2014). Most were Caucasian, worked in clerical/administrative roles and had tenures >5 years. The sites were varied in their composition, for example, the proportion university qualified ranged from 14% (site G) to 75% (site D).

On average, approximately four-fifths of working hours were spent sitting, with 42% spent in prolonged sitting bouts. Comparatively less time was spent standing and stepping (Table 2). Sitting time was proportionately higher on work days than non-work days.

3.2. Correlates of total workplace sitting time

In terms of socio-demographic and health-related variables (Block 1), marital status and BMI category were significant correlates of total workplace sitting time, while work smoking status, ethnicity, non-work MVPA and education dropped out of the model (see Table 3). Of the work-related variables (Block 2) only tenure was significantly associated with total workplace sitting. No cognitive-social variables (Block 3) were significantly correlated, with all factors other than knowledge and use of self-regulation strategies dropping out. Adjustment for cognitive-social variables did not significantly alter effect sizes, although the overall test for marital status became non-significant ($p = 0.07$). In the fully adjusted model, participants with an obese BMI averaged 21 min (per 8-h workday) less workplace sitting time (ref: healthy BMI). Tenure of 3–5 years was associated with an average 23 min additional workplace sitting time (ref: >5 years). Participants who were separated, divorced or widowed spent on average 15 min less time sitting (ref: married/de facto). Neither age, nor gender was significant correlates.

The significant variation between sites remained evident across each model. In the final model, the ICC was 0.144 (95% CI: 0.042, 0.388), indicating that 14% of workplace sitting variation was explained by worksite differences (although the margin of error was wide). Fig. 1 shows the worksite variation in total workplace sitting time. Unadjusted, the site average was 378 min/8-h workday (95% CI: 368, 389 min). Worksites varied from 21 min below (worksite A) to 22 min above average (worksite N). After adjusting for socio-demographic and health-related variables, worksites varied from 21 min below (worksite B) through to 27 min above (worksite N) the average (388 min/8-h workday, 95% CI: 357, 418 min).

3.3. Correlates of workplace sitting time accumulated in prolonged bouts

Table 4 shows the correlates of workplace sitting time accumulated in prolonged bouts. BMI category was the only significant Block 1 variable. In Block 2, the only significant correlate was tenure, although occupational category remained in the model. None of the cognitive-social variables (Block 3) were significantly associated with prolonged sitting, although perceived behavioral control and perceived organisational norms remained in the model. The addition of these cognitive-social variables did not attenuate associations of BMI and tenure with prolonged sitting time. Participants who were overweight or obese averaged 50 and 40 min/8-h workday respectively, less prolonged sitting time (ref: healthy BMI). Tenure of 3–5 years was associated with an average 50 min/8-h workday additional prolonged workplace sitting (ref: >5 years). The non-significant variables remaining in the model were estimated with a wide margin of error but indicated potentially large differences in prolonged sitting time (e.g. nearly 1 h difference between professionals/associate professionals and managers).

Table 1
Descriptive characteristics of worksites.

Worksite	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total
Site/team attributes															
Site size*	M	S	M	L	L	L	M	L	M	M	L	M	S	M	
Number in team (s)**	14	30	21	50	180*	150*	25	60	22	74	166*	48	22	18	
n (enrolled)	12	5	13	9	38	17	7	24	11	35	18	25	9	8	231
Predominately phone-based?	No	No	No	No	Yes	Yes	No	Yes	No	Mixed	Mixed	Yes	Mixed	No	
Individual attributes															
n (complete demographics)	12	5	13	8	36	17	7	22	11	35	18	25	9	8	226
Socio-demographic															
Female	10 (83)	3 (60)	7 (54)	3	26 (72)	14 (82)	6 (86)	16 (73)	8 (73)	19 (54)	11 (61)	17 (68)	8 (89)	7 (88)	155 (69)
Age	49.3 ± 7.9	49.3 ± 7.7	48.0 ± 8.2	42.5 ± 13.3	48.3 ± 9.3	43.1 ± 9.6	44.0 ± 8.6	41.6 ± 9.5	51.8 ± 8.1	45.9 ± 9.0	40.9 ± 8.2	44.6 ± 9.3	44.0 ± 9.7	46.6 ± 10.5	45.5 ± 9.4
Marital status															
Married/de facto	6 (50)	4 (80)	11 (85)	4 (50)	26 (72)	10 (59)	6 (86)	14 (64)	7 (64)	22 (63)	11 (61)	16 (64)	6 (67)	5 (63)	148 (65)
Ethnicity															
Caucasian	9 (75)	3 (60)	10 (77)	8 (100)	23 (64)	17 (100)	6 (86)	20 (91)	9 (82)	30 (86)	16 (89)	18 (72)	6 (67)	5 (63)	180 (80)
Education															
High school or less	5 (42)	2 (40)	4	0 (0)	18	4	2	5	2	14 (40)	6	7	3	3	75
Trade/vocational	3	0 (0)	5	2	7	10 (59)	4 (57)	7	3	5	7	7	3	0 (0)	63
University level	4	3 (60)	4	6 (75)	11	3)	1	10 (45)	6 (55)	16 (46)	5	11 (44)	3	5 (63)	88
Health-related															
BMI (kg/m^2)															
Healthy (<25 kg/m^2)	4	1	2	2	12	5	0 (0)	11 (50)	4	11)	3	6)	4 (44)	2	67
Overweight (25 − <30 kg/m^2)	2	3 (60)	7 (54)	3	13)	5	4 (57)	8	2	13	6	10 (40)	2	2	80
Obese (≥30 kg/m^2)	6 (50)	1	4	3	11	7 (41)	3 (43)	3	5 (45)	11	9 (50)	9	3	4 (50)	79
Smokes at work	1	1	0 (0)	1	7)	0 (0)	0 (0)	3	1	5	4	6	0 (0)	2	31
Non-work MVPA (average min/day)***	17 ± 12	25 ± 21	25 ± 21	41 ± 18	17 ± 12	36 ± 18	20 ± 17	28 ± 20	18 ± 14	22 ± 17	21 ± 14	19 ± 15	22 ± 22	13 ± 8	23 ± 17
Work-related															
1.0 FTE	11 (92)	3 (60)	7 (54)	8 (100)	29 (81)	11 (65)	6 (86)	17 (77)	9 (82)	28 (80)	15 (83)	22 (88)	7 (78)	6 (75)	179 (79)
Occupational category															
Managers	1	2 (40)	0 (0)	2	5	1	0 (0)	3	0 (0)	1	1	0 (0)	0 (0)	0 (0)	16
Professional/Assoc. Professional	1	0 (0)	0 (0)	5 (63)	4	1	0 (0)	6	1	5	1	5	1	1	31
Clerical, sales & services	10 (83)	3 (60)	13 (100)	1	27 (75)	15 (88)	7 (100)	13 (59)	10 (91)	29 (83)	16 (89)	20 (80)	8 (89)	7 (88)	179 (79)
Tenure at workplace															
3 years	2	0 (0)	1	2	2	1 (0)	1	0 (0)	0 (0)	11	3	4	1	0 (0)	28
3–5 years	0 (0)	0 (0)	1	0 (0)	5	3	1)	5	1	2	5	4	1	1	29
>5 years	10 (83)	5 (100)	11 (85)	6 (75)	29 (81)	13 (76)	5 (71)	17 (77)	10 (91)	22 (63)	10 (56)	17 (68)	7 (78)	7 (88)	169 (75)

Notes: Descriptive characteristics are reported as n (%) for categorical variables and mean ± standard deviation for continuous variables. * Site size: S (Small) - <50; M (Medium) – 50–150; L (Large): >150, ** Team numbers are approximate; *** n = 223. Data were collected in Victoria, Australia in 2012–13.

Table 2
Description of participants' percentage of time spent in various activities as measured by the activPAL3[a].

	Workplace (n = 229)	Workdays (n = 229)	Non-workdays (n = 227)	Overall (n = 229)
Sitting (%)	78.8 ± 9.5	69.4 ± 8.0	55.9 ± 13.0	64.6 ± 8.4
Prolonged sitting (≥30 min bouts) (%)	42.1 ± 19.4	35.7 ± 12.9	27.7 ± 14.8	32.9 ± 11.5
Standing (%)	14.3 ± 8.2	21.0 ± 6.4	31.0 ± 10.4	24.6 ± 6.8
Stepping (%)	6.9 ± 2.9	9.6 ± 3.1	13.1 ± 4.5	10.8 ± 3.1

[a] Data are mean ± standard deviation with linearized variance estimation. Percentages are calculated as a proportion of waking monitor wear time.

Worksites varied significantly in average prolonged workplace sitting time, even in the full adjusted model. Fig. 2 depicts the worksite variation in prolonged sitting time, unadjusted and after adjustment for socio-demographic and health characteristics. Around a mean of 197 (95% CI: 173, 220) min/8-h workday of prolonged sitting time, sites varied from 44 min below (Site B) to 57 min above average (Site N). After adjustment, sites varied from 49 min below (Site B) to 62 min above (Site N) the overall mean (200 min/8-h workday; 95% CI: 135, 265).

4. Discussion

To our knowledge, this study is the first to examine correlates of workplace sitting time (total and in prolonged bouts) using high-quality objective measurement. Shorter occupational tenures were associated with higher levels of total and prolonged workplace sitting, while excess BMI was associated with lower levels of total and prolonged workplace sitting.

This sample of office-based workers engaged in high amounts of workplace sitting on average, with wide variation between individuals and worksites. On average, 79% of working hours were spent sitting; more than half of which was prolonged sitting (≥30 min bouts). These findings are consistent with other studies within office environments (Parry and Straker, 2013; Clemes et al., 2014; Healy et al., 2013) and highlight the need for interventions in these settings.

None of the socio-demographic factors emerged as significant correlates of workplace sitting. Previous studies with population-based samples have reported other socio-demographic factors such as younger age (De Cocker et al., 2014; Bennie et al., 2015) and higher educational attainment (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) to be associated with higher self-reported workplace sitting. The homogeneity of our sample—involving a single employer and industry—may have limited the ability to test these associations.

BMI emerged as a significant inverse correlate of total and prolonged workplace sitting, contrary to previous studies (De Cocker et al., 2014; Chau et al., 2012; Levine et al., 2005). Higher BMIs have been associated with increased prevalence of work-related musculoskeletal disorders (da Costa and Vieira, 2010; Schmier et al., 2006). Participants with greater adiposity may possibly experience more physical discomfort in traditional seated arrangements, which could be alleviated by more frequent breaks (Thorp et al., 2014). However, we cannot rule out possible bias and measurement error. The knowledge of having activity

Table 3
Linear mixed models examining correlates of total workplace sitting time (min/8-h day).

	Empty model	Block 1[a]	Block 2[b]	Block 3[c]
		b (95% CI)	b (95% CI)	b (95% CI)
Intercept	378.49 (368.36, 388.63)	387.67 (357.21, 418.14)	380.76 (349.88, 411.65)	360.20 (310.30, 410.10)
Socio-demographic and health-related				
Age (years)		0.10 (−0.51, 0.72)	0.34 (−0.28, 0.96)	0.33 (−0.29, 0.94)
Gender				
Male (ref: female)		7.33 (−4.68, 19.34)	8.99 (−3.09, 21.07)	8.06 (−4.04, 20.15)
Marital status		*p = 0.035*†	*p = 0.055*†	*p = 0.067*†
Married/de facto		Ref	Ref	Ref
Separated/divorced/widowed		−16.76 (−32.00, −1.51)*	−15.90 (−30.90, −0.89)*	−15.24 (−30.17, −0.31)*
Never married		−13.43 (−28.25, 1.38)	−11.58 (−26.18, 3.03)	−11.21 (−25.74, 3.33)
BMI		*p = 0.014*†	*p = 0.007*†	*p = 0.010*†
Healthy (<25 kg/m^2)		Ref	Ref	Ref
Overweight (25 − <30 kg/m^2)		−9.44 (−23.22, 4.35)	−11.86 (−25.50, 1.78)	−10.86 (−24.51, 2.79)
Obese (≥30 kg/m^2)		−20.54 (−34.42, −6.67)**	−22.06 (−35.73, −8.39)**	−21.05 (−34.70, −7.39)**
Work-related				
1.0 FTE (ref: <1.0)			−9.95 (−23.76, 3.86)	−9.38 (−23.20, 4.44)
Tenure at workplace			*p = 0.012*†	*p = 0.008*†
<3 years			16.72 (0.24, 33.20)*	15.45 (−0.97, 31.88)
3–5 years			20.31 (4.14, 36.49)*	22.59 (6.37, 38.82)**
>5 years			Ref	
Cognitive-social				
Knowledge				8.07 (−2.55, 18.69)
Use of self-regulation strategies				−5.76 (−13.26, 1.75)
Random effects‡				
Worksite (p-value)	p < 0.01	p < 0.01	p < 0.01	p < 0.01
Variance: worksite (between worksites)	236.37 (62.36, 895.84)	288.82 (85.76, 972.69)	279.25 (81.89, 952.23)	246.73 (68.25, 891.93)
Variance: residual (within worksite)	1696.10 (1391.67, 2067.12)	1563.13 (1282.61, 1905.01)	1489.08 (1221.54, 1815.20)	1471.79 (1207.10, 1794.51)
ICC	0.122 (0.034, 0.355)	0.156 (0.050, 0.394)	0.158 (0.050, 0.400)	0.144 (0.042, 0.388)
AIC	2219.56	2216.70	2212.46	2212.89
BIC	2229.66	2247.00	2252.85	2260.01
P vs previous block		p = 0.021	p = 0.017	p = 0.168

n = 214; * p < 0.05; ** p < 0.01; † *p* represents overall significance test for variable, ‡ Worksite specified as a random effect.
Note: ICC – Intracluster correlation coefficient; AIC – Akaike's Information Criterion; BIC – Bayesian Information Criterion. Data were collected in Victoria, Australia in 2012–13.
[a] Work smoking status, ethnicity, non-work MVPA, education eliminated.
[b] Occupational category eliminated.
[c] Workspace satisfaction, job control, barrier self-efficacy, desired sitting level, perceived behavioral control, perceived organisational norms, overall stress eliminated.

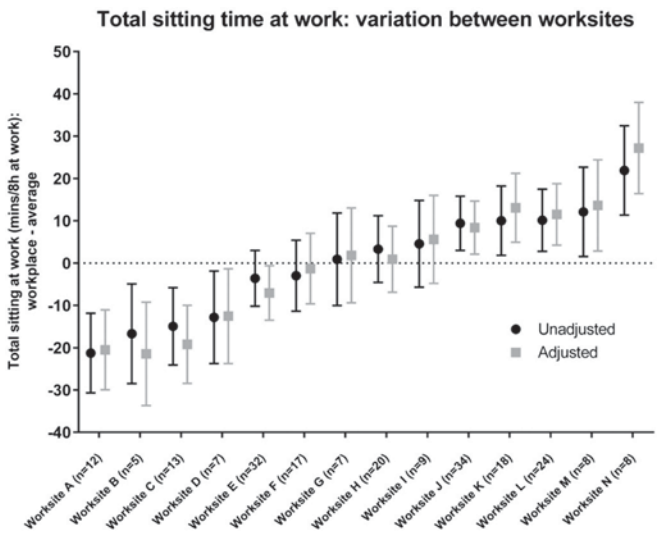

Fig. 1. Variation in total sitting time between worksites.

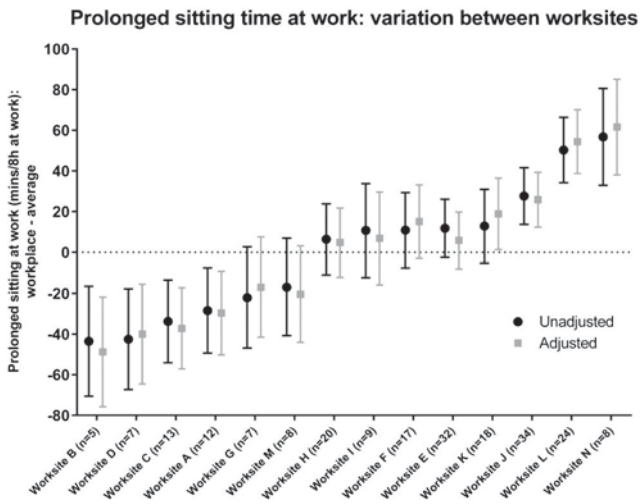

Fig. 2. Variation in prolonged sitting time between worksites.

monitored could have altered behavior differentially in our sample. Another possible explanation concerns the validity of the activPAL. While the activPAL appears to perform similarly for obese and healthy weight participants when assessing walking (Ryan et al., 2006), this has not been established for sitting and standing (delineated by estimated monitor angles, assumed to indicate thigh angle). Differential measurement error could arise if overweight/obesity affects thigh shape in a way relevant to device function, or how participants sit. Perching forward, in particular, can register as standing (Steeves et al., 2015).

Of the work-related factors, tenure greater than five years was associated with less total and prolonged workplace sitting time. Previous

Table 4
Linear mixed models examining correlates of prolonged workplace sitting time (min/8-h day).

	Empty model	Block 1[a]	Block 2[b]	Block 3[c]
	b (95% CI)	b (95% CI)	b (95% CI)	b (95% CI)
Intercept	196.6 (172.96, 220.24)	200.08 (134.77, 265.40)	216.87 (138.57, 295.16)	184.43 (68.93, 299.94)
Socio-demographic and health-related				
Age (years)		0.66 (−0.65, 1.97)	0.86 (−0.44, 2.17)	0.83 (−0.46, 2.12)
Gender				
Male (ref: female)		16.86 (−8.72, 42.44)	17.35 (−7.89, 42.59)	17.09 (−7.91, 42.10)
Marital status		*p = 0.100*†	*p = 0.104*†	*p = 0.198*†
Married/de facto		Ref	Ref	Ref
Separated/divorced/widowed		−23.09 (−55.58, 9.39)	−22.05 (−53.87, 9.78)	−19.41 (−51.22, 12.41)
Never married		−29.63 (−61.18, 1.93)	−28.76 (−59.60, 2.09)	−24.01 (−54.95, 6.94)
BMI		*p = 0.007*†	*p = 0.002*†	*p = 0.002*†
Healthy (<25 kg/m^2)		Ref	Ref	Ref
Overweight (25 − <30 kg/m^2)		−44.66 (−74.03, −15.29)**	−50.90 (−79.81, −21.98)**	−50.00 (−78.71, −21.29)**
Obese (≥30 kg/m^2)		−37.44 (−66.99, −7.89)*	−40.48 (−69.47, −11.48)**	−40.12 (−68.96, −11.28)**
Work-related				
Occupational category			*p = 0.142*†	*p = 0.148*†
Managers			Ref	Ref
Professionals/Assoc. Professionals			−53.92 (−107.58, −0.26)*	−53.50 (−107.17, 0.16)
Clerical, sales & services			−32.76 (−78.09, 12.58)	−33.84 (−79.63, 11.95)
Tenure at current workplace			*p = 0.005*†	*p = 0.008*†
<3 years			31.06 (−3.97, 66.09)	31.49 (−3.36, 66.33)
3–5 years			53.01 (18.04, 87.98)**	49.92 (15.12, 84.71)**
>5 years			Ref	Ref
Cognitive-social				
Perceived behavioral control				−15.71 (−34.30, 2.87)
Perceived organisational norms				22.93 (−3.48, 49.34)
Random effects‡				
Worksite (p-value)	p < 0.001	p < 0.001	p < 0.001	p < 0.001
Variance: worksite (between worksites)	1402.79 (430.77, 4568.13)	1498.77(485.61, 4625.70)	1473.84 (474.87, 4574.33)	1539.73 (503.76, 4706.16)
Variance: residual (within worksite)	7667.92 (6294.98, 9340.29)	7080.30 (5813.05, 8623.83)	6676.80 (5480.36, 8134.45)	6547.51 (5374.00, 7977.29)
ICC	0.155 (0.051, 0.383)	0.175 (0.062, 0.404)	0.181 (0.064, 0.416)	0.190 (0.069, 0.428)
AIC	2544.94	2541.32	2537.18	2537.65
BIC	2555.04	2571.61	2580.94	2588.14
P vs previous block		p = 0.016	p = 0.016	p = 0.171

n = 214; * p < 0.05; ** p < 0.01; † *p* represents overall significance test for variable, ‡ Worksite specified as a random effect.
Note: ICC – Intracluster correlation coefficient; AIC – Akaike's Information Criterion; BIC – Bayesian Information Criterion. Data were collected in Victoria, Australia in 2012–13.
[a] Education, non-work moderate-vigorous physical activity, ethnicity, work smoking status eliminated.
[b] Employment status eliminated.
[c] Use of self-regulation strategies, desired sitting level, overall stress, job control, workspace satisfaction, barrier self-efficacy, knowledge eliminated.

research has found tenures of at least five years to be associated with higher self-reported sitting (Vandelanotte et al., 2013). It is possible that tenure acts indirectly through other factors such as seniority; workers with longer tenure may have responsibilities requiring greater movement around the office. However, only 7% reported their occupation as managerial. The underlying mechanisms behind this finding should be explored further.

The effect sizes for BMI and tenure for prolonged sitting time were large, meeting the minimum difference of interest set for the broader intervention trial (45 min of total/prolonged sitting) (Dunstan et al., 2013). Effect sizes for total sitting time were more modest—approximately 15–30 min—although these differences were seen in the absence of any workplace intervention.

None of the cognitive-social constructs emerged as significant correlates. Similar cognitive-social constructs assessed previously (Wallmann-Sperlich et al., 2014; De Cocker et al., 2014) were also not found to be strong influences on workplace sitting. Nonetheless, with the observed margins of error our study did not provide evidence to rule out the importance of these factors. There were indications of a potential positive association between prolonged sitting time and perceived organisational norms and a potential negative association between prolonged sitting time with perceived behavioral control; the latter finding is in line with some previous studies (De Cocker et al., 2014; Prapavessis et al., 2015).

We observed large and significant differences between worksites in total and prolonged workplace sitting time, in unadjusted and adjusted models. Anecdotally, the level of task variation differed between sites—the teams with lower than average sitting time (sites A-D) were not predominately telephone-based, unlike others (e.g. H and L) that had higher sitting levels. More detailed assessment of job tasks or content (i.e. beyond assessing occupation) should be considered in future studies. Further exploration is needed to identify potential worksite-level factors influencing sitting that were not measured in our study.

An ecological model of sedentary behavior (Owen et al., 2011) suggests that there are multiple levels of influence on behavior. A significant limitation is that the variables assessed as potential correlates—and thus, our findings—reflect a data-driven approach. Not all of these potential influences were captured and others that were not assessed may also be of importance. In addition, while the cognitive-social constructs had theoretical relevance to the logic of the intervention, we did not aim to comprehensively test a single theory. The newly developed measures may also be affected by measurement error. This could account for the large proportion of unexplained variance in workplace sitting. Future studies should assess the potential influence of variables such as physical environments, organisational and social factors on total and prolonged sitting as these may be amenable to workplace environmental and policy changes.

Participants were government employees with mostly administrative and telephone-based customer service roles and were not randomly sampled. Our findings may not be generalizable to all office-based workers or organisations. However, we found limited evidence to suggest that participants were atypical, with high participation rates within most teams, and participants broadly similar to the departmental gender and age profile. While the broader intervention trial was powered to assess changes in the primary outcome, wide estimates of error suggest this study was underpowered and meaningful associations were possibly not detected. Studies that investigate the correlates of objectively measured sitting across larger, more diverse groups of workers are required to address these issues.

5. Conclusions

In this sample of office-based workers, shorter tenure and lower BMI levels were associated with higher levels of total and prolonged workplace sitting time, while significant variation in sitting time was observed across worksites. This suggests that identifying and assessing potential workplace-level correlates, such as physical environment and social-cultural factors, may be a useful next step in the research agenda for understanding and influencing workplace sitting. Overall, while these findings contribute to the existing limited evidence base on correlates of workplace sitting, replication and confirmation of our findings is needed.

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.pmedr.2016.06.011.

Conflict of interest statement

The funding bodies had no influence on the conduct nor the findings of the study. No financial disclosures were reported by the authors of this paper, and the authors declare that there are no conflicts of interest.

Authors' contributions

DD, GH, EE, NO, AL, MM conceived the Stand Up Victoria (SUV) trial. GH, NO, EE, AL, MM, GW, LW, and DD participated in the design and coordination of the methodology and measurement tools for the SUV trial. NH, GH, NO, BL, EW & DD contributed to the conception and design of the study. NH analysed and interpreted the data and drafted the manuscript. EW and PS provided assistance with statistical analyses and interpretation. All authors were involved in manuscript development and critical review for important intellectual content. All authors read and approved the final manuscript.

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Note: Table 1 is replicated below due to errors introduced into the paper during the publication process.

Table 3.1: Descriptive characteristics of worksites

Worksite	A	B	C	D	E	F	G	H	I	J	K	L	M	N	Total
Site/team attributes															
Site size*	M	S	M	L	L	L	M	L	M	M	L	M	S	M	
Number in team (s)**	14	30	21	50	180*	150*	25	60	22	74	166*	48	22	18	
n (enrolled)	12	5	13	9	38	17	7	24	11	35	18	25	9	8	231
Predominately phone-based?	No	No	No	No	Yes	Yes	No	Yes	No	Mixed	Mixed	Yes	Mixed	No	
Individual attributes															
n (complete demographics)	12	5	13	8	36	17	7	22	11	35	18	25	9	8	226
Socio-demographic															
Female	10 (83)	3 (60)	7 (54)	3 (38)	26 (72)	14 (82)	6 (86)	16 (73)	8 (73)	19 (54)	11 (61)	17 (68)	8 (89)	7 (88)	155 (69)
Age	49.3± 7.9	49.3 ±7.7	48.0± 8.2	42.5± 13.3	48.3± 9.3	43.1± 9.6	44.0± 8.6	41.6± 9.5	51.8± 8.1	45.9± 9.0	40.9± 8.2	44.6 ± 9.3	44.0 ± 9.7	46.6± 10.5	45.5± 9.4
Marital status															
Married/de facto	6 (50)	4 (80)	11 (85)	4 (50)	26 (72)	10 (59)	6 (86)	14 (64)	7 (64)	22 (63)	11 (61)	16 (64)	6 (67)	5 (63)	148 (65)
Ethnicity						17									180
Caucasian	9 (75)	3 (60)	10 (77)	8 (100)	23 (64)	(100)	6 (86)	20 (91)	9 (82)	30 (86)	16 (89)	18 (72)	6 (67)	5 (63)	(80)
Education															
High school or less	5 (42)	2 (40)	4 (31)	0 (0)	18 (50)	4 (24)	2 (29)	5 (23)	2 (18)	14 (40)	6 (33)	7 (28)	3 (33)	3 (38)	75 (33)
Trade/vocational	3 (25)	0 (0)	5 (38)	2 (25)	7 (19)	10 (59)	4 (57)	7 (32)	3 (27)	5 (14)	7 (39)	7 (28)	3 (33)	0 (0)	63 (28)
University level	4 (33)	3 (60)	4 (31)	6 (75)	11 (31)	3 (18)	1 (14)	10 (45)	6 (55)	16 (46)	5 (28)	11 (44)	3 (33)	5 (63)	88 (39)
Health-related															
BMI (kg/m^2)															
Healthy (<25 kg/m^2)	4 (33)	1 (20)	2 (15)	2 (25)	12 (33)	5 (29)	0 (0)	11 (50)	4 (36)	11 (31)	3 (17)	6 (24)	4 (44)	2 (25)	67 (30)
Overweight (25-<30 kg/m^2)	2 (17)	3 (60)	7 (54)	3 (38)	13 (36)	5 (29)	4 (57)	8 (36)	2 (18)	13 (37)	6 (33)	10 (40)	2 (22)	2 (25)	80 (35)
Obese (≥30 kg/m^2)	6 (50)	1 (20)	4 (31)	3 (38)	11 (31)	7 (41)	3 (43)	3 (14)	5 (45)	11 (31)	9 (50)	9 (36)	3 (33)	4 (50)	79 (35)

Smokes at work	1 (8)	1 (20)	0 (0)	1 (13)	7 (19)	0 (0)	0 (0)	3 (14)	1 (9)	5 (14)	4 (22)	6 (24)	0 (0)	2 (25)	31 (14)
Non-work MVPA (average min/day)***	17±12	25±21	25±21	41±18	17±12	36±18	20±17	28±20	18±14	22±17	21±14	19±15	22±22	13±8	23±17
Work-related															
1.0 FTE	11 (92)	3 (60)	7 (54)	8 (100)	29 (81)	11 (65)	6 (86)	17 (77)	9 (82)	28 (80)	15 (83)	22 (88)	7 (78)	6 (75)	179 (79)
Occupational category															
Managers	1 (8)	2 (40)	0 (0)	2 (25)	5 (14)	1 (6)	0 (0)	3 (14)	0 (0)	1 (3)	1 (6)	0 (0)	0 (0)	0 (0)	16 (7)
Professional/ Assoc. Professional	1 (8)	0 (0)	0 (0)	5 (63)	4 (11)	1 (6)	0 (0)	6 (27)	1 (9)	5 (14)	1 (6)	5 (20)	1 (11)	1 (13)	31 (14)
Clerical & services	10 (83)	3 (60)	13 (100)	1 (13)	27 (75)	15 (88)	7 (100)	13 (59)	10 (91)	29 (83)	16 (89)	20 (80)	8 (89)	7 (88)	179 (79)
Tenure at workplace															
≤ 3 years	2 (17)	0 (0)	1 (8)	2 (25)	2 (3)	1 (0)	1 (14)	0 (0)	0 (0)	11 (26)	3 (11)	4 (16)	1 (11)	0 (0)	28 (10)
3-5 years	0 (0)	0 (0)	1 (8)	0 (0)	5 (14)	3 (18)	1 (14)	5 (23)	1 (9)	2 (6)	5 (28)	4 (16)	1 (11)	1 (13)	29 (13)
>5 years	10 (83)	5 (100)	11 (85)	6 (75)	29 (81)	13 (76)	5 (71)	17 (77)	10 (91)	22 (63)	10 (56)	17 (68)	7 (78)	7 (88)	169 (75)

Notes: Descriptive characteristics are reported as n (%) for categorical variables and mean ±standard deviation for continuous variables. * Site size: S (Small) - <50; M (Medium) – 50-150; L (Large): >150 ** Team numbers are approximate; *** n=223. Data were collected in Victoria, Australia in 2012-13.

Supplementary Table 1: Individual items within each social-cognitive construct and internal consistency of the scales

Construct and scale items	Response	Internal Consistency (Cronbach's Alpha)
Workspace satisfaction		
a. I'm proud to show my workspace to others	Strongly disagree - Strongly agree	0.82
b. My workspace helps me get work done efficiently		
c. All things considered, I am very satisfied with my workspace		
d. The physical layout of my workspace is well suited to the tasks I do		
Knowledge		
a. Sitting for most of the time at work does not impact on my health *(NB: reverse scored)*	Strongly disagree - Strongly agree	0.50
b. Sitting for most of the time at work is bad for my health		
c. Any health impact of sitting for most of the time at work can be off-set by exercising at other times of the day *(NB: reverse scored)*		
d. It is beneficial for my health to stand up at least once every 30 minutes while I am at work		
e. It is beneficial for my health if I am as active as possible throughout my working day (e.g. by using the stairs instead of the lift)		
Barrier self-efficacy		
a. Stood up during meetings at work, even though no one else was	Not at all confident - Very confident	0.92
b. Stood up during meetings at work, even when supervisors were sitting down		
c. Stood up at your desk at work, even though your colleagues were not		
d. Stood up at your desk at work, even when you felt tired		
e. Stood up at your desk at work, even if your footwear was uncomfortable		
f. Stood up at your desk at work, even though you were really busy at work		

g. Stood up at your desk at work , even when your tasks required looking at multiple papers		
h. Stood up at your desk at work , even when your tasks required talking on the phone		
i. Walk to talk to a colleague at work instead of emailing them, even though others didn't		
Perceived behavioural control		
a. It is my choice whether I stand up or sit at my desk while at work	Strongly disagree - Strongly agree	0.72
b. It is my choice whether I stand up or sit during a meeting with colleagues at work		
c. It is my choice whether I stand up or sit during a meeting with my supervisor/s at work		
d. It is my choice whether I walk over to talk to a colleague (*iMail)* or send them an eMail		
e. It is my choice whether I walk over to talk to a supervisor (*iMail)* or send them an eMail		
Perceived organisational social norms		
a. My workplace is committed to supporting staff health and well-being	Strongly disagree - Strongly agree	0.81
b. My workplace is committed to supporting staff choices to stand or move more at work		
c. My colleagues would not mind if I chose to stand up while working at my desk		
d. My supervisor/s would not mind if I chose to stand up while working at my desk		
e. My colleagues would not mind if I chose to stand during a work meeting		
f. My supervisor/s would not mind if I chose to stand during a work meeting		
g. My colleagues would not mind if I chose to walk over and talk to them (*iMail*) rather than sending them an eMail		
h. My supervisor/s would not mind if I chose to walk over and talk to them (*iMail*) rather than sending them an eMail		

Self-regulation strategies		
a. Thought about how much I sit at work	Never -Very often	0.90
b. Recorded my sitting or standing at work in a written record		
c. Paid attention to specific things to help me stand at work (e.g., I have more energy in the morning so I stand during this time)		
d. Set short-term goals (daily or weekly) related to how often I stand up at work		
e. Broken down larger goals into smaller, more manageable goals (e.g. accumulate 40 minutes of standing in 4 x10minute bouts)		
f. Thought about my standing goals		
g. Reminded myself of the health benefits of standing at work (e.g., reduced risk of Type 2 diabetes, premature death)		
h. Scheduled specific times to stand up at work		
i. Paid attention to barriers which got in the way of my standing at work		
j. Planned ways to overcome barriers to my standing at work		
Desired sitting at work		
If you were given a choice, how much time would you like to spend SITTING AT WORK? In this question, please think about how you felt in the past month.	None; 10-30%; 30-50%; 50-80%; 80-100%	N/A

3.3 Summary and implications of the findings

The office workers participating in this study spent the vast majority (79%) of their working hours sitting; over half of this time (42% of work hours) was accumulated in prolonged bouts of 30 minutes or more. Only 14% and 7% of work hours were spent standing and stepping, respectively. These findings are largely consistent with, or slightly higher than other studies within office environments that have used activPAL devices (4, 5, 106), and highlight the sedentary nature of this type of work.

Only two significant correlates of total and prolonged sitting time were identified in this study – tenure and BMI. Having an organisational tenure of 3-5 years was associated with more total and prolonged workplace sitting time relative to tenures >5 years. Only one other study (using a self-report measure of occupational sitting time) has assessed tenure as a potential correlate, with contrasting findings to this study (179). Future studies with larger groups of workers with varied tenure lengths may assist with further elucidating the consistency of this relationship. The majority (75%) of participants in this study had organisational tenures greater than five years and the categorical nature of this question precluded analysis of whether different length tenures within this group influenced workplace sitting time. Should this finding be replicated, possible implications could be the promotion of policies and strategies to reduce sitting time to newer employees; for example, through inclusion in staff inductions.

Participants with obese BMIs ($\geq$ 30 kg/m^2) had lower total and prolonged workplace sitting time compared to those with a healthy BMI; those with an overweight BMI also had lower prolonged workplace sitting time. As discussed in 3.2, these findings also require replication to determine whether they reflect a true finding or measurement error.

Education and occupation have been found to be correlates of occupational sitting time in larger studies using self-report measures (181, 184, 227). The homogeneity of the sample may explain why this study did not identify these as significant correlates. Participants were volunteers from teams within worksites of a single employer, not a randomly-selected, population-based sample. For example, the majority (79%) reported the same occupational skill level (clerical, sales and services), limiting the ability to examine variation in this attribute. It is also of potential interest that no evidence for an association between workplace sitting time and MVPA was observed, in light of the findings reported in Chapter 2. Differences in measurement (i.e. self-report versus objective measures of sitting time and physical activity) may be one explanation for the discrepancy in findings. As discussed within the paper presented in 2.2 (227), there is a need for further research, with larger and more diverse populations, to examine whether workplace sitting time is associated with activity levels outside of the workplace.

An interesting finding from this study was the significant variation in total and prolonged sitting time observed across the 14 worksites, which remained even in fully adjusted models (adjusting for socio-demographic, health-related, work-related and social-cognitive constructs). Figures 1 and 2 in 3.2 depict the extent of this variation. In models adjusted for age, gender, marital status and BMI, there was an approximate 40 minute difference in total sitting time between worksites with the lowest and highest average amount of sitting. In similarly adjusted models for prolonged sitting time, the difference between sites with the lowest and highest average amounts was nearly two hours per 8-h workday (111 minutes).

A limitation of this study was the inability to identify and examine the factors contributing to the variation in workplace sitting time across the worksites. As a secondary analysis, the factors chosen to examine as potential correlates were limited to those that were measured in the broader SUV study, which predominately focused on individual-level variables. Although participants worked for a single organisation, they were located at geographically separate workplaces with other employees and teams that were not involved in SUV. Differences in broader environmental factors, policies and social norms between worksites were unlikely to have been adequately captured in this study and may account for the worksite variation observed. A key strength of this study however, was that it was the first to examine correlates of objectively measured workplace sitting time, including time spent in prolonged bouts.

This study and the previous study in Chapter 2 provide some insight into correlates of occupational sitting time, suggesting potential targets for intervention. The second part of this thesis extends on these findings to understand factors that are associated with the initiation of, and processes of, workplace sedentary behaviour change.

PART 2: INFLUENCES ON WORKPLACE SEDENTARY BEHAVIOUR CHANGE

CHAPTER 4

THE FEASIBILITY AND ACCEPTABILITY OF REDUCING WORKPLACE SITTING TIME

Part 1 of this thesis explored the context of workplace sedentary behaviour, specifically the correlates of self-reported and objectively measured workplace sitting time. This addressed the first research aim: to identify socio-demographic, health-related, work-related and social-cognitive correlates of workplace sitting time.

A limitation of the two studies in Part 1, and other studies examining the correlates of workplace sitting time (181, 184), is that they have predominately focused on individual-level factors. Significant worksite variation in total and prolonged sitting time was observed in the study presented in Chapter 3, even after adjusting for socio-demographic, work-related and social-cognitive factors. As this suggests that individual-level factors are unable to fully account for variation in workplace sitting time, there is a need to examine other potential influences, including factors acting at the social and environmental levels of the ecological model (102). In the absence of a strong body of evidence on the correlates of workplace sitting time, as discussed in section 1.5.3, exploratory qualitative research can be informative for identifying factors that have the potential to be important influences on behaviour. Findings from these smaller studies can then lay the groundwork for hypothesis testing in larger, quantitative studies.

One of the main goals underlying research into correlates or factors associated with workplace sitting time is to identify potential pathways for intervention. It is therefore important to understand the factors or attributes that might influence the initiation of attempts to reduce workplace sitting. Previous qualitative research related to workplace sitting time has predominately occurred as an evaluative component of intervention studies; for example, examining the feasibility and acceptability of sit-stand workstations (198, 215). There has been limited exploration of workers' perspectives of the feasibility of reducing workplace sitting prior to, or in the absence of, an intervention. These "baseline" perspectives are important, as they can enable the identification of factors that may impede or facilitate intervention success, including local contextual factors that may influence how strategies can be implemented.

While the efficacy (8, 220) and feasibility (198, 215) of environment-based interventions, such as active workstations, has had increasing attention in recent years, less is known about the acceptability of lower-cost, less resource-intensive strategies (such as standing meetings). The cost implications of sit-stand workstations have previously been noted as a potential barrier to

their implementation (210). Low-cost strategies may therefore be more accessible for organisations seeking to address workplace sitting time. For this reason, it is important to understand how they might be perceived by workers and employer representatives, in terms of their acceptability and feasibility.

The peer-reviewed paper in section 4.1 was published in *BMC Public Health* in 2016 (234). It reports findings arising from 20 semi-structured interviews conducted by the candidate across three organisations in Melbourne, Australia, from November 2015 to January 2016. The main aims were to explore barriers to reducing workplace sitting amongst office-based workers, and understand the feasibility and acceptability of strategies targeting prolonged sitting in this context. Section 4.2 summarises the main findings and discusses implications. A copy of the questionnaire used in this study is included in Appendix B.

4.1 Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers

Hadgraft NT, Brakenridge CL, LaMontagne AD, Fjeldsoe BS, Lynch BM, Dunstan DW, et al. Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers. BMC Public Health. 2016;16:933.

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Feasibility and acceptability of reducing workplace sitting time: a qualitative study with Australian office workers

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Abstract

Background: Office workers spend a large proportion of their working hours sitting. This may contribute to an increased risk of chronic disease and premature mortality. While there is growing interest in workplace interventions targeting prolonged sitting, few qualitative studies have explored workers' perceptions of reducing occupational sitting outside of an intervention context. This study explored barriers to reducing office workplace sitting, and the feasibility and acceptability of strategies targeting prolonged sitting in this context.

Methods: Semi-structured interviews were conducted with a convenience sample of 20 office workers (50 % women), including employees and managers, in Melbourne, Australia. The three organisations (two large, and one small organisation) were from retail, health and IT industries and had not implemented any formalised approaches to sitting reduction. Questions covered barriers to reducing sitting, the feasibility of potential strategies aimed at reducing sitting, and perceived effects on productivity. Interviews were audiotaped and transcribed verbatim. Data were analysed using thematic analysis.

Results: Participants reported spending most (median: 7.2 h) of their working hours sitting. The nature of computer-based work and exposure to furniture designed for a seated posture were considered to be the main factors influencing sitting time. Low cost strategies, such as standing meetings and in-person communication, were identified as feasible ways to reduce sitting time and were also perceived to have potential productivity benefits. However, social norms around appropriate workplace behaviour and workload pressures were perceived to be barriers to uptake of these strategies. The cost implications of height-adjustable workstations influenced perceptions of feasibility. Managers noted the need for an evidence-based business case supporting action on prolonged sitting, particularly in the context of limited resources and competing workplace health priorities.

Conclusions: While a number of low-cost approaches to reduce workplace sitting are perceived to be feasible and acceptable in the office workplace, factors such as work demands and the organisational social context may still act as barriers to greater uptake. Building a supportive organisational culture and raising awareness of the adverse health effects of prolonged sitting may be important for improving individual-level and organisational-level motivation for change.

Keywords: Sedentary behaviour, Workplace, Qualitative, Occupational health

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Background

With technological advances and shifting economic demands, the average energy expenditure for many occupations has declined and a high proportion of the workforce is engaged in sedentary jobs [1]. For those working in office environments, the workday is often characterised by high levels of sedentary behaviour (or sitting) with minimal time spent in activities of a moderate or vigorous intensity [2–4]. Epidemiological studies have found that office-workers can spend at least two-thirds of their workday sitting [5, 6], with a large proportion of their total daily sitting time occurring within the traditional working hours of 9 am-5 pm [7]. The sedentary work environment may have broad implications for population health – accumulating evidence links high levels of sitting with increased risk of premature mortality and chronic diseases, such as type 2 diabetes and cardiovascular disease [8–10].

With this in mind, sedentary behaviour is now being considered as a potential work health and safety issue [11], with associated implications for employers in how they address this emerging concern [12]. For organisations considering strategies to assist workers to break up and reduce their sitting, it is important to identify barriers that may impede effective implementation of these strategies. Understanding the conditions under which approaches to sitting reduction are likely to be feasible and acceptable will assist with tailoring programs to suit organisational needs.

A number of studies have explored workers' perceptions of the acceptability of sedentary behaviour interventions, such as the provision of sit-stand desks [13–15]. However, only a few studies have explored workers' perceptions of reducing workplace sitting in organisations prior to implementing formalised programs [16, 17]. In 2011, an Australian study undertaken with government office workers found that concerns about perceived loss of productivity were a barrier to more frequent interruptions to sitting [16]. Features of the office environment (such as fixed-height desks) were also suggested as barriers to increased movement [16]. In contrast, participants identified leadership support for reducing sitting and the availability of multiple alternatives to sitting, tailored to workgroups, as potential enablers of reducing sitting [16]. A recent study in Belgium [17] also identified productivity concerns and lack of management support as key barriers to reducing sitting time. Interestingly, this study identified that there appeared to be limited knowledge amongst workers and employers about the broader cardio-metabolic health implications of sedentary behaviour; participants typically linked excessive sitting with musculoskeletal concerns [17]. The authors suggested that this may indicate less awareness within Europe of the potential health impacts of high levels of sedentary behaviour [17].

A recent review of sedentary behaviour interventions in adults concluded that those incorporating environmental restructuring (changing the social or physical environment) were amongst the most promising interventions, in addition to those involving education and persuasion [18]. Physical workplace changes—specifically, activity-permissive workstations —have been the most frequently assessed workplace sedentary behaviour reduction intervention [19]. These include height-adjustable, or sit-stand workstations, which allow workers to alternate their posture between sitting and standing throughout the day. While height-adjustable workstations have been shown to be acceptable [13, 14] and effective at reducing workplace sitting time [20, 21], the cost implications of these workstations may affect their broader feasibility [17]. Standing or walking meetings, taking more frequent breaks, and replacing emails with face-to-face communication have also been suggested as low-cost alternatives [22]. However, evidence on the feasibility and acceptability of these is limited [23].

With increasing public awareness of the health risks associated with excessive sitting within Australia [11], it is of interest to assess whether workers' perceptions of the feasibility of reducing workplace sitting have evolved since earlier research [16, 24]. To guide recommendations and health promotion efforts, it is also important to understand workers' perceptions of sitting reduction approaches, including those that have been identified in previous interventions in the office environment. This study aimed to explore office workers' perceptions of barriers to reducing sitting time at work and the feasibility of commonly identified strategies.

Methods

Organisations

Three organisations located in Melbourne, Australia were identified based on the researchers' networks and invited to participate. Details of the three organisations are provided in Table 1. Organisation 1 was a large, not-for-profit organisation in the health sector, involved in advocacy, research and support programs. Participants in organisation 2 were recruited from the administrative head office of a large, multi-state retail organisation. Organisation 3 was a small business in the IT industry, predominately focused on software development. Although the three organisations differed by industry and organisational size, most potential participants at each organisation had job roles that were predominately desk-based. None of the organisations had previously implemented a formalised sedentary behaviour reduction program; although, senior leaders at each had expressed interest to the research team about potentially addressing workplace sedentary behaviour amongst their staff. Some strategies for reducing sitting time were in place in each organisation. Organisations 1

Table 1 Employer and participant characteristics

Organisation and size	Industry	*n*	Gender (% women)	Age median (min-max)	% Managers	Occupational sitting time (hr) Median (min-max)[a]
Organisation 1 250– < 500 employees	Not for profit charity	7	71 %	36 (23–52)	43 %	7.2 (4.2–8.0)
Organisation 2 > 30,000 employees	Retail	9	44 %	43 (25–62)	44 %	8.1 (6.4–9.5)
Organisation 3 < 50 employees	Information Technology	4	25 %	29 (27–32)	75 %	6.6 (4.0–8.8)
Total		20	50 %	36 (23–62)	50 %	7.2 (4.0–9.5)

[a]Calculated from the OSPAQ based on reported hours/days worked in the past seven days

and 2 had height-adjustable workstations available to employees on request; generally these were provided for staff with pre-existing medical conditions (mostly musculoskeletal). Organisation 1 also had bookable height-adjustable hot desks in some areas of the organisation, while organisation 3 had a standing (non-adjustable) hot desk area. Organisations 1 and 2 occupied multiple floors of multi-storey buildings while organisation 3 was located on a single floor in a multi-storey building. Only organisation 1 had a policy on physical activity; none had specific workplace policies on reducing sedentary behaviour.

Participants

In each organisation a contact person was asked to assist with identifying and inviting five to eight potential participants to form a convenience sample, however final participant numbers at each site ranged from four to nine. Inclusion criteria included working at the current workplace for at least 3 months, working at least 0.5 full-time equivalent (FTE), being ambulatory and not currently pregnant. These criteria were used to exclude participants who may have altered their physical activity patterns mainly for health reasons, and those who may have had less exposure to the influence of the organisational environment, likely due to shorter job tenure or part-time working hours. The contact person was asked to identify participants with predominately sedentary jobs, from different levels and areas of the organisation (including a variety of job roles, representatives from varying management levels and occupational health and safety roles). Recruitment ceased when data saturation was achieved ($n = 20$). All participants provided written informed consent. Ethics approval was granted by The Alfred Health Human Ethics Committee (Melbourne).

Procedures

Interviews were conducted from November 2015 to January 2016, with each participant interviewed face-to-face during working hours by the first author (NH). Prior to the interview, each participant completed a one-page questionnaire to collect demographic (gender, age) and work-related (job title, FTE, tenure, management responsibilities) information. The Occupational Sitting and Physical Activity Questionnaire (OSPAQ) [25] was incorporated into this questionnaire as a measure of self-reported sitting time. The OSPAQ is a brief instrument that asks participants to report the proportion of time spent sitting, standing, walking, and doing heavy labour or physically demanding tasks on a typical work day in the last 7 days, and the number of hours and days worked in the last 7 days, allowing the calculation of time spent sitting, standing and moving [25].

A semi-structured interview approach was used. This format was chosen as it enabled specific topics to be covered with each participant, while also ensuring that the participant's responses determined the weight and importance of each area [26]. The interview guides were developed with reference to an ecological model of sedentary behaviour [27], and informed by recent findings suggesting that workplace-delivered interventions are most successful if they address multiple influences on sitting, including intrapersonal, interpersonal, policy, and environmental (physical and social) factors [21]. Key questions asked of all participants (shown in Table 2) related to barriers to reducing sitting in the workplace, the feasibility and acceptability of strategies to reduce sitting in the workplace, and potential impacts on productivity associated with reducing sitting time. Managers were also asked to consider the perceived impact of these factors on their staff. Prompting questions were used to follow up participants' answers or to seek additional information about their perspectives on specific strategies. Interviews lasted approximately 25–30 min and were audio-recorded and transcribed verbatim.

Analysis

Thematic analysis was used to identify key themes from the interview data. Two researchers (NH, CB) first undertook a process of familiarisation, reading and re-reading the transcripts. The two researchers separately identified initial codes and applied these to the dataset using NVivo 10/11 for Windows (QSR International). From these codes, overarching themes and subthemes were identified by each researcher and data relevant to those themes were congregated together. At this point the

Table 2 Main questions used in the semi-structured interviews (examples of prompt questions are in italics)

Introductory questions	To start, could you please briefly tell me a bit about your role, including the types of tasks you do on a typical day?
	Is your job predominately desk-based?
	Do many staff in your organisation have predominately desk-based jobs? (*managers)*
Current workplace activity	Is your desk adjustable to allow you to move from a sitting to a standing posture?
	Does your workplace provide staff with desks that are adjustable to enable them to move from a sitting to a standing posture? *(managers)*
	If so, what are the criteria for getting one of these desks?
	How satisfied are you with the proportion of time you spend sitting, standing and moving in the workplace?
Barriers and facilitators to reducing workplace sitting	Thinking about your current job and the existing policies and procedures within your workplace, can you identify anything that would make it difficult for you to reduce how much time you spent sitting at work? *(employees)*
	Does the workplace culture influence how much time you spend sitting or how often you take breaks?
	Thinking about the sorts of jobs that people do and the existing policies and procedures within your organisation can you identify anything that would make it difficult for staff to reduce how much time they spend sitting at work? *(managers)*
	Does the physical environment, such as access to furniture and the facilities, influence how much time staff spend sitting?
	Can you suggest any way that your job could be altered to assist you to sit less and move more throughout the day? (*employees only)*
	Are there any tasks that you could perform away from your desk?
Strategies to reduce workplace sitting	Can you please tell me about any strategies your organisation has implemented that encourage workers to move more and sit less during the workday?
	Are you aware of any other strategies that people in your workplace might be able to use to reduce sitting time at work? *For example:* *-Standing or walking meetings* *-Computer prompts to reminder you to take a break* *-Walking to communicate with a co-worker* Are these strategies that you have mentioned likely to be broadly feasible and acceptable in your workplace?
	Which of these strategies would be most/least likely to be feasible?
Productivity	I am now interested to know whether you think these strategies would have any impact on productivity within your workplace?
	In particular, do you think these would affect: *-Task completion and work flow* *-Communication* *-Collaboration*
Organisational influences	What level of priority do you think your organisation places on reducing sitting time at work?
	Do you think there should be less or more priority given to reducing sitting time?
	How important do you think it is for employees to have "permission" from management to break up prolonged sitting or reduce their sitting time?

two researchers came together to review and compare the coding frameworks, and come to consensus on the final themes and their definitions. The content and description of themes were discussed with two other researchers (BF & SL) and consensus was reached on the finalised themes and descriptions of the theme content. Quotes were selected to characterise each theme and accompanied with unique participant codes, and the gender and age range of participants. Descriptive statistics were calculated from the questionnaire data for demographics and self-reported sitting time, summarised by organisation.

Results

Participant characteristics, summarised by workplace, are provided in Table 1. Overall, there was equal

representation of women and men, though representation varied across the worksites, reflective of the distribution within the respective worksites. Participants' ages ranged from 23 to 62 years, with half of participants aged 35 years or less. A range of different job roles were represented including administration, human resources, project management, health and safety, finance, communications and telephone support. Half of the staff had some management responsibilities. On average, participants reported sitting at work for 7.2 h per day (min, max: 4.0, 9.5 h).

Key themes

Themes about the feasibility and acceptability of reducing workplace sitting time were grouped under three main areas: barriers to reducing sitting at work; strategies for reducing sitting at work; and, overarching perceptions around addressing workplace sitting.

Barriers to reducing workplace sitting

Three prominent sub-themes were identified relating to barriers to reducing workplace sitting: the nature of work; organisational social norms; and, office furniture and layout.

The nature of work The reliance on computers for the majority of work tasks was considered to be a major barrier to reducing sitting time. Participants reported that it would be difficult to reduce their sitting since using a computer required them to be sitting down. This was particularly the case for participants whose work required the use of spreadsheets and online systems, or involved tasks such as computer programming that could not be done off-screen:

> *It would be hard because we're so email based. A lot of our work comes via email so I don't think there'd be a way to reduce that [sitting] because that's just the nature of the beast.* E2: female employee, 40–49y

Workload was also a significant barrier. Some participants suggested that time critical work tasks would often be prioritised, and that more frequent breaks had the potential to consume valuable work time.

> *It's just, like, you have to get it done by a certain time. If you take 5 or 6 breaks in between, that 2 or 3 minutes is quite valuable.* M20: female manager, 30–39y

However, others noted that spending time in prolonged periods of sitting was not necessarily a conscious decision. Becoming immersed in work and not realising how much time had passed was commonly reported.

> *I think you can definitely get distracted and just caught up in your work. 'Cause like sometimes I'll look at the time and I'm like, "how is it 4 o'clock?" and I've realised I haven't gone outside all day.* E6: female employee, 20–29y

The increasing reliance on technology and electronic systems was suggested to have reduced incidental opportunities to get up and move around. The need for all work to be documented electronically acted as a barrier to working with hard copy documents as this ultimately led to increased workload through double-handling of information. Similarly, while the benefits of face-to-face communication were acknowledged, some participants noted that the need for a paper trail encouraged the use of email.

> *I think we've evolved from paper to IT which has sort of hindered us from all that other stuff we used to do like walk around and talk to people.* M20: female manager, 30–39y

> *I guess another barrier is actually the way I've learnt my job and the way I should do things, is to have everything in writing, so you know you do spend time when you could speak to someone to make sure it's all confirmed, it's all in writing, it's all backed up.* E5: male employee, 20–29y

Organisational social norms Perceptions of what was considered to be 'normal' workplace behaviour influenced the feasibility of breaking up or reducing sitting. Participants at all three organisations reported workplace cultures that supported taking regular breaks, such as getting a coffee, and that they did not feel pressured to be constantly at their desk. However, they noted that concerns about looking "weird" or feeling self-conscious were barriers to standing up, stretching or moving around the office outside of these purposeful breaks.

> *But I guess there's also that people don't want to stand out, people don't want to look like, you know, they're different from the rest of their peers.* E5: male employee, 20–29y

> *My gut feeling is that if no one else was standing then you probably wouldn't? We do tend to copy one another's behaviour I think.* E10: female employee, 30–39y

There was also a perceived need to have a reason for standing up or being away from the desk and have an

explanation for behaviour that went against these social norms.

…probably anybody who's standing needs to talk about why they're doing it, like, "Why am I standing? Oh, I'm trying to get healthy, I'm trying to reduce my chance of injury, stretch my back, I want to be more active." If they can explain the why to others then it's more likely the other people are likely to do it as well, buy into that vision.
M11: male manager, 30–39y

Other workers modelling behaviours, such as standing up in meetings or stretching, made these behaviours appear more normal. One participant suggested that this could be a way to encourage greater take up of strategies, such as sit-stand desks.

Or maybe if there's a couple of people that are, I guess, commissioned to use that [standing workstation] for a certain amount of time so it becomes more of a workplace norm rather than an outlier or someone doing something real random thing out there.
E5: male employee, 20-29y

Office furniture and layout Participants noted that the physical workplace environment, specifically their workstations, made it difficult for them to reduce their sitting time. None of the workers interviewed had access to a personal height-adjustable workstation, however two of the three workplaces provided staff with height-adjustable or standing desks that could be used as "hot desks".

While a couple of participants liked this hot desk arrangement, most participants didn't make use of the desks. Barriers identified included ergonomic issues, and the inconvenience of using a desk that wasn't as well equipped as participants' individual workstations, which was perceived to impact on productivity.

[Organisation] does have some standing desks that we all share but they're not actually very configurable for your own personal ergonomics which is one reason that I don't use them 'cause I get a sore wrist within minutes of using it. So I don't really find that an option for me.
E10: female employee, 30–39y

I can go over to the standing zone and stand for a bit, and I do that some times. Not as much as some of the others, but I find I'm less efficient there without my screen. I'm sure I'd be able to manage, but I feel like I can get a lot more done on my big screen. E1: male employee, 20–29y

Strategies to reduce workplace sitting

The second key area related to perceptions about strategies to reduce workplace sitting. Two overall themes were identified: promoting and optimising existing opportunities to reduce sitting; and workplace interventions need a suite of additional strategies. Table 3 summarises the main findings on the perceived feasibility and acceptability of specific workplace sitting reduction strategies, with illustrative quotes.

Promoting and optimising existing opportunities to reduce sitting All three organisations provided opportunities for employees to reduce their sitting, although these were not always identified as such by employees. At two of the organisations, senior leaders noted that the office layout had been specifically designed to encourage staff to move around more in the office through centralised facilities (kitchens and bins) and office furniture (e.g. standing height benches in kitchens). However, this did not always appear to change behaviour.

We don't have any bins at desks so all staff need to go to a central location to put rubbish in a bin. The intention was that people would do that regularly but now what we're finding is people.... they have a mound of rubbish that sits there for a week and they go to the bin once. Great. Good idea, but in reality it doesn't quite work. M19: male manager, 30–39y

Standing meetings and in-person communication—two strategies previously suggested as options to reduce sitting time—were also conducted to some extent in each organisation. However, the primary purpose was related to business benefits (e.g. shorter meetings) rather than reducing sitting. Short standing meetings were generally viewed as acceptable and feasible. Longer standing meetings were perceived as less feasible without the option to also sit.

There are some parts of the organisation that still do have standing meetings and it's literally that kind of, the more traditional standing meeting of, this is going to be a five minute meeting… we're going to talk about what's really important and we're not going to bring all our wads of stuff with us.
M18: female manager, 50–59y

I guess it really depends what type of meeting it is and whether you're like, taking notes and stuff like that. If it's a meeting where it's just an update, happy to stand, but if it's a meeting where you're like, really concentrating and taking notes, I think it's sort of difficult to be standing. E6: female employee, 20–29y

Table 3 Summary: perceived feasibility and acceptability of strategies to reduce workplace sitting with illustrative quotes

Strategy	Feasibility and acceptability	Quote/s
Height-adjustable/standing desks	Most participants were supportive of height-adjustable desks as a strategy to reduce sitting time, however noted that cost was the main factor influencing the feasibility of providing them to all staff. Factors influencing the feasibility of existing standing or height-adjustable "hot desks" included design issues, such as configurability to suit individual ergonomic and work needs, and location.	*You have to be careful because when you say reduce sitting, people immediately think about stand up desks. And I am conscious that we are a not for profit organisation, so it's not feasible.* M20: female manager, 30–39y.
		There are standing desk areas but then you have to take your laptop, go and stand there and you don't have the big monitor, you don't have your own set up and everything. M13: female manager, 30-39y
Centralised facilities (e.g. bins, printers)	All three organisations had centralised facilities to some degree (printers and/or bins). This didn't always seem to lead to frequent interruptions from sitting as some participants admitted to saving up jobs so they only had to make one trip.	*But usually I just keep a little pile on my desk and at the end when it starts annoying me at the end of the day or at the middle I go and discard it.* E7: female employee, 20–29y
Communicating face-to-face	All three organisations encouraged in-person communication to varying degrees as it was perceived to be beneficial for collaboration and relationship-building. However, time pressures and the need to have conversations recorded in writing often acted as barriers to carrying this out.	*If you need to, you go and speak to the person but sometimes it's easier to write people an email 'cause then you've got a document trail as to what's been discussed.* E2: female employee, 40–49y
Standing meetings	Standing meetings occurred in parts of all three organisations, mostly for shorter, progress or catch up meetings. These were generally considered to be acceptable and feasible, although generally only if most people were standing. Standing meetings were considered by managers to also have a business benefit through encouraging shorter meetings. Office furniture (i.e. seated desks in meeting rooms) was seen as a barrier to longer standing meetings. One organisation had previously had height-adjustable meeting room tables which were perceived to have been acceptable.	*The aim is if you sat around a table and had that meeting it would be 1 h of sitting versus 10 min of standing and the movement before and afterwards. Which encourages people to get straight to the point. So there's a business, a benefit to that meeting, a business benefit and outcome, and there's also a physical one as well.* M11: male manager, 30–39y
		There are some people who are a bit weirded out when a couple of people are standing in the meeting room and others aren't. M17: male manager, 30–39y
Prompts to reduce sitting (such as a specific software program or calendar reminders)	There were mixed views about prompts to reduce sitting. While some participants thought they would be a feasible way to break up sitting, others thought they would get irritating.	*That's something easy to implement 'cause you can literally just put it in people's calendars and it will come up with a prompt…That's probably sort of like a small change but could make a big difference.* E6: female employee, 20–29y
		Yeah well, the thing is you override it. So if I'm in the middle of trying to work out some finance numbers I'm not going to get up I'll just override it. M20: female manager, 30–39y
Walking meetings	Walking meetings were not widely carried out, nor considered to be particularly feasible, apart from less formal, 1-on-1 catch up meetings.	*One of our managers…sometimes he might walk to the shop and there's a meeting as he walks along. But I don't know that it's actually, if you like, encouraged or anything like that…I think maybe it's a time issue more than anything with him.* E4: male employee, 60–69y
Knowledge and awareness raising	Some participants believed that education and awareness about the health impacts of excessive sitting and potential strategies could potentially be helpful as part of a broader intervention. Some organisational leaders thought that a broader communication campaign around excessive sitting could be considered.	*Yeah, I think it's so normal to sit down throughout your whole day that people think it's fine. If people knew that it wasn't as great as… if they were educated about it. A bit like smoking cigarettes, before people knew it was bad for you, everyone did it.* E5: male employee, 20–29y
Activity trackers, smart phone apps, competitions	A few participants suggested that activity trackers (such as pedometers) or smart phone apps that provided real-time feedback on behaviour could be helpful in motivating people to reduce their sitting. It was also suggested that this could assist in creating a discussion around sitting less and moving more. However, the sustainability of these approaches was questioned.	*I suppose the other thing with this steps [competition]… it's okay at the beginning but sometimes it drops off. You know, once the excitement etc. is all gone by the by.* E4: male employee, 60–69y

Communicating in-person with colleagues was also generally encouraged from a collaboration and relationship-building perspective. While this was supported by the majority of participants as an acceptable and feasible strategy, work pressures appeared to be the main barrier to this occurring more frequently.

As much as we encourage more conversation and just getting up and walking and talking, it's very easy just to get stuck and time passes and the day's gone and we've been sitting all day. M14: male manager, 40–49y

Some participants reported having opportunities within their jobs to perform tasks away from their desk (such as filing), reducing the amount of time they spent sitting. Those with management responsibilities tended to have more relationship-focused tasks that enabled them to break up their sitting through the day. For those without these opportunities it was suggested that managerial support or intervention may be required or, alternatively, for job roles to be redesigned in order to create those opportunities.

There are some jobs where you are chained to the desk because it's all data entry and in that space maybe the different challenge is the leader creating those times and space to actually physically remove people from that space. M18: female manager, 50–59y

We from time to time need to check things in the filing room so we need to get up and go there, but yeah, it's maybe breaking up the job a bit more too. If we had, I guess, other tasks that involved getting up for a period of time that would probably help as well.
E8: male employee, 40–49y

Workplace interventions need a suite of additional strategies – not just height-adjustable desks When participants were asked to consider other strategies that their organisation could implement to reduce sitting, there was widespread support amongst employees for increasing the availability of individual height-adjustable desks. However, while these desks were acceptable, the cost implications were seen by both employees and managers as making these a less feasible option than some low-cost strategies to reduce sitting. For the small business and the not-for-profit organisation, implementing height-adjustable desks across the entire organisation was not presently considered to be a feasible solution to reducing workplace sitting:

There are some wonderful standing desks on the market but they're also prohibitively expensive…it's just not attainable for us as a small business.
M11: male manager, 30–39y

However, a manager in the largest organisation noted that he believed these desks were becoming more affordable, as additional lower-cost models had started to come onto the market:

I reckon if we were to talk again in 12 to 18 months I'd be telling you that we had a lot more standing workstations. M14: male manager, 40–49y

In addition to cost implications, there was also general caution from some managers about rushing in to the purchase of height-adjustable desks. It was pointed out that simply providing height-adjustable desks in isolation was insufficient to change behaviour.

I've seen organisations with the best standing desks on the market but no one stands at them, they just sit there down the whole time. M11: male manager, 30-39y

Certainly I think sit to stand workstations are great to a point, but I think there's still that opportunity to get people physically moving. M18: female manager, 50–59y

There was also a concern from one occupational health and safety representative that, if not used correctly, these workstations could potentially lead to other health issues.

We've also had people use them 100 % or 90 % of the time and they then have issues because they're standing up all the time. So there is a.... there's got to be a balance between how these things are used.
M19: male manager, 30–39y

There were differing opinions about the acceptability of other strategies to reduce sitting (see Table 3). For example, while many participants liked the idea of a prompt that reminded users to take a break from sitting, others (particularly some who had trialled prompts) disagreed, noting that a forced break in concentration would be detrimental for certain jobs.

I've often thought, "oh what I should do is bring in a little alarm clock to prompt me that I've been sitting here too long". And as I said earlier on, sometimes I get focused on what I'm doing and I forget the fact that I've been sitting here too long. So a prompt I think would be useful. E4: male employee, 60–69y

One of the challenges I think with that is, depending on the work you're doing, you're sometimes on a roll. And you don't want the interruption, or when it comes

up it will break the train of thought so it's a bit hard to know what will work for everyone. I think that sort of thing would probably work for a number of people, I'm not sure it would work for everyone. M17: male manager, 30–39y

Wearable technology, phone apps and pedometer challenges were also suggested as possible strategies to encourage people to move more throughout the day. However, participants questioned the long-term sustainability of these approaches once the initial novelty had worn off.

Overarching perceptions around addressing workplace sitting

Three themes relating to overarching perceptions about addressing workplace sitting were identified: perceived individual responsibility or motivation; addressing musculoskeletal injuries vs universal health promotion; and workplace priorities.

Perceived individual responsibility or motivation There was a perception among many participants that reducing or breaking up workplace sitting was the responsibility of individuals and required a conscious decision on their part. Thus, it was perceived that, while organisational support may be an important facilitator, it ultimately would be up to individuals to change their behaviour.

Ultimately you, the employee, controls how often you take a break, if you work your hours, if you go home on time, so it is your own initiative.
E7: female employee, 20–29y

You can't force people to get up and move around. You can only do so much. M19: male manager, 30–39y

Some of the managers questioned this philosophy, suggesting that accountability to others was a stronger motivator.

I think as individuals we never do anything unless we're actually held on to it by other people.
M12: male manager, 20-29y

Addressing musculoskeletal injuries vs universal health promotion Organisational measures to reduce prolonged sitting were generally viewed in the context of addressing pre-existing musculoskeletal injuries. This was in contrast to the more universal primary preventive approach taken with physical activity or exercise, with each organisation investing resources to some extent in initiatives such as fitness classes (generally outside of work hours) and active transport facilities.

In two of the organisations, participants reported that sit-stand desks were generally provided to people with specific health needs as a remedial measure; although in one of these organisations senior managers were also reported to have access in the absence of health issues. As one manager noted, this had led to a perceived exclusivity about them.

It's still seen as a bit of, "oh that's a bit of a luxury", whereas if they were more widespread I think that would be less the case. M18: female manager, 50–59y

In the context of sit-stand workstations being viewed as a remedial measure or an exclusive item, there were some judgements by managers and employees around how these were used, i.e. the amount of time that people spent standing. As one manager noted:

Sit to stand workstation is something that everybody wants all of a sudden, it's great, it's the "it" thing. Use it for a week or so and then it ends up in down position and everybody's sitting back down and not used.
M19: male manager, 30–39y

A couple of participants that reported attempts to reduce their sitting time noted pre-existing musculoskeletal-related issues that prompted them to make these changes. Others also reported sometimes noticing physical effects when they had days with particularly long periods of time spent sitting:

If you've just sat at your desk all day you can really feel, like when you leave to go home you're just like, "oh I'm really sore" or I just feel really lethargic because I've just been inside looking at a computer screen all day. E6: female employee, 20–29y

One manager noted the challenge of encouraging those without symptoms to reduce their sitting.

The hardest thing is actually linking back the benefits of why you should be moving more. I think that's a really hard message to get across. You're not going to break a leg if you sit too long. It's not an immediate impact; it's a long term impact on health. M11: male manager, 30–39y

However, there was also general acknowledgement from employees that breaking up sitting throughout the day could have beneficial effects on productivity-related factors such as concentration, focus and fatigue.

I personally find it a bit helpful sometimes if you're a bit stuck on something, you can just walk away and get a glass of water and come back. It's sometimes just giving your brain a little bit of a break. E10: female employee, 30–39y

Workplace priorities Managers expressed a need for stronger evidence showing that sedentary behaviour was a significant issue for their organisation – both in terms of general research about the health implications of sedentary behaviour and specific data relevant to their business operations (such as injury compensation claims). Addressing sedentary behaviour was seen in the context of a range of competing priorities and limited resources; there was a reluctance to rush into investing in strategies that may not be evidence-based.

If the information was compelling enough to say that prolonged sitting causes or contributes to x, y and z. Don't know if the information is that compelling at the moment. I think it's just general awareness and generally people will say you shouldn't sit for long periods of time. M14: male manager, 40–49y

We facilitate that but we don't necessarily point it out as a problem, so we don't say to people "this is a problem in our organisation and we need to fix it", 'cause I don't even know if it is a problem. M11: male manager, 30–39y

Discussion

This study assessed perceptions about reducing workplace sitting amongst Australian office workers from three organisations. None of the workplaces had implemented any formal intervention to reduce prolonged sitting time. The issues identified, including barriers to reducing sitting and perceptions about a range of sitting reduction strategies, provide some insight into the feasibility of intervening in this work context and approaches that will need to be considered to improve acceptability of initiatives to reduce sitting time in workplaces.

Barriers to reducing workplace sitting

The nature of work and currently available office furniture were perceived to be the most significant barriers to reducing workplace sitting time across all three organisations. Workload pressures and the reliance on computers meant that participants found it difficult to identify many opportunities to significantly reduce their workplace sitting. Most participants had few, if any, tasks that could be performed away from their computers. With their existing workstation arrangements it was indicated that computer-based tasks required them to be seated. Thus, breaks from sitting were generally viewed as interruptions to work flow. Computer-based work presents a challenge to reducing prolonged sitting time in office workplaces. There is a need to consider how job roles and work tasks can be redesigned in a way that provides opportunities for more light to moderate intensity physical activity during the work day [28].

Unlike previous studies [16, 17], the perception of being seen as unproductive while away from the desk did not emerge as a significant barrier to reducing sitting in this sample. Encouragingly, management in all three organisations were perceived to be supportive of staff taking regular breaks. Managers also reported encouraging face-to-face communication within their teams. Participants at two of the three organisations reported that their organisational structures were not strongly hierarchical. This less traditional managerial approach could be one explanation for our findings differing somewhat to those of prior qualitative research. However, social norms ultimately appeared to influence how comfortable workers felt about standing up or moving more throughout the office, outside of a purposive break (e.g. using the bathroom). In particular, it was perceived that standing during meetings or at the desk would be viewed as "weird" or abnormal by co-workers unless there was a stated reason for doing so, such as a musculoskeletal injury.

The perceived barriers to reducing sitting time identified in this study include factors operating at the individual, social and environmental levels, supporting an ecological model of sedentary behaviour [29]. This highlights the importance of interventional approaches that address these multiple, interrelated levels of influence on behaviour, rather than focusing solely on environmental factors (e.g. height-adjustable desks) or individual-level behavioural change strategies. Noting the importance of organisational influences, it has been suggested that an organisational cultural framework could be helpful in the design of workplace sedentary behaviour interventions [30]. For example, Schein's model of organisational culture [31], suggests that there are three key levels of culture: i) basic underlying assumptions (which are unconscious; e.g. values and belief systems), ii) espoused values (explicit; e.g. strategies, goals) and iii) artefacts (visible behaviour). Applying this model to workplace sitting, intervention strategies may need to focus on addressing each of these multiple implicit and explicit influences, in order to achieve a workplace culture that is more supportive of reducing sitting [30]. For example, while the underlying value systems in these three organisations appeared to be broadly supportive of taking regular breaks from sitting, the next steps to addressing this issue may need to include the development of a formal organisational policy addressing prolonged sitting and targeting of the workplace social norms that reinforce workplace

sedentary behaviour. Possible strategies could include engaging workplace champions of localised and organisation-wide 'sit less' strategies [32], who can model the desired behaviour (i.e. standing and moving more) and motivate their peers. This approach may assist in modifying the organisational culture by shifting norms around appropriate office behaviour.

Strategies for reducing workplace sitting

While participants expressed an interest in the idea of sit-stand desks, widespread implementation was considered unlikely to be feasible in at least two of these organisations for financial reasons. However, in the participating organisations, sit-stand or standing hot desks were not always used when they were provided, with ergonomic issues, configurability and location cited as potential barriers to use. As a result, participants still equated computer-based work with sitting despite the availability of alternatives that facilitated standing. Design issues have previously been cited as influencing the acceptability of sit-stand desks [13, 14]. In addition, previous research has found wide individual variation in standing hot desk usage within an office environment [33]. With resource constraints likely to be a key issue for many workplaces—particularly for small businesses and not-for-profit organisations—there is a need for greater understanding of whether these hot desk arrangements can be optimised to create a more acceptable option to reduce sitting time. More recent models of height-adjustable workstations provide larger, adjustable work surfaces and options for dual monitors. As the design of these workstations evolve they may become more acceptable to a broader range of workers.

All three organisations provided staff with other opportunities to reduce and break up their sitting time during the day. In particular, two organisations provided office layouts designed to facilitate movement through centralised facilities and all three performed standing meetings and promoted face-to-face communication with colleagues. Staff did not often readily identify these as specific 'sit less' strategies unless prompted; however, this may be due to the lack of formalised awareness campaigns about workplace sitting. This study was not able to assess whether these were effective in nudging employees to move around more in the office. When planning a workplace intervention to reduce sitting an audit should be considered to identify existing workplace practices that encourage movement. For example, while standing meetings were reported to predominately occur for business reasons (i.e. shorter meetings) the existing practice may also be an opportunity to promote the additional benefits of reducing sitting time. Identifying practices that have dual benefits may encourage greater buy-in from leaders.

As noted by others [16], a 'one size fits all' approach is unlikely to be effective for addressing workplace sitting time. Within this small study, participants had varied views on the feasibility of different workplace strategies. Providing a range of options could assist with catering to different preferences and job requirements. It may also be the responsibility of organisational leaders to identify sitting hot spots within their organisation and provide these staff with opportunities to reduce their sitting time across the work day. Participative approaches, where staff are involved in selecting the most appropriate strategies for their workplace, may be important for promoting ownership of the program and ensuring that strategies align with workers' needs [22, 34, 35].

Future directions for workplace interventions

There has been significant media attention given to the issue of workplace sedentary behaviour in recent years, particularly in Australia [11]. In this context, it is of interest to see that the health implications of sitting at work were still generally viewed with a musculoskeletal lens, similar to previous findings in Australia and Belgium [16, 17]. In the workplace, musculoskeletal injuries are more immediate by nature than chronic diseases and potentially more easily attributable to work practices. In two of the organisations sit-stand desks were provided as a remedial measure to those with pre-existing injuries. The awareness of excessive sitting as a cardio-metabolic risk factor may still not be sufficiently high in the general population [36], suggesting that education and awareness raising should be incorporated into workplace sedentary behaviour interventions or broader occupational health and safety training.

Leaders across all three organisations indicated that they needed a stronger evidence base that excessive sitting was impacting on their core business and that it should be treated as a priority issue. With limited resources and competing workplace health priorities, organisations need a compelling business case for investing in sedentary behaviour interventions. Research outlining the economic benefits of reducing workplace sitting may be required to facilitate unreserved support from senior leaders [24, 37]. A recently completed multicomponent workplace intervention trial incorporating sit-stand desks demonstrated that substantial and sustainable reductions in workplace sitting time are achievable and feasible [21]. An economic evaluation planned as part of this trial [38] may assist with filling this evidence gap.

There may be opportunities for researchers to collaborate with various workplace stakeholders (including peak industry bodies, trade unions, occupational health and safety professionals, and workplace health promotion practitioners) to assist with disseminating messages about the health implications of excessive sitting and developing

specific guidelines about reducing and breaking up sitting [21, 29]. An expert statement released in 2015 provides some initial guidelines for appropriate levels of workplace sitting [37]. This advice is likely to evolve as the results of higher quality intervention studies emerge.

Strengths and limitations

The strengths of this study include the representation of workers from different organisational levels and across a range of different occupations. There was also equal representation of genders and a broad range of ages. The inclusion of younger workers (less than 35 years) was also a key strength, providing insight into a demographic at the start of their careers that may be less affected by ingrained workplace behaviours.

Limitations were that the study involved a small, convenience-based sample in one Australian city, and the themes encountered may not necessarily be generalisable to all office-based workplaces. As participants volunteered to take part in a study about workplace sitting they may have been generally more engaged with this issue and more receptive to change. Nonetheless, we still encountered a range of perspectives on this issue with differing levels of knowledge about sedentary behaviour. Another limitation of our study is that the interview guides were not first piloted. However, the questions were refined and revised during the development process with reference to experience with a recent large-scale worksite trial [21] and through discussions with multiple co-authors who are experienced with qualitative research (SL, AL, BF).

The organisations selected had all expressed some level of interest in addressing sedentary behaviour in the workplace, although none had initiated a formalised sedentary behaviour policy or intervention. Each organisation had some standing/sit-stand workstations available to staff, which suggests they already had some awareness of issues around sitting at work. Participants also reported that their respective workplace culture was generally encouraging of taking breaks and movement throughout the office. As a result, these organisations may have a higher level of readiness to change than some other organisations, which could limit the generalisability of these findings. However, we found through conducting these interviews that the organisations were still in the early stages of responding to the issue; namely, they had not widely communicated to staff that sedentary behaviour was a priority issue.

Conclusions

This study provides insight into workers' perceptions on the feasibility of reducing sitting in office workplaces. The common themes identified around the feasibility of reducing workplace sitting time may be helpful for informing health promotion initiatives in this setting. Promoting low-cost strategies, such as standing meetings and computer prompts, may be feasible short-term approaches for businesses, particularly those for which height-adjustable desks are unaffordable. However, when implementing such approaches, it is important to consider the influence of factors such as social norms and workload pressures that may impact their success. Raising awareness of the cardio-metabolic risk of sedentary work and building supportive organisational cultures are likely to be key foundations for behavioural change. Overall, a comprehensive systems-based approach that integrates sedentary behaviour reduction strategies into existing occupational health and safety frameworks will be important for achieving population-level health impacts. Further intervention research employing rigorous study designs, including the incorporation of measures of productivity and cost-effectiveness, is required to strengthen the business case for reducing prolonged sitting in the workplace.

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Availability of data and materials

The data from this study will not be shared publicly for ethical requirements. Participant consent was not given for data to be provided to third parties.

Authors' contributions

NH conceived the study, participated in its design and coordination, carried out the interviews, analysed and interpreted the data and drafted the manuscript. CB analysed the data and assisted with interpretation of the findings. AL, BF, BL, DD, NO, GH and SL contributed to the conception and design of the study. BF and SL assisted with analysis of the data and interpretation of the findings. All authors were involved in manuscript development and critical review for important intellectual content. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate
Ethics approval for this study was granted by The Alfred Health Human Ethics Committee (Melbourne). All participants provided written informed consent.

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4.2 Summary and implications of findings

This study identified that factors acting at the individual, social and environmental levels are perceived to influence workplace sedentary behaviour, and potentially act as barriers to reducing sitting time. The main themes relating to barriers to reducing workplace sitting were: the nature of work (including the predominance of computer based-tasks and the amount of work); organisational social norms about acceptable or normal workplace behaviour; and, office furniture and layout that promoted a seated posture. Interestingly, similar themes emerged across the three workplaces, despite the organisations being of varied sizes and from different industries.

A key finding was that workers did not perceive that reducing and breaking up their sitting time would have a negative impact on their work performance or productivity. They did not perceive that their managers or team leaders had an issue with them taking breaks if there was a reason for doing so (e.g. a tea/coffee break). This is a promising finding in light of some previous studies that have suggested that productivity concerns could be a barrier to more frequent interruptions of sitting time (191, 212). However, some participants suggested that there may be a point at which too much wandering around the office without a specific purpose could be problematic, both from the perspective of completing work tasks and potential negative reactions from their co-workers. It is important to note that participants reported having a fair degree of control over how they structured their work tasks and managed their time including when they could take breaks. These findings are therefore unlikely to be directly applicable to workers whose job tasks are not in their direct control, e.g. call/contact centre workers.

Other important findings from this study related to how sedentary behaviour strategies were implemented, promoted and utilised within the office. Variability within and between organisations in terms of the acceptability of different strategies suggests that a ‘one size fits all’ approach is unlikely to be effective. At all three organisations, employees were provided with opportunities to reduce their sitting time. These included standing or sit-stand hot desks, standing height benches in communal areas, and centralised facilities (such as bins and printers). However, these weren’t necessarily recognised as opportunities to reduce and break up sitting time. For example, standing meetings occurred predominately for business reasons, to promote short, efficient meetings. Communicating face-to-face, rather than through email, was also promoted, but generally because it was recognised to be beneficial for relationship building and effective communication. This finding is not necessarily negative, and highlights that strategies that facilitate reductions in sitting time may also have other benefits for businesses. Identifying and promoting the dual benefits of strategies to reduce sitting time may be the key for

organisational buy-in and could increase their likelihood of being incorporated within existing workplace policies and procedures. This will also assist with providing the business case for addressing high levels of workplace sitting, which was a theme of the feedback received from organisational leaders in this study.

Useful insights emerged in relation to the acceptability of hot desk arrangements for standing desks or height-adjustable workstations. In the two organisations where these arrangements were available, the convenience of their location and adaptability of the ergonomic set up were reported to influence whether they were used. Previous research has found high individual variability in the use of standing hot desks, with minimal reduction in sedentary time (235). While hot desk arrangements may appear to be a feasible and affordable approach for organisations in lieu of providing each worker with their own sit-stand workstation, if the workstations are poorly used this raises questions about whether such an approach is a worthwhile investment.

A limitation of this study is that it presents workers' perceptions of barriers that have the potential to affect their ability to reduce their sitting time, not their actual experiences of these barriers. As such, additional and/or different barriers may be experienced if a workplace sedentary behaviour program was to be initiated within their organisation. However, for understanding factors that may influence the initiation of behavioural change or impede the success of workplace interventions, these findings are informative. In addition, the findings align with other recent qualitative research that has identified work tasks, and the social and physical workplace environment (and how supportive this is perceived to be), as barriers and facilitators to behavioural change during interventions (197, 213, 236).

One element of the ecological model of sedentary behaviour that had limited focus in this study was the role of policy in influencing workplace sitting time. None of the participating organisations had specific workplace policies on reducing sedentary behaviour and only one had a policy addressing physical activity. This is unsurprising given the limited policy advice about workplace sedentary behaviour currently available from national or international agencies (237). While there were some informal strategies in place to assist employees to reduce their workplace sitting time, an overarching policy detailing the organisation's approach to addressing the issue may be the next step to demonstrate to workers that this is a priority issue.

Overall, this study provides insight into the perceived feasibility of reducing workplace sitting time in desk-based office environments. Addressing these identified barriers through the design of sedentary behaviour interventions may be beneficial for improving uptake and effectiveness.

Variation in the perceived feasibility of different strategies to reducing workplace sedentary behaviour suggests the need for localised, participatory approaches in intervention design.

The next two chapters aim to identify and examine factors that influenced reductions in workplace sitting time during the SUV intervention. Chapter 5 focuses on the potential mechanisms through which this multi-component workplace intervention led to behaviour change by examining social-cognitive mediators of intervention effects on workplace sitting time. Chapter 6 aimed to provide further understanding of potential barriers and facilitators to reducing workplace sitting time through a qualitative study that examined participants' experiences of participating in SUV.

CHAPTER 5

SOCIAL-COGNITIVE MEDIATORS OF WORKPLACE SITTING REDUCTION

Chapter 4 examined perceived barriers to reducing workplace sitting time amongst office workers who had not previously been exposed to a workplace intervention, with findings suggesting contextual factors that may need to be considered when planning workplace sedentary behaviour programs. The nature of work, workplace social norms, and the physical workplace environment were perceived to be important influences on the amount of time these participants spent sitting at work and the feasibility of reducing this sitting time.

When considering the range of influences that may be important for workplace sedentary behaviour change, one area that has received limited attention is the potential role of social-cognitive factors. Social-cognitive constructs derived from health behaviour theories, such as social cognitive theory (228) and the theory of planned behaviour (238), are often targeted in physical activity interventions (239) under the assumption that these factors may be important mediators of behavioural change. Whether these factors underpin the mechanisms of behavioural change during workplace sedentary behaviour interventions is of interest to explore further.

There is emerging evidence from cross-sectional studies suggesting that certain social-cognitive factors may be associated with the amount of time spent sitting at work. In particular, having higher levels of perceived behavioural control over workplace sitting has been found to be associated with lower workplace sitting time (181, 186, 187) and higher levels of workplace standing (240). As identified in the previous chapter (234) and in another study (186), social norms around workplace behaviour (i.e. that sitting is the normal, expected behaviour) may also influence the amount of time spent sitting. Another social-cognitive factor that could potentially be related to workplace sitting time is self-efficacy, the confidence an individual has in being able to perform a certain behaviour. Self-efficacy has been shown to be a consistent correlate of physical activity in adults (241), however, whether it is associated with sedentary behaviour is unknown.

The SUV intervention, previously described in Chapter 3, was a multi-component workplace intervention that was demonstrated to be successful at reducing workplace sitting time at three and 12 months (208). SUV had a theoretical basis in social cognitive theory (228), but did not aim to comprehensively test this or other theories. Examining the potential role of these theoretical constructs in workplace sedentary behaviour change may provide useful insights into

the mechanisms through which SUV was effective and inform the refinement of intervention strategies for future programs.

Prior to the publication of the study in section 5.1, no previous research had assessed whether changes in social-cognitive factors mediate intervention effects on workplace sitting time. This knowledge is likely to be important for further development of strategies for reducing workplace sitting time by identifying intervention targets that appear to be important for behavioural change.

Section 5.1 contains a peer-reviewed paper published in the *International Journal of Behavioral Nutrition and Physical Activity* in 2017 (242). This study first aimed to examine whether the SUV intervention led to changes in four targeted social-cognitive constructs (knowledge, barrier self-efficacy, perceived behavioural control, and perceived organisational norms) at short- (three month) and long-term (12 month) follow-ups. Secondly, it aimed to examine whether these constructs mediated the significant intervention effects on participants' workplace sitting time at these two time points.

As noted in the paper in section 5.1, of the 231 SUV participants at baseline, a total of 208 (121 intervention and 87 control) and 167 (97 intervention and 70 control) participants completed the 3 month and 12 month follow up assessments, respectively. Complete data for the mediation analyses was available for 186 participants at 3 months and 145 participants at 12 months. Logistic regression analyses identified that, compared to those included in the mediation analyses, those who were not included for the 3 month analyses were broadly similar in terms of baseline socio-demographic, health-related and social-cognitive characteristics. However, reporting high mental demands was associated with reduced odds of being included.

Characteristics associated with reduced odds of being included in the 12 month mediation analyses were: smoking, not having completed post-school education, having a higher BMI, reporting high mental demands, or reporting upper extremity musculoskeletal problems that affected activity. Having a higher barrier self-efficacy score at baseline was also associated with reduced odds of being included at 12 months; none of the other social-cognitive constructs were significantly associated.

Further details of the methods are included in the paper in section 5.1. Section 5.2 includes further discussion of the implications of the findings.

5.1 Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial

Hadgraft NT, Winkler EA, Healy GN, Lynch BM, Neuhaus M, Eakin EG, et al. Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial. Int J Behav Nutr Phys Act. 2017;14:27.

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Intervening to reduce workplace sitting: mediating role of social-cognitive constructs during a cluster randomised controlled trial

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Abstract

Background: The Stand Up Victoria multi-component intervention successfully reduced workplace sitting time in both the short (three months) and long (12 months) term. To further understand how this intervention worked, we aimed to assess the impact of the intervention on four social-cognitive constructs, and examined whether these constructs mediated intervention effects on workplace sitting time at 3 and 12 months post-baseline.

Methods: Two hundred and thirty one office-based workers (14 worksites, single government employer) were randomised to intervention or control conditions by worksite. The intervention comprised organisational, environmental, and individual level elements. Participant characteristics and social-cognitive constructs (perceived behavioural control, barrier self-efficacy, perceived organisational norms and knowledge) were measured through a self-administered online survey at baseline, 3 months and 12 months. Workplace sitting time (min/8 h day) was measured with the activPAL3 device. Single multi-level mediation models were performed for each construct at both time points.

Results: There were significant intervention effects at 3 months on perceived behavioural control, barrier self-efficacy and perceived organisational norms. Effects on perceived organisational norms were not significant at 12 months. Perceived behavioural control significantly mediated intervention effects at 3 months, accounting for a small portion of the total effect (indirect effect: −8.6 min/8 h day, 95% CI: −18.5, −3.6 min; 7.5% of total effect). At 12 months, barrier self-efficacy significantly mediated the intervention effects on workplace sitting time (indirect effect: −10.3 min/8 h day, 95% CI: −27.3, −2.2; 13.9% of total effect). No significant effects were observed for knowledge at either time point.

Conclusions: Strategies that aim to increase workers' perceived control and self-efficacy over their sitting time may be helpful components of sedentary behaviour interventions in the workplace. However, social-cognitive factors only partially explain variation in workplace sitting reduction. Understanding the importance of other levels of influence (particularly interpersonal and environmental) for initiating and maintaining workplace sedentary behaviour change will be informative for intervention development and refinement.

Trial registration: This study was prospectively registered with the Australian New Zealand Clinical Trials register (ACTRN12611000742976) on 15 July 2011.

Key words: Sedentary, Workplace, Intervention, Mediation

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Background

The workplace is a priority setting for initiatives targeting behavioural risk factors for chronic disease [1]. Time spent sitting (sedentary behaviour) is an identified health risk [2, 3] and many adults accumulate large volumes of sitting during their working hours [4–6]. Accordingly, there has been considerable recent attention to the evaluation of interventions to reduce workplace sitting [7, 8]. Despite evidence of intervention efficacy, there has been much less attention to the pathways through which interventions to reduce sitting in the workplace may exert their impact. An ecological approach—targeting physical and social environmental factors, alongside individual-level factors—is considered best practice for workplace health promotion [9] and for interventions aimed at reducing sedentary behaviour [10]. However, there has been limited empirical investigation into how such an approach may lead to successful behavioural change. Understanding the potential role of social-cognitive factors in contributing to behavioural change may provide insight into some of these mechanisms.

Constructs derived from health behaviour theories, such as Social Cognitive Theory [11] and the Theory of Planned Behaviour [12], are often targeted in physical activity interventions [13]. There is fairly consistent evidence suggesting that self-efficacy (confidence in one's ability to perform a behaviour) is a correlate of physical activity [14] while social support also appears to be important [14, 15]. Fewer studies have explored associations between social-cognitive factors and sedentary behaviour. A relatively modest body of evidence from cross-sectional studies suggests that certain social-cognitive constructs may be correlates of workplace sitting time. For example, a greater level of perceived behavioural control over sitting has been found to be associated with less workplace sitting time [16, 17] and higher levels of standing at work [18], which is consistent with findings from qualitative research [19]. Social norms that reinforce sitting as being the expected or most appropriate workplace behaviour may also lead to higher levels of workplace sitting [17, 20], while there is some evidence to suggest that knowledge about the potential benefits of regularly breaking up sitting positively impacts on this behaviour [21].

With increasing attention to interventions to reduce workplace sitting, understanding how they work – that is whether the constructs targeted to change are actually being impacted, and whether in turn, a change in targeted constructs mediates a change in workplace sitting – is important to inform their continued development and to improve their effectiveness. No previous studies have examined the social-cognitive mediators of multi-component interventions to reduce workplace sitting time.

To address this evidence gap we examined short (3 month) and long (12 month) term changes in social-cognitive constructs (knowledge, barrier self-efficacy, perceived behavioural control, and perceived organisational norms) following a worksite sedentary behaviour intervention, Stand Up Victoria (SUV). In the SUV trial, significant reductions in workplace sitting time were observed in the intervention group relative to the control group of 99.1 min/8 h workday (95% CI −116.3 to −81.8 min/8 h workday) at three months, and 45.4 min/8 h workday (95% CI: −64.6 to −26.2 min/8 h workday) at 12 months [22]. We also examined whether these constructs mediated the significant intervention effects on participants' workplace sitting time at these two time-points.

Methods

Study design and participants

Stand Up Victoria (SUV) was a cluster randomised controlled trial (RCT) of a multi-component workplace intervention aimed at reducing workplace sitting time. Ethics approval was granted by Alfred Health Human Ethics Committee (Melbourne, Australia), with prospective trial registration with the Australian New Zealand Clinical Trials register (ACTRN12611000742976) on 15 July 2011. The trial was conducted in accordance with the CONSORT guidelines for cluster randomised trials (http://www.consort-statement.org/). Further details of participant recruitment [23], study procedures [24], and the main outcomes [22] have previously been published. In brief, participants were 231 government office-based workers recruited from 14 geographically separate worksites from a single employer in Melbourne, Australia between April 2012 and October 2013. Cluster sizes ranged from 5 to 39 participants. A total of 208 (121 intervention and 87 control) and 167 (97 intervention and 70 control) participants completed the 3 month and 12 month follow up assessments respectively. Randomisation to the control or intervention conditions occurred at the worksite level; outcomes and covariates were measured at the individual level. Due to the nature of the intervention, participants and study staff were not blinded to group allocation.

Intervention

A multi-component intervention, incorporating elements at the organisational level (e.g. tailored management emails), the built/physical environmental level (sit-stand workstations) and the individual level (e.g. health coaching), was delivered to participants in the intervention sites. Individual- and organisational-level strategies were delivered for 3 months, while the workstations were retained for 12 months. The three intervention messages of "Stand Up, Sit Less, Move More" intended to reduce sitting time, particularly prolonged durations of sitting time, through replacement with standing or light intensity (e.g. walking) activities. Control site participants were advised of the aim

of the study and continued their usual work practices. Further details of the iterative development of the intervention have been published previously [25]. Briefly, the intervention was informed by Social Cognitive Theory [11], workplace health promotion frameworks including the World Health Organization's Healthy Workplace Framework [26], and formative research [4, 27, 28]. The final SUV intervention also incorporated a participatory approach that influenced the specific behaviour change techniques adopted [25].

The intervention components (detailed in Table 1) aimed to positively influence four key social-cognitive constructs: perceived behavioural control, barrier self-efficacy, organisational social norms and knowledge. The SUV intervention components had an explicit theoretical and pragmatic basis [25], however, the trial did not aim to comprehensively test a single behavioural theory.

Data collection and measures

Workplace sitting

Onsite assessments were conducted at baseline, 3 and 12 months for both intervention and control groups. These included collection of anthropometric and cardiometabolic measures and provision of instructions for wearing the activPAL3 activity monitor (PAL Technologies Limited, Glasgow, UK), which was used to measure the primary outcome, workplace sitting time. The activPAL3 is considered accurate and responsive in measuring sitting time [29]. The monitor was waterproofed and attached to participants' right thigh with a hypoallergenic patch. Participants were asked to wear the monitor for seven days, 24 h/day, following the onsite assessment. A diary was provided for participants to record their working hours, wake and sleep times, and any monitor removal periods. To account for differences in working hours, workplace sitting time was standardised to an 8 h work day.

Social-cognitive constructs and covariates

Following each onsite assessment, participants completed a self-administered online questionnaire [30] to collect data on socio-demographic, work-related and health-related factors, and the social-cognitive constructs. Details of the tools used to assess the social-cognitive constructs, including their psychometric properties, are shown in Table 1. As there were no existing measures specific to workplace sitting for these constructs, scales were adapted from the physical activity

Table 1 Description of hypothesised social-cognitive mediators and associated intervention strategies

Hypothesised mediators	Scale description	Response	Targeted intervention strategies	Internal consistency (Cronbach's alpha)
Perceived behavioural control	Perceived control over sitting less at work. E.g. *It is my choice whether I stand up or sit at my desk while at work"*	Five items; 1–5 Likert scale. Strongly disagree - Strongly agree	- Participant brainstorming session to identify strategies to reduce sitting. - Establishing new workplace policies & practices (e.g. standing meetings, no emails within organisational units) - Installation of height-adjustable workstations - Environmental changes to encourage movement (e.g. signs at lifts prompting use of stairs)	0.72
Barrier self-efficacy	Confidence about overcoming barriers to sitting less at work. E.g. *How confident would you have been that you could have stood up during meetings at work, even though no one else was.*	Nine items; 1–5 Likert scale. Not at all confident - Very confident	- SMART goal setting for use of workstations with health coach - Problem solving with health coach to overcome barriers - Encouraging use of prompts (e.g. stand when telephone rings) - Encouraging use of strategies (e.g. "imails" instead of emails)	0.92
Perceived organisational norms	Perceived organisational/social support for sitting less at work. E.g. *My workplace is committed to supporting staff choices to stand or move more at work*	Eight items; 1–5 Likert scale. Strongly disagree - Strongly agree	- Organisational/upper management support - Team champions acting as role models and spokespersons - Tailored management emails sent from team champions - Establish new workplace policies & practices (e.g. standing meetings, no emails within organisational units)	0.81
Knowledge	Knowledge about the health effects of prolonged sitting. E.g. *Sitting for most of the time at work is bad for my health*	Five items; 1–5 Likert scale. Strongly disagree - Strongly agree	- Information session on the health consequences of excessive sitting - Health coaching - Management emails with information on health effects	0.50

literature or purposively developed for the study. These measures have previously been pilot-tested [4]. Scores for each construct at the three time points were calculated by averaging responses to individual items and were measured on 5-point Likert scales. The change in participants' scores on each construct were calculated from i) baseline to three months, and ii) baseline to 12 months; these change scores were used in the mediation analyses.

Statistical analyses

Analyses were conducted in STATA v.14 (STATACorp LP) and statistical significance was set at $p < 0.05$. To examine the potential mediating role of changes in social-cognitive constructs on workplace sitting at three, and 12 months, mediational analyses using a completers analysis were performed using STATA's "ml mediation" package (P.B. Ender, UCLA). This package performs a series of multi-level linear regression analyses to obtain coefficients for: Path A, the effect of the intervention on changes in the social-cognitive constructs; Path B, the relationship between changes in the social-cognitive constructs and changes in workplace sitting; and, Path C', the direct effects of the intervention on workplace sitting time (see Fig. 1). Mediational effects were calculated by the product of coefficients (a*b) method [31], with bias-corrected confidence intervals determined using cluster bootstrapping with 5000 replications. The coefficients indicate changes in minutes per day of workplace sitting time for each one point increment (on the 5-point Likert scale) for each of the social-cognitive constructs. Separate models were run for each mediator separately (i.e. single mediation) at both time points (i.e. concurrent mediation). All models adjusted for baseline sitting time and potential confounders, and corrected for clustering via a random intercept for worksite. Potential confounders were identified a priori and included in the models if they predicted workplace sitting changes at either 3 or 12 months at $p < 0.20$ using backwards elimination (age and gender were included in all models regardless of significance). Indirect effects are also reported as a percentage of the total intervention effect. Worksite variation was reported from the mixed models in terms of intracluster correlations and the significance of the random intercept for worksite, accounting for confounding variables and intervention/control status. The SUV trial was powered a priori on detecting a minimum difference of interest (MDI) for workplace sitting of 45 min/8 h day between the intervention and control groups with 90% power [22]. Our MDI in the social-

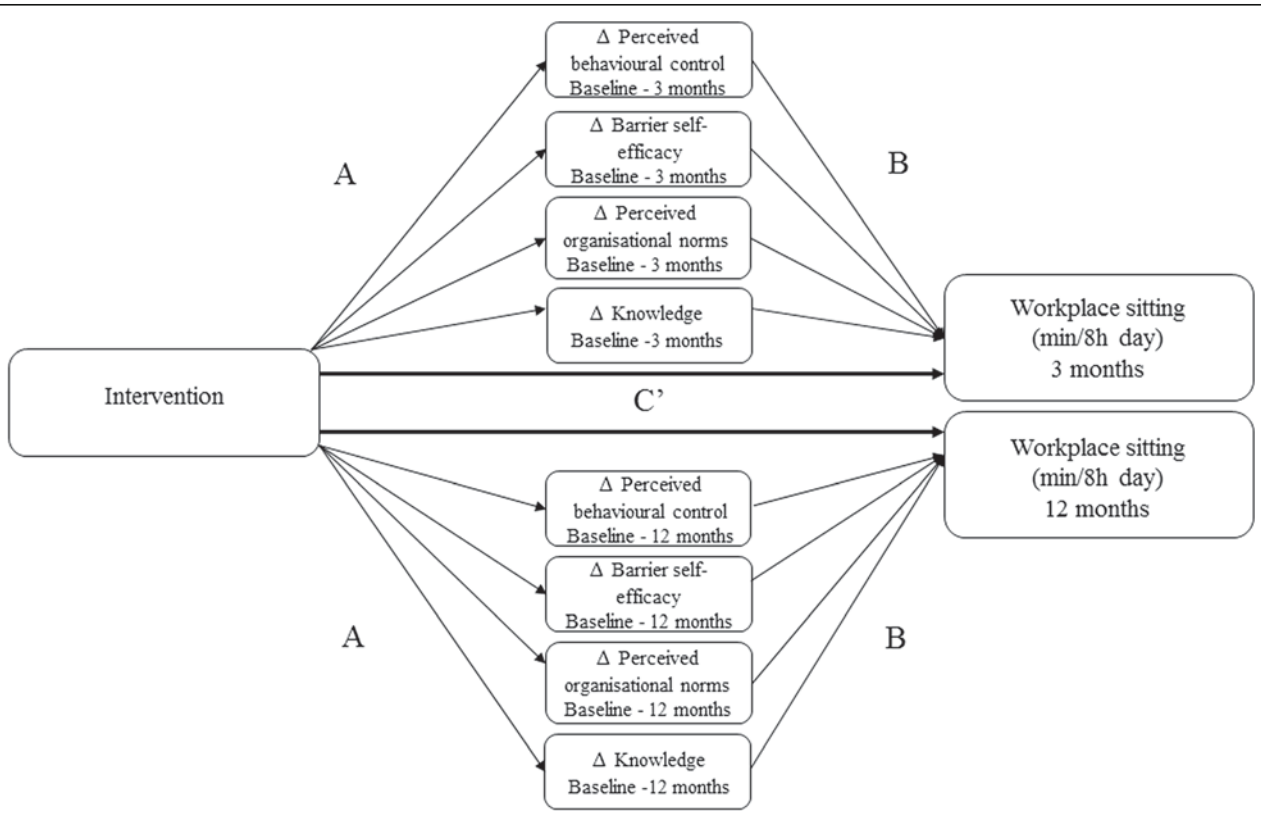

Fig. 1 Mediation analysis overview. Path **a** effect of the intervention on the social-cognitive constructs; Path **b** effect of changes in the social-cognitive constructs on workplace sitting time at 3 and 12-months; and Path **c'** direct effects of the intervention on workplace sitting time

cognitive constructs was 0.5, which is equivalent to 50% of participants changing by 1 point on the 5-point Likert scales. Effects less than this were considered "small".

As a sensitivity analysis, the effect of the intervention on the social-cognitive constructs (Path A) was analysed using intention-to-treat principles [32]. All randomised participants were evaluated using multiple imputation (m = 30 imputations) by chained equations.

Results

The mean age of the 231 participants at baseline was 45.6 ± 9.4 years. A majority were female (68.4%), Caucasian (79.7%), had post-school education (66.8%) and worked full-time (79.2%). Additional baseline characteristics by worksite have been reported previously [23]. Complete data for the mediation analyses were available for 186 participants at 3 months and 145 participants at 12 months; participants included in the analyses were representative of the sample as a whole with regards to socio-demographic and work characteristics. Additional file 1 shows participant scores for the social-cognitive constructs, including individual items, at baseline, 3 months and 12 months.

Intervention effects on social-cognitive constructs (Path A)

The effect of the intervention on the social-cognitive constructs is presented in Table 2. At 3 months, there were significant intervention effects on perceived behavioural control, barrier self-efficacy and perceived organisational norms, favouring the intervention group. The effects on perceived behavioural control and barrier self-efficacy met the MDI. Significant differences between the intervention and control groups persisted at 12 months in perceived behavioural control (0.63 points) and barrier self-efficacy (0.54 points). However, at 12 months the effects on perceived organisational norms were small and no longer statistically significant. There was no significant or meaningful intervention effects on knowledge at either time point. As per the main trial outcomes [22], similar results were obtained with multiple imputation and with completers (Additional file 2).

The intervention effects on the social-cognitive constructs did not differ significantly by worksite at 3 months (Additional file 3). However, statistically significant worksite effects at 12 month changes were observed for perceived behavioural control ($p = 0.014$, ICC = 0.128, 95% CI: 0.029, 0.421) and perceived organisational norms ($p = 0.003$, ICC = 0.169, 95% CI: 0.042, 0.487).

Relationships of changes in social-cognitive constructs with changes in workplace sitting (Path B)

Increases in each of the social-cognitive constructs tended to be associated with reductions in workplace sitting (Table 3), although these were only statistically significant for barrier self-efficacy at 12 months (19 min additional reduction in sitting per one point increase on the 5-point scale). Effects of perceived behavioural control at 3 months and knowledge at 3 and 12 months on reductions in sitting were sizeable (approximately 10–15 min per point increase), but did not reach statistical significance.

Mediation effects

Only one social-cognitive construct—perceived behavioural control—significantly mediated the intervention effects for workplace sitting (Table 4) at 3 months, although only a relatively small percentage of the total effect was explained (7.5%). An intervention effect of a 9 min/8 h day reduction co-occurred with each one-point increase in perceived behavioural control (indirect

Table 2 Effect of the SUV intervention on targeted social-cognitive constructs at 3 and 12 months (Path A)

		Mean change (SE)		Intervention effect (95% CI)[a]	*p*
		Intervention	Control		
Perceived behavioural control	3 months[b]	0.80 (0.09)	0.18 (0.06)	0.67 (0.40, 0.95)	**<0.001**
	12 months[c]	0.82 (0.14)	0.18 (0.10)	0.63 (0.23, 1.03)	**0.002**
Barrier self-efficacy	3 months[b]	0.94 (0.07)	0.11 (0.09)	0.87 (0.58, 1.16)	**<0.001**
	12 months[d]	0.78 (0.11)	0.21 (0.16)	0.54 (0.07, 1.00)	**0.023**
Perceived organisational norms	3 months[b]	0.31 (0.05)	0.07 (0.03)	0.25 (0.10, 0.41)	**0.001**
	12 months[d]	0.22 (0.08)	0.04 (0.07)	0.18 (−0.07, 0.43)	0.163
Knowledge	3 months[b]	0.20 (0.05)	0.02 (0.07)	0.17 (−0.01, 0.36)	0.070
	12 months[c]	0.22 (0.05)	0.19 (0.08)	0.00 (−0.22, 0.23)	0.982

Note: For each construct, minimum score = 1 and maximum score =5. SE = standard error, CI = confidence interval. Mean change (SE) are calculated with linearized variance estimation. Significant effects are indicated in bold.

[a]Adjusted for baseline values of the following potential confounders: workplace sitting (min/8 h), age (years), gender (men/women), Caucasian ethnicity (yes/no), current smoking (yes/no), body mass index (log-transformed), AQoL-8D physical superdomain score (log-transformed), AQoL-8D mental superdomain score (log-transformed), TV viewing time (log-transformed), job control category (high/low), weekly headaches (yes/no), musculoskeletal symptoms in the upper extremities (none/does not interfere with activities/interferes with activities)

[b]Intervention: $n = 110$, Control: $n = 76$; [c] Intervention: $n = 89$, Control: $n = 57$ [d] Intervention: $n = 88$, Control: $n = 57$

Table 3 Relationships between concurrent changes in social-cognitive constructs with changes in workplace sitting time at 3 and 12 months (Path B)

	Workplace sitting time change Baseline to 3 months[a]		Workplace sitting time change Baseline to 12 months	
	b (95% CI)[c]	*p*	b (95% CI)[c]	*p*
Perceived behavioural control	−12.74 (−27.08, 1.61)	0.082	−0.44 (−19.72, 18.84)[b]	0.964
Barrier self-efficacy	−5.63 (−16.10, 4.85)	0.292	−19.17 (−32.45, −5.90)[c]	**0.005**
Perceived organisational norms	−5.20 (−24.70, 14.29)	0.601	−0.20 (−23.08, 22.67)[c]	0.986
Knowledge	−11.92 (−27.95, 4.11)	0.145	−13.62 (−33.83, 6.58)[b]	0.186

Note: For each construct, minimum score = 1 and maximum score = 5. Significant effects are indicated in bold.
Models adjusted for intervention status and baseline values of the following potential confounders: workplace sitting (min/8 h), age (years), gender (men/women), Caucasian ethnicity (yes/no), current smoking (yes/no), body mass index (log-transformed), AQoL-8D physical superdomain score (log-transformed), AQoL-8D mental superdomain score (log-transformed), TV viewing time (log-transformed), job control category (high/low), weekly headaches (yes/no), musculoskeletal symptoms in the upper extremities (none/does not interfere with activities/interferes with activities)
[a]$n = 186$; [b]$n = 146$ [c]$n = 145$

effects); the remaining 106 min/8 h day reduction occurred independently (direct effects). Barrier self-efficacy was a significant mediator of the intervention at 12 months (indirect effect = 10 min/8 h day, 95% CI: −27.26, −2.16), explaining a slightly higher proportion of the total effect (14% mediation). Other indirect effects were all small (<5 min/ 8 h day) and non-significant.

Discussion

This multi-component sedentary behaviour intervention significantly improved perceived behavioural control, barrier self-efficacy and perceived organisational norms in the short-term. Knowledge scores increased slightly for intervention group participants at 3 months; however, increases did not significantly exceed control changes. Only changes in perceived behavioural control and barrier self-efficacy reached the minimum difference of interest. Significant intervention effects on perceived behavioural control and barrier self-efficacy were still present at 12 months; effects for perceived organisational norms were no longer statistically significant. In practical terms, this suggests that intervention group participants were more confident that they could overcome barriers to reducing workplace sitting and felt that they had greater levels of control over their activity levels in the workplace, compared with control participants. They also perceived their colleagues and managers to have increased their support of the main intervention messages, particularly in the initial stages of the intervention.

For perceived organisational norms, the non-significant intervention effect at 12 months appeared to be due to a slight drop off in intervention group scores between 3 and 12 months. In our trial, the organisational-level intervention components designed to foster workplace culture largely ceased at 3 months. Future workplace interventions should examine how much additional and/or longer-

Table 4 Mediation of short- and long-term intervention effects on workplace sitting (min/8 h day) by concurrent changes in social-cognitive constructs

Mediators		Direct effect c' (95% CI)	Indirect effect a*b (95% CI)	Percentage of total intervention effect[d] mediated
Perceived behavioural control	3 months[a]	−106.34 (−129.35, −75.37)	−8.57 (−18.46, −3.57)	7.46%
	12 months[b]	−74.52 (−114.78, −26.61)	−0.28 (−11.03, 12.99)	0.37%
Barrier self-efficacy	3 months[a]	−110.15 (−135.25, −81.62)	−4.89 (−17.12, 3.82)	4.25%
	12 months[c]	−64.09 (−105.64, −23.41)	−10.34 (−27.26, −2.16)	13.89%
Perceived organisational norms	3 months[a]	−113.74 (−133.79, −85.90)	−1.31 (−5.49, 1.94)	1.14%
	12 months[c]	−74.85 (−112.07, −30.85)	−0.04 (−5.44, 2.86)	0.05%
Knowledge	3 months[a]	−112.85 (−134.65, −85.80)	−2.07 (−8.31, 0.45)	1.80%
	12 months[b]	−73.59 (−109.00, −32.54)	−0.03 (−3.85, 4.15)	0.05%

Note: For each construct, minimum score = 1 and maximum score = 5
Models adjusted for baseline values of the following potential confounders: workplace sitting (min/8 h), age (years), gender (men/women), Caucasian ethnicity (yes/no), current smoking (yes/no), body mass index (log-transformed), AQoL-8D physical superdomain score (log-transformed), AQoL-8D mental superdomain score (log-transformed), TV viewing time (log-transformed), job control category (high/low), weekly headaches (yes/no), musculoskeletal symptoms in the upper extremities (none/does not interfere with activities/interferes with activities)
[a] $n = 186$; [b] $n = 146$ [c] $n = 145$ [d] Total intervention effect (c) comprises direct effect that occurs independently of the mediator (c') and the indirect effect (ab) that that occurs via the mediator

term support is needed in order to sustain perceived cultural changes related to moving more and sitting less.

Interestingly, there appeared to be a rise in control group participants' knowledge scores across the intervention, with participants in both the control and intervention groups reporting approximately the same level of knowledge at 12 months. These increases could reflect the significant media attention about sedentary behaviour in Australia during the period in which the trial was conducted [33]. Moreover, as described elsewhere [22], control group participants received the same feedback on their objectively-measured activity levels as did the intervention group participants at three and 12 months. This may also have played a role in fostering their knowledge regarding the detrimental health impacts of high sedentary time. While a recent review found education to be one of the more promising intervention techniques for sedentary behavioural change [34], this may be more relevant for those with a lower starting level of knowledge.

Only one statistically significant mediator of workplace sitting change was identified at 3 months – perceived behavioural control. Consistent with a multi-component intervention (many contributors to the intervention effect), the extent of mediation was small at 10% of the total effect. Previous cross-sectional research [16, 17] has linked higher levels of perceived behavioural control with lower levels of workplace sitting time. In a recent study exploring the utility of the Theory of Planned Behaviour for explaining variation in standing time amongst workers with sit-stand desks, perceived behavioural control was the only theoretical construct found to be significantly related to behaviour [18]. Perceptions of behavioural control may be particularly important for sedentary behaviour in the workplace where there is generally less volitional control than in other settings, such as the home environment [17]. Whether the main driver of changes in perceived behavioural control was the provision of the sit-stand workstations, or a combination of targeted strategies, requires further investigation. Perceived behavioural control was no longer a mediator of workplace sitting time at 12 months. This may suggest that this factor may be more important for the short-term initiation of behavioural change. However, due to the unknown effects of missing data at 12 months (reducing the sample size), caution should be taken in interpreting these results.

Of the other constructs, barrier self-efficacy was a significant mediator at 12 months, explaining nearly 14% of the intervention effect on workplace sitting time. These findings suggest that having the confidence to overcome potential barriers may be important to sustain sitting time reductions in the long-term. Considering that sitting is a highly habitual behaviour [35], participants' confidence in their ability to stand up in the workplace despite potential barriers may have been particularly important following conclusion of the individual-level support elements (i.e., after 3 months). This is in contrast to two cross-sectional studies (including baseline results of this trial [23]) that failed to find an association between workplace sitting time and self-efficacy [16, 23]. Low levels of self-efficacy amongst participants was suggested as an explanation for the null finding in one of these studies [16]. There is evidence to suggest that high levels of self-efficacy are associated with maintenance of physical activity levels [36, 37]. The potential role of barrier self-efficacy in the maintenance of workplace sitting reduction over time is of interest for future research, as the factors contributing to the sustainability of this behaviour are currently unclear.

Identification of effective elements of multi-component interventions is challenging, but fundamental to advancing knowledge of pathways of successful health behaviour change [38]. This study aimed to understand the mechanisms through which a multi-component intervention contributed to workplace sitting time reductions, by examining the role of social-cognitive influences only. The small effect sizes observed in the mediation analysis suggest that while these social-cognitive factors may play a role in reducing workplace sitting, they are unlikely to have been the main drivers of change. This is in line with a recent review of workplace sedentary behaviour interventions reporting that multi-component interventions, followed by environmental-only interventions, achieved the largest reductions in workplace sitting time, while interventions focusing only on individual-level strategies tended to have a smaller impact [39]. This is further supported by evidence demonstrating the efficacy of a multi-component intervention over a physical environmental change (e.g. sit-stand desk) in isolation [27]. Future studies employing multi-component interventions should also examine other levels of influence, such as interpersonal, environmental and policy factors, and interactions between these levels where possible. The SUV intervention primarily focused on reducing total and prolonged workplace sitting time and was effective in achieving these aims [22]. For future translational research, it may be of interest to consider whether other health risk factors could be addressed alongside the issue of prolonged workplace sitting. For example, workplace policies and support for healthy eating, smoking cessation and active transport could be promoted in conjunction with interventions targeting workplace sitting as part of a comprehensive workplace health promotion program.

This study is the first to examine both short- and longer-term mediation of workplace sitting time reduction. The objective measurement of workplace sitting time and the follow up at two time points are key

strengths of this study, as the available evidence on social-cognitive factors associated with sedentary behaviour has largely been limited to cross-sectional studies [16–18]. The main limitations are that these secondary analyses were likely underpowered, particularly at 12 months where over 35% of participants had missing data and were excluded from analyses. We cannot exclude the possibility that significant mediation effects were present at 12 months but were not identified, or that our results were influenced by attrition or participation biases. In addition, the tools used to assess social-cognitive constructs in this study, although previously pilot-tested [4], have not been validated.

Conclusions

The multi-component Stand Up Victoria trial successfully reduced sitting in the workplace. This study provides insight into some of the mechanisms through which these reductions may have occurred, including examination of short- and long-term mediation effects. Future interventions and programs could consider incorporating behaviour change techniques that aim to foster participants' level of perceived behavioural control and self-efficacy over their workplace sitting time, alongside modifications to the physical workplace environment. This could include encouraging workers to set goals to increase the time they spend standing or moving, and problem solving barriers to sitting less. Further understanding of the broader array of potential determinants of workplace sitting change will likely be needed to support novel approaches to address this emergent work health and safety issue.

Additional files

Additional file 1: Control and intervention group scores on social-cognitive construct items at each time-point. (DOCX 20 kb)

Additional file 2: Effect of the SUV intervention on targeted social-cognitive constructs at 3 and 12 months – intention to treat analysis. (DOCX 15 kb)

Additional file 3: Worksite variation (ICCs) in changes in social-cognitive constructs at 3 and 12 months. (DOCX 14 kb)

Abbreviations

CI: Confidence interval; MDI: Minimum difference of interest; RCT: Randomised controlled trial; SUV: Stand Up Victoria.

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Availability of data and materials

The intervention material and questionnaire items are available in the previously published protocol paper (24). The availability of the data from the SUV study is subject to the approval of a formal application made to the Chief Investigators.

Authors' contributions

DD, GH, EE, NO conceived the SUV trial and subsequently obtained funding from the National Health and Medical Research Council and the Victorian Health Promotion Foundation. DD, EE, NO, MN, EW, BF and GH participated in the design and coordination of the SUV methodology and measurement tools. All authors participated in the design of this secondary analysis. NH conducted the statistical analyses and drafted the manuscript. EW provided expert input on statistical analyses. All authors contributed to the manuscript development. All authors read and approved the final manuscript.

Competing interests

Ergotron Pty Ltd (www.ergotron.com) has previously provided workstations for formative research related to the topic (4) Dunstan presented at the 'JustStand Wellness Summit', a conference organised by Ergotron, in 2012 and Healy presented at the same summit in 2013. Ergotron covered travel and accommodation expenses for both Dunstan and Healy. No further honoraria or imbursements were received. There are no other competing interests that could appear to have influenced the submitted work.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Ethics approval for this study was granted by The Alfred Health Human Ethics Committee (Melbourne, Australia). All participants provided written informed consent.

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Additional file 1: Control and intervention group scores on social-cognitive construct items at each time-point

	Baseline		3 months		12 months	
	Control n=89 mean (sd)	**Intervention** n=133 mean (sd)	**Control** n=80 mean (sd)	**Intervention** n=118 mean (sd)	**Control** n=64 mean (sd)	**Intervention** n=96[a] mean (sd)
Perceived behavioural control						
a. It is my choice whether I stand up or sit at my desk while at work	2.39 (1.24)	2.50 (1.31)	2.49 (1.21)	4.24 (0.79)	2.44 (1.19)	3.95 (1.04)
b. It is my choice whether I stand up or sit during a meeting with colleagues at work	2.87 (1.16)	3.20 (1.17)	3.23 (1.12)	4.07 (0.78)	3.47 (1.02)	4.02 (0.78)
c. It is my choice whether I stand up or sit during a meeting with my supervisor/s at work	2.78 (1.15)	2.95 (1.17)	3.03 (1.15)	3.69 (1.00)	3.20 (1.04)	3.79 (0.91)
d. It is my choice whether I walk over to talk to a colleague (*iMail)* or send them an eMail	3.76 (0.89)	3.61 (1.05)	3.81 (0.95)	3.97 (0.88)	3.70 (0.98)	4.00 (0.83)
e. It is my choice whether I walk over to talk to a supervisor (*iMail)* or send them an eMail	3.70 (0.99)	3.67 (1.00)	3.83 (0.92)	3.92 (0.94)	3.72 (0.93)	4.01 (0.85)
Overall perceived behavioural control score	3.10 (0.72)	3.18 (0.80)	3.28 (0.72)	3.97 (0.66)	3.31 (0.74)	3.95 (0.62)
Barrier self-efficacy						
a. Stood up during meetings at work, even though no one else was	2.47 (1.27)	2.53 (1.27)	2.64 (1.38)	3.36 (1.23)	2.63 (1.31)	3.24 (1.21)
b. Stood up during meetings at work, even when supervisors were sitting down	2.27 (1.25)	2.40 (1.24)	2.51 (1.34)	3.19 (1.33)	2.52 (1.38)	3.11 (1.21)
c. Stood up at your desk at work, even though your colleagues were not	2.75 (1.36)	3.09 (1.29)	2.88 (1.28)	4.24 (0.86)	2.89 (1.29)	3.93 (1.07)
d. Stood up at your desk at work, even when you felt tired	2.69 (1.32)	2.71 (1.23)	2.80 (1.27)	3.60 (1.05)	2.59 (1.38)	3.31 (1.14)
e. Stood up at your desk at work, even if your footwear was uncomfortable	2.33 (1.33)	2.49 (1.15)	2.43 (1.36)	3.28 (1.21)	2.23 (1.25)	3.07 (1.30)
f. Stood up at your desk at work, even though you were really busy at work	2.28 (1.39)	2.53 (1.28)	2.44 (1.30)	3.75 (1.04)	2.42 (1.38)	3.33 (1.20)

g. Stood up at your desk at work, even when your tasks required looking at multiple papers	2.13 (1.32)	2.34 (1.22)	2.29 (1.26)	3.25 (1.25)	2.33 (1.37)	3.04 (1.30)
h. Stood up at your desk at work, even when your tasks required talking on the phone	2.49 (1.34)	2.69 (1.36)	2.61 (1.35)	3.81 (1.11)	2.55 (1.40)	3.56 (1.21)
i. Walk to talk to a colleague at work instead of emailing them, even though others didn't	3.39 (1.26)	3.45 (1.23)	3.49 (1.11)	3.98 (0.96)	3.34 (1.24)	3.94 (0.94)
Overall barrier self-efficacy score	2.53 (1.05)	2.69 (0.97)	2.68 (1.04)	3.61 (0.74)	2.61 (1.08)	3.39 (0.82)
Perceived organisational norms						
a. My workplace is committed to supporting staff health and well-being	3.60 (0.92)	3.47 (0.87)	3.66 (0.88)	3.64 (0.95)	3.70 (1.01)	3.45 (1.02)
b. My workplace is committed to supporting staff choices to stand or move more at work	2.88 (1.07)	3.14 (0.97)	2.93 (1.05)	3.65 (0.94)	3.06 (1.06)	3.22 (1.09)
c. My colleagues would not mind if I chose to stand up while working at my desk	3.71 (0.87)	3.86 (0.68)	3.71 (0.84)	4.20 (0.71)	3.80 (0.74)	4.15 (0.68)
d. My supervisor/s would not mind if I chose to stand up while working at my desk	3.57 (0.87)	3.91 (0.63)	3.59 (0.93)	4.24 (0.76)	3.75 (0.79)	4.09 (0.82)
e. My colleagues would not mind if I chose to stand during a work meeting	3.54 (0.82)	3.68 (0.71)	3.60 (0.80)	4.01 (0.77)	3.61 (0.82)	4.04 (0.77)
f. My supervisor/s would not mind if I chose to stand during a work meeting	3.46 (0.86)	3.59 (0.74)	3.51 (0.82)	3.93 (0.89)	3.61 (0.77)	3.92 (0.84)
g. My colleagues would not mind if I chose to walk over and talk to them (*iMail*) rather than sending them an eMail	3.84 (0.78)	3.87 (0.72)	3.99 (0.64)	4.11 (0.68)	3.92 (0.69)	4.07 (0.67)
h. My supervisor/s would not mind if I chose to walk over and talk to them (*iMail*) rather than sending them an eMail	3.74 (0.92)	3.71 (0.80)	3.81 (0.90)	3.87 (0.96)	3.84 (0.78)	3.93 (0.77)
Overall perceived organisational norms score	3.54 (0.57)	3.66 (0.52)	3.60 (0.58)	3.96 (0.60)	3.66 (0.54)	3.86 (0.60)
Knowledge						
a. Sitting for most of the time at work does not impact on my health (reverse scored)						

	2.13 (1.06)	2.08 (1.07)	2.26 (1.13)	2.03 (1.06)	1.95 (1.07)	1.92 (1.02)
b. Sitting for most of the time at work is bad for my health	3.79 (1.16)	4.04 (0.91)	3.95 (0.96)	4.00 (1.06)	4.09 (0.93)	4.09 (1.06)
c. Any health impact of sitting for most of the time at work can be off-set by exercising at other times of the day (reverse scored)	3.27 (0.92)	3.00 (0.91)	3.31 (1.00)	2.58 (1.06)	3.17 (0.93)	2.66 (1.02)
d. It is beneficial for my health to stand up at least once every 30 minutes while I am at work	4.11 (0.76)	4.10 (0.80)	4.23 (0.74)	4.40 (0.70)	4.39 (0.72)	4.39 (0.77)
e. It is beneficial for my health if I am as active as possible throughout my working day (e.g. by using the stairs instead of the lift)	4.22 (0.78)	4.26 (0.75)	4.26 (0.85)	4.50 (0.61)	4.33 (0.81)	4.50 (0.72)
Overall knowledge score	3.74 (0.56)	3.86 (0.51)	3.77 (0.56)	4.06 (0.57)	3.94 (0.57)	4.08 (0.57)

Note: For all questions and scales, minimum score=1; maximum score=5. Mean (standard deviation) are calculated with linearized variance estimation.

[a] n=95 for barrier self-efficacy and perceived organisational social norms

Additional file 2: Effect of the SUV intervention on targeted social-cognitive constructs at three and 12 months – intention to treat analysis

		Mean change (SE)[a]		Intervention effect (95% CI) [a b]	p
		Intervention n= 136	Control n=95		
Perceived behavioural control	3 months	0.81 (0.08)	0.18 (0.08)	0.69 (0.51, 0.87)	<0.001
	12 months	0.77 (0.14)	0.17 (0.12)	0.61 (0.24, 0.98)	0.001
Barrier self-efficacy	3 months	0.93 (0.08)	0.13 (0.11)	0.93 (0.67, 1.19)	<0.001
	12 months	0.72 (0.11)	0.17 (0.17)	0.66 (0.25, 1.06)	0.002
Perceived organisational norms	3 months	0.31 (0.05)	0.07 (0.05)	0.28 (0.11, 0.45)	0.002
	12 months	0.20 (0.02)	0.09 (0.14)	0.09 (-0.32, 0.50)	0.658
Knowledge	3 months	0.19 (0.05)	0.04 (0.07)	0.22 (0.05, 0.38)	0.013
	12 months	0.20 (0.08)	0.20 (0.09)	0.06 (-0.23, 0.35)	0.684

Note: For each construct, minimum score = 1 and maximum score = 5. CI = confidence interval, ICC = intracluster correlation.

[a] Missing data imputed by chained equations, m=30 imputations (largest fraction of missing information =0.29) [b] Assessed by mixed models, performed separately for short and long-term changes, with random intercept to correct for clustering, and adjusting as fixed effects for baseline values of the outcome, and other potential confounders measured at baseline: age, gender (male/female), workplace sitting time (min/8-h), Caucasian ethnicity (yes/no), current smoking (yes/no), body mass index (log-transformed), AQoL-8D physical superdomain score (log-transformed), AQoL-8D mental superdomain score (log-transformed), TV viewing time (log-transformed), job control category (high/low), weekly headaches (yes/no), musculoskeletal symptoms in the upper extremities (none/does not interfere with activities/interferes with activities).

Additional file 3: Worksite variation (ICCs) in changes in social-cognitive constructs at three and 12 months

	3 months		12 months	
	ICC (95% CI)	p	ICC (95% CI)	p
Perceived behavioural control	[a]	>0.999	0.128 (0.029, 0.421)	0.014
Barrier self-efficacy	0.007 (<0.001, 0.978)	0.405	0.032 (0.001, 0.664)	0.282
Perceived organisational norms	0.027 (0.001, 0.458)	0.239	0.169 (0.042, 0.487)	0.003
Knowledge	[a]	>0.999	0.088 (0.013, 0.407)	0.061

ICC = intracluster correlation coefficient; CI = confidence interval

[a] ICC inestimably small <0.001

5.2 Summary and implications of findings

The study in section 5.1 found that the SUV intervention had significant effects (relative to the control group) on three of the four targeted social cognitive constructs at three months – perceived behavioural control, barrier self-efficacy and perceived organisational norms; with intervention effects on perceived behavioural control and barrier self-efficacy remaining significant at 12 months. Perceived behavioural control was the sole mediator of the intervention effect on workplace sitting at three months, explaining 7.5% of the total effect, while barrier self-efficacy was a significant mediator of the intervention at 12 months, explaining 13.9% of the total intervention effect. Indirect effects for perceived organisational norms and knowledge were small and non-significant at the two time points.

As noted in the paper, the small proportion of the intervention effects that were explained by these four social-cognitive factors suggests that they played a small role, but were unlikely to have been the main drivers of change. SUV was a multi-component intervention comprising individual, organisational and environmental-level strategies. Two key principles of ecological models are that there are likely to be multiple levels of influence on behaviour and that environmental contexts are important determinants of health behaviours (99). In line with an ecological model of sedentary behaviour and prior empirical evidence (8, 220), the environmental component (provision of a sit-stand desk) is likely to have been a significant contributor to behavioural change.

As noted in the paper in section 5.1, there appeared to be a slight reduction in intervention group scores on perceived organisational norms from 3 to 12 months, which coincided with the withdrawal of individual and organisational-level intervention components. This suggests that longer-term support may be required to sustain changes in organisational norms around reducing workplace sitting time. Strategies to achieve this could include reminders (or “reinvigoration”) (243) of the intervention messages at regular intervals (e.g., every three months) until sustainable changes to organisational norms are achieved.

This study was unable to determine the relative contribution of each component of the SUV intervention (i.e. individual, organisational and environmental) to the effects observed on the social-cognitive constructs and workplace sitting change more broadly. For example, it is not known whether provision of the sit-stand workstations in of itself increased participants’ levels of perceived behavioural control. This is a common challenge experienced in the evaluation of many complex multi-component public health interventions (244). However, unpacking intervention effects to try to identify essential and non-essential strategies is important for

designing more efficient and targeted interventions. This requires consideration in the design of evaluations for future workplace sedentary behaviour interventions.

Another limitation of the study worth noting is that the intervention did not use and measure a comprehensive set of mediators comprising a meaningful grouping (such as each component of social cognitive theory) and therefore no meaningful test of the collective action of mediators working together — such as would be achieved via multiple mediation — was conducted. The results presented from the single mediation models can only be interpreted as the effect of each particular mediator considered separately. Further, the effect of each mediator was not considered independently of the other mediators (e.g., perceived behavioural control and barrier self-efficacy might operate to some degree via a shared pathway). However, even if all four mediators operated completely independently, with such small effects for each mediator their total collective impact would still be limited, consistent with these four mediators together forming a small portion of the multicomponent intervention.

There were some interesting findings when examining intervention effects on individual items within each social-cognitive construct (see Additional file 1). For example, in the perceived organisational social norms construct, there was little difference between intervention and control groups at three or 12 months in the perceived acceptability of' 'iMails' – walking and talking to a colleague or supervisor rather than sending an email (*My colleagues/supervisor would not mind if I chose to walk over and talk to them (iMail) rather than sending them an eMail*). In contrast, the scores on items that related to the acceptability of standing up during a meeting or standing at one's desk revealed improvements from baseline to three and 12 months in the intervention group, but minimal change in the control group. Scores on the items relating to iMails under perceived behavioural control (*It is my choice whether I walk over to talk to a colleague/supervisor (iMail) or send them an eMail*) were also quite high at baseline, suggesting that this may have been a reasonably acceptable workplace practice prior to the intervention.

The results suggest that certain strategies for reducing workplace sitting may initially be more acceptable and feasible than others. As these results were obtained from one organisation, caution should be taken in generalising these findings. However, it does align with findings reported in Chapter 4 where participants reported that face-to-face communication with co-workers was generally encouraged in their organisation. Determining which strategies are already acceptable in organisations, and promoting these, may be a helpful starting point in initiating a workplace sedentary behaviour intervention.

The study included in section 5.1 was the first to examine the potential mediators of a workplace sedentary behaviour intervention at both short and long-term time points. Subsequent to the

publication of this paper, another study has been published examining the potential social-cognitive mediators of a web-based intervention targeting workplace sitting time (245). The research failed to find any significant mediation effects from the constructs assessed (knowledge, attitudes, self-efficacy, social support and intention), however the follow-up period was only one month and sitting time was self-reported (245). In addition, unlike the multi-component nature of the SUV intervention, this intervention centred on individual-level strategies (e.g. education and goal setting).

Overall, the findings of the study presented in this chapter suggest that incorporating strategies designed to foster participants' perceived control and self-efficacy over their sitting at work could be beneficial, but may not led to substantial reductions in workplace sitting unless they are implemented as part of a broader multi-component approach.

Chapter 6 presents findings from the qualitative study performed at the end of the SUV trial. This qualitative study aimed to examine participants' perspectives of the acceptability of the SUV intervention, including factors perceived to act as barriers and facilitators to reducing workplace sitting, and perceived effects on workplace culture, productivity and health-related outcomes. This study provides insight into some of the other perceived influences on participants' behavioural change during SUV.

CHAPTER 6

FACTORS INFLUENCING WORKPLACE SITTING CHANGE DURING AN INTERVENTION

Chapter 5 examined whether targeted social-cognitive constructs mediated the SUV intervention effects on workplace sitting time. These factors were found to explain a relatively small proportion of the total intervention effect, suggesting that other influences may have been of greater importance.

As per the findings presented in Chapter 4, qualitative research may be able to provide insight into other factors that were influential for behavioural change during SUV. In particular, identifying perceived barriers and facilitators experienced by participants when attempting to reduce their sitting time, and understanding the acceptability of the SUV intervention more broadly. Identifying factors or conditions that may have inhibited intervention success during SUV could assist with informing the design of approaches to address these barriers in future interventions. In contrast, if supportive factors are identified, these can be encouraged and promoted to optimise intervention effectiveness.

Chapter 4 examined perceived barriers to reducing sitting time, and the perceived feasibility and acceptability of strategies targeting prolonged sitting amongst office workers that had not been exposed to a formal workplace sedentary behaviour intervention. These findings will be informative for the initial planning stages of workplace sedentary behaviour initiatives. However, as noted, it is possible that additional or different barriers and facilitators are experienced during an intervention when workers begin the process of behavioural change. For this reason, the perspectives of those who have participated in a workplace sedentary behaviour intervention are also required.

While there has been some previous qualitative research related to workplace sedentary behaviour interventions, as outlined in sections 1.6.4 and 1.6.5, the majority of these studies have considered only the acceptability of sit-stand workstations (198, 215, 217). As discussed in Chapters 3 and 5, an important feature of SUV was the multi-component nature of the intervention, which incorporated individual and organisational-level strategies, in addition to the provision of sit-stand workstations. Another key strength of SUV relative to previous workplace intervention studies was the longer study duration, with follow-up assessments at both three and 12 months (230). SUV therefore provided a unique opportunity to understand factors influencing the acceptability and feasibility of intervening to reduce workplace sitting over the medium to long-term.

The previous chapter, Chapter 5, examined the relative contribution that social-cognitive changes made to the reductions in workplace sitting time observed during SUV. This chapter reports on findings from the qualitative component of SUV, to examine other factors perceived to have influenced workplace sitting change and workers' engagement with the intervention. Here, the aim was to assess the acceptability of the intervention, barriers and facilitators to reducing workplace sitting, and perceived effects on workplace culture, productivity and health-related outcomes.

As described in section 3.1.5, within the online questionnaire component of the 12 month SUV assessment, intervention group participants were offered the opportunity to participate in an interview or focus group to discuss their experience. Twenty-one semi-structured interviews (n=21) and two focus groups (n=7) were conducted in total.

This chapter includes a paper published in *International Journal of Physical Activity and Behavioral Nutrition* in 2017. Further details of the study methodology are described within the paper.

6.1 Reducing workplace sitting: Workers' perspectives on a multi-component workplace intervention

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Reducing occupational sitting: Workers' perspectives on participation in a multi-component intervention

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Abstract

Background: Office workers spend much of their time sitting, which is now understood to be a risk factor for several chronic diseases. This qualitative study examined participants' perspectives following their involvement in a cluster randomised controlled trial of a multi-component intervention targeting prolonged workplace sitting (Stand Up Victoria). The intervention incorporated a sit-stand workstation, individual health coaching and organisational support strategies. The aim of the study was to explore the acceptability of the intervention, barriers and facilitators to reducing workplace sitting, and perceived effects of the intervention on workplace culture, productivity and health-related outcomes.

Methods: Semi-structured interviews (n = 21 participants) and two focus groups (n = 7) were conducted with intervention participants at the conclusion of the 12 month trial and thematic analysis was used to analyse the data. Questions covered intervention acceptability, overall impact, barriers and facilitators to reducing workplace sitting, and perceived impact on productivity and workplace culture.

Results: Overall, participants had positive intervention experiences, perceiving that reductions in workplace sitting were associated with improved health and well-being with limited negative impact on work performance. While sit-stand workstations appeared to be the primary drivers of change, workstation design and limited suitability of standing for some job tasks and situations were perceived as barriers to their use. Social support from team leaders and other participants was perceived to facilitate behavioural changes and a shift in norms towards increased acceptance of standing in the workplace.

Conclusions: Multi-component interventions to reduce workplace sitting, incorporating sit-stand workstations, are acceptable and feasible; however, supportive social and environmental conditions are required to support participant engagement. Best practice approaches to reduce workplace sitting should address the multiple levels of influence on behaviour, including factors that may act as barriers to behavioural change.

Keywords: Workplace, Sedentary behaviour, Sitting, Intervention, Qualitative

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Background

The modern office workplace is conducive to workers spending large amounts of time sitting [1], which is a potential risk factor for chronic disease and premature mortality [2–4]. In recent years there has been increasing interest in understanding the efficacy of a broad range of interventions targeting workplace sitting [5]. Sit-stand workstations, which facilitate postural shifts from sitting to standing and vice versa throughout the day, have been shown to be an effective environmental-based tool, leading to moderate to large reductions in sitting time [6, 7] with minimal or no impacts on productivity or work performance [8–10]. However, evidence reviews have suggested that greater impacts on workplace sitting may be achieved if sit-stand workstations are implemented as part of a broader approach that addresses the multiple levels of influence on behaviour [5, 11, 12]. While previous qualitative studies have assessed workers' perspectives of sit-stand workstations in isolation [13–16], there is limited knowledge about the feasibility and acceptability of incorporating them within a multi-component, participatory workplace intervention.

The recently completed Stand Up Victoria (SUV) trial demonstrated that a multi-component approach, incorporating individual, organisational and environmental-level strategies, was effective at reducing both total and prolonged workplace sitting time relative to a control group at three and 12 month follow-up [17]. As one of the first multi-component workplace interventions targeting workplace sitting, understanding the participant perspective can help to identify the factors that contributed to its effectiveness.

Previous qualitative research has generally evaluated perceptions of sit-stand workstations in isolation, trialled over a short time period (1 month or less) [13, 16]. These findings suggest that sit-stand workstations are considered to be acceptable and feasible, although issues associated with the design of certain models, and concerns about reduced audio and visual privacy with standing have been raised as potential barriers to their use [13, 15, 16]. There is a need to understand the longer-term feasibility and sustainability of a multi-component workplace intervention featuring sit-stand workstations, including the role of broader workplace culture and organisational factors in supporting reductions in sitting time. The present study examined participants' perspectives of a multi-component intervention to reduce workplace sitting, including the acceptability of the intervention, barriers and facilitators to reducing workplace sitting, and perceived effects on workplace culture, productivity and health-related outcomes.

Methods

Study setting and design

This qualitative study was part of the broader Stand Up Victoria (SUV) trial. SUV, conducted in Victoria, Australia, was a 12 month cluster-randomised controlled trial of a multi-component workplace intervention to reduce prolonged sitting in office workers. Full details of the study design [18], intervention development [19], and main outcomes [17] have been described previously. In brief, participants were recruited between 2012 and 2013 from selected teams at 14 different worksites of a government department. Randomisation to control or intervention condition (seven sites for each) occurred at the worksite-level. The SUV trial was granted approval by the Alfred Health Human Ethics Committee (Melbourne, Australia) and had prospective trial registration with the Australian New Zealand Clinical Trials register (ACTRN12611000742976; registered 15 July 2011). Participants provided written informed consent.

Intervention

The intervention was multi-component and comprised organisational-, environmental [sit-stand workstations]-, and individual-level strategies (see [18] for further details), with the primary aim being to reduce workplace sitting time. Strategies included an individual sit-stand workstation (Ergotron WorkFit-S; www.ergotron.com) that was retained by each participating worker for 12 months; face-to-face and telephone health coaching (for the first 3 months); and organisational-level strategies that were selected through a group participatory brainstorming session at each worksite prior to commencement of the intervention. Ongoing organisational support was provided by team champions (typically team leaders) who promoted the selected strategies and the intervention messages of "Stand Up, Sit Less, Move More". In general, workstations were removed at the end of the 12 month trial, however some participants retained them for medical reasons.

Procedure

At the final 12 month assessment, intervention participants were asked whether they wished to be contacted about contributing to further research. Following completion of the trial, those who opted in (n = 56 of 94 who completed the online questionnaire) were contacted by telephone and offered the opportunity to partake in either a face-to-face interview at their workplace, or a telephone interview at a time that was convenient for them. The option of participating in a focus group discussion was offered to participants at one of the intervention sites due to a high proportion of intervention participants opting in for an interview. Team leaders from six of the seven intervention sites consented to participate and were able to provide managerial/supervisory perspectives of the implementation of the intervention within their teams. The number of participants at each site ranged from two to five. Five interviews were

conducted face-to-face at participants' workplaces and 16 were conducted by telephone (n = 21). Two focus groups were conducted, involving three and four participants, respectively (n = 7). Interviews and focus groups occurred across the seven intervention sites between July 2013 and December 2014 (between one and 4 months after participants completed the final questionnaire).

Each interview was semi-structured and conducted by one of the authors (LW) using an interview guide. This researcher had postgraduate qualifications in public health and previous experience conducting qualitative interviews. At the time of the interviews, she was employed as the SUV project coordinator and was known to the participants through this position, and her role in conducting the onsite assessments. The interview guide was adapted for the focus groups, to be appropriate for the needs of a group discussion (Additional file 1). Both focus group sessions were facilitated by a member of the research team (LW), ran for approximately 45 min to 1 h, and were digitally audio-recorded. Interview/focus group question topics covered the feasibility and acceptability of the individual, organisational and environmental components of the intervention; perceived productivity and health effects of reducing workplace sitting time; and organisational support for the key messages of the study (Table 1). Participating team leaders were also asked about the role they played as "champions" throughout the intervention duration. Participants were advised that the researchers had no commercial interest in the workstations, and were therefore encouraged to speak freely about this aspect of the intervention.

To assess whether additional themes arose that were not anticipated during the development of the original interview guide, the first 11 interviews were transcribed and examined. Through this process, unanticipated themes relating to the impact of the intervention on non-participants were identified. Subsequently, additional prompts were added to the interview guide for the remaining interviews, to further explore these new findings. Interviews ran for approximately 20–40 min and were all digitally audio-recorded. All participants provided verbal consent at the beginning of the interviews and focus groups for the audio recording.

Analysis

The audio-recordings were transcribed verbatim. For one interview, only a partial recording was available for analysis due to technical issues. Initial analysis of the data was conducted by two of the authors using Microsoft Word (LW) and NVivo 11 (QSR International Pty Ltd.) (NH) software, separately for the interview and focus group data. A familiarisation process was conducted first by reading and re-reading each transcript. Each researcher then independently coded each transcript, with codes identified based on a priori themes of interest and emergent themes. Initial codes were then grouped together into sub-themes and overarching themes and relevant data to each theme collated. The coding frameworks developed by the two researchers were then compared to identify similarities and discrepancies. A third researcher (SL) coded a subset of the interviews and was involved in discussions around the final themes. This process enabled resolution of any differences between the two initial coders and led to consensus on the names and descriptions of the final themes and sub-themes. Quotes from participant interviews were selected to portray the content of each theme/sub-theme.

Results

Participants

Participant baseline characteristics for this study, as well as the baseline characteristics of the whole intervention group are described in Table 2. Participants were broadly similar to all SUV participants in the intervention arm of the trial in terms of socio-demographic and work-related characteristics, but had higher reductions in workplace sitting. Similar themes emerged from the interview and focus group data, although the focus groups revealing richer data relating to workplace culture and team dynamics. For simplicity of reporting, data from the interviews and focus groups were combined.

Themes and illustrative quotes are listed below. These are grouped into the following key areas: overall experience of the intervention; work performance and productivity; organisational support and workplace culture; and processes of behavioural change. An overview summary of the number of participants responding to each theme is provided in Table 3.

Overall experience

Participants' overall experience of the SUV intervention was very positive, with participants enjoying the opportunity provided by participating in the study. While a small number reported a negative component of their experience, these participants also additionally reported positive aspects of participation (see Table 3).

> *I thought it was a really good, unique kind of experience. I have worked for (organisation) for 11, 12 years and this is the first time I have been involved in such a unique initiative.* Site J, Participant 8 (J8), male team leader

Awareness raising

Participants reported that the SUV intervention increased awareness of their own behaviour—particularly

Table 1 Questions covered during the interviews for employees and team leaders

Theme: Global Satisfaction

1. How was your overall experience with the Stand Up Victoria study? (All participants)
   - How satisfied were you with your experience?
   - What were some of the positives about the experience?
   - What do you see as the physical advantage/s of standing more at work?
   - What do you see as the cultural advantage/s of standing more at work?
   - What do you see as the disadvantages of standing more at work? Are there any areas for development/improvement?
   - Do you feel that the movement improved your wellbeing/comfort? How?
   - What could be improved upon in future projects that are introducing sit/stand workstations? (Be sure to let participants know that we have no commercial interest in the workstations)
   - Did you feel that you/your team were provided with the right knowledge to allow you to stand up, sit less, and move more within your workplace?
   - Would you recommend sit-stand works stations to other teams/ workplaces? Why/Why not?

Theme: Motivation and sustainability

Interviewer to bring in the strategies that they agreed on at the initial group info session

2. Thinking about your team as a whole... (Team leaders)
   - What strategies worked? Why do you think that is?
   - What did you see as the most commonly used strategy by your team? (If stated above, skip this question)
   - Are your team still using these strategies?
   - If changes were made, what is it going to take for these changes to become sustainable in your group in the long-term?
   - What didn't work? Why do you think that they didn't work?
   - Did you feel that your team had enough knowledge of the product to make the changes to their working position?
   - How suitable do you think your workplace is for sit/stand workstations? If not, what needs to change to make it suitable?
   - Could you see your workplace taking on any other changes now that the study is complete?
3. If you could reflect on your own individual strategies... (Employees)
   - Which ones motivated you the most to change your working position? Why do you think that was?
   - Where there any strategies that you tried that didn't work? Why do you think that was?
   - If changes were made, what is it going to take for these changes to become sustainable in your group in the long-term?
   - Now that the study is over and your desks have been removed, are you still trying to follow the objectives of the study – standing up, sitting less, moving more?
   - How suitable do you think your workplace is for sit/stand workstations? If not, what needs to change to make it suitable?
   - Could you see your workplace taking on any other changes now that the study is complete?

Theme: Workplace Culture

4. To what extent do you feel the workplace 'culture' has changed to support the Stand Up Sit Less Move More messages? (All participants)
   - Did you feel you had the support of senior/upper management to make these changes within your team? Why, why not? (Team leaders only)
   - Did you feel you had the support of your team leader/upper management to make these changes at your workstation? Why, why not? (Employees only)
   - Was it an accepted norm to stand and use the workstation?
   - Did the opportunity to have a sit-stand workstation make you feel more valued as employees? (Employees only)
   - Did the sit-stand workstation make you feel more in control of your workspace? (Employees only)
5. Did you feel that the sit-stand workstation impacted on your/your team's sense of privacy – either audio or visual privacy? (All participants)
   - Did you feel that the sit-stand workstations impacted on the sense of visual privacy of others around you? If yes, how so?
   - Did you feel that the sit-stand workstations impacted on the sense of audio privacy of others around you? If yes, how so?
6. Did managers let non-participants know about the study and the changes that were going to be made to the workplace by having the workstations installed? (Team leaders)
   - Did you witness any informal or formal negotiation between participants and non-participants with respect to the utilisation of the workstations?
   - Was there any feedback as a result of these changes to the workplace?
   - If any, were they mainly from participants or non-participants?
   - Did the increased standing infiltrate to other non-participant team members? I.e., was there a ripple effect or by-product of having others standing within your workplace?
   - Did you feel that the level of movement in general changed around the workplace during the study period? If there was a change, what impact did this have on the way in which your team worked? (positive/negative?)

Theme: Empowerment (Team leaders only)

7. As a team leader, did you feel you had a responsibility to act as a role model for the duration of the study? If so, how did you find this leadership role?
   - Do you feel that your efforts were recognised? (by management/ other staff)
   - Was it a positive responsibility/role to have? If not, why?
   - Do you feel that your leadership role made a contribution to any changes that occurred in your work place? If so, how? If not, why?

Theme: Productivity

8. What did you think about the impact of the workstations on you/your team's productivity, in terms of: (All participants)
   - Communication (between each other and clients)
   - Collaboration
   - Timeliness of task completion/ work flow

how much time they spent sitting at work—and the health consequences of excessive levels of sitting.

> *You didn't really think about it that much but now that I have been forced to stand up you start taking your health more seriously. And just think… maybe I shouldn't be sitting down for so long.* L10, female employee

> *It's changed my whole mindset, even at home, not just at work. I'm constantly now aware of sitting for more than 30 minutes at a time. I never was aware of that before.* H3, female employee

The reports provided after each assessment summarising the objective data from the activity monitors were

Table 2 Participant characteristics at baseline

	Interview participants	Focus group participants	All intervention participants
n	21	7	136
Gender (women)	12 (57%)	6 (86%)	89 (65%)
Age (years)	48.9 (8.5)	45.6 (11.3)	44.6 (9.2)
% Married/living together	15 (71%)	2 (29%)	86 (64%)[a]
BMI (kg/m^2)	27.9 (4.0)	24.6 (4.4)	28.6 (6.5)
% Tenure >5 years	16 (76%)	5 (71%)	94 (70%)[a]
% 1.0 FTE	16 (76%)	6 (86%)	107 (80%)[a]
Mean change in workplace sitting (mins) baseline-12 months[b]	−97.9 (121.4)	−89.5 (125.3)	−78.8 (100.6)[c]

n (%) or mean (SD). *FTE* full-time equivalent, *BMI* Body mass index
[a]n = 134
[b]Unadjusted data
[c]97

particularly important in facilitating this awareness raising and helped participants to understand how sedentary they were in the workplace.

> *Seeing it on paper – seeing my graph, I think that was a really positive part of the trial – that was very impacting on me, to visually see what I did for a week before I actually went on the trial and then see, "Oh my God, I sat that much."* H3 female employee

For some participants the intervention had a broader impact on awareness beyond workplace sitting. It was an *"awakening"* that prompted them to think about their health more generally.

> *It's definitely helped to highlight that I need to look after myself more. I need to drink more water, I need to be moving so that I'm not, yeah, stagnant and, yeah, bringing on any* [health] *conditions I guess.* M8, female employee

Many participants noted that since the study concluded, they found it difficult to sit for prolonged periods of time; one participant noted that they now started to feel *"edgy"* (C9, female employee). However, with the desks removed it became more difficult to break up their sitting time.

Improved health and well-being

The intervention was generally considered to have had a positive impact on both physical and mental well-being. Some participants reported that replacing some sitting with standing alleviated musculoskeletal issues (such as neck or back pain) or that physically they generally felt better. Participants also reported feeling more alert, having greater concentration and energy as a result of increased time spent standing.

> *Before I started the study I was experiencing some pain in my shoulder and neck on the left side, and I found that by standing it actually alleviated those problems.* M9, female employee

> *When you're standing up you felt so much looser, I suppose. After sitting down for a while you got really stodgy and sluggish, but when you're standing up you feel a lot freer, more relaxed, more alert. You concentrate better, I suppose.* K4, male employee

However, when the desks were removed at the end of the intervention participants noted musculoskeletal pain returning.

> *After going through hoops I managed to keep the desk but there was a period of time for about six weeks where I didn't have the desk and I immediately got back pain. I didn't tell anybody anything because I didn't want to come across like I was just whinging but I actually went home with really sore back pain through that four to six weeks where I didn't have the stand up desk.* H3, female employee

Work performance and productivity

Effects on work performance

Participants generally did not believe that the use of the sit-stand workstations had any impact on their productivity, either positive or negative. Some thought that it may have had a positive impact on their work performance as a result of perceived improvements in alertness and concentration (see Table 3).

> *Having the stand up desk definitely helps me to communicate with my customers that I'm speaking to. It helps me to think. I'm much more productive with a stand up desk. I'm clear minded, I'm focussed, I'm standing, I'm getting oxygen in me.* H3, female employee

However, work tasks sometimes made it difficult for participants to use their workstations in the standing position. Some reported that they chose to sit for certain tasks to increase their audio and visual privacy, for example, when taking more complex phone calls with clients or when dealing with sensitive information on their computers.

> *In difficult clients, I had to sit down even though, if I had my freedom, I probably would be standing up*

Table 3 Summary of participants' responses to each theme

Themes	Interviews (n = 21)	Focus groups (n = 7)
	n	n
Overall experience[a]	Positive: 21	Positive: 7
	Negative: 4[a]	
Awareness raising	Positive: 15	Positive: 4
	Neutral: 1	
Improved health and well-being[a]	Positive: 18	Positive: 5
	Negative: 3	
Work performance and productivity		
Effects on work performance	No effect: 11	Positive: 4
	Positive: 5	
	Negative: 2	
Long-term productivity outcomes	Positive: 2	Positive: 2
Workstation design[a]	Negative: 12	Negative: 7
	Positive: 1	
	Neutral: 6	
Communication and team dynamics[a]	Positive: 9	Positive: 3
	Negative: 1	Negative: 1
	Neutral: 2	
Organisational support and workplace culture		
The importance of social support[a]	Positive: 16	Positive: 5
	Negative: 1	Negative: 1
	Neutral: 1	
Intervention effects on non-participants[a]	Positive: 4	Positive: 2
	Negative: 5	Negative: 3
	No effect: 6	No effect: 3
Organisational support post-intervention[a]	Uncertain: 8	Uncertain: 2
	Certain (for OHS issue/request): 9	Certain (for OHS issue/request): 4
Processes of behavioural change		
Sit-stand workstations as the key facilitator of behavioural change[a]	Yes: 13	Yes: 7
	No: 1	
Diversity in use and engagement with intervention strategies around 'stand up, sit less and move more'	Yes: 21	Yes: 7
Health coaching and behavioural change	Useful: 13	Useful: 4
	Neutral/not useful: 6	Neutral/not useful: 3

[a]Note: some participants in more than one category

> *because I just needed to be able to have a close conversation with the client without the background noise.* J7, female employee

Long-term productivity outcomes

A couple of participants remarked that the provision of sit-stand workstations had the potential to lead to productivity benefits for the organisation in the longer-term as a result of reductions in absenteeism and potentially avoiding compensation claims.

> *It's also about getting people back to work as well too – [one of the girls in our team's] got a back injury and her physician basically gave her a five day pass to not come to work because of her back, but because she had the stand-up, sit-down desk she said, "I was able to come to work because I could stand and relieve that pressure" – so there's five days there of a person who wouldn't have come to work.* FG2 H24, female employee

Workstation design

While the concept of having a sit-stand workstation was appreciated and valued, nearly all participants reported issues with the design of the model (*Ergotron WorkFit-S;* www.ergotron.com), with some reporting that this impacted on their work performance. Most considered the size of the platforms to be too small to accommodate the mouse and for work tasks requiring hard copy documents. Some reverted back to sitting so that they could access the larger work surface on their normal seated desk. Others expressed dissatisfaction with the workstation stability, noting that the platform shifted too easily from standing to sitting with minimal force applied.

> *In my role that I do…I write a lot. So there is not enough adequate space for me to actually write properly and feel comfortable at the desks, so I suppose I sat a lot. In the beginning I was standing up but even when you are standing up or sitting down you have only got that tiny little area around you.* L18, female employee

Communication and team dynamics

There was a perception that increased standing facilitated communication with co-workers and team members, as participants were more visible in the open plan office. For team leaders this was considered positive, whereas other employees found it distracting when it interrupted their work flow.

> *I felt like I was more connected to my team because I could see more, I could instantly – not instantly run around, but you know I was a bit more hands-on, rather than when you're sitting you sort of wait until something's got your attention.* FG1 H6, female team leader

> *I think it actually improved interaction with colleagues because you're sitting at your desk you see the tops of people's heads but you never actually talk*

to people, but you stand and you're actually making eye contact with people and having a wave… if you're sitting at your desk you just never see anybody, I mean people are right beside you and it's almost as if they don't exist. FG2 H19, female employee

Organisational support and workplace culture

The importance of social support

The collegiality and peer support experienced by sharing the intervention experience with co-workers was valued and appeared to encourage participants to increase their standing and movement. As indicated in Table 3, the social support from other participants and team leaders was perceived by the majority of participants to have been an important facilitator of behaviour change and engagement with intervention strategies. In particular, participants reported using others' behaviour as a prompt to remind them to stand up.

I was lucky because I had two other people in my row that had them [sit-stand workstations] *so when one of us would stand up it would prompt the rest of us to. And we used to guilt each other a little bit into standing. It was like "You haven't stood today what's going on?" "Oh, yeah, alright, oh I've been a bit busy…" I suppose the mutual guilting into it worked quite well.* FG1 H8, female employee

The importance of social support for encouraging use of the intervention strategies was further highlighted through the contrasting perceptions from a couple of employees who were physically isolated from other study participants. They reported not using the desks as much as they would have liked.

I didn't have anyone else so there wasn't quite that public knowledge on my level that I'm part of a study. There was a bit more self-conscious to actually like, stand up with my desk. I never did the standing up in meetings because I totally was self-conscious about it. There's two people in our team meetings that would do that but that's because they have an injury so I was actually thinking, "I can't stand up because I don't have that excuse, I don't have any injury" FG1 H14, female employee

Support from team leaders during the intervention was important in increasing the acceptability of the intervention and shifting organisational norms. Participants at most sites felt that they were supported by their team leaders and this made them feel more comfortable and confident taking up the intervention strategies.

As soon as managers say, "If you want to stand, feel free to," you can guarantee it there'll be people immediately that will stand because managers have given them that permission to do it and therefore they've got the permission from everyone else to do it. H3, female employee

Intervention effects on non-participants

As only selected teams within each worksite were invited to participate in the SUV trial, and some team members were ineligible, or chose not to participate, participants were often sitting adjacent to non-participants without sit-stand workstations. In some situations there were issues raised about audio and visual privacy, including increased noise when participants stood up or concerns about participants looking over them.

They didn't really look at where people were sitting before they put the stand-up desks in, and my friend just couldn't use hers at all because where she was sitting there were people around her who were more sensitive to hearing her voice when she was standing up. C9, female employee

Some team leaders managed this issue by moving employees or asking participants to lower their voice. In most sites, concerns about audio privacy became less of an issue over time. A few of the team leaders noted that noise was an unavoidable feature of open plan offices and such complaints were not solely attributable to the intervention.

I just think you've got some loud talkers and you've got some quiet talkers. And being a team leader I had to move people because they didn't want to sit next to the loud talker. This was before they even had the stand up desks. J8, male team leader

Organisational support post-intervention

There was general uncertainty about the long-term commitment to the intervention messages from upper levels of management, particularly as the majority of sit-stand workstations had been removed after the study concluded. Participants reported having to *"jump through hoops"* to keep the desks, and that sit-stand workstations were only available to those who had been able to provide evidence from a medical practitioner that it was necessary for their health (see Table 3). This had created dissatisfaction and frustration amongst participants who wanted to—but were unable to—keep the desks and tension with the employees that were able to retain them.

If the organisation was willing to just give them [sit-stand workstations] to every single person without a fight or without any qualms then I would be thinking that they're treating their staff as if they're

important but at the moment they're still not really doing that. You've got to, you know, put in all your med certs [medical certificates of need] and you've got to have a reason why. M8, female employee

Towards the end of the trial, non-participants had also started to express interest in obtaining a sit-stand workstation.

When it [the intervention] *was in its latter stages, people were saying, "how can I get one of those? How can I stand up?" Even though people weren't participating, they were seeing it and they must have been thinking about how it could be of some benefit to themselves.* A1, male team leader

Processes of behavioural change

Sit-stand workstations as the key facilitator of behavioural change

While the SUV intervention was multi-component in nature, the sit-stand workstation was perceived to be the key driver of behavioural change and the principal element of the intervention. This likely reflected participants' roles as predominately desk-based, with few job tasks able to be performed away from their workstations. The sit-stand workstation was perceived to be a more effective tool for reducing sitting than previously trialled strategies within the organisation, such as computer prompts.

You need to have the physical ability to do it... I've had back issues in the past and I know I shouldn't sit for long. So before I had the Ergotron theoretically the Work Rate [computer software] *would remind me to get up and walk around but if I'm in the middle of something I'll just, you know, skip it and keep working. Whereas I had a reminder... I would just, you know, lift the whole Ergotron up and keep working, no drama and then I'm standing.* M5, female team leader

After the desks were removed, participants reported it was difficult to increase their standing time in the context of predominately desk-based tasks.

When you don't have the desk I found it really hard to stand and work. Because everything like computer and the keyboard and the writing pads are always on the desk, so if you need to use any of those, you can't really stand up and do it. C2, male employee

The desk was also perceived to assist with normalising standing within the workplace. Without the desks, participants no longer felt they had a reason for standing that was justifiable to their colleagues.

Now you stand up and you probably feel a little bit self-conscious because people are going "who's that weirdo, what's she doing –", whereas if you've got the desk then people can see, "oh she's got her desk up that's why she's standing." FG1 H14, female employee

Diversity in use and engagement with intervention strategies around 'stand up, sit less and move more'

There was wide variety in participants' reports of the ease and extent to which they were able to reduce their workplace sitting during the study. While some participants reported being highly motivated and driven to stand from the outset of the intervention, others perceived that they hadn't changed as much as they had initially intended, noting the difficulty of shifting engrained habits of prolonged sitting or external factors (such as demanding caring responsibilities outside of work) that had limited their ability to engage with the intervention.

I didn't really use any prompts I think, I was already keen on standing so, you know, I just did it. C5, male team leader

I guess it's like an exercise or going for a run or a walk or something. When you're doing it it's feeling really good and you think, "I should do this all the time," but then somehow you don't do it. I think it's a bit like that. If it's there [the sit-stand workstation] *I think that it will be utilised, but maybe not as often as it should be.* A3, female employee

Many spoke about the importance of self-motivation for successful behavioural change.

the people that are motivated and are happier tend to adapt better to the stand up/sit down and are more able to follow and get the most out of the health benefits. The people that are less motivated, and are less happy, don't. J7, female employee

Participants reported using a variety of strategies to increase their standing and moving time in the office. Commonly reported prompts used in conjunction with the workstation were time-based (e.g. use the workstation in the standing position during the morning) and task-based (e.g. stand while performing particular job tasks).

The one that really stuck with me was at the end of the day to put the desk in the 'up' position. So I just came in to start the day with it ready to go. FG1 H6, female team leader

I tried to base it around the type of work... so at the end of that process you might say to yourself, "well I've

been sitting down for a while so I can stand up now" A6, male employee

Strategies most commonly used by participants to move more included: more frequent trips to the kitchen, bathroom, or to use the printer. A few reported going for walks during breaks. Participants also perceived that using their sit-stand workstation in the standing position made it easier to move more, as the transition to walking was easier from standing than from sitting.

I felt like it [standing] *was easy as a starting block. If I'm doing something and I have to go and see somebody it's just easier to just walk instead of, ooh I have to get up like this and go.* FG1 H14, female employee

Health coaching and behavioural change

One-on-one health coaching was provided to all participants with the aim of supporting behavioural change. However, there were differing perspectives on its effectiveness (see Table 3) – those who considered themselves self-motivated did not perceive it to be very helpful.

I didn't find them useful, the strategies, because I was already doing it. I was self-motivated. I was very enthusiastic. I answered all my own questions. I just thought, great for people that needed it but I didn't actually need it. I found it really pointless. H3, female employee

Most frequently, participants saw the health coaching as a useful prompt or reminder by making them accountable to one of the study staff. One participant noted that the *"value was in the contact"* (K4, male employee) – having someone checking in to see how things were going. A few suggested that it would have been helpful for this check-in to have continued beyond the initial 3 month intervention period to support the sustainability of new habits.

You know there's going to be a contact in a month or two, you know you've got to be able to provide some feedback, so you've got to do the stuff in the meantime. You can't just not do anything. So probably one or two, even after the three months. Not to go through, "Look are you doing this, this, this, and this?" But just around saying, "How are you going? What do you think is working, what's not working?" K4, male employee

Discussion

These qualitative findings provide insights into the experiences of office workers during a 12 month intervention to reduce workplace sitting, including perceived barriers and facilitators to behavioural change, and effects of the intervention on workplace culture and work performance. They have relevance for research and practice by highlighting contextual factors that may need to be considered when implementing interventions, in order to increase the likelihood of reducing and breaking up sitting time.

Overall, the majority of participants reported positive experiences with the intervention and were interested in retaining the sit-stand workstations at the conclusion of the 12 month period. While there were a small minority of participants who reported negative physical effects (e.g. musculoskeletal problems) during the trial as whole [17], participants in these qualitative interviews perceived that the increased workplace standing time had had positive impacts on alertness, concentration and energy, and for some, had relieved their musculoskeletal complaints. These observations are consistent with a growing body of research suggesting that workers perceive a range of health and well-being benefits from using a sit-stand workstation [15, 16, 20]. However, despite the potential for sit-stand workstations to be an effective health promoting strategy, previous studies have suggested that the workstations are viewed as an aid for addressing pre-existing musculoskeletal conditions, rather than for preventive health [21, 22]. This mindset is likely to continue to be perpetuated while sit-stand workstations are only provided selectively, rather than universally to all employees.

When prompted about their perceived productivity during the trial, participants generally reported that the use of the sit-stand workstations had had no noticeable impact on their performance. Some reported feeling that increased standing facilitated improved communication and interaction with co-workers, which may be beneficial to team performance. However, there appeared to be certain job tasks that were more difficult to perform standing with this particular workstation, leaving some participants sitting more than desired. A number of studies have now reported that workers perceive either a negligible or positive impact on self-reported work performance when using sit-stand workstations for short periods of time [13, 14, 16, 23–25]. In addition, a recent study evaluating the impact of sit-stand workstations on work performance amongst call centre workers found no significant difference in a number of objective measures of productivity, including call handling time, attendance and sick leave [9]. Longer term studies are required to assess productivity effects for organisations at a macro level; however, it is a positive finding that in the short-medium term, sit-stand workstations appear to have negligible negative impact on work performance.

The intervention encompassed strategies acting at the individual, organisational and environmental-levels. There

appeared to be variation in the strategies that participants found to be useful. Overall, the sit-stand workstation was reported to be the main driver of behavioural change, with most reporting that they were unable to reduce their sitting time after the workstations were removed. This is indicative of the job roles of participants, which included predominately desk and phone-based tasks. From a whole of workday perspective, sit-stand workstations will have greater potential to facilitate large reductions in sitting time relative to other strategies that were promoted, such as standing in meetings. However, consistent with an ecological model of sedentary behaviour [11], individual and social factors interacted with the environmental modification provided by the sit-stand workstation to influence behaviour. In particular, the social support provided by other participants (e.g. through seeing others stand up with the workstation) and team leaders (who provided permission and support for change) were perceived to be important facilitators. In contrast, those who were physically isolated from other users of sit-stand workstations felt more self-conscious using the workstations. Others [25] have reported similar findings, suggesting the importance of the social environment for facilitating, or impeding, reductions in workplace sitting time.

Organisational cultural norms around "appropriate" workplace behaviour have previously been found to be barriers to behavioural change when attempting to shift engrained patterns of workplace sitting [21]. Some participants reported that the sit-stand workstation itself appeared to influence social norms by facilitating a cultural shift in the acceptability of standing and moving more within the workplace. However, where participants were isolated from other study participants, cultural shifts were less apparent. In some sites, tensions between participants and non-participants over issues such as audio and visual privacy led to some not fully utilising the workstations. Some of these issues reflect the limitations of a research trial as not all employees were eligible or consented to participate. However, these findings may have implications for worksites considering a selective roll-out of sit-stand workstations. Programs that aim to engage entire worksites, and consider workspace design and layout, may be more successful in shifting workplace culture and organisational norms towards acceptance of reducing workplace sitting.

Despite an overall positive view of sit-stand workstations in general, most participants had some negative feedback about the design of the particular model trialled (Ergotron WorkFit-S), including the size of the work surface and workstation stability. Previous studies using the same or similar models have reported comparable feedback [13, 15, 16, 25], suggesting that workstation design is an important consideration. Since the study commenced in 2012, a number of other sit-stand workstation models have come on to the market, many of which provide larger, more stable work surfaces, which may address these shortcomings.

Many participants wished to retain the workstations at the conclusion of the trial despite these concerns about the design, suggesting that interest in sit-stand workstations can be sustained over the medium-long term. However, it is worth noting that, on average, participants reduced the amount of time spent standing as the study progressed [17]. There is a need for additional research to identify the determinants of sustained behavioural change over time, particularly at the organisational and environmental level.

Lessons learned from the SUV trial and recommendations for future workplace sitting programs/interventions

The findings from this study have implications for researchers designing interventions and for organisations seeking to promote more activity-friendly environments for their employees. Table 4 summarises the lessons learned from the SUV intervention and key recommendations for future workplace programs.

This study adds to and extends the growing literature evaluating participants' perspectives of sit-stand workstations in office workplaces [13–15, 23, 26]. Similar themes were identified to those in previous research relating to perceived barriers and facilitators to using sit-stand workstations [13, 15]. In addition to evidence of their efficacy for reducing workplace sitting time [17], this study suggests that sit-stand workstations are acceptable and feasible to office-based employees across the medium-long term, and are perceived to have positive physical and mental impacts. However, it is acknowledged that the cost implications of purchasing sit-stand workstations for all employees may be a barrier for some organisations. A comprehensive cost-effectiveness analysis of the SUV intervention is currently in progress, which will provide insight into the economic credentials of the intervention, including the costs of the workstations.

Key strengths of the present study include the 12 month duration of the intervention, medium to long-term follow up and the ecological validity, featuring office workers across multiple geographically separate worksites. It is worth noting, however, that this qualitative study was an additional voluntary component of the SUV trial, occurring after the intervention had concluded. While participants did appear to be broadly representative of intervention participants in terms of socio-demographics, workplace sitting reductions were higher among these participants than intervention participants as a whole. Participants who volunteered for the qualitative component may have been more engaged than those who did not—potentially biased towards those who wished to retain the sit-stand workstations—which could mean these findings present an overly

Table 4 Implementing strategies to reduce workplace sitting: lessons from the SUV trial and recommendations for research, policy and practice

Lessons learned	Recommendations
• Awareness of current activity levels (i.e. time spent sitting and moving) may be important for behavioural change.	• Assess and provide feedback on employees' behaviour, preferably with objective measures. • If resources do not facilitate objective measurement, a questionnaire can provide relevant insights.
• Sit-stand workstations are integral to achieving large reductions in workplace sitting time for those with largely desk-based roles. Participants in this study reported having limited opportunities to stand once the workstations were removed.	• Provide employees with access to sit-stand workstations where organisational resources permit. • Attempt to replace fixed height workstations with sit-stand workstations (or static standing workstation options) during scheduled office furniture upgrades. • Provide opportunities for job tasks to be performed at alternative work points (e.g. communal standing or sit-stand workstations) to encourage greater movement throughout the day.
• The design of sit-stand workstations can be a barrier to use. Stability and size of the work surfaces are important features.	• When selecting sit-stand workstations for purchase consider: - Ease of movement (manual vs electric adjustment; speed and noise of movement) - Ergonomic and occupational health and safety (OHS) requirements (compliance with standard height range, height indicators to facilitate use at appropriate height, addressing any pinch points associated with moving elements). - Suitability of work surface size and monitor arrangement for predominant job tasks)
• Installing sit-stand workstations in open plan environments can have implications for audio and visual privacy, particularly when the provision of workstations is not universal.	• Create supportive social and environmental conditions to support sit-stand workstations. For example, higher partitions, separate quiet spaces for phone calls, reorienting of desks or relocation of workers. • Provide and encourage use of alternative work points with audio and visual privacy to support tasks, such as phone calls. • Managers/team leaders should monitor interactions between workers and provide advice/conflict resolution as needed.
• A whole of organisation approach to promoting sit less, move more strategies is important, including support from middle and senior levels of management as well as peer support.	• Managers/team leaders should lead by example and support and encourage sit less strategies. For example, providing permission for employees to stand in meetings. • Co-workers play an important role in prompting and supporting positive behaviour change.
• Existing preconceptions around sit-stand workstations and their purpose may be a barrier to their use. For example, workstations traditionally only being provided to those with musculoskeletal issues.	• Review and, where appropriate, update and promote policies around the provision and use of sit-stand workstations. • Ensure that key business stakeholders, including OHS representatives, are included in process of on-boarding sit-stand workstations to increase their relevance. • Consider piloting sit-stand workstations to increase positive perceptions and knowledge prior to full roll out.
• Ongoing support and encouragement is important for the creation of new habits relating to sitting less and moving more. For some employees this may be required for longer than 3 months.	• Discuss benefits and challenges to reducing sitting through organisation social media platforms and intranets. • Regular competitions or events to promote sitting less may assist to reinvigorate strategies. • Use signage to provide behavioural prompts to reduce workplace sitting.

favourable impression of the intervention. However, it is worth noting that this study found a range of favourable and unfavourable perspectives. This study also did not approach workers who initially consented to the trial but withdrew prior to the study completion, who may have had more adverse experiences. The use of focus groups at only one of the participating sites is also a limitation, however arguably this is offset by the insights gained into group-level dynamics during the intervention. Finally, the interviews were conducted between one and 4 months after the intervention had concluded, which may have affected participant recall, and only at one time point, limiting understanding of whether participants' experience of the intervention changed over time. Future studies should consider conducting qualitative interviews at both short and long-term follow-up periods to gain these perspectives.

Conclusions

These findings are supportive of the notion that sit-stand workstations are an effective and acceptable method for reducing sitting time in office workers. However, to support their use, best practice workplace initiatives should

be multi-component in nature and address the individual, social and environmental-related influences that may act as barriers to effective uptake. The findings from this study and suggested recommendations may be informative for organisations considering approaches for reducing workplace sitting.

Additional file

Additional file 1: Questions covered during the focus group discussions. (DOCX 15 kb)

Abbreviations

BMI: Body mass index; FTE: Full-time equivalent; SUV: Stand Up Victoria

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Availability of data and materials

The availability of the data from the SUV study is subject to the approval of a formal application made to the Chief Investigators.

Authors' contributions

DD, AL, GH, MM, EE, NO conceived the SUV trial and subsequently obtained funding from the National Health and Medical Research Council and the Victorian Health Promotion Foundation. AL, LW, KM, GH, DD, MM, EE, NO, SL participated in the design and coordination of the study and development of the interview guides. LW conducted the interviews and focus groups. NH, LW and SL analysed and interpreted the data. NH drafted the manuscript. All authors contributed to the manuscript development. All authors read and approved the final manuscript.

Competing interests

Ergotron Pty Ltd. (www.ergotron.com) has previously provided workstations for formative research related to the topic (4) Dunstan presented at the 'JustStand Wellness Summit', a conference organised by Ergotron, in 2012 and Healy presented at the same summit in 2013. Ergotron covered travel and accommodation expenses for both Dunstan and Healy. No further honoraria or imbursements were received. Malkoski is employed by Schiavello International, an organisation involved in the design and manufacturing of office furniture, including sit-stand workstations. Her primary role, and association to this study, is workspace strategy and change management with psychology qualifications. There are no other competing interests that could appear to have influenced the submitted work.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Ethics approval for this study was granted by The Alfred Health Human Ethics Committee (Melbourne, Australia). All participants provided written informed consent for the Stand Up Victoria trial and verbal consent for the qualitative interviews.

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Additional File 1: Questions covered during the focus group discussions

Theme: Global Satisfaction

1. **How was your overall experience with the Stand Up Victoria study?**
   - How satisfied were you with your experience?
   - What were some of the positives about the experience?
   - What do you see as the advantage/s of standing more at work?
   - Do you feel that the movement improved your wellbeing/comfort? How?
   - What could be improved upon in future projects that are introducing sit/stand workstations? (Be sure to let participants know that we have no commercial interest in the workstations)
   - Do you feel that the movement within the workplace negatively impacted on the way in which you worked? How?
   - Do you feel like you could control the workstation with ease? i.e., do you think you could make the change from standing to sitting easily? If not, why?
   - Did you feel that you were provided with the right knowledge to allow you to stand up, sit less, and move more within your workplace?
   - Would you recommend sit-stand works stations to others? Why/Why not?

Theme: Motivation and sustainability

2. **If each of you could reflect on your own individual strategies:**
   - Which ones motivated you the most to change your working position? Why do you think that was?
   - Where there any strategies that you tried that didn't work? Why do you think that was?
   - If changes were made, what is it going to take for these changes to become sustainable in your group in the long-term?
3. **Now that the study is over and your desks have been removed, are you still trying to follow the objectives of the study – standing up, sitting less, moving more?**
4. **How suitable do you think your workplace is for sit/stand workstations? If not, what needs to change to make it suitable?**
5. **Could you see your workplace taking on any other changes now that the study is complete?**

Theme: Workplace Culture

6. **To what extent do you feel the workplace 'culture' has changed to support the Stand Up Sit Less Move More messages?**
   Prompts

   - Did the opportunity to have a sit-stand workstation make you feel more valued as employees?
   - Did the sit-stand workstation make you feel more in control of your workspace?
   - Did you feel you had the support of your team leader/upper management to make these changes at your workstation? Why, why not?
   - Where you conscious of your perceived productivity as a result of using the workstation?

- How did the sit-stand workstation impact on your sense of privacy? (audio vs. visual)
- Did you feel that the sit-stand workstations impacted on the sense of audio/ visual privacy of others around you? If yes, how so?
- Where there others in close proximity to you that had sit-stand workstations?
    - If no, did you feel comfortable changing your behaviour in such an isolated area?
    - If yes, did being in close proximity with others with workstations have an impact on your behaviour? Were you encouraged/discouraged from changing your behaviour as a result?

Theme: Productivity

7. **What did you think about the impact of the workstations on your productivity, in terms of:**
    - Communication (between each other and clients)
    - Collaboration
    - Task completion/ work flow

6.2 Summary and implications of findings

Overall, participants in this study reported that the SUV trial had been a positive experience. Many reported that the intervention had increased their awareness of their sitting time and that spending more time standing had resulted in benefits to their health and well-being. Similar to findings reported in other recent studies (216, 217, 246), participants perceived that standing more during the workday had had positive effects on concentration and energy, and for some, had also improved existing musculoskeletal issues.

Although SUV was a multi-component intervention, the sit-stand workstation (the environmental-level component) was perceived to be the main driver of reductions in sitting time. This was particularly apparent for participants when the desks were removed after the 12 month intervention period and they found it difficult to reduce their sitting. For workers in jobs where few tasks can be performed away from personal workstations—such as the participants in this study—other strategies such as standing or walking meetings may be less helpful for reducing workplace sitting time.

A key finding from this study was the role of the social environment in either supporting or inhibiting workers' engagement with the intervention, which aligns with the findings reported in Chapter 4. Social support and encouragement from peers appeared to be an important facilitator of sit-stand workstation use. Participants also noted that explicit support from team leaders or managers made them feel more comfortable to stand in meetings. Within SUV the provision of the sit-stand workstation was complemented by organisational-level approaches that aimed to build a workplace culture supportive of efforts to reduce sitting. These strategies are likely to have assisted with shifting organisational norms towards greater acceptance of standing and moving within the office.

Table 4 in the paper summarised the main lessons learned from the SUV trial and provided some recommendations for addressing these issues in future interventions or programs. The importance of promoting a supportive social and physical environment for reducing workplace sitting was highlighted. Specific recommendations relating to sit-stand workstations were also provided, noting that if they are to be implemented into an office environment, consideration should be given to job tasks, workstation design and office layout. It was suggested that pre-conceptions around sit-stand workstations only being for those with musculoskeletal conditions should also be addressed.

While previous qualitative studies have explored users' experiences of sit-stand workstations (198, 215, 217), this study was the first to examine the acceptability and feasibility of a multi-

component intervention for reducing workplace sitting time. The 12 month duration of the SUV trial was a strength and these interviews provide insight into the acceptability of reducing sitting time over the medium to long-term. The findings from this study and associated recommendations are likely to be informative for future research and practice.

The main limitations were reported in the manuscript. Specifically, interviews and focus groups were conducted only at the conclusion of the 12 month intervention, rather than at multiple time points. While the sit-stand workstations were retained for 12 months, other aspects of the intervention (individual and organisational-level strategies) ceased at three months. Conducting interviews at both three and 12 months may have provided greater insight into factors influencing initial and sustained sitting reduction, and participants' engagement with the intervention over time. The length of time between the conclusion of the intervention and when the interviews and focus groups were conducted may also have negatively impacted participants' recall and their ability to provide in-depth feedback about the acceptability and feasibility of the intervention. This potentially could have had a greater impact on the components that were only provided for the first three months (health coaching and organisational strategies). It is also possible that participants who volunteered for the interviews and focus groups comprised a particularly engaged group that had more positive experiences than those who did not participate. This is supported by the findings revealing that participants in this qualitative study had larger reductions in sitting time at 12 months than those achieved by all intervention participants.

The final chapter in this thesis, Chapter 7, summarises the main findings from each of the preceding thesis chapters, reports on the strengths and limitations of the body of work, provides directions for further research, and highlights the implications for policy and practice.

CHAPTER 7

DISCUSSION

This final Discussion chapter considers, in overview, the main findings from the five studies presented in Chapters 2–6 of the thesis. Here, material covered in the Discussion sections of the peer-reviewed papers and the summaries within each chapter have been integrated and elaborated upon. The strengths, limitations and implications of the main findings are discussed, together with suggestions for further research to extend the knowledge of the emerging field of research, practice and policy on workplace sedentary behaviour and health. In light of this body of findings and a book chapter completed during the candidature (see Appendix A), this chapter presents some further conceptual perspective on understanding and influencing workplace sedentary behaviour. Practical implications of the thesis findings, including recommendations for public health policy and practice are presented at the conclusion of this chapter.

During the period of candidature, there has been rapid growth of the research literature pertaining to interventions targeting workplace sedentary behaviour and factors influencing the feasibility of reducing and breaking up sitting time. This chapter reviews the thesis findings in the context of recent evidence in this field.

7.1 Overview of the findings

This section will summarise the methods and main findings of each of the studies, with reference to the three thesis research aims:

- To identify socio-demographic, health-related, work-related and social-cognitive correlates of workplace sitting time.
- To determine key barriers and facilitators for reducing high levels of sitting in the workplace, and the feasibility of change.
- To understand the mechanisms through which a workplace sedentary behaviour intervention leads to successful behaviour change.

Part 1 of this thesis comprised two studies relevant to the first primary research objective. **Chapter 2** assessed the correlates of self-reported occupational sitting time amongst 1,235 Australian adults in a cross-sectional analysis of data from the AusDiab3 study. It also assessed the correlates of occupational sitting time and TV viewing time in combination. Factors associated with high levels of occupational sitting time (>6 h/day) differed slightly between

genders. For women, older age was associated with being in the high occupational sitting time category, while for men, higher educational attainment and having a professional/managerial occupation were associated with being in this category. Higher household income was associated with high occupational sitting time for both genders. Factors associated with having both high occupational sitting time and high TV viewing time (≥1.5 h/day) (relative to low levels of both behaviours) for women were being single (relative to de facto/married), having higher energy consumption, and having lower levels of LTPA. For men, a higher BMI, a lower level of LTPA, and having a white collar/administrative occupation (relative to a professional/managerial occupation) were associated with increased risk of being in this group. In contrast, men in blue collar occupations were less likely to be in this group compared to men in professional/managerial roles.

Chapter 3 extended upon the findings from Chapter 2 to examine worksite variation, and the correlates of objectively measured total and prolonged workplace sitting time in a sample of office-based workers. This study used data from the baseline assessment of the Stand Up Victoria cluster randomised controlled trial (n=231). Of the socio-demographic, work-related and social-cognitive factors assessed as potential correlates, only BMI and tenure were associated with workplace sitting time. Obesity (≥30kg/m^2) was associated with less total and prolonged workplace sitting time compared to having a healthy BMI (<25kg/m^2), while having a tenure of 3–5 years was associated with more total and prolonged workplace sitting time compared to those with tenures greater than five years. Significant variation in total and prolonged workplace sitting time was observed across the 14 worksites; this variation remained in the fully adjusted models. This study was the first to examine the correlates of objectively measured total and prolonged workplace sitting time.

Part 2 of the thesis focused on identifying factors associated with workplace sedentary behaviour change. **Chapter 4** examined the perceived feasibility of reducing workplace sitting time, including barriers to change and the feasibility of specific strategies, in a group of office-based workers not previously exposed to a formal workplace sedentary behaviour intervention (n=20, three organisations). Similar themes emerged across the three organisations. The main perceived barriers to reducing sitting at work related to: the nature of work (including workload and predominance of computer-based tasks); organisational social norms around acceptable workplace behaviour; and, office furniture and layout (in particular, seated height workstations). It was considered that having a range of potential strategies for reducing workplace sitting would be most appropriate, particularly due to the cost implications associated with sit-stand workstations. There also appeared to be an opportunity to promote and optimise existing

strategies to reduce sitting time, such as standing meetings or face to face communication, that were often already performed for business reasons. Managers expressed a need to have stronger evidence and a business case for investing in strategies to reduce workplace sitting in light of competing workplace priorities. This study highlighted the importance of the social and physical environment as perceived influences on the feasibility of reducing workplace sitting time.

Chapter 5 aimed to understand some of the mechanisms through which the SUV intervention led to successful reductions in workplace sitting time. Four social-cognitive constructs targeted by the intervention (perceived behavioural control, barrier self-efficacy, perceived organisational norms, and knowledge) were assessed as potential mediators of the intervention effects on workplace sitting time at three and 12 months. Significant intervention effects on perceived behavioural control, barrier self-efficacy and perceived organisational norms were present at three months; intervention effects on perceived behavioural control and barrier self-efficacy were also significant at 12 months. Perceived behavioural control significantly mediated the intervention effect on workplace sitting time at three months, but explained only a small proportion of the total effect (7.5%). Barrier self-efficacy was the sole significant mediator at 12 months, explaining 13.9% of the total effect. These findings suggested that social-cognitive factors were significant, but small contributors to the overall intervention effects on changes in workplace sitting time during this multi-component workplace intervention. This study was the first to examine potential mediators of intervention effects on workplace sitting time change.

In order to identify some of the other factors perceived to influence participants' behavioural change during the SUV intervention, and gain insight into their overall intervention experience, **Chapter 6** analysed data from qualitative semi-structured interviews (n=21) and two focus groups (n=7), conducted with intervention participants after the 12 month assessment. Overall, participants reported that their engagement with the SUV intervention was a positive experience which had increased their awareness of how much time they sat at work. Use of the sit-stand workstations in particular was perceived to have had positive impacts on health and wellbeing with little noticeable impact (positive or negative) on productivity or work performance. Social support from co-workers and management appeared to increase the acceptability of the intervention and be important for shifting organisational norms. Barriers to workers taking full advantage of intervention strategies included the workstation design (with concerns raised about the size and stability of the work surface and suitability for work tasks), and the impact of the intervention on non-participants (such as issues relating to audio and visual privacy in the open plan office). The extent to which intervention strategies were used, and their perceived effectiveness, varied between participants. Despite the multi-component nature of the

intervention, the sit-stand workstations were generally viewed as the main driver of behavioural change. Participants reported that they had found it more difficult to reduce their workplace sitting time after the intervention concluded and the workstations had been removed. A key strength of this study was the insight it provided into the feasibility and acceptability of a multi-component workplace sedentary behaviour, implemented over a 12 month period. This study extended upon previous qualitative research that had assessed the feasibility of sit-stand workstations in isolation, generally for three months or less (198, 215, 217).

Overall, the thesis findings highlight the importance of considering factors operating at multiple levels, including individual, social and environmental, as influences on workplace sitting time. The social and physical environment of the workplace appear to be particularly important in influencing workers' perceived feasibility of reducing and breaking up sedentary behaviour in this setting. In this context, the strength of individual-level, social-cognitive factors as determinants of workplace sitting and their potential as elements of interventions requires further clarification.

7.2 Strengths, limitations and directions for further research

As noted above, the studies within this thesis have a number of strengths and have provided insights into the range of factors influencing workplace sitting time. Overall, this body of work demonstrates the capacity of the candidate to apply a variety of research designs and analytic approaches to appropriately address research questions of interest. The findings have relevance across multiple disciplines of research and practice, including for occupational health and safety, ergonomics, urban design, and public health more broadly.

Notwithstanding these strengths there are some limitations, which have been described in more detail in Chapters 2–6. Provided below is an overarching summary of the main strengths and limitations of this body of work, with recommended directions for further research.

7.2.1 Comprehensiveness of potential correlates

A strength of this thesis was the use of multiple methodologies to address the three research objectives. Quantitative and qualitative study designs were used across three different datasets to identify factors associated with workplace sedentary behaviour and sedentary behaviour change. The quantitative component included the use of cross-sectional study designs to identify correlates of workplace sedentary behaviour, and mediation analyses to identify factors

associated concurrently with workplace sedentary behaviour change. The objective measurement of workplace sitting time in SUV was a particular strength.

The two qualitative studies were able to provide perspectives from both those who had, and those who had yet to experience, strategies to reduce sedentary behaviour. The inclusion of employees and managers, and organisations from different industry sectors (including one small business) contributed to the richness and novelty of the findings. As noted earlier, previous qualitative research relating to workplace sedentary behaviour has predominately focused on perceptions of sit-stand workstations trialled for relatively short periods (198, 215, 217). The SUV qualitative study provided important insight into the feasibility and acceptability of a 12 month intervention where sit-stand workstations were supported by individual-level health coaching and organisational support strategies.

One main limitation of the thesis relates to the comprehensiveness of the correlates of workplace sitting that were examined. Despite the use of different methodologies and datasets, it is unlikely that the factors identified represent a complete taxonomy of workplace sedentary behaviour correlates. The use of pre-existing datasets—AusDiab3 and SUV—in Part 1 meant that the range of potential correlates examined was limited to those that were assessed in these studies, which were predominately individual-level attributes. As noted in Chapter 3, the significant worksite-level variation in baseline sitting time in SUV was not able to be explained by the variables assessed as potential correlates (247). Few significant factors were identified to be associated with total sitting time, or sitting accumulated in prolonged bouts. By design, the study in Chapter 5 only considered the role of social-cognitive factors as potential mediators of intervention effects on workplace sitting time. However, as per the earlier SUV findings, the small proportion of the total effect explained suggests the likely contribution of other factors that were not examined.

A priority for future research should be to examine a broader range of potential factors as influences on total and prolonged workplace sitting time, in an attempt to understand significant variations between individuals and workplaces. In particular, work or job characteristics that were not addressed in this thesis should be examined in more detail. This should include factors such as task variation, job control or work engagement; work arrangements, such as job rotation, hot-desk arrangements and flexible work patterns; and physical environment characteristics, such as office layout.

The two qualitative studies complemented the findings from Part 1 of the thesis by identifying factors that were perceived to influence workplace sitting at an organisational-level, including workplace social norms, social support, and office furniture and layout. These findings provided

some additional insight into factors likely to influence workplace sitting time beyond individual-level attributes. However, to determine whether these perceived influences translate to effects on behaviour, associations with objectively measured workplace sitting time now need to be tested in larger, quantitative studies.

Another limitation is that while discrete correlates were identified, there remains limited understanding of the extent to which these factors may interact together to influence behaviour. This has been a key criticism of ecological models in general (248, 249). Recognising the limitations of the ecological model in dealing with the complexity of behavioural influences, it has been suggested that systems-based frameworks may be helpful for guiding future research into the determinants of sedentary behaviour, including understanding relationships between different factors. During the period of candidature, the author was involved in an international consensus process to develop a systems-based SOS (Systems of Sedentary behaviours) framework (248). The publication of these findings occurred during the latter stages of the candidature, limiting the ability to incorporate this framework into the thesis structure. However, the process highlighted the necessary complexity of research that seeks to identify the determinants of sedentary behaviour.

Recommendations: Future research aimed at identifying correlates of workplace sitting time should examine a broader range of variables operating at individual and organisational-levels. In particular, greater attention should be focused on work-related factors, such as job control, job demands and task variety; and different work arrangements, such as activity-based working and flexible work arrangements. This will provide insight into how specific job tasks and the nature of work more broadly can be altered to facilitate greater levels of movement in the workplace. With evidence suggesting an association between the frequency of breaks from sitting and cardiometabolic risk biomarkers (79, 81), identifying factors associated with higher levels of prolonged workplace sitting time, in particular, will also be informative for designing intervention strategies.

Associations of the social and environmental factors identified in Chapters 4 and 6 with workplace sitting time (and workplace sitting time change) should be examined in larger quantitative studies with broad industry representation to determine the extent to which perceptions of barriers impact on behaviour. This may require the development of new questionnaires or tools specific to workplace sitting to assess these variables. Natural experiments and case studies of exemplar workplaces may also provide useful insights into additional social and environmental factors associated with successful behaviour change.

Recognising the limitations of the ecological model of sedentary behaviour, as discussed in the book chapter contained in Appendix A, there is a need for the development of a model or framework for research that is specific to workplace sedentary behaviour change. This may assist to identify significant knowledge gaps relating to the determinants of workplace sedentary behaviour and guide interventions in this setting. A focus on systems-level thinking, such as through the use of the SOS framework, may facilitate a greater focus on possible interactions between different levels of influence (248). This could include exploring whether individual-level attributes, such as socio-demographic or health-related factors moderate the effects on workplace sitting time of environmental-level influences (e.g. sit-stand workstations).

7.2.2 Measurement error and bias

Limitations of the measures used to assess correlates and outcomes in the studies could potentially have introduced bias into the findings. In Chapter 2, workplace sitting time was measured using a self-report measure. Self-report measures of sitting time can be affected by recall or social desirability biases (27) and have been found not to be highly accurate at the individual-level when compared to objective measures (29, 226). However, as participants' self-reported sitting time was dichotomised into low or high sitting time categories in this study, risk of misclassification was considered to be low. As discussed in more detail in Chapter 2, assumptions made about standard work weeks and hours worked per day may have introduced bias if subsequent misclassification was related to the potential correlates examined, e.g. education or occupational status.

The limitations of the occupational sitting measure used in AusDiab3 were largely addressed in Chapters 3 and 5 with an objective measure of workplace sitting time (the activPAL activity monitor), combined with self-report diaries that provided information on work hours. However, the unexpected inverse association between BMI and workplace sitting time raised the question of whether this was a true finding or reflective of measurement error associated with the activPAL.

The social-cognitive factors assessed in SUV had also not been validated. Due to the absence of validated measures to assess social-cognitive constructs relating to workplace sitting time at the time of baseline assessment, these scales were specifically developed for this study. The scales had been pilot-tested (5), with test-retest reliability and internal consistency previously reported (230), however, validity studies had not been conducted.

Recommendations: Studies examining the correlates of workplace sedentary behaviour should use objective measures of sitting time where feasible, to provide greater accuracy of measurement and enable examination of sitting accumulation patterns. Diaries or logs should be used in conjunction with activity monitors to enable recording of work hours. In cases where objective measures are not feasible, there is potential for the use of statistical models to calibrate self-report measures and facilitate prediction of objectively assessed sitting time. Research conducted in blue collar workers has led to the development of initial models for predicting objectively assessed workplace sitting time from questionnaire data (250). A multi-variable prediction model, including socio-demographic and health-related variables commonly assessed in epidemiological studies, was found to explain 63% of the variation in objectively measured workplace sedentary time (250). In comparison, a single categorical question on workplace sitting time explained only 38% of the variation in the objective measure. In another study assessing the prediction of objectively-measured total sitting time, the use of a prediction model with socio-demographic, work and health-related variables reduced the mean difference between self-reported and accelerometer-based sitting time by 42%, or 74 minutes (28). Further development of these models will require determining the most appropriate predictor variables for inclusion across diverse groups of workers. The use of statistical prediction models has the potential to lead to less biased estimates in future research using self-reported workplace sitting data.

To further reduce the potential for measurement error and bias, it is recommended that validation studies be conducted to determine whether commonly used activity monitors, such as the activPAL, perform equally well across the body mass index spectrum. There is also a need for validated scales for assessing potential correlates of workplace sitting time, particularly social-cognitive factors, to improve the quality of future research in this area.

7.2.3 Few prospective analyses

The paper presented in Chapter 5 (242) made a novel contribution to the literature as the first study to assess potential mediators of workplace sedentary behaviour change. Only a small number of studies have previously examined predictors of sedentary behaviour using prospective designs, and no previous research has examined factors associated with changes in sitting in the workplace setting (223).

However, a limitation is that the study in Chapter 5 was the only one to include prospective data. The cross-sectional studies presented in Part 1 therefore only allowed for inferences to be made

about correlates, rather than determinants of workplace sitting time (137). While the SUV qualitative study sought to obtain participants' perspectives of their experience across the 12 month intervention, interviews and focus groups were only conducted at one time point, after the intervention had concluded. Therefore, it could not be determined whether participants' perspectives of the intervention and the impact on the workplace environment changed over the course of the 12 month intervention. The temporal sequence of the reported behavioural change and perceptions of the intervention experience is also unknown.

Recommendations: Prospective studies (using sample sizes with sufficient power to detect associations) are required to identify determinants of workplace sitting and predictors of workplace sitting reduction. This will require the use of appropriate analytic techniques that can account for the time varying nature of both predictor and outcome variables. For example, the parametric g-formula is a method that can estimate the causal effects of factors such as office design, or provision of sit-stand workstations, over time in the presence of time-varying confounding (such as changing BMI or smoking status). This approach can accommodate the frequent 'real-world' scenario where confounders are affected by prior exposure status (and vice versa). The g-formula fits regression models that are used to simulate what would have happened to study participants if exposures of interest were altered via 'hypothetical interventions'. Assessing the determinants of workplace sitting change at multiple time points should also be considered to identify important influences of, or attributes associated with, short, medium and long-term behavioural change. Qualitative research accompanying interventions should also be conducted at multiple time points, to determine whether barriers and facilitators to behavioural change, and the perceived intervention experience more broadly, alter over the time course of the intervention.

7.2.4 Generalisability

Participants in four of the five studies within this thesis (of which SUV represented three) were exclusively office-based workers, and, for the SUV studies, were from the one organisation. The overall findings are therefore unlikely to be generalisable to workers in other sedentary workplace settings, such as those within transport industries and highly mechanised manufacturing roles, or indeed other desk-based workplaces that might have different policies and cultures related to activity within the workplace. In addition, participants in the SUV study were relatively homogeneous in their job roles and did not represent a random sample.

While the AusDiab study was originally a population-based cohort, AusDiab3 was a 12 year follow-up study. The sub-sample of AusDiab3 used in Chapter 2 (limited to people working the equivalent of full-time hours) were on average, middle-aged (mean age 53 years), with no representation of younger workers (<35 years). There were also few women working in blue collar occupations, which limited the ability to examine associations between occupation and workplace sitting time amongst women.

The characteristics of those who participated in the two qualitative studies (Chapters 4 and 6) may also not be representative of all desk-based workers, or of workers within their organisations more broadly. SUV participants who volunteered for the additional qualitative component had larger reductions in sitting time than the intervention group as a whole and individuals who withdrew from the study prior to the final assessment were not included. The findings may therefore have reflected an overly favourable perspective of the SUV trial. Participants of the qualitative study reported in Chapter 4 volunteered for a study about workplace sitting. While this sample was recruited with the aim to have representation across different work areas of the participating organisations, the resulting participants may have been more interested in reducing their sitting time than those who did not choose to volunteer.

Recommendations: To provide further insight into the correlates of workplace sitting beyond desk-based settings studies with diverse samples, encompassing a broad range of industries and occupations, are required. This could be facilitated in existing population-based cohort studies through the inclusion of a question(s) relating to workplace sitting time, and/or asking participants to report work hours in a diary or log where objective measures of sedentary time are included in such studies. However, for this data to be informative the range of potential correlates examined will need to be broader than the typical socio-demographic and health-related factors that have been most commonly measured. One potential issue with using cohort studies is that there are likely to be limitations on the scope of possible influences able to be examined, based on the primary aims of the study and the need to limit participant burden.

With increasing knowledge about what is effective for reducing sitting among desk-based workers (111), there is a need to explore the feasibility of reducing sitting time in other highly sedentary sectors. Workers in industries such as transport and manufacturing may face distinct and/or additional barriers to reducing sitting time and require different approaches to intervention. In addition, these workers may also be more likely to have additional risk factors for chronic disease relative to white collar or professional office workers (251, 252) which could place them at higher need for interventions. Future research should also aim for representation of

different sized businesses as the feasibility of strategies is likely to depend on the available resources of the organisation (234). Small businesses, in particular, are often less likely to take up workplace health promotion initiatives, citing cost and time constraints as particular barriers (253).

To improve the representativeness and usefulness of qualitative research conducted in the context of intervention studies, participants who have negative experiences or experience adverse events should be purposefully selected. Insights relating to why an intervention did not work for specific participants will be informative for future intervention design and implementation.

7.2.5 Sedentary behaviour, physical activity and health across the entire workday

The workplace was identified as a key setting for reducing sedentary behaviour, and the research within this thesis was informed by the ecological model of sedentary behaviour, which emphasises a settings-based approach for understanding determinants and developing interventions (102). As such, the aims of this thesis focused on understanding and influencing sedentary behaviour in the workplace specifically. Only the first study assessed factors associated with a sedentary behaviour that occurs outside of the workplace, in this case, TV viewing (227).

However, when seeking to identify those who are most at risk of adverse health outcomes associated with workplace sedentary behaviour, it may be beneficial to also consider the impact of activity across the whole working day. For example, recent evidence suggests that achieving high levels of MVPA may offset the negative effects of excessive total sitting time (77). It is therefore possible that different activity profiles during non-working hours could moderate the potential health risks associated with desk-based work. If so, this knowledge could inform education and awareness strategies used in workplace interventions—such as recommendations or tips to encourage increased activity both at work and during leisure—and also enable the identification of higher risk sub-groups. The findings from Chapter 2 indicating that high amounts of workplace sitting and TV viewing time are associated with other health risk factors (227), suggest that targeting behaviours that occur both within and outside of the working environment could be beneficial.

As noted in section 1.4.1 of the Introduction, the evidence linking workplace sitting time with incidence of adverse health outcomes is still quite limited (111, 112). High quality studies are

needed to determine the volume, or accumulation patterns of workplace sitting time that are most detrimental (and beneficial) to the health of workers, and explore any moderation of this risk that may occur by LTPA or sitting outside of work. This research should focus on a broad range of health and productivity-related outcomes that have relevance to the workplace setting, including physical and mental health, and measures of work performance. Strengthening this aspect of the evidence relating to sedentary behaviour and health is important groundwork for then examining factors or attributes that may be associated with "high risk" workplace sitting time, and informing evidence-based policy and guidelines (see 7.3.5 below). Determining which elements of sedentary behaviour should be changed to have the greatest impact on preventing and managing chronic disease is a broader research question to be addressed in the sedentary behaviour field (see Appendix C for a paper recently co-authored by the candidate that considers this issue) (254).

Recommendations: Future research targeting the working population should assess the impact of different activity profiles across the whole work day (including the relative contribution of work and leisure sedentary behaviours and LTPA) on health and productivity measures. This could assist with identifying at-risk groups and developing evidence-based education material for workplace intervention studies. Such knowledge could also inform more specific recommendations relating to physical activity and sedentary behaviour targets across the working day. Workplace sedentary behaviour interventions should also consider examining the potential role of activity profiles as moderators of intervention effects, to determine whether strategies are more or less effective depending on levels of LTPA.

7.2.6 Summary of areas for future research

The key areas for future research suggested in this Chapter, and identified through the body of work completed during the candidature, are summarised below.

- Examine the correlates of workplace sitting time in larger, more diverse cohorts, using objective measures of workplace sitting time if feasible.
- Develop a specific framework for guiding research and interventions for workplace sedentary behaviour change, building upon the strengths of the ecological model of sedentary behaviour (102) and the SOS framework (248).

- Examine associations between work-related factors and workplace sitting time, including job tasks and job content; shift work status; and work arrangements, such as job rotation, hot-desk arrangements and flexible work patterns.
- Examine associations between factors identified in the qualitative research and workplace sitting time (or changes in sitting time) in larger quantitative studies.
- Develop or refine questionnaire measures that assess the social and environmental factors identified through qualitative research.
- Identify key characteristics of exemplar workplaces that have been successful in reducing workplace sitting time.
- Assess the feasibility and acceptability of strategies for reducing workplace sitting in other high-risk occupational sectors, such as transport and manufacturing.
- Assess the impacts on physical health, mental health, and indicators of productivity at work of different activity profiles across the whole work day (including the relative contribution of work and leisure sitting and LTPA) to identify the most beneficial and adverse activity patterns for workers.

7.3 Implications and recommendations for policy and practice

The key implications and recommendations for policy and practice arising from this thesis are presented below. This section incorporates insights and recommendations from SUV which were summarised in Table 4 of the paper presented in Chapter 6.

7.3.1 Supportive workplace cultures are necessary for change

A key finding from the studies in Chapters 4 (234) and 6 (255), conducted with desk-based workers, was the perceived importance of the social environment for supporting attempts to reduce workplace sitting. In particular, social norms appeared to dictate the types of activities that were considered acceptable within the office environment. The feasibility of reducing prolonged workplace sitting time was therefore strongly related to whether breaks in sitting would be viewed within the scope of “normal” workplace behaviour.

In SUV, the collegiality provided by other participants was perceived to make it easier to sit less, and also contributed to cultural shifts in the acceptability of standing. Observing other co-workers using their sit-stand workstations was reported to be a useful visual prompt to stand up. Importantly, having multiple users of sit-stand workstations clustered together within a work

area facilitated a shift in organisational norms around standing and moving more. In contrast, changes in workplace culture were less apparent for those who were physically isolated from other participants and who lacked this social support (255). These findings align with other recent qualitative research which has reported that the social environment influences the extent to which workers feel comfortable using sit-stand workstations (197, 215).

In addition to support from peers, visible endorsement from management and team leaders, demonstrated through actions such as inviting standing in meetings, was also considered to be an important facilitator. This was described by one participant as providing the "permission" to stand. Similar findings have been reported in other studies from Australia (236) and Belgium (210). In the Belgian study, however, there appeared to be some discrepancy between employee and employer views regarding the need for senior level support. While employees believed that support from management, including role modelling of behaviour, would be an important step in making them feel comfortable making these changes, some employer representatives appeared surprised that this was necessary (210). This highlights the need for involvement of employees from all levels of an organisation when designing workplace sedentary behaviour interventions, as recommended by best practice workplace health frameworks (206, 256).

The importance of senior management support for strategies to reduce workplace sitting time did not come through as strongly in the original qualitative study reported in Chapter 4 (234). However, participants in these three organisations reported that their workplace cultures were already quite supportive of taking regular breaks, and thus it is possible that a sufficient baseline level of leadership support was already present.

In the initial stages of designing a program to reduce workplace sitting time, it may be helpful to conduct a scoping exercise to determine the level of organisational support for integrating more movement into the workday. This should include whether social norms around time away from one's desk, or movement more generally, are considered by workers to act as barriers to reducing their workplace sitting time. As has been demonstrated previously, the provision of sit-stand workstations or other physical environmental modifications may not be sufficient to facilitate sizeable behavioural change if not implemented within a supportive workplace culture (106). Organisational-level strategies that aim to foster acceptance of activity in the workplace should therefore be considered integral components of any broader sedentary behaviour intervention.

7.3.2 A whole of organisation approach may be more feasible and effective than targeted approaches

The studies in Part 1 of this thesis focused on individual-level factors, with the aim to identify population sub-groups that may be at higher risk of accumulating large amounts of workplace sitting time. When considering the cost implications of sit-stand workstations, an efficient approach for organisations may be to selectively provide these tools to workers based on some pre-specified criteria, such as additional health risk factors. The research in this thesis found that this approach is already often used in practice, with sit-stand workstations prioritised for those with medically-certified musculoskeletal conditions (234, 255). However, it is important to consider the limitations of a targeted workplace program focusing on high-risk individuals, relative to a universal approach that includes all workers (257).

As described earlier, the social environment appears to be either a key facilitator or a barrier to engagement with strategies to reduce workplace sitting time. With this in mind, targeted approaches to reducing workplace sitting—such as through selective provision of sit-stand workstations—may be unlikely to provide the same social support benefits that could be gained with a whole-of-organisation program. The findings from this research and others (197) suggest that an individual who is the only person in their team or work area with a sit-stand workstation may feel self-conscious using it, due to concerns about the impact on their colleagues (e.g. issues relating to audio or visual privacy) or social norms more generally. If an individual-based approach is to be considered, it is more likely to be successful in organisations where there is already a supportive social environment (258).

Another potential limitation of a selective approach is that it does not address the underlying causes of prolonged sitting time within organisations, such as the methods in which job tasks are performed. While there may be some workers for whom prolonged sitting poses a greater risk, due to additional health risk factors or health conditions, the overarching contextual factors leading to extended periods of sitting are likely to affect most, if not all, employees. As described in more detail in section 7.3.4 below, there is a need for economic evaluations of sedentary behaviour interventions to provide organisations with evidence for the cost-effectiveness of organisation-wide versus individually-focused approaches.

7.3.3 Workplace sedentary behaviour strategies should be tailored to local organisational needs and resources

From the original qualitative study presented in Chapter 4, it was apparent that there was diversity in the perceived feasibility of different strategies to reduce workplace sitting time (234). For this reason, "one size fits all" approaches to addressing workplace sedentary behaviour are unlikely to be effective. Similar to other workplace health promotion programs, strategies for addressing workplace sedentary behaviour should be tailored to meet local organisational needs and priorities (259).

Participatory approaches—where workers are involved in the process of designing interventions and programs—are advocated by the World Health Organization in their Healthy Workplace Model (206) and have been used for workplace ergonomic (260) and physical activity interventions (261). More recently, their application has been demonstrated in the development of workplace sedentary behaviour interventions (207, 213, 262, 263). Participatory approaches benefit from the use of local knowledge, ensuring that the strategies to be implemented are appropriate for the workplace and that workers are provided with a sense of ownership of the process (262, 264). Involving workers in the design of sedentary behaviour interventions from the beginning may assist to identify potential barriers that could impede intervention success (such as audio and visual privacy issues) and develop appropriate, localised solutions.

Despite general acceptability of the concept of sit-stand workstations, there was dissatisfaction raised by many SUV participants about features of the specific sit-stand workstation model used in the study, including the size and stability of the work surface. Similar concerns have been raised by participants in other research studies that have utilised the same, or associated models (197, 215-217). Although a participatory approach was used in SUV to select site-specific organisational-level strategies (207), workers were not consulted about the design of the workstation. As the findings reported in Chapter 6 suggest that the workstation design may have impacted on some participants' work performance, or affected their ability to use the desk to its full potential, organisations considering purchasing sit-stand workstations should ensure that affected workers are involved in the decision-making process about model selection.

Above all, approaches or interventions for addressing workplace sitting time will need to align with organisational resources. Although the largest reductions in workplace sitting time are achieved following environmental or multi-component workplace interventions (204), sit-stand workstations require an investment that may not be affordable for all businesses. This may particularly be an issue for small businesses and not for profit organisations, as reported in Chapter 4. Promisingly, there is emerging evidence that low-cost organisational strategies

provided in the absence of sit-stand workstations can also lead to significant reductions in workplace sitting time (205), although the magnitude of change has been smaller than those observed with multi-component approaches. This suggests that effective and feasible solutions for reducing workplace sitting time are available even for organisations that do not have the capacity to purchase sit-stand workstations for all employees. In recognition of the demand from employers for low-cost, evidence-based solutions for addressing workplace sitting, a freely available resource—the BeUpstanding Champion toolkit (265)—has recently been developed and pilot tested, and will be launched as a free, online resource in 2017. This evidence-informed toolkit aims to assist workplaces to develop localised, low-cost interventions using participatory approaches.

7.3.4 Conduct economic evaluations to provide organisations with the "business case for change"

As noted above, programs addressing workplace sedentary behaviour need to align with the available resources within an organisation. However, to date there has been little published evidence of whether the investment in strategies to reduce sitting time delivers productivity benefits to organisations through, for example, improved work performance, reduced absenteeism, or lower workplace injury rates. The potential benefits of workplace interventions have largely been inferred indirectly. Epidemiological observational studies have demonstrated that high levels of total sitting are associated with increased chronic disease risk (6, 7). High rates of chronic disease, in turn, have been shown to negatively affect productivity measures, such as presenteeism and absenteeism (266). However, the direct link between reducing workplace sitting time and productivity has not yet been adequately established.

A few studies have examined the perceived effects on workplace productivity associated with the provision of sit-stand workstations. Similar to the findings from the SUV qualitative component (Chapter 6), these studies suggest that workers do not perceive any significant negative effects on productivity with increased standing time (196-198, 215, 216). A recent study involving Australian call centre workers is one of the few to have used objectively assessed productivity measures (e.g. call handling time, absenteeism), finding no significant difference in these measures between participants with and without access to a sit-stand workstation (267). However, there has been no comprehensive economic evaluation conducted to date that outlines whether investment in sit-stand workstations, or other strategies for reducing sitting time, is offset or outweighed by benefits to employee health and well-being or productivity.

Managers in the original qualitative study in Chapter 4 spoke about the need for an evidence-based business case to support decisions to invest in workplace sedentary behaviour interventions. This was particularly relevant for strategies with inherent cost implications, such as sit-stand workstations. Larger scale and longer-term economic evaluations of workplace sedentary behaviour reduction interventions are required to provide the scientific evidence for the potential business benefits of addressing this issue. Impacts on worker health (including measures such as sick leave, injury rates or compensation claims) should be important components of these evaluations. The cost-effectiveness evaluation of the SUV intervention currently in progress will provide important insight in this regard.

7.3.5 Workplace sedentary behaviour should be addressed within organisational policies

An important step in demonstrating that addressing prolonged workplace sitting is an organisational priority is the explicit documentation of this in formal policies. Specific workplace policies around sedentary behaviour would demonstrate organisational (and senior management) commitment to addressing the issue, and provide employees with knowledge about employer expectations and the resources available to them. If sit-stand workstations are available to staff, policies should outline a clear and equitable process for obtaining these workstations and address issues relating to the design or choice of model, to ensure they are suitable for job tasks and ergonomic requirements (255).

Recently, there has been a push within Australia to recognise workplace sedentary behaviour as an occupational work health and safety issue and address it within these pre-existing frameworks. Specifically, it has been argued that high levels of sitting are not a “safe system of work”, due to the available evidence on the health effects of prolonged sitting, and the knowledge base around appropriate control measures to minimise risks to health (110). In 2016, Safe Work Australia, the Australian Government body responsible for developing policy relating to OHS and workers compensation, designated sedentary work as an “emergent work health and safety issue”, although in light of the existing evidence base stopped short of producing specific guidelines (111).

It is acknowledged that there is currently limited guidance available around appropriate or safe levels of workplace sitting time, presenting a challenge for organisations seeking to develop policy on workplace sedentary behaviour. A recent review was unable to identify a policy specifically addressing the issue of occupational sedentary behaviour from an Australian, or

international, ergonomics or OHS agency (237). In line with this, employer representatives in the first qualitative study (Chapter 4) expressed some uncertainty about whether the current evidence linking prolonged sitting with adverse health outcomes was sufficiently specific to recommend targets for sitting time or to justify investment of resources.

An international expert statement published in 2015 (136) provides some useful guidance for employers seeking to introduce policies for reducing workplace sitting time, including targets based on the available evidence at that time. However, there is clearly a need for formal guidance from local regulatory bodies about employers' obligations to address prolonged workplace sitting within their workforce, including specific recommendations for frequency and duration of breaks from sitting and appropriate control measures. Researchers should continue to work with policymakers and practitioners in the development of evidence-based guidelines around employer obligations for addressing workplace sedentary behaviour.

7.4 Conclusions

This Thesis aimed to examine correlates of workplace sitting time, using both self-report and objective measures; understand potential mechanisms for successful behaviour change; and understand the feasibility of reducing workplace sitting, including identifying factors that may facilitate or act as barriers to change.

Overall, the findings have added to the previously limited evidence base in this area and identified a broad range of factors that appear to influence workplace sitting time and the feasibility of reducing sitting in this setting. Specifically, this thesis has demonstrated the need to consider the role of individual-level, social and environmental factors in the design and implementation of workplace interventions; and for further research to particularly focus on examining potential correlates at each of these levels. Factors identified as perceived influences on behavioural change in qualitative research should be examined in larger quantitative studies, across diverse occupational sectors, to determine whether they are associated with objectively measured workplace sitting time.

These findings have practical implications through highlighting contextual factors to consider when implementing strategies to reduce workplace sitting time. A number of opportunities for further research have been identified to strengthen the breadth and depth of knowledge in this field.

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APPENDICES

Appendix A:	Peer-reviewed book chapter, Models for understanding sedentary behaviour, accepted for publication in the edited book, *Sedentary Behaviour Epidemiology* (Springer).
Appendix B:	Demographic and work sitting questionnaire (Chapter 4)
Appendix C:	Invited commentary published in *Research Quarterly for Exercise and Sport* (accepted manuscript).
Appendix D:	Essay published in the Public Health Association of Australia's monthly publication, *intouch* (1st prize, student essay writing competition).
Appendix E:	Thought piece included in the Global Chief Medical Officer Network report, *Health our business: Studies in behaviour change to improve the health of the world*.

APPENDIX A

Chapter 12
Models for Understanding Sedentary Behaviour

Nyssa T Hadgraft, David W Dunstan, Neville Owen

Abstract

With the recognition that prolonged periods of sitting can have adverse health consequences, a research priority is to build the requisite knowledge base for effective interventions – that is, what needs to be changed in order to change sitting time? To do so requires an understanding of the determinants of sedentary behaviours. Conceptual models can assist in developing this key element of the overall sedentary behaviour epidemiology research agenda. Sedentary behaviours can usefully be understood as inherently context-specific – taking place in domestic environments, during transportation, and in the workplace. Within this perspective, an ecological model emphasizes the role of 'behaviour settings' – context-specific environmental influences – as being of particular relevance. This chapter presents an approach informed by a Behavioural Epidemiology framework that draws on evidence about sedentary behaviour and health, and also policy contexts that influence sitting, to gain a greater understanding of the determinants of sedentary behaviour. To demonstrate how this approach may assist our understanding of sedentary behaviour in a particular setting, we apply the five principles of an ecological model to sitting in the workplace. We outline how this model can provide an environmentally-focused perspective and help to direct attention to multiple levels of influence on sedentary behaviour. A case study of an intervention trial addressing multiple levels of potential determinants of workplace sedentary behaviour is presented, emphasizing the importance of conceptually-informed and practically-grounded research to underpin approaches to sedentary behaviour change. We discuss some of the strengths and limitations of our approach and suggest opportunities for future research.

12.1 Introduction

As noted in previous chapters, research into all aspects of sedentary behaviour has increased considerably in recent years. As highlighted in Part II of this book, there is now a substantial body of sedentary behaviour epidemiology evidence linking high levels of sitting with increased risk of a number of chronic diseases, risk factors and premature mortality. Furthermore, evidence from experimental studies in laboratory settings has begun to confirm and elaborate upon the implications of this observational-study evidence (see Chapter 5 for further detail). These findings point to the need for intervention trials to identify the feasibility and benefits of changing sedentary behaviours (1-5).

As with research involving other health behaviours, conceptual frameworks – models and theories – can assist in explaining and predicting sedentary behaviour, and can provide strong guidance for developing interventions. With the rapidly strengthening evidence base on the adverse health outcomes associated with sedentary behaviours, greater attention now needs to be focused on understanding the factors that influence too much sitting – *the determinants of sedentary behaviours*. Specific knowledge of the antecedents of sedentary behaviours in the *contexts in which they take place* is crucial to the design and implementation of effective, evidence-based interventions. The application of theories and models to the study of sedentary behaviour is central to developing this stage of the research agenda.

To place the focus of this chapter in the perspective of sedentary behaviour epidemiology, Figure 12.1 outlines the *Behavioural Epidemiology framework* (6, 7). This framework proposes six main phases of research on sedentary behaviour, and their interrelationships. For example, understanding the important influences on particular sedentary behaviours (Phase IV) associated with adverse health outcomes (as identified within Phase I) will assist judgements about how difficult or how easy it may be to change them. Or, conducting real-world assessments of the impact of manipulating such influences through intervention trials (Phase V) can provide strong clues for possible research directions on the determinants of behaviour.

A key underpinning of the framework shown in Figure 12.1 is that all of these phases of research can inform and influence each other. In this chapter we will focus on the relevance of conceptual models and frameworks for informing research in Phases IV and V of the Behavioural Epidemiology framework, where the evidence base is more limited.

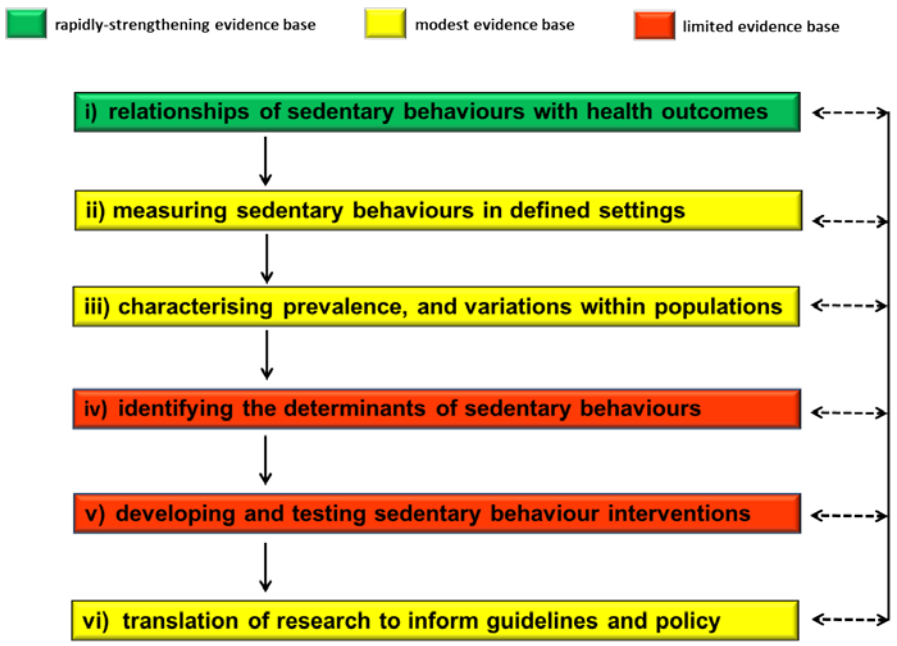

Figure 12.1: Behavioural Epidemiology perspective on understanding the determinants of sedentary behaviours

Research in phases I through to VI, as illustrated in Figure 12.1, may be thought of as a logical sequence of evidence building. However, considering the set of arrows on the right-hand side of the figure, this perspective on sedentary behaviour epidemiology research should not be taken to imply that each respective phase will require evidence from the preceding phases as essential building blocks. As evidence emerges on sedentary behaviour determinants and interventions (phases IV and V) for example, this may point to fruitful new research directions identifying health outcomes and relevant mechanisms (Phase I); or, as the policy context around sedentary behaviours is elaborated (Phase VI), research on determinants of sedentary behaviour (Phase IV) may require a different focus and novel opportunities for intervention trials (Phase V) may arise.

This chapter outlines a strategic perspective for research employing theories and models in the sedentary behaviour field. Specifically, we use particular illustrations of how conceptual frameworks can assist in progressing our understanding of the factors that can influence sitting, and can strengthen, in practical ways, the knowledge base underlying interventions. *This requires a conceptual perspective to capture the complexity of the determinants of sedentary behaviours across the key settings in which they occur.* We propose an ecological model of sedentary behaviour (8) as a framework for guiding future research studies. We employ this model throughout this chapter and demonstrate how it can be used to progress knowledge in the field.

Research in this relatively new and emerging field of sedentary behaviour epidemiology has been informed by theories and models used in physical activity research (9, 10). However, as we will discuss, there are unique characteristics of sedentary behaviour that suggest the need for a distinct, strategic approach to guide future research.

12.2 Novel strategies for understanding sedentary behaviour

Research into the determinants of sedentary behaviour can be seen as both related to, and distinct from, research on physical activity and exercise. For the purposes of this chapter, when we refer to 'physical activity' we are generally referring to activity performed at a moderate-to-vigorous intensity – activity that increases heart rate and is often performed as planned bouts, which would be inclusive of 'exercise'. While we make a clear and explicit distinction between physical inactivity (too little exercise) and sedentary behaviour (too much sitting), we understand that these are two distinct attributes that nevertheless may mutually influence each other, with synergistic health-related behavioural and biological impacts (11-14).

12.2.1 Physical activity and sedentary behaviour: some key differences

Interventions designed to increase physical activity or reduce sedentary behaviour have a common goal: to reduce the population-wide chronic disease burden associated with inactivity. Both approaches generally aim to encourage people to introduce more activity into their day; although the intensity of that activity is likely to differ. Sedentary behaviour interventions are designed to support people to shift some of their sitting time to light intensity activities, such as standing or slow walking, physical activity interventions tend to focus on encouraging participants to accumulate more moderate-to-vigorous physical activity.

While there are close links between physical activity and sedentary behaviour, there are key qualitative differences between the two behaviours that underpin the need for novel strategies to guide research in the emerging area of sedentary behaviour interventions. In this context, Biddle and Gorely (15, 16) provide an informative elaboration of some of the distinctions between the nature of the relevant behaviours and are the factors likely to determine these behaviours, moderate-to-vigorous physical activity and for two specific examples of sedentary behaviour:

- Moderate-to-vigorous physical activity: Low frequency and short duration, often taking place as a bout on one occasion (or fewer) each day. It requires both conscious planning and

moderate-to-high effort to carry out and is likely to be influenced by factors at multiple levels including individual-level goals and motivation, social support and a supportive physical environment.

- Domestic sedentary behaviour (television viewing and other screen time): Occurs in regular prolonged bouts, typically in the evening and on weekends for working adults. It can be of long duration, in bouts of 2 to 3 hours with infrequent breaks. It requires a low level of effort and little conscious planning. It is highly habitual and influenced by individual preferences, social norms and typically by the physical environment – including furniture arrangements – of the domestic lounge room.

- Occupational sedentary behaviour (workplace sitting): Takes place in regular prolonged bouts for office workers, typically occurring on weekdays. It is often of very long duration – 6-7 hours accumulated across a day with infrequent breaks. It requires minimal effort or conscious planning and is highly habitual. Key drivers include habit, social norms, job requirements (such as computers) and the workplace physical environment (in particular, available office furniture).

As noted above, there are some key differences in the attributes of moderate-to-vigorous physical activities and sedentary behaviours – particularly related to the frequency and duration of the two behaviours. Sitting is highly frequent and can occur in long bouts that may only be interrupted briefly for a short duration. In contrast, physical activities (specifically those of a moderate-to-vigorous nature) tend to occur at lower frequencies in relatively short, distinct bouts (e.g., 30 minutes to 1 hour). An active person may go to the gym for an hour, four times a week, but may do little physical activity outside of these sessions. Importantly, the influencing factors or drivers of these behaviours are likely to differ, including the relative importance of habit and individual motivation. Please also refer to Chapter 1.2 for further detail on the differences between sedentary behaviour and physical activity, and to Chapter 4 for further detail on the prevalence and correlates of sedentary behaviour.

Even the two examples of sedentary behaviour provided – TV viewing and workplace sitting – are likely to be influenced by different factors. Biddle and Gorely (15) suggest that this key difference in the level of conscious processing is likely to have implications for the application

of particular theories of behaviour to the study of sedentary behaviour. While approaches for physical activity have typically focused on the role of conscious decision making, individual-level theories for sedentary behaviour may need to have a greater focus on the importance of habit, or unconscious decision making.

As outlined above, physical activity and sedentary behaviour should not be treated simply as two sides of the same coin (17, 18); inactivity (low/insufficient levels of moderate-to-vigorous physical activity) is not the same as being sedentary (high levels of sitting). It is possible, for example, to be both highly sedentary and highly active (consider an office-worker who cycles to work and then sits at a computer for long, unbroken blocks of time). Recognising the distinct determinants of physical activity and sedentary behaviour is particularly important for understanding these behaviours and appropriately intervening (8, 15, 19). Influencing sedentary behaviour requires specific, targeted approaches based on the rapidly progressing research in this field, rather than just applying the approaches that have previously been found to be effective for understanding physical activity.

12.2.2 Identifying determinants of sedentary behaviour: a population-health perspective

The current sedentary behaviour epidemiology knowledge base provides indications of possible correlates (cross-sectional associations or predictors) of sedentary behaviour. Considerably less evidence exists on 'determinants' of sedentary behaviour (20) – a term implying a cause and effect relationship of one or more attributes with the probability or the extent of engagement, in a particular sedentary behaviour (21).

Of the correlates that have been identified, the most consistent evidence relates to individual-level factors, such as socio-demographics and health behaviour-related attributes (22). Please refer to Chapter 4 for further detail on the correlates of sedentary behaviour. Evidence for environmental correlates of sedentary behaviour is increasing, although this has largely been limited to exploring associations with the neighbourhood built environment (20) see Chapter 16 for more details). The relationship between interpersonal or social influences with sedentary behaviour is also less clear from existing quantitative studies. A recent review by O'Donoghue and colleagues (20) found that family-related factors, specifically household composition and the presence of children, appeared to be associated with sedentary time but found no evidence to support an association between social norms or social interactions with non-family members (e.g., colleagues, friends) with sedentary behaviour, although the number of studies reviewed was small.

Interestingly, findings from qualitative research provide some additional evidence to suggest that aspects of the socio-cultural and physical environmental may be important influences of behaviour. Interviews with office-based workers suggest, for example, that perceived social norms linking productivity with being at one's desk create a barrier to taking more regular breaks from sitting (23). In addition, office furniture that feasibly only allows computer-based work to be performed seated is likely to be a key factor influencing sedentary behaviour in office-based workers (24, 25).

Another example of informative qualitative evidence on social attributes is the study by Chastin and colleagues (26), who reported how social influences may play a significant role in influencing sedentary time for older adults. The older women interviewed for their study identified perceived societal expectations that older adults should sit frequently, combined with insufficient environmental features to accommodate brief pauses from sitting, as key factors influencing the amount of time they spent sitting. A further nuance is that older adults' sitting varies significantly across the day, likely reflecting the interactions of settings, social and physical health influences (27, 28).

While the above provide only snapshots of the existing evidence pertaining to social determinants of sedentary behaviour (which are addressed in more detail in Chapters 4, 13, 15 and 16) it highlights the need to broaden our thinking beyond individual-level factors and attempt to identify potentially modifiable environmental and social influences on sedentary behaviour. Conceptual models of the social and environmental determinants of sedentary behaviour can assist with this process, but need to incorporate such nuances and complexities, including the differences that may emerge across the wide range of different settings in which these behaviours take place (29, 30) and the interaction between different levels of influence (20, 31).

As we will illustrate in the following section with reference to Figure 12.2, there are challenges in taking an explicit social and environmental perspective on the determinants of sedentary behaviour. This reflects, in part, some of the roots of research in our relatively new sedentary behaviour field. Within physical activity research, individual-level theoretical models primarily have been employed in the design of interventions (6). For example, social-cognitive approaches include strategies to try and increase participants' self-efficacy for physical activity, such as using goal setting and feedback on performance to alter participants' belief in their capability to undertake physical activity (32).

However, strategies that only target factors influencing behaviour at the individual level, and fail to take account of the broader social and environmental context in which it occurs, will not be

sufficient to achieve changes that are of public health significance. In order to appropriately target such a prevalent and ubiquitous behaviour in a population health context, it will be necessary to incorporate an understanding of multiple levels of influences across different settings.

There are still a number of gaps in our understanding of the determinants of sedentary behaviour; the evidence for this phase of the Behavioural Epidemiology framework is comparatively less developed than the preceding phases (33). As an example, while a large body of research has focused on understanding attributes associated with TV viewing time or overall sitting time (15, 20, 22), less research has explored likely determinants of occupational sitting (despite the significant contribution of this setting to many adults' overall levels of sitting). Later chapters in this book will outline the current state of knowledge relating to correlates of sedentary behaviour at the individual level (Chapter 13), the community level (Chapter 15) and related to the social and physical environment (Chapter 16).

We suggest that the use of an ecological model for sedentary behaviour may assist to address some of these research gaps and improve our understanding of the underlying determinants. Understanding the determinants of sedentary behaviours across different settings is particularly important as the factors that influence the amount of sedentary time a person engages in and related health consequences may depend on the specific setting in which it takes place (34).

12.3 An Ecological Model of Health Behaviour

Ecologic models have been used to explore and address a number of different health behaviours, including physical activity, healthy eating and tobacco smoking (35). These ecological approaches largely arose after recognition that methods focused predominately on individual-level factors failed to achieve inroads in promoting healthy behaviours (35, 36).

Ecological models aim to recognise the complexity of health behaviours, acknowledging that there is unlikely to be a single cause and effect pathway. In line with approaches used to address some of these other health risk factors, the application of an ecological model to sedentary behaviour may also assist in guiding future research and identifying novel intervention targets across the multiple levels of influence.

A key distinction is that while individual-level models emphasize the role of person-level attributes (e.g. motivation, self-efficacy) that influence individual behavioural choices, ecologic models focus to a greater extent on individuals' interactions with their physical and sociocultural environments (37). According to this notion, the act of motivating or educating a person to

change their behaviour is expected to be limited if social and environmental conditions are not also supportive of this behaviour. However, while supportive environments are considered necessary for healthy behaviours, the idea that there are multiple levels of influence on behaviour means that altering the environment on its own may not be sufficient for behavioural change (38).

Ecological perspectives of health behaviour have five key principles that can be used to guide research and understand the precursors to behaviour (35):

1. There are multiple levels of influence on health behaviours
2. Environmental contexts are significant determinants of health behaviours
3. Influences on behaviours interact across levels
4. Ecological models should be behaviour-specific
5. Multi-level interventions should be most effective in changing behaviours

We provide examples to illustrate each of these points later in the chapter (*see 12.5.2*).

12.3.1 Applying an ecological model: multi-level approaches for understanding the determinants of sedentary behaviours

It has been noted previously that the choice of approaches for addressing health behaviour interventions tends to be influenced by disciplinary backgrounds of researchers rather than what may necessarily be the best approach (39). For example, psychological influences highlight the importance of individually-focussed solutions to addressing health behaviours, while a practitioner from an urban design background may emphasize the importance of environmental influences on behaviour (40). A disadvantage of this approach is that it has the tendency to lead to narrow, silo-type approaches to analysing problems and developing solutions (39).

Increasingly it is being recognised that behavioural health risk factors such as insufficient physical activity and excessive levels of sedentary behaviour are complex problems, requiring multi-faceted solutions. To address these issues we therefore require theoretical frameworks that can recognise and incorporate this complexity (41). We suggest that ecological models are better suited to this task when compared with individually-focused models and can provide the framework for developing appropriate interventions.

Importantly, ecological models have much in common with best-practice health promotion approaches. The Ottawa Charter for Health Promotion (42) emphasizes the importance of multi-

faceted approaches, suggesting that the ideal conditions for encouraging healthy behaviours include supportive environments and policies, and ensuring that individuals are educated, but also that they have sufficient resources to make healthy choices. The national preventive health framework in the United States launched in December 2010, *Healthy People 2020*, was influenced by ecological principles and outlines the importance of addressing the social and environmental determinants of health, in addition to individual level factors (43). In line with these approaches to preventive health and health promotion more generally, an ecological model may also be beneficial for guiding research and interventions into the new public health challenges posed by excessive sedentary behaviour, with ultimate translational relevance.

12.3.2 Ecological model principles compared to individual-level theories

Ecological models do not discount that individual-level characteristics, such as motivation or individual preferences, may influence sedentary behaviour. Social-cognitive theories formed the basis of many interventions that have aimed to encourage higher levels of physical activity in the population (35). The direct application of social-cognitive theories to sedentary behaviour is still somewhat limited (33). However, there is some evidence to suggest that dual-process theories may be helpful for understanding some of the cognitive influences on sedentary behaviour. Dual-process theories propose that we have two processing pathways – one, automatic and non-conscious, the other, controlled and reflective. As discussed earlier, it is highly probable that automatic, cue-driven processing plays an important role in sedentary behaviour, whereas physical activity, which occurs in less frequent bouts, may involve more controlled processing (15). Some studies have found evidence to support an association between habits and sedentary behaviour amongst university students (44) and older adults (45) where those with stronger habits reported spending more time sitting. Interestingly, the application of a form of controlled processing – having specific intentions to reduce sedentary behaviour – was associated with lower levels of sitting time in both samples (44, 45), suggesting a possible explanation for some of the variation in sedentary behaviour, and a pathway to explore within interventions.

However, a limitation of individual-level theories, including the dual-process model, is that their specificity does not account for the broader social and contextual attributes that can influence behaviour. While an ecological model does not discount the role of cognitive processes in influencing behaviour, it is considered that individual attributes are only one level of influence of sedentary behaviour and should not be considered in isolation from contextual factors that are also likely to be influential. From an ecological perspective, approaches centred on solely educating individuals about the health consequences of their behaviour and motivating them to

change are not expected to be sustainable in the long-term, unless combined with strategies targeting the broader environmental, social and policy context in which the behaviour occurs (35).

12.4 An Ecological Model of Sedentary Behaviour

An ecological model of sedentary behaviour identifies four domains – *leisure, household, transport* and *occupation* (8). The range of potential influences and their relative importance is considered to differ in each of these domains (8). This is based on a preceding ecological model of physical activity behaviour. Figure 12.2 depicts a simplified version of the main levels of influence that ecological models identify. This perspective directs research attention to broader potential influences on sedentary behaviours, beyond the more usual focus on individual level attributes that are addressed by psychological and social-cognitive theoretical models (33).

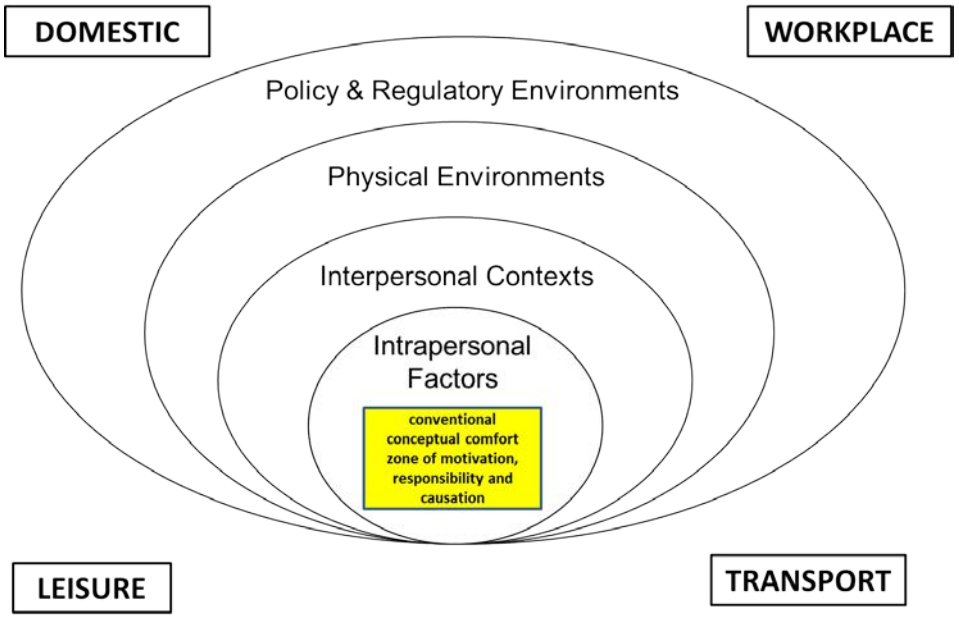

Figure 12.2: A simplified Ecological Model of Health Behaviour

As previously stated, a key underpinning of ecological models is the emphasis on environmental and social factors as important influences of behaviour. While the empirical evidence for environmental determinants of sedentary behaviour is still emerging (20), the habitual,

unconscious nature of many instances of sedentary behaviour leads to the hypothesis that particular cues in our environment acts as triggers for sitting. When one takes the time to think about what influences sitting throughout the day, this makes some intuitive sense. For example, are you sitting down right now while reading this book? If so, perhaps this is because you are at a desk – at home, in the library, or at your workplace – which is at a fixed height designed for use with a chair. Perhaps you are also sitting down because this is the behaviour demonstrated by others in your environment and social norms encourage you to emulate that behaviour. The social norms around what is "normal" or "acceptable" behaviour are likely to be important influences of when and where we sit, as they are with other behaviours.

12.4.1 The 'behaviour settings' construct within an ecological model of sedentarybehaviour

The potential utility of an ecological model for sedentary behaviour also arises from the importance that it places on 'behaviour settings' (46) – the physical and social context in which sedentary behaviour takes place. The complexity of understanding and influencing sedentary behaviour stems from the reality that sitting occurs in numerous contexts and a blanket approach targeting "sedentary behaviour" fails to take these nuances into account. Common examples of sedentary behaviours – such as watching television, driving a car and sitting at a desk at the workplace are each likely to have distinct determinants and require different approaches (8). The relative importance of each of these settings is also likely to differ across population groups. For working adults in sedentary jobs, intervening in the workplace setting may have the biggest impact on total daily sitting time (47). For retirees, the household setting is often where the largest proportion of sedentary time occurs and thus intervening in this setting may be most effective (48). For adults living in outer suburban areas, addressing time sitting in motor vehicles may be fruitful (31). Feasible strategies for reducing sitting are also likely to differ between settings. In the workplace, for example, activity-permissive workstations are becoming increasingly common (49), while in the home environment feasible strategies may include encouraging people to take more frequent breaks from sedentary leisure activities (such as standing up and moving during commercial breaks (50)). For further detail on sedentary behaviour interventions targeting different population subgroups and settings, please refer to Chapter 14.

Further empirical research is needed to test the principles of an ecologic model of sedentary behaviour as outlined above. Using the ecologic model as a guide, there are opportunities for novel research questions about the possible determinants of sedentary behaviour in each of the

common domains. This evidence will further our understanding of this highly prevalent health risk factor and provide an important knowledge base to inform settings-based interventions.

12.4.2 Environmental influences on sedentary behaviour

When thinking about environmental influences on behaviour these can include perceptions and objectively measured aspects of the built environment, the natural environment, and the sociocultural environment. There is a significant body of research linking aspects of the built environment, particularly population density and access to destinations, with walking (51, 52) and with cycling for transport (53). Following on from these findings there has been interest in whether similar associations of environmental attributes with sedentary behaviours can be found.

A recent review of the evidence linking neighbourhood environmental attributes with sedentary behaviours by Koohsari and colleagues (31) found somewhat mixed evidence. Less than 30% of instances examined were significantly associated in the expected direction (i.e., environmental attributes more-favourable to physical activity being associated with lower levels of sedentary behaviour). Many of the studies found no evidence for the expected associations. One possible explanation that was suggested was a lack of correspondence between the setting (neighbourhood environment) and the behaviours measured in the studies; the sedentary behaviour outcome was frequently an assessment of total sitting time accumulated across the day. In accordance with the ecological model, it would be expected that neighbourhood environment features would be most relevant to behaviour that occurs in that setting (i.e., the home) and would not necessarily influence behaviour in other settings, such as the workplace. The review recommended the need for improved measures of sedentary behaviour and environmental attributes (objective rather than self-report) and more prospective study designs. In addition, the limited understanding of possible interactions between environmental factors with other levels of influence on sedentary behaviour, such as socio-demographic characteristics, was also noted. The review also highlighted the need for studies to consider a distinct analytic approach for understanding the determinants of sedentary behaviour, rather than viewing it as simply a contrasting behaviour to physical activity.

The Koohsari review did not include studies assessing environmental features of internal environments such as the workplace or home environment. This is an important research gap as altering the indoor environment – such as through replacing traditional seated desks with height-adjustable desks – has become a key focus of many interventions to reduce sedentary time. An ecological approach may assist in identifying the specific, and potentially distinct, (indoor and

outdoor) environmental determinants of sedentary behaviour in key settings and thus provide a stronger underlying evidence base for this growing field.

12.4.3 Application of an Ecological Model in Sedentary Behaviour Research: The Workplace

To illustrate how the ecological model can assist to guide research and understanding of sedentary behaviour, we will use the workplace as an example. As will be discussed in further detail in Chapter 14.2, of the four key domains of sedentary behaviour (17) the workplace is of particular interest, largely due to the volumes of time that adults spend in the workplace and the increasingly sedentary nature of jobs.

The workplace as a sedentary behaviour setting

For those in office-based jobs, at least two-thirds of working hours can be spent sedentary (54-56). Thus, workplace sitting on its own contributes a significant proportion of total daily sitting time for many adults. Reducing the amount of time that people spend sitting at work may therefore have broad ranging effects on population levels of sedentary behaviour. Sedentary behaviour in the workplace may also be amenable to change, relative to sedentary behaviour occurring in other settings, as it occurs within a regulatory context where employers have legal responsibilities for the health and safety of their employees. Indeed, researchers in this field have called for sedentary behaviour to be considered explicitly as an occupational health and safety issue and treated accordingly within this framework (57).

The workplace has been used as a setting for implementing strategies targeting a range of health risk behaviours including physical activity, nutrition and tobacco control (9). Working adults spend a significant proportion of their waking hours at work and can be viewed as a captive audience for these messages (58). For employers, implementing health promotion programs in the workplace can make good business sense, with the potential for economic benefits arising from lower workplace injury rates, reduced absenteeism, and greater staff retention (59).

In workplace health promotion, ecological models are consistent with best practice guidelines. For example, the World Health Organization's Healthy Workplaces Model (60), identifies four areas to incorporate into strategies for improving workplace health: the *physical workplace environment*, the *psychosocial work environment*, *personal health resources* and *enterprise community involvement*. These four pillars emphasize the importance of considering the multi-level influences on health behaviour, in line with principles of an ecological model of health

behaviour. In Chapter 14.2, examples will be presented of how a sedentary behaviour program can address the keys to a healthy workplace outlined by this model.

Ecological model principles applied to occupational sedentary behaviour

The value of using an ecological model for thinking about the possible determinants of behaviour is that, from the outset, we are challenged to consider how multiple different levels of influence may be involved. Rather than just focus on the most conspicuous factors or those in a particular disciplinary area, an ecological model can encourage a broader, multidisciplinary perspective that can take into account factors that may not previously have been considered.

An ecological model also aligns with our understanding of the workplace as a complex social system (61). Sedentary behaviour, like other behaviours that occur in this setting, is likely to be influenced by a range of factors including individuals' health status and motivations, beliefs, social norms, social climate, environmental features, and organizational policies and procedures (61-63). To give an example of how an ecological model of sedentary behaviour can be applied, we will now step through the five principles of ecological models as they apply to the workplace. For illustrative purposes, we focus on office-based workplaces.

1. <u>There are multiple levels of influence on health behaviours</u>

Thinking about how much time we spend sitting at work, we can identify a range of factors that influence this behaviour. Many of us rely on computers to perform our work and the typical furniture set up to facilitate this work is a desk and chair. Thus, environmental influences are prominent. However, we can also consider individual-level factors. Some might enjoy sitting down and find this a more comfortable posture than standing. We may have health-related issues that are benefited by sitting. Social norms are also likely to be influential. Perceptions of expected behaviour in the workplace (e.g. that workers are not productive unless they are at their desk), or fear of not wanting to stand out by behaving differently (e.g. by getting up more frequently to stretch or move around the office) may also play a role (23, 24).

2. <u>Environmental contexts are significant determinants of health behaviours</u>

The environmental features of the workplace are likely to be important contributors to the amount of time spent sitting. As mentioned above, fixed height desks often limit workers' ability to stand or move throughout their work day. Furniture in meeting rooms and office kitchens is

often designed for sitting. Others aspects of the physical environment, such as the location of communal equipment (e.g., printers, bins, kitchens, bathrooms), can encourage or limit the opportunities that people have to move away from their sedentary desk work. The availability and accessibility of staircases as an alternative to lifts is another environmental factor influencing activity more generally.

3. Influences on behaviours interact across levels

As outlined, we can identify multiple different influences of sedentary behaviour in the workplace. There is also evidence to suggest that these factors are likely to interact across levels as specified by the ecological model. Studies that have explored barriers and enablers to using height-adjustable desks in the workplace provide some indication of this phenomenon. One study found that workplaces that simply provided staff with height-adjustable desks with minimal other instruction had lower use of these desks compared to a workplace that supplemented the desks with education and encouragement of their use (64). Similarly, interpersonal or social factors can interact with individual and environmental level factors to influence workplace sitting. Seeing others use their height-adjustable workstation can provide important social support that can encourage workers to stand up (65) – indicating an interaction between environmental and social influences. In contrast, negative interpersonal interactions (such as concerns about noise projection with standing) may also influence take up or use of workstations that facilitate standing (65).

4. Ecological models should be behaviour-specific

When thinking about how to address sedentary behaviour, it is important to consider the setting in which it takes place. In contrast to the relative privacy and freedom of the home environment, behaviour in the workplace is influenced by a range of social norms, organizational policies and expectations about behavioural conduct. For many, the degree of volition we have with our behaviour differs markedly. For these reasons the underlying models of behaviour underpinning strategies for addressing sedentary behaviour should differ between these two settings. This follows the underlying premise of ecological models – that they should be behaviour-specific. Even within the workplace setting there are different contexts in which sedentary behaviour occurs that should be considered when planning interventions. Some examples of sedentary behaviour that occur in a workplace include: sitting at a desk in front of a computer, sitting in a meeting and sitting in a kitchen/tea room during a break. Each can be explained by multiple

levels of influence; however the relative importance of each of these levels may differ according to the behavioural context.

5. Multi-level interventions should be most effective in changing behaviours

To date, few examples exist of workplace sedentary behaviour interventions that have been designed using an ecological framework. The majority of interventions in the published literature have focused attention on the discernible environmental influences by altering the physical workstations used by workers (66). As many of these studies have been short-term pilot studies, the long-term sustainability of this approach has not been clear. However, there are some more recent examples of intervention development that have taken a broader approach along the lines of an ecological model. These provide some evidence that multi-level interventions may be more effective than those that just focus on a singular level.

Case study: Stand Up Victoria

The Stand Up Victoria study is an example of a workplace intervention targeting sedentary behaviour that was developed using an ecologic model of sedentary behaviour as the guiding framework (67). The intervention involved an environmental component, but also targeted organizational and individual factors thought likely to influence sedentary behaviour (see Table 12.1). Within this ecological framework, social cognitive theory was also used to guide the development of the intervention (67, 68).

Table 12.1: A multi-level intervention designed to reduce and break up workplace sitting in office workers: *Stand Up Victoria*

Level of influence	**Strategies**
Individual	• Face-to-face and telephone health coaching, focusing on goal setting and providing support, behaviour change strategies, instruction/demonstration on workstation use.
Organizational	• Senior management and staff representative consultation

	• Participant brainstorming session to identify suitable strategies for that worksite • Leadership support and communication through tailored management emails
Environmental	• Sit-stand workstation

The design of the study involved an initial three-month intervention period (when the full multi-component intervention was applied), followed by a nine-month maintenance period. During the maintenance period participants in the intervention group retained their workstations, however the other intervention components ceased at three months (68).

In recent years, an increasing number of studies have been conducted assessing the effectiveness of various activity permissive workstations for reducing sitting. Generally, these have been shown to lead to reductions in sitting time (66, 69, 70). However, as will be discussed further in Chapters 13-17, there is some evidence to suggest that a multi-component approach targeting influences at the individual, organizational and environmental level may lead to greater reductions in sitting time when compared with the provision of a sit-stand workstation in isolation (49). This would support the premises of the ecological model; particularly the need to identify and target the multiple levels of influence on behaviour. Further research is needed to assess the relative importance and contribution of each of these different levels of influence in the context of sedentary behaviour interventions.

Stand Up Victoria provides an example of how an ecological model can be used to guide sedentary behaviour intervention development; in contrast to initial intervention trials in the field which tended to use single-focus and/or individually-oriented approaches (71). It is also important to note that within the ecological framework used to guide the *Stand Up Victoria* approach, strategies designed using a social-cognitive theoretical approach were able to be incorporated successfully within a broader strategy addressing aspects of organizational, social, and physical environments at work.

While the use of ecological models within sedentary behaviour interventions is still in development, this example provides emerging evidence to demonstrate how interventions at multiple levels (*Principle 5 above, arguably the strongest test of the utility of the ecological approach*) may be carried out in practice.

12.5 Limitations of Models and Theories from Behavioural and Social Science

Models and theories can assist us to make sense of behaviour and the world around us. For behaviours that pose a risk to health, theories can help to provide a framework for understanding their underlying causes and guide intervention development. Broader models can assist with identifying relationships between different factors and understanding the pathways through which these impact on behaviour. Understanding these interactions can aid in identifying the most appropriate and effective intervention targets within complex causative pathways.

However, there may be inherent limitations with the use of currently available models and theories of behavioural and social sciences in the context of understanding the determinants of sedentary behaviour. Many theories that have been used to describe health behaviours focus on individual-level influences, including education and awareness-raising, motivation, and other cognitive processes. When applied with a focus primarily at the individual-level, they often do not account for the other levels of influence – social, environmental or policy – which may also encompass relevant determinants of sedentary behaviour. For these reasons, the predominant social-cognitive models may provide a helpful, but only partial account of the range of relevant determinants. For practitioners involved in designing an intervention, it can also be difficult to identify which of the multitude of theories available in the literature would be most useful or relevant for the health behaviour of interest.

Additionally, it may be unclear as to how such theories can actually be translated from the research environment into programs that can be scaled up and applied in real-world settings. The overall outcome of interventions aimed at reducing sedentary behaviour should be to ultimately effect change on a population level. As such, it is important to consider the need for theories and models to be accessible so that they can also be up-scaled and usefully translated to broader scale interventions, not just applicable in smaller scale laboratory studies.

12.5.1 Limitations of ecological models

We have emphasized the potential utility of an ecological model for understanding and influencing sedentary behaviour. However, although we have outlined the strengths of such a model, there are limitations. A key principle of ecological models is that there are multiple levels of influence, all of which are deemed to be important (albeit varyingly so, depending on the setting, the person and other factors). It has been suggested that when these models have been applied in practice there has at times been an exclusive focus on environmental influences. This parallels criticisms of individual-level models – that they provide a narrow, incomplete account

of human behaviour (39). Multidisciplinary research partnerships that involve team members with broad expertise in interests and backgrounds may foster research that is more true to a fundamental principle of ecological models: addressing multiple levels of influence and their interactions.

Another limitation is that the application of models identifying multiple levels of influence is that they can be difficult to design, evaluate and measure, due to their complexity. Public health programs designed with an ecological framework in mind may feature large scale environmental and policy changes that occur in natural, uncontrolled settings. What is delivered in practice often will be out of the hands of researchers and like many public health interventions, will not be amenable to evaluations using controlled experimental methods. This poses challenges for evaluating the effectiveness of intervening on multiple levels and unpicking which components of which levels of the intervention are most effective. Nevertheless, this reflects the real-world complexity of the strategies likely to be necessary in order to make significant progress in addressing large scale and complex public health issues

From a researcher's perspective, the use of an ecological model presents challenges as multilevel studies are complex and demanding. Teams from a broad range of disciplines are likely to be needed to provide the expertise on the different levels of influence and assist with measurement and analysis of these components. However, this could also be viewed as a positive step. It is increasingly recognised that the public health challenges we face are multi-faceted and will not be successfully addressed by applying a narrow mind-set that focuses all attention on individual choice. By encouraging the framing of these issues through an ecological model there is the opportunity to encourage researchers and practitioners from different backgrounds to collaborate, share perspectives and break down research silos. New insights and perspectives on approaching a particular challenging problem may arise from the opportunity to knowledge share across disciplinary areas.

A further limitation is that ecological models do not specify the processes through which different variables interact to influence behaviour. Unlike individual-level theories of the determinants of health behaviours, which specify within a formal framework the interrelationships between variables and how these are thought to determine behaviour, an ecological model does not provide this level of specificity. Sallis and Owen (35) propose that this is a key issue to keep in mind when applying ecological models; they should be viewed as guiding frameworks, rather than as explanatory theories. Instead of being a formal theoretical model, a key feature of ecological frameworks is that they can incorporate specific individual-level, more-formally articulated theories into a broader framework.

Recognising some of the limitations of ecological models, there has been a broad collaborative project to develop a systems-based approach to understanding the multiple levels of determinants of sedentary behaviour and how they may interact (72). This approach specifically aims to address the limitation that ecological models do not specify the connections between different levels of influences. Following a consensus process, some recommendations for priority research areas have been suggested. While this model has only recently been proposed, it will be highly informative to see its use in future research.

12.6 An Ecological Model of Sedentary Behaviour: Research Opportunities

There is still more to be done to further our understanding of the most effective ways to influence and reduce sedentary behaviour. From the ecological model and associated principles we have outlined in this chapter, we propose eleven research questions to be addressed:

1. What are the broader and more-generalizable social, environmental and policy level determinants of sedentary behaviour?
2. What specific social, environmental and policy level determinants are influential for the key ‘behaviour settings’ - the home environment, transportation and the workplace/school?
3. Are there cultural or national level variations in the relative importance of individual, social, environmental and policy influences on sedentary behaviour?
4. How do environmental determinants of sedentary behaviour interact with other more well-studied levels of influence on health behaviours, such as personal characteristics and social influences?
5. Do environmental factors have differential strengths of influence on sedentary behaviours in some population groups compared with others? (For example, across different age groups; among those from different socioeconomic status backgrounds)
6. What is the feasibility of multi-level interventions in different settings – from design, implementation and evaluation perspectives?
7. Do interventions that target multiple levels of influence result in more sustainable changes than those that target single, or fewer, levels of influence?
8. What are the key sociocultural determinants of sedentary behaviour and how do these factors influence intervention effectiveness and sustainability?

9. What are the essential (and non-essential) components of multi-level sedentary behaviour interventions in the workplace that can achieve sustainable behavioural change?
10. What are the features of exemplar organizations (workplaces, schools etc.) that have been successfully in reducing sedentary behaviour?
11. How best to assess the quality and comprehensiveness of studies that report using an ecological framework?

12.7 Summary

An ecological model of sedentary behaviour can provide strong guidance in understanding how the determinants of sedentary behaviours in particular settings may be better understood and influenced. This evidence, in turn, can influence the development of interventions and strategies to address sedentary behaviour through a focus on improving health outcomes, in line with the six phases of the Behavioural Epidemiology framework (Figure 12.1). While individual-level attributes that may be addressed with conceptual and methodological rigour using social-cognitive theories remain important, the field of sedentary behaviour epidemiology will advance in ways more relevant to improving health outcomes if its research strategy proceeds using a broader multidisciplinary, ecologic perspective. Workplace sitting provides a case in point for how an ecological model can help to broaden our understanding of a key health risk behaviour and its determinants in a particular behaviour setting. The example presented provides a perspective on how interventions may be developed, drawing upon a model that takes into account the multiple levels of influence on health behaviours. Taking forward a rigorous and relevant research agenda within the framework of an ecological model of sedentary behaviour is challenging, but there are many new and potentially fruitful directions for research.

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APPENDIX B

ID: ☐-☐☐☐

Demographics & work information:

Gender: Female ☐ Male ☐ **Age:** ☐

Job title: ☐

What is your full time equivalent (FTE) at this workplace? ☐

Note: Each full working day per week = 0.2 FTE. For example, if you typically work 5 days per week then your FTE is 1.0.

How long have you been in your current workplace?

☐ Less than 1 year ☐ 1–2 years ☐ 3–4 years ☐ 5-9 years ☐ 10 years or more

Do you manage other staff?

☐ Yes ☐ No

Workplace sitting questions

These questions are designed to find out more about how much time you spend sitting at work.

1. How many hours did you work in the last 7 days? _______________ hours

2. During the last 7 days, how many days were you at work? ______________ days

3. How would you describe your typical work day in the last 7 days? (This involves only your work day, and does not include travel to and from work, or what you did in your leisure time)

Example:
Jane is an administrative officer. Her work day involves working on the computer at her desk, answering the phone, filing documents, photocopying, and some walking around the office.
Jane would describe a typical work day in the last 7 days like this:

Sitting (including driving)	90 %
Standing	5 %
Walking	5 %
Heavy labour or physically demanding tasks	0 %
Total	100%

Your workday:

a. Sitting (including driving)	____%
b. Standing	____%
c. Walking	____%
d. Heavy labour or physically demanding tasks	____%
Total	____%

Make sure this adds up to 100%

Thank you for completing this questionnaire

APPENDIX C

Hadgraft N, Owen N. Sedentary behavior and health: Broadening the knowledge base and strengthening the science. Res Q Exerc Sport. 2017;88:123-129. (Accepted manuscript)

***Sedentary Behavior and Health*:**

Broadening the Knowledge Base and Strengthening the Science

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Abstract

We provide an overview of a recently published, edited book in a rapidly emerging field of research, policy, and practice for physical activity: *Sedentary Behavior and Health*. In this commentary, we highlight the broad perspectives provided in the 27 chapters of *Sedentary Behavior and Health* and suggest a research strategy to move the field forward – not only with scientific rigor, but also with breadth of scholarship. The book's chapters provide an overview of the background to and contexts for sedentary behavior and health. They then highlight the importance of understanding health consequences and underlying mechanisms; introduce key measurement technology and analytic strategies; consider sedentary behavior in subpopulations; describe conceptual models and theories to guide sedentary behavior interventions; and, explain what is known about interventions in different settings. Considering the breadth of perspectives brought to bear on the field and the plethora of opportunities for research, policy, and practice, we suggest three elements of an interdisciplinary research strategy drawing upon the primary knowledge bases of physical activity and health – through the experimental methods of exercise science, through the observational tools of epidemiology, and through the conceptual approaches and methods of behavioral science. A better understanding of the health consequences of sedentary behavior and how they may be influenced can be encompassed by three key questions: What changes will be needed to most effectively influence sedentary behaviors? What elements of sedentary behavior should be changed to improve health outcomes? What are the feasibility of, and the benefits from, changing sedentary behavior?

KEY WORDS: sitting; inactivity physiology; environmental determinants; intervention

In developed countries, and in the rapidly urbanizing populations of developing countries, prolonged periods of time spent sitting are now ubiquitous in the workplace, in commuting, and during leisure time. Many adults have long commutes to their workplace in cars, spend their working hours in front of computers, and then end their day with long periods of television viewing or other screen time. Children and youth are increasingly exposed to extended periods of time spent in front of screens and sitting in cars, and are required to sit for much of their school day. Sitting has become the default behavioral option – inextricably embedded in work, school, transport and leisure.

Exercising and moderate-vigorous activity remain the mainstays of physical activity research and practice for disease prevention and health promotion. However, a new perspective on physical activity and health has emerged: sedentary behavior (or prolonged sitting) has been identified as a health risk in addition to physical inactivity or insufficient exercise. Over the past 15 years, there has been an accumulation of evidence relating to the health consequences of sedentary behavior, with many of the initial findings summarised in the Bergin (2011) edited volume. Cross-sectional and prospective epidemiological studies have revealed associations between sitting time (generally measured as total sitting time or TV viewing time) with a number of serious cardiometabolic diseases (Biswas et al., 2015; de Rezende, Rodrigues Lopes, Rey-Lopez, Matsudo, & Luiz Odo, 2014)—and risk biomarkers (Brocklebank, Falconer, Page, Perry, & Cooper, 2015). With this knowledge, there is now increasing interest in the development of interventions to reduce sitting time, targeting specific population groups within settings such as the workplace (Neuhaus, Eakin, et al., 2014) and the school environment (Minges et al., 2016).

There are emerging implications for research, policy and practice from the sedentary behavior field and many questions still to be answered. *Sedentary Behavior and Health* (Zhu & Owen, 2017), resulting from the conference of the same title at the University of Illinois at Urbana-Champaign in October 2015, provides an overview of the current state of knowledge and points to some of the broader social, economic and environmental questions about sedentary behavior that now need to be addressed. The 27 chapters in *Sedentary Behavior and Health* provide a broad-based account of the field, including the historical and scientific background; evidence on sedentary behavior and key health outcomes; issues pertaining to measuring and analyzing sedentary behavior; issues relating to sedentary behavior in different subpopulations; and, approaches to changing sedentary behavior.

First, we provide a commentary on the material covered and key issues that have been canvassed within the main sections of *Sedentary Behavior and Health*. Second, we propose three key research questions that embody a strategy for how the science of sedentary behavior can be

progressed and strengthened in the context of physical activity and health as an interdisciplinary research field.

Broadening the Knowledge Base for Sedentary Behavior

Background and Context for Sedentary Behavior and Health

Understanding the 'sources of sitting' is helpful, if changes to reduce the health impacts of too much sitting are to be pursued. For example, the chair plays a central role in promoting sedentary behavior, but our interactions with chairs have changed over time. Increasingly there has been a focus on designing more ergonomic chairs to encourage sitting, rather than considering whether our reliance on chairs is optimal (Cranz, 2017); understanding the history of the chair from a sociological perspective provides insights into how to intervene to reduce sitting time. Other important contextual factors to consider in relation to sedentary behavior are the increasingly reliance on screens (phones, tablets, computers) for everyday tasks and the role of the car as the default form of transportation. Large amounts of screen use now begin in early childhood and are generally considered unavoidable in modern life. Car time is also a significant source of sedentary behavior for many, and has been associated with cardiometabolic risk biomarkers (Sugiyama et al., 2016).

Sedentary Behavior: Health Consequences and Underlying Mechanisms

As noted earlier, the accumulating prospective epidemiological evidence suggests that high levels of sitting time are associated with premature mortality and cardio-metabolic chronic disease incidence, including increased risk of developing type 2 diabetes, cardiovascular disease and colorectal, endometrial and lung cancer (Biswas et al., 2015; de Rezende et al., 2014; Lynch & Friedenreich, 2017). As well as being a determinant of aspects of metabolic health, there is also emerging evidence on sedentary behavior and lower back pain (Boscolo & Zhu, 2017), mental health (Biddle & Bandelow, 2017) and cognitive function (Falck, Davis, & Liu-Ambrose, 2016).

When considering the underlying mechanisms through which sedentary behavior may influence health outcomes, laboratory trials can provide useful insight to support findings from epidemiological studies. For example, studies conducted through the United States and international space programs have demonstrated the biological consequences of prolonged bed rest and time spent in zero gravity, which may be informative for the study of sedentary behavior and health (Bergouignan, Rudwill, Simon, & Blanc, 2011). Although extreme, prolonged sitting

may share some physiological similarities with bed rest, including low levels of energy expenditure.

Laboratory experimental studies of sedentary behavior are also starting to examine models of typical daily activity and assess the impact on markers of cardiometabolic health. Such studies have begun to identify how adverse health consequences may be remediated through interrupting sitting time – particularly through improvements in the control of blood glucose and insulin (Dempsey, Larsen et al., 2016; Dunstan et al., 2012).

While many epidemiological studies assessing associations between sedentary behavior and health outcomes have controlled for physical activity (albeit to varying degrees) (Biswas et al., 2015), there is emerging evidence to suggest that high levels of physical activity may moderate this association, at least with mortality (Ekelund et al., 2016).

Measuring and Analyzing Sedentary Behavior

To fully understand the relationship between sedentary behavior and health, it is crucial to have high quality and accurate measures of the exposure – the amount and pattern of sitting accrued across the day. Much of the evidence linking sedentary behavior with health outcomes has arisen from studies using questionnaire-based methods. These self-report methodologies are feasible for use in large scale population-based studies and are useful for characterizing the purpose, location and context of behaviors (Troiano, Gabriel, Welk, Owen, & Sternfeld, 2012). Currently used activity monitors, such as the activPAL device, are considered to provide more accurate measures of sitting time and patterns of sitting than self-report, however, they still must be supplemented with self-reported diaries or logs to provide contextual information (Edwardson et al., 2016).

Encouragingly, there continue to be innovations in measurement techniques for physical activity and sedentary behavior. The sensitivity, battery life and storage capacities of small, wearable devices continue to improve and now provide numerous opportunities for innovative research to characterize sedentary behavior. Combining commonly used motion sensors (e.g., accelerometers) with physiological sensors (e.g., to measure heart rate or oxygen uptake) has also been suggested as a method to improve the accuracy of sedentary behavior measurement (Bassett & John, 2017).

The challenge with all “objective” measures of activity is to determine the appropriate methods for processing the data into a useable form for analysis. The development of new psychometric tools for sedentary behavior research is crucial.

Sedentary Behavior and Sub-populations

To design effective policies and programs for reducing the health impacts of too much sitting, there is the need to better understand variations in sedentary behaviors within and between populations, including potential differences in correlates and health outcomes.

For example, the predominant settings in which sedentary behavior occurs often differ between children, working adults and older adults. Similarly, the correlates (or influencing factors) may also be subtly different. While the workplace is a key target setting for adults working in sedentary jobs (such as office workers), this will be less relevant for those in manual occupations, or for adults who are not participating in the labor force – such as stay at home parents, retirees, or people who are unemployed. Addressing sedentary behavior amongst children and adolescents will require approaches that differ from those used for adults.

It is also important to consider the impacts of sedentary behavior on health for different population groups. For example, high levels of sitting time may have particular health consequences for older adults (Dogra & Stathokostas, 2012; Gianoudis, Bailey, & Daly, 2015), or persons with illness or chronic diseases (Ellingson, Shields, Stegner, & Cook; Lynch, Cerin, Owen, Hawkes, & Aitken, 2011). Although not conclusive, some studies have observed gender differences in the extent to which sitting time is associated with health outcomes (Bertrais et al., 2005; Healy, Dunstan, Salmon, Shaw, et al., 2008). Socio-economic factors and locality may also be associated with variations in sedentary time and health consequences. For example, whether someone lives in an urban or rural setting, or suburban versus inner urban is likely to influence access to services and neighborhood amenities. The potential influence of built environment characteristics on sedentary behavior requires further investigation (Koohsari et al., 2015).

Changing Sedentary Behaviors

Psychological and behavior-based interventions from the physical activity field, including social-cognitive and ecological models have relevance for changing sedentary behavior. There is also the need to consider broader community-based interventions to influence sedentary behavior. Environment and policy interventions have considerable potential. The evidence on worksite interventions to change sedentary behavior shows that relatively simple innovations such as the availability of sit-to-stand workstations can significantly reduce sedentary time at work, particularly if supported by organizational policies and procedures (Healy et al., 2016).

There is considerable potential for the use of new technologies (e.g., apps delivered on smart phones and tablets) as intervention tools to change sedentary behaviors, particularly if they can be informed by theories of behavioral change. The field of sedentary behavior interventions is still at an early stage – much remains to be developed and tested before strong evidence-based claims can be made about behavioral change.

Strengthening the Science of Sedentary Behavior and Health

The book *Sedentary Behavior and Health* (as described above) provides much of the relevant background for understanding this developing field and introduces several new areas for research. For the purposes of taking a research strategy forward, it is useful to consider this field from the point of view of the interdisciplinary underpinnings of the field – exercise science, epidemiology and behavioral science. With this as the frame, we now propose three broad questions as guides for research strategy:

- What changes will be needed to most effectively influence sedentary behaviors?
- What elements of sedentary behavior should be changed to improve health outcomes?
- What is the feasibility of, and the benefits from, changing sedentary behavior?

What Changes Will Be Needed to Most Effectively Influence Sedentary Behaviors?

Understanding the determinants of sedentary behavior is an important step in designing effective interventions. There are still large gaps in our knowledge about the individual, social and environmental factors that influence sedentary behavior. Research has at times bypassed this phase and progressed to designing interventions without specific evidence identifying factors that may be most beneficial to target to bring about reductions in sitting.

A recent systematic review (O'Donoghue et al., 2016) identified that the knowledge base relating to the correlates of sedentary behavior; i.e., factors shown to be associated cross-sectionally with sitting, has progressed markedly since the previous review on the topic (Rhodes, Mark, & Temmel, 2012). However, few studies have used prospective datasets to identify predictors or determinants of sedentary behavior, limiting inferences about causality. In addition, the strongest evidence relating to the correlates of sedentary behavior still relates to individual-factors, such as demographic attributes or socio-economic factors, which largely are non-modifiable.

A priority for research into the correlates and determinants of sedentary behavior should be examining potentially modifiable social and environmental factors associated with high levels of sitting. Qualitative studies have provided insight into what some of these factors may be. For example, in the workplace context, social norms and the workplace culture dictate acceptable behavior for that particular setting, which often involves large amounts of sitting (Gilson, Burton, van Uffelen, & Brown, 2011; Hadgraft et al., 2016). The workplace environment also promotes sitting through furniture designed to be used in this posture (Owen et al., 2011). Similarly, older adults have reported a strong social influence that encourages sitting, with family members and social activities encouraging this behavior, and a physical environment that often does not support non-sedentary activities (Chastin, Fitzpatrick, Andrews, & DiCroce, 2014).

As noted previously, intervention trials in the workplace have demonstrated that environmental changes, such as the introduction of activity-permissive workstations can be an effective measure for reducing workplace sitting (Alkhajah et al., 2012; Chu et al., 2016; Neuhaus, Eakin et al., 2014). However, an environmental modification in isolation is unlikely to be sufficient to modify behavior. In line with an ecological model of sedentary behavior (Owen et al., 2011), multi-component interventions that target individual factors and the broader organizational context appear to be more successful than those that solely address environmental factors (Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014). In addition, there can be large individual variation in the amount of sitting time change that occurs (Healy et al., 2016) suggesting the moderating role of other factors that may impact on intervention effectiveness.

What Elements of Sedentary Behavior Should Be Changed to Improve Health outcomes?

Progressing the sedentary behavior and health research agenda requires cross-talk between epidemiological and human-experimental evidence, to clarify relevant mechanisms and the changes in sedentary behavior that will be most beneficial. Epidemiological studies that have assessed associations between sitting time and health outcomes have been able to provide some evidence of the amount or volume of sitting that may be detrimental to health (Ekelund et al., 2016; van der Ploeg, Chey, Korda, Banks, & Bauman, 2012). With the use of objective measures in large data sets such as NHANES, there is also epidemiological evidence to indicate that the way that sedentary behavior is accumulated (i.e., the amount of time spent in periods of prolonged sitting) can also influence cardiometabolic risk (Healy, Dunstan, Salmon, Cerin et al., 2008; Healy, Matthews, Dunstan, Winkler, & Owen, 2011).

Controlled human experimental studies that have manipulated the frequency at which breaks are accumulated, and the activity that is performed during these breaks, have been able to provide useful insights into the duration, intensity and frequency of activity that may be required to provide health benefits (Dunstan et al., 2012; Peddie et al., 2013). In addition to primary prevention of chronic disease, reducing sedentary time is also likely to be of benefit for managing existing chronic diseases. A recent experimental trial has demonstrated that regularly breaking up sitting time with light intensity activities (walking or simple resistance exercises) can have beneficial effects on glycemic control and blood pressure for adults with type 2 diabetes (Dempsey, Larsen, et al., 2016; Dempsey, Sacre, et al., 2016). These experimental findings provide the proof of concept evidence that can be used to inform larger intervention trials in specific populations. This will facilitate examination of whether patterns of behavior involving regular breaks in sitting time are feasible in "real world" settings, as outlined in the following section.

Developing cross-talk between epidemiological studies and human experimental evidence will be important for furthering our understanding of which elements of sedentary behavior need to be changed to have the greatest benefit on health. Some of the questions still to be addressed include: are regular breaks from sitting sufficient to offset the negative health effects associated with high volumes of sitting? Are breaks from sitting more effective when they take place at particular time points throughout the day (for example, soon after meals)? What are the optimal patterns of activity throughout the day for the prevention and management of chronic disease?

Improving understanding of the mechanisms through which sedentary behavior leads to adverse health outcomes will be helpful in answering these questions. It is also important to further our understanding of the potential moderating effect of physical activity on the link between sedentary behavior and health outcomes.

Prospective epidemiological studies continue to provide important insights into associations between volumes of sedentary behavior and disease incidence, enabling modelling of the population health risks associated with high levels of sitting. Complementary evidence from well-controlled experimental studies (e.g., crossover randomized controlled trials) can largely eliminate the effects of confounding that affect observational studies and provide more specific evidence on the dose and frequency of activity required for health benefits. This can provide insight into the specific mechanisms through which sitting may be detrimental to health which can, in turn, inform recommendations for the ideal combination of behaviors from across the activity spectrum throughout the day.

What is the Feasibility of, and the Benefits from, Changing Sedentary Behavior?

A priority for the sedentary behavior and health research field is to conduct intervention trials and to evaluate 'natural experiments' on changing sedentary behavior: in workplaces, schools and neighborhood environments. Human experimental trials can provide high quality evidence of associations between sedentary behavior patterns and health outcomes through the controlled measure of both exposure and outcome, as described in the previous section. Assessing whether these behavioral conditions are feasible in the real world is an essential step in translating this research to practice.

The evidence for the effectiveness of interventions targeting sedentary behavior has grown rapidly in recent years. The workplace, in particular, has become a key target setting for reducing sedentary behavior (Shrestha et al., 2016), however, interventions within schools (Minges et al., 2016) are also increasing. These studies suggest that it is feasible to reduce sedentary behavior in the short-term through targeted interventions. However, whether this translates to improved health outcomes is generally unclear (Martin et al., 2015). Few sedentary behavior intervention studies conducted to date have incorporated medium or long-term follow up periods, which limits understanding of whether such behavioral change is feasible and sustainable beyond the initial intervention period. Higher quality intervention trials, with sufficient controls and adequate sample sizes to detect changes in outcomes, are required to determine the types of interventions and behavior change techniques that will have the largest impact on health outcomes.

For the interventions that have demonstrated effectiveness at reducing sitting time in the general population, there is also a need to specifically assess their feasibility, acceptability and effectiveness within populations with chronic diseases. Experimental studies suggest that reducing and breaking up sedentary behavior may have a greater positive impact on those with risk factors or pre-existing conditions, compared with those who are generally healthy (Dempsey, Owen, Yates, Kingwell, & Dunstan, 2016). An evaluation of whether these controlled findings can translate to a real-world setting, such as through a workplace intervention, and whether there are subsequent benefits for disease management, would be informative.

Assessing the impact of natural experiments will also be important for evaluating the ecological validity of intervention strategies. A small number of evaluations have occurred of activity permissive workplaces, where physical environment modifications have occurred to promote movement around the workplace (Foley, Engelen, Gale, Bauman, & Mackey, 2016; Gorman et al., 2013). While effects on changing sedentary behavior have generally been

minimal to modest, longer-term evaluations of behavior change (i.e., greater than 12 months) will be particularly important for assessing whether there are potential health or productivity benefits from these environments.

Conclusions

The field of sedentary behavior and health has only recently begun to consolidate, and there has been considerable progress in understanding the health consequences of sedentary behavior. There nevertheless remain many novel and interesting directions to progress the science and inform a broader understanding of this emerging health risk. We have suggested a focused research strategy for the field, addressing central research issues such as: what needs to change to facilitate changes in sedentary behavior, how feasible and acceptable these changes are likely to be for different population groups and the patterning of activity across the day that will be most beneficial for health outcomes. Improving knowledge in these key areas will be highly informative for the development of clinical and public health guidelines, new programs and policy initiatives.

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PHAA Essay Writing Competition Winner: Nyssa Hadgraft

Targeting sedentary work environments for chronic disease prevention

Nyssa Hadgraft, PhD candidate, Monash University and Baker IDI Heart and Diabetes Institute

The conditions in which we live, work and age—the social determinants of health (Wilkinson & Marmot, 2003)—are strong contributors to health inequities in chronic disease. For many adults, the workplace environment has a significant impact on their overall physical, social and emotional health and well-being. It is becoming increasing apparent that our modern, sedentary work environments may be contributing to the increasing burden of chronic disease in our community. As such, a public health focus on reducing prolonged sitting and increasing workplace activity could lead to significant health gains in the working population.

PHAA CEO Michael Moore presenting the first prize to Nyssa Hadgraft at the Conference Dinner.

The changing nature of work

Over the past several decades, developed countries such as Australia have seen a declining manufacturing sector, and a rise in service-related jobs and computer-based work (Australian Bureau of Statistics, 2012; Straker & Mathiassen, 2009). The implications of these economic and technological shifts are fewer jobs that are physically demanding and a greater proportion that are largely sedentary (Church et al., 2011). While our modern workplaces are safer in many other aspects – through control or elimination of hazards that previously resulted in serious injury or death (Coggon, 2005) – these sedentary work environments may be a ticking time bomb for chronic disease.

High levels of sitting – a risk factor for chronic disease

There is accumulating evidence to suggest that high volumes of sedentary behaviour (or sitting) are associated with increased risk of chronic diseases, such as type 2 diabetes and cardiovascular disease; certain cancers; and premature mortality (Biswas et al., 2015; Lynch, 2010; Thorp, Owen, Neuhaus, & Dunstan, 2011). Sedentary behaviour is distinct from physical inactivity – high levels of sitting can pose a risk to health even amongst those who meet guidelines for recommended levels of moderate-vigorous physical activity (Owen, Healy, Matthews, & Dunstan, 2010). Overall, it has been estimated that 5.9% of deaths may be attributable to sedentary behaviour, a similar estimate to that attributed to physical inactivity (Chau et al., 2013).

Population-level surveillance data indicates that many adults spend upwards of seven hours sitting per day (Bennie et al., 2015; Matthews et al., 2008); a level at which the risk of premature mortality appears to significantly increase (Chau et al., 2013). As the majority of this sitting time may be accumulated during work (Bennie et al., 2015), there is a potential to reduce chronic disease risk in a significant proportion of the population by facilitating more activity-conducive working environments.

Addressing occupational sedentary behaviour

The Public Health Association of Australia's Physical Activity Policy (2014) notes that "It is important to make physical activity choices convenient, easier, safer and more enjoyable so that they can be incorporated into people's everyday activities". Many workplaces now offer opportunities for staff to be physically active; for example, by providing facilities for active transport or offering group fitness classes. While physical activity is also important for reducing chronic disease risk, a small amount of activity at lunchtime may not be sufficient to completely counteract the detrimental effects of excessive levels of sitting (Biswas et al., 2015). There is also a concern that structured workplace physical activity programs may not reach the target audiences, instead attracting those who already meet recommended levels of physical activity (Macniven, Engelen, Kacen, & Bauman, 2015).

Keeping with the aim to make physical activity choices "convenient, easier, safer and more enjoyable", a public health approach should consider how our workplace social and physical environments can be altered to make it easier for everyone to incorporate more activity throughout the workday. Organisational policies and cultures that support more dynamic work practices and lead to changes in social norms will be integral to achieving this goal.

To reduce health inequities in chronic disease, targeted health promotion efforts may also be warranted for those with multiple health risk factors. A lack of control over working conditions is an important determinant of health (Wilkinson & Marmot, 2003). Workers with limited control over the timing and frequency of sitting breaks, such as in call centres or the transport industry, may particularly benefit from interventions to reduce workplace sedentary behaviour. (Thorp et al., 2012).

Managing chronic disease

Reducing sedentary behaviour is not only important for primary prevention of chronic disease, but may also have implications for disease management. For example, regularly interrupting sitting has been shown to have beneficial effects on cardio-metabolic biomarkers, include blood glucose, triclycerides and blood pressure (Brocklebank, Falconer, Page, Perry, & Cooper, 2015; Dunstan et al., 2012; Larsen et al., 2014). Therefore, as non-communicable disease burden increases, addressing occupational sitting may also be an important strategy in the secondary and tertiary prevention of chronic conditions, such as type 2 diabetes and cardiovascular disease (Dempsey, Owen, Biddle, & Dunstan, 2014).

A public health approach to addressing sedentary work environments

Public health campaigns to tackle chronic disease are likely to be more successful if they involve a collaborative, multi-sectoral approach (World Health Organization, 1986). Addressing the sedentary nature of modern work environments will also require a partnership approach that moves beyond individual workers and their workplaces. Possible stakeholders could include occupational health and safety practitioners, ergonomists, urban planners, health promotion practitioners and primary health care providers. This interdisciplinary approach could lead to creative ways of thinking of the nature of work and the conditions in which it is performed in the modern economy. Representative bodies such as the Public Health Association of Australia can play an important role in advocating for healthy public policy in occupational health, and the promotion of activity-permissive environments (PHAA, 2014).

With the potential to reach a large proportion of the population, the workplace should be considered a priority setting for addressing risk factors for chronic disease, including our sedentary work environments. Comprehensive public health approaches that aim to modify the physical and social workplace environments encouraging sedentary behaviour will be important for achieving impacts at the population level. Integrating more movement across the working day could be a feasible goal for most workers and, if sustainable, could have a measurable impact on the incidence and management of chronic disease.

Nyssa Hadgraft accepting her prize at the Conference Dinner

Creating dynamic workplaces: a pathway to healthier workers and productive businesses

by David Dunstan, Genevieve Healy, Nyssa Hadgraft and Duncan Young

Prolonged sitting – a modern workplace health hazard

With increasing computerisation of job tasks (and longer work hours), it comes as little surprise that sitting now predominates our working lives. As awareness grows about the harmful health effects of too much sitting, it is becoming more and more apparent that the modern workplace environment may be a ticking time bomb for workplace illness and injury. Strategies for reducing sitting time are needed if we want to reduce the risk for future chronic diseases.

Rather than focus on structured workplace physical activity programmes, we contend that a more achievable, and potentially more sustainable, step to getting workers more active is to embed more movement and less sitting throughout the day via the creation of dynamic working environments.

Organisations that emerge as leaders in dynamic working environments could even promote themselves as employers of choice to attract the best and brightest talent

What do we mean by dynamic working environments?

Dynamic (or activity permissive) working environments are those that encourage more movement, more often. Shifting thinking away from the idea that the productive worker must be chained to their desk, dynamic workplaces facilitate and support opportunities to be active throughout the day, including frequent transitions between sitting, standing and walking. Consistent evidence indicates that these frequent postural shifts are beneficial for both heart and musculoskeletal health. In addition to reducing sitting time and promoting improved health, dynamic workplaces have further potential to improve communication and collaboration between co-workers, increase energy levels and reduce fatigue. Dynamic workplaces could therefore boost productivity within workplaces in two interrelated ways – by improving worker health and safety and encouraging greater collaboration and engagement.

A dynamic workplace is not just about creating a physical environment that facilitates movement, but also shaping a workplace culture that supports it. Organisational "buy-in" is thus critical for the promotion and support of these spaces.

How to promote dynamic working environments

Environmental-based strategies aimed at encouraging employees to sit less and move more are more likely to be effective on a larger-scale than individual-focused, educational interventions. Long term change requires habit modification through a multi-interventional approach and social norms to embed these new behaviours. Modifications to the workplace physical environment, coupled with a supportive culture for change, should therefore be integral components of a healthy workplace strategy.

Height-adjustable workstations (allowing movement from sitting to standing) are becoming increasingly popular and have been shown to lead to reductions of over two hours in workplace sitting time when part of a multi-component approach. However, modifications to desks are only one option – there are many low cost and easily administered strategies that can also be pursued. For example, walking meetings have been shown to increase divergent thinking outcomes, while standing meetings are often shorter with no detrimental productivity effect. Rethinking how the working day is scheduled could also facilitate more light to moderate physical activity.

Cleverly designed spaces that encourage increased movement, combined with supportive organisational policies and cultures, can use behavioural insights and nudge workers towards healthier behaviours. By integrating dynamic working strategies into the everyday environment, the aim is for moving more to be the default option, rather than a conscious behavioural decision. These subtle changes reinforce the 'social norm'; the more people who are displaying positive new habits, the more likely other people will also try them.

A move to this new way of working will depend on engagement and participation by all levels of an organisation. If workers cannot envisage the benefits of modifying existing work practices, success rates will be low. Additionally, while leadership in health does not always begin at the top, senior leadership support and alignment with company values is critical. A whole-of-organisation approach that integrates dynamic work practices within existing health and safety, human resources and change management frameworks, will increase the potential for sustainability.

Evaluating change using supportive technology

Wrist-worn activity tracking devices have become an increasingly popular way for tracking physical activity levels through the day. These devices, and other types of supportive technology, could also be used to monitor the effectiveness of dynamic work environments.

Supportive technology (including activity trackers and apps) can help workers gain an awareness of their own behaviour (eg. monitoring sitting time throughout the day) but also could be useful for evaluating and tracking activity behaviour at an organisational level. Increasingly, organisational performance in employee health and well-being is being incorporated into Key Performance Indicators (KPIs). In line with this, the Global CMO Network could drive the inclusion of reporting on employee activity levels, such as sitting time, into regular reporting to boards and potentially, to external networks.

Effective use of supportive technologies in combination with social media provides opportunities to share learnings and achievements on implementing dynamic workplaces. Organisations that emerge as leaders in dynamic working environments could even promote themselves as employers of choice to attract the best and brightest talent.

How the Global CMO Network can take the lead

The Global CMO Network is uniquely placed to take a leadership role in advocating dynamic workplaces. The network can facilitate resource and knowledge sharing, including solutions to common barriers to change. The network can also foster links with organisations with expertise in behavioural change, such as health promotion organisations, universities and research institutes. In addition, as global leaders, the network could use their influence to put this issue on the international agenda.

Similar to initiatives such as the Global Corporate Challenge, the Global CMO Network could initiate the Sit Less, Move More Global Challenge, encouraging teams around the world to set goals to reduce their daily sitting time. Supportive technologies could be used to measure behaviour, and motivate employees to achieve set goals. At an organisational level, benchmarking against other companies can provide the healthy competition needed to sustain commitment to initiatives.

Overall, dynamic activity permissive work spaces have the potential to reduce chronic disease risk, encourage greater collaboration and lead to productivity gains. As an emerging area of occupational health, the Global CMO Network can be forefront in setting the dynamic workplace agenda.

Professor David Dunstan

David Dunstan is an NHMRC Senior Research Fellow and the Head of the Physical Activity laboratory within the Division of Metabolism and Obesity at the Baker IDI Heart and Diabetes Institute. He is an Adjunct Professor in the School of Sports Science, Exercise and Health at The University of WA, an Adjunct Associate Professor in the School of Population Health at the University of Queensland, an Adjunct Associate Professor the School of Exercise and Nutrition Sciences at Deakin University and an Adjunct Senior Lecturer in the Department of Epidemiology and Preventive Medicine at Monash University.

David's research focuses on the role of physical activity and sedentary behaviour in the prevention and management of chronic diseases and he is the author of 130 peer-reviewed papers. His research outcomes have been recognised extensively in the international/national media, as indicated by more than 350 media features in 2013, including interviews for substantial featured print articles (The Economist, New Scientist, Wall St J, NY Times) and television (60 minutes, Catalyst).

Dr Genevieve Healy

Genevieve Healy is a Senior Research Fellow at the School of Public Health at the University of Queensland. Her research focuses on understanding how much we sit and how this influences our health, as well as the feasibility and acceptability of reducing this behaviour in key settings, including the office workplace. Her work has influenced policy and guidelines regarding the importance of reducing prolonged sitting time, and has been featured in >1200 online, print or broadcast media articles.

Dr Healy co-leads the Stand Up Australia program of research: a program which aims to investigate the benefits of reducing prolonged sitting time in the workplace, and includes multiple industry and government partner organisations. The quality of her work has been recognized by over 20 awards, including the 2014 Research Australia Griffith University Discovery Award, and the 2012 Scopus Young Researcher of the Year (Medicine and Medical Sciences).