SEDENTARY WORK
EVIDENCE ON AN EMERGENT WORK HEALTH AND SAFETY ISSUE

Report

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Executive summary

Sedentary behaviours are characterised as low energy expenditure behaviours that occur in a sitting or reclining position while awake. Common sedentary behaviours include watching television, sitting working on a computer, or driving a vehicle. Notably, a worker can be physically active (meeting the physical activity guidelines of at least 2.5 to 5 hours of moderate intensity or “huff and puff” physical activity per week), and still spend much of their time being sedentary.

Sedentary behaviour is common in Australia and is linked with an increased risk of premature mortality, chronic health disorders and detrimental work outcomes. Moreover, with the rapid advances in technology and the changes in the environment in the last few decades, the proportion of time spent sitting is likely increasing across the transport, leisure, domestic and occupational domains.

Occupational sitting is common among workers, with 81% of Australian workers reporting some exposure and one half of workers reporting sitting often or all of the time at work. Exposure to occupational sitting occurs across different industries and skill levels. While occupational exposure can account for half of the total sitting exposure for workers, there is no clear definition of *excessive* occupational sitting exposure.

A range of initiatives have been proposed to reduce occupational sitting exposure, including those focussed on the design of safe work systems via the work environment (physical and psychosocial), work tasks, work tools and the individual worker. Multi-component interventions targeting multiple elements of work systems appear to have been most successful. To date, assessment of occupational exposure and workplace interventions to reduce sitting have largely been focussed on office work environments, with limited evidence for exposure or interventions in non-office environments.

The increasing public awareness, along with a rapidly growing evidence base on health impacts and interventions, the widespread exposure of Australian workers and growing advice from various authorities suggest it is time to consider the growing hazard of excessive occupational sitting.

Key messages covered in this report

- Occupational sitting exposure is common, probably increasing, and contributes a large proportion of overall sedentary exposure for many workers.
- Excessive sitting is consistently associated with markers of poor health, however evidence for occupational sitting is less clear.
- Early evidence suggests occupational interventions targeting sitting reduction can substantially reduce occupational sitting, at least in office workplaces.
- A rapidly growing evidence base, increasing public awareness, widespread exposure and growing advice from various authorities suggest it is time to consider addressing the growing hazard of occupational sitting.

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1. Background and rationale

Safe Work Australia has identified excessive occupational sedentary behaviour – or too much sitting - as a potential workplace health and safety issue based on: a rapidly growing body of scientific evidence on the potential harms; increasing public awareness of these harms; a high proportion of workers with exposure to sitting; recent recognition by various national and international authorities of sedentary behaviour as a health concern; and emerging evidence of effective and feasible risk controls.

1.1 Growing body of evidence

Within the scientific community, research on sedentary behaviour has rapidly gained prominence over the last 10 years. Prior to 2005 there were few publications each year on sedentary behaviour and the nature of the risks associated with excessive sedentary behaviour. However there has since been an exponential increase, with a five-fold increase in the number of scientific publications in the last decade (Figure 1, upper panel). In contrast to the rapid rise in publications on sedentary behaviour, the publication rate for other traditionally important work safety and health issues (such as occupational lifting) has been relatively stable over the last decade (Figure 1, lower panel).

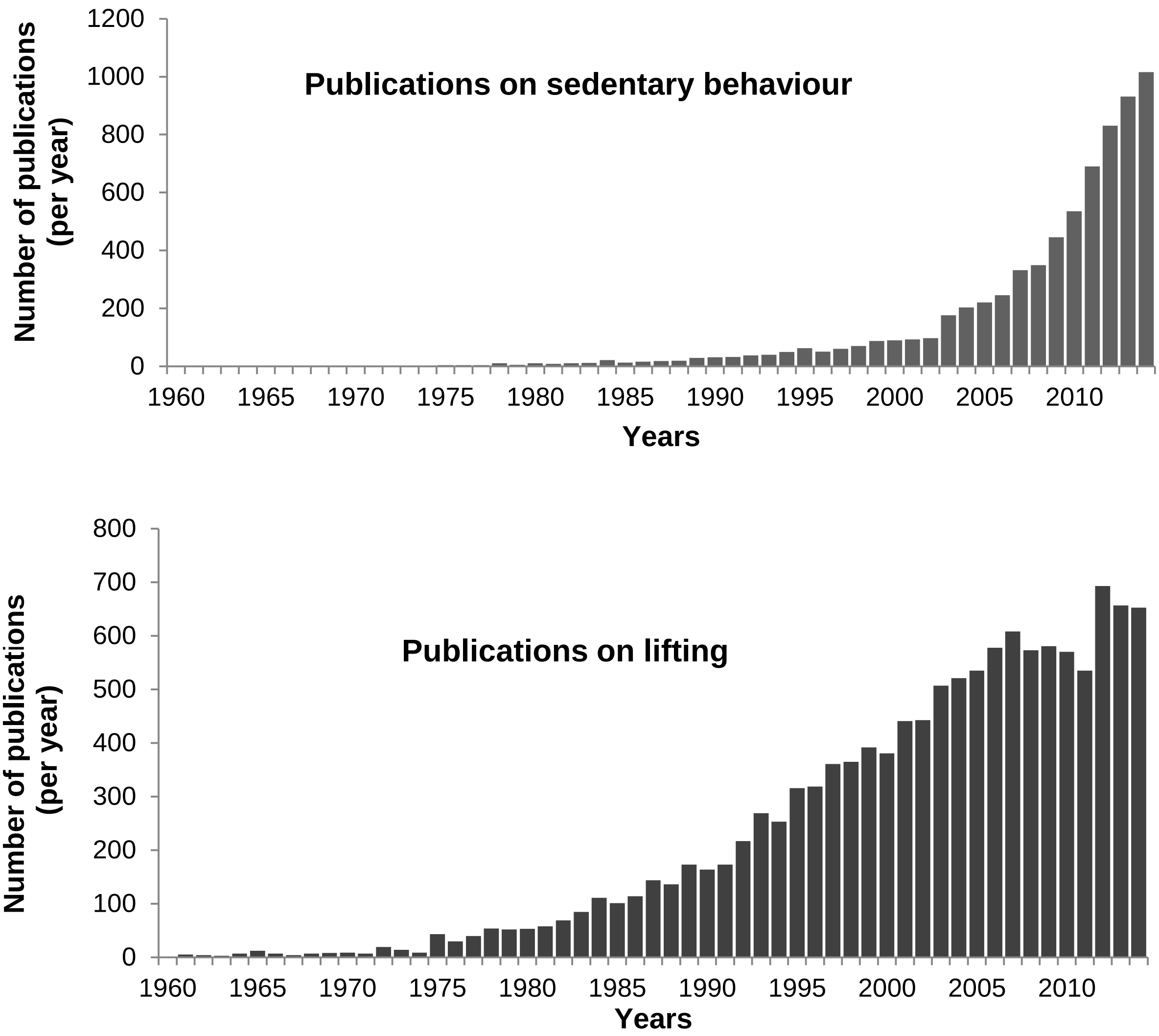

Figure 1. Scientific publications on 'sedentary behaviour' (upper panel) and 'lifting' (lower panel) per year sourced from PubMed.

1.2 Increasing public awareness

The research findings on the potential health risks arising from excessive sedentary behaviour ('too much sitting') have been widely promulgated in the Australian community via mass media. For example, recent media headlines have stated that: *'sitting for long periods hurts our health'* (The Australian, 6 Feb 2015) and *'sitting down raises cancer risk no matter how much exercise'* (Sydney Morning Herald, June 17, 2014). Consequently there appears to be heightened community awareness that sedentary behaviour is a substantial hazard for several health issues including cardio-vascular disorders, cancer and even premature mortality.

There have also been mass media stories about the potential hazards of excessive *occupational* sitting, for example, *'The panic about sitting down at work'* (SBS news, 23 September 2014). The Australian community therefore appears to have been introduced to salient messages related to the emerging scientific evidence that occupational sitting is a potential health issue that needs to be addressed.

1.3 High proportion of workers with exposure

Available evidence suggests that many Australians sit for considerable amounts of time each day. Furthermore many Australian workers also have a high exposure to sitting at their workplace. For example, data from the Australian Health Study (Australian Bureau of Statistics, 2013a) showed that adults report on average 39 hours per week being sedentary, with about 10 of these hours spent sitting at work. A recent study by Safe Work Australia found that 81% of Australian workers reported at least some amount of sitting at work (Safe Work Australia, 2011c). Further, use of objective measures of sitting have shown that 'white' collar[1] office workers spend around three-quarters of their working hours sedentary (Healy et al., 2013; Parry & Straker, 2013; A.A. Thorp et al., 2012). Many 'blue' collar non-office workers also accrue considerable amounts of sitting time at work (Pontt, Rowlands, & Dollman, 2015; Wong, Gilson, Bush, & Brown, 2014).

1.4 Recent recognition by health authorities

Reflecting this new understanding of the potential health implications of too much sitting, governments and professional bodies – including in Australia – are updating physical activity guidelines to include explicit recommendations to minimize prolonged sitting time. For example, the American College of Sports Medicine advises to reduce overall sedentary time (Garber et al., 2011). In Australia, the Department of Health recently released its first statement regarding sedentary behaviour, advising Australian adults to '*minimise the amount of time spent in prolonged sitting*' and to '*break up long periods of sitting*' as often as possible (Australian Government - Department of Health, 2014).

Regarding occupational sedentary behaviour in particular, a forecast report by the European Agency for Safety and Health at Work identified occupational sitting as one of the 'top' emerging risks among workers (European Agency for Safety and Health at Work, 2005). In Australia, the National Heart Foundation produced a consumer advice resource advising and supporting adults to reduce the total amount of sitting per day and notes the workplace as a key environment that can contribute to achieving reductions (National Heart Foundation, 2011). Australian government physical activity guidelines do not provide specific thresholds for *excessive* sedentary behaviour in general nor excessive occupational sedentary exposure, however they do acknowledge the importance of occupational exposure by providing specific strategies that could be used to reduce occupational exposure: for example "Walk to deliver a message rather than emailing or making a phone call" and "Organize walking meetings" (Australian Government - Department of Health, 2014).

1.5 Emerging evidence of effective and feasible controls

Recently a number of trials have demonstrated that interventions targeting organisational physical and cultural environment, tools/equipment/furniture and individual worker factors are feasible and acceptable to implement in office workplaces and can lead to substantial reductions in occupational sedentary exposure (G.N. Healy et al., 2012; Neuhaus, Eakin, et al., 2014; Shrestha, Ijaz, Kukkonen-Harjula, Kumar, & Nwankwo, 2015; Tew, Posso, Arundel, & McDaid, 2015; Torbeyns, Bailey, Bos, & Meeusen, 2014). Evidence on interventions to reduce occupational sedentary exposure of 'blue' collar workers is currently very limited,

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[1] 'white' and 'blue' collar terms will be used in this report although they have limitations – as discussed in section 5

though early reports suggest it is also possible to substantially reduce exposure for these workers (N. D. Gilson, Pavey, et al., 2015).

1.6 Aims

Given the rapid growth in scientific evidence and changes in community awareness regarding the hazards of too much sitting, the likely common and high-volume exposure of working Australians and the recognition of the issue by national and international health authorities, occupational sitting has been nominated by Safe Work Australia as an emerging work health and safety issue. Safe Work Australia has therefore requested this research project to evaluate existing evidence, create new evidence and provide background reports to assist Safe Work Australia in determining a suitable policy response.

The aim of this report is to provide a concise expert summary on this hazard, the likely consequences and the potential control options.

2. Scope and definitions

2.1 Scope

This report on emerging work health and safety issues regarding occupational sitting in both 'blue' and 'white' collar occupations provides key information on:

- Definitions of fundamental sedentary behaviour concepts.
- Exposure to sedentary behaviour in general.
- Exposure to occupational sitting.
- Outcomes associated with overall sedentary behaviour.
- Outcomes associated with occupational sitting.
- What is excessive sitting.
- Potential mechanisms for harm from occupational sitting.
- Key aims to minimise harm from occupational sitting.
- Potential substitutes for occupational sitting.
- Potential interruptions or breaks2 from occupational sitting.
- Effectiveness of interventions to reduce occupational sitting.

In a supplementary report, information on the following issues is provided:

- Overview of Australian legal and policy setting.
- Overview of policy from national and international jurisdictions specifically relevant to 'blue' and 'white' collar occupational sitting.
- Potential policy implications regarding both 'blue' and 'white' collar occupational sitting.

The following sections describe definitions of key constructs around sedentary behaviour. This includes a description of the following: sedentary behaviour (as opposed to 'physical inactivity'), domains and context of sedentary behaviour, occupational sitting, models of risk control and measurement of sedentary behaviour.

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[2] There is no consensus on exactly what constitutes a break. See sections 8, 10, and 12 for further discussion.

2.2 Sedentary behaviour

The term 'sedentary' originates from the Latin word *sedere* 'to sit'. To minimise confusion in the literature, in 2012 a group of international researchers developed a consensus definition[3]. 'Sedentary behaviour' was defined as *"any waking behaviour characterized by an energy expenditure ≤1.5 METs[4] while in a sitting or reclining posture"* (Sedentary Behaviour Research Network, 2012).

Sedentary behaviour thus refers to a distinct class of behaviours with two characteristics:

a) performed while sitting or reclining, and

b) low energy expenditure.

These two aspects of the definition for sedentary behaviour are important. Standing, which typically would be ≤1.5 METs, is *not* a sedentary behaviour as it occurs in the upright position. Similarly, bicycling is *not* a sedentary behaviour as it usually occurs at a higher intensity, despite being undertaken in a seated position. Sedentary behaviour does not include sleep.

Sedentary behaviour is conceptually different 'physical inactivity', which is defined as "performing insufficient amounts of moderate- to vigorous-intensity physical activity (i.e., not meeting specified physical activity guidelines)" (Sedentary Behaviour Research Network, 2012). Moderate- or vigorous-intensity physical activity (MVPA) is defined as ≥3 to <6 METs for moderate- and ≥6 METs for vigorous-intensity activity. An example of a moderate intensity activity is brisk walking; an example of a vigorous intensity activity is running. Sedentary behaviour and MVPA are therefore at the ends of a spectrum of activity behaviour based on intensity. Light activity is in between the two, composing the >1.5 to <3 METs band (Figure 2). A broad range of behaviours fall within this band: one example of a light intensity activity is slow walking.

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[3] Authors of this report are members of the network and more details about the network can be found at http://www.sedentarybehaviour.org/.

[4] Metabolic equivalent of task (MET) is the energy expended for an activity - defined as a ratio of the energy expended during quiet sitting (stated as oxygen used per kilogram of body weight per minute: 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$).

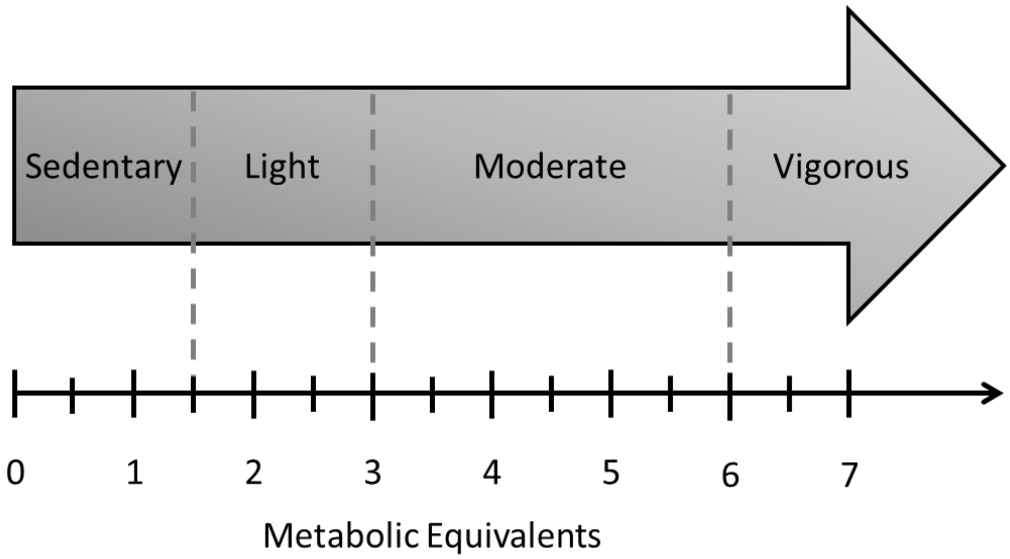

Figure 2. Comprehensive spectrum of activity behaviour from sedentary (~1 metabolic equivalents) through to vigorous (6 or more times energy of just sitting and resting).

There is a large body of research that has shown that MVPA is an effective primary and secondary prevention tool for numerous health outcomes (Haskell et al., 2007; Warburton, Katzmarzyk, Rhodes, & Shephard, 2007). As a result of this knowledge, health guidelines have traditionally targeted recommending people achieve sufficient levels of MVPA. Australian guidelines on physical activity recommend 2.5 to 5 hours of moderate intensity physical activity per week (Australian Government - Department of Health, 2014), which is roughly 30 to 60 minutes per day.

Considering that adults are often awake for 16 hours in a day, meeting these physical activity guidelines would mean that there are still up to 15.5 hours left to spend on alternative activities each day.

Notably, it is possible for a person to be both physically active (i.e. meet the MVPA guidelines) *and* be highly sedentary (i.e. spend much of their day sitting), as shown in the upper panel of Figure 3. This individual went for a 30 minute run in the morning, but was mainly sedentary for the rest of the day. The individual whose activity is shown in the lower panel was ‘inactive’ (i.e. they did *not* meet the MVPA guidelines) but was also not overly sedentary (i.e. they sat very little throughout the day).

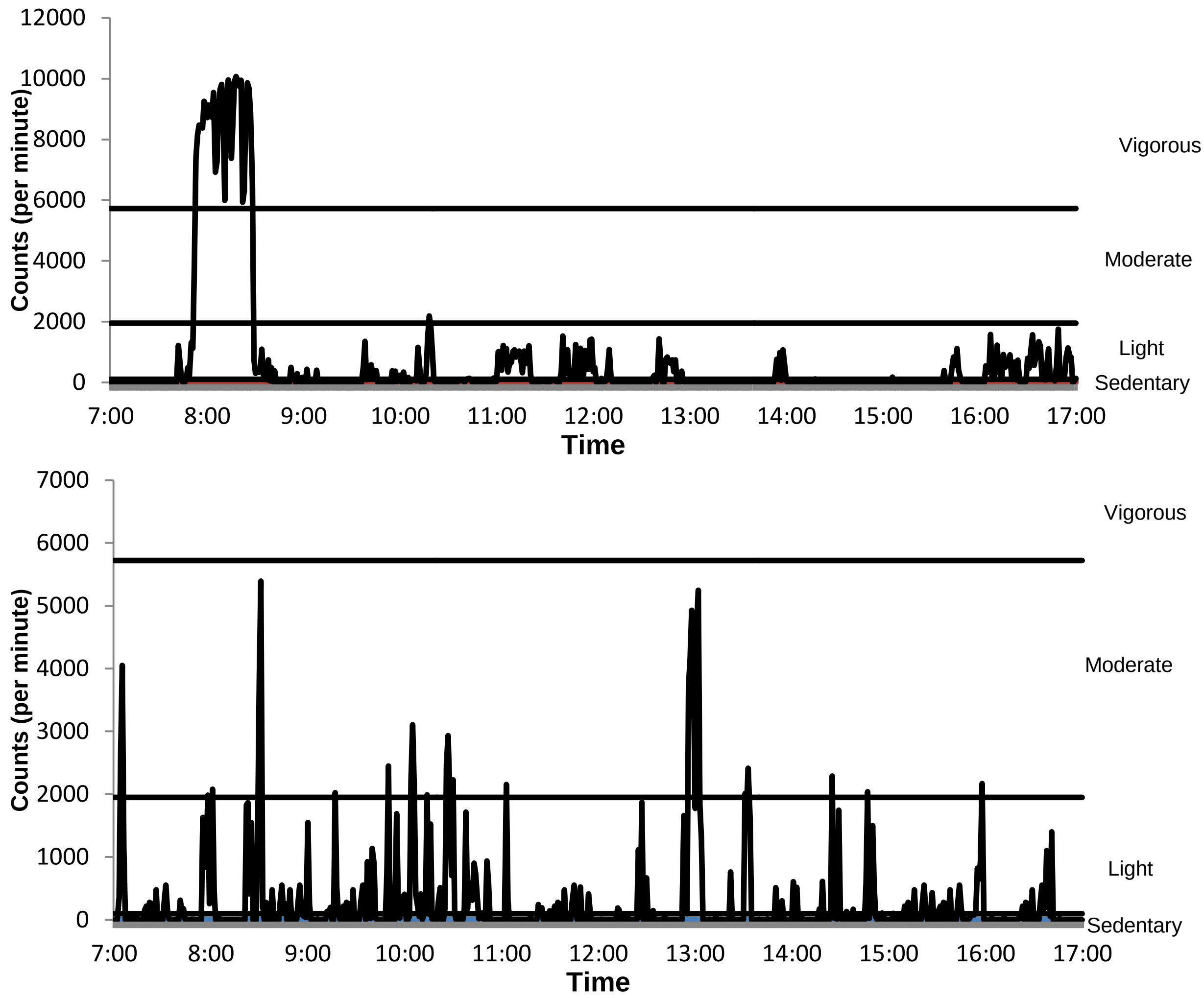

Figure 3. Activity levels of two participants during a typical day. Intensity of activity behaviour is expressed in activity monitor 'counts per minute' (data from the authors, see measurement section (2.6) for more details on activity monitors)

To conclude, sedentary behaviours are characterised by low energy expenditure and a sitting or lying posture during waking hours. Sedentary behaviour is conceptually different from inactivity, which is defined as a lack of MVPA. Importantly, research has shown that there are different predictors of how sedentary a person is as opposed to how much MVPA they perform, and that the health risks are at least partly additive – i.e. being inactive and highly sedentary is a greater risk than being inactive with low sedentary exposure.

2.3 Domains of sedentary behaviour

Sedentary behaviours can occur across multiple domains, with multiple influences (environmental, social, political, cultural) impacting on the behaviour (Owen et al., 2011). The four main domains in which adults typically accumulate sedentary time are: transport, leisure, domestic and occupational (Owen et al., 2011).

In transport, using a car or public transport rather than walking or riding a bike can result in sedentary behaviour. In leisure, using electronic screen based devices (such as television, computer and mobile touch screen devices) are commonly known sedentary behaviours, in addition to more traditional reading from paper or craft activities. In the domestic domain, devices such as washing machines and dryers reduce the need for light activity chores around the home. Finally, in the occupational domain, computer-based tasks or driving a vehicle can lead to high accumulations of sedentary behaviour. Given the proportion of time many adults spend at work, the occupational domain is an important domain for sedentary behaviour.

2.4 Occupational sitting

Occupational sitting is defined as sedentary behaviour that is accrued as part of, or relating to, work. Traditionally this has concerned activities within a workplace, including productive tasks and lunch/morning/afternoon breaks from productive tasks. However, there is also additional sitting which can be considered work-related. For example, commuting to and from work is often addressed in health promotion interventions conducted at the workplace. Similarly, work is increasingly being conducted outside of traditional workplaces, such that domestic and community environments are also contexts where work-related sitting occurs.

2.5 Models of risk control and occupational sitting

The risk control hierarchy model promoted for sustainable management of risk associated with occupational hazards recommends elimination of the risk where reasonably practicable, and minimisation of risk using task substitution or furniture, equipment and tools engineering controls, ahead of administrative controls reliant on worker training and behaviour management (Figure 4) (International Labour Organisation, 1981; Safe Work Australia, 2011a). Elimination of sitting from workplaces could be attempted by removal of all seats, but is unlikely to be desirable given some sitting is likely to be useful in reducing fatigue at work. Substituting work sitting tasks with non-sitting tasks is a potential strategy, and could be combined with engineering controls which provide work equipment and tools to enable productive tasks to be performed while not sitting. Environments could also be designed to include aspects which substitute sedentary tasks for non-sedentary tasks (e.g., enabling walking meetings rather than sitting). Administrative controls could include scheduling breaks from sedentary work tasks. Currently there do not appear to be options for personal protective equipment to minimise harm from sitting exposure.

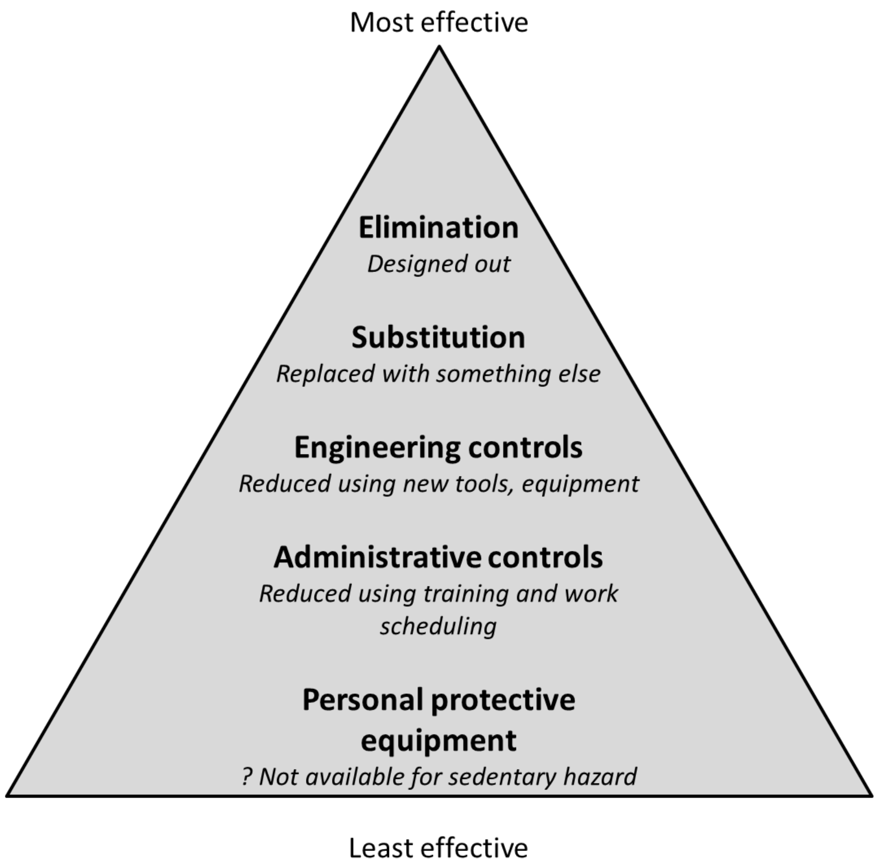

Figure 4. Representation of the hierarchy of control from least to most effective (developed by the authors).

While the hierarchy of control model provides a priority for interventions, it does not articulate what aspects within a system of work should be targeted. Thus an ergonomics systems model is commonly used in hazard identification, risk assessment and risk control – with the system elements including the individual worker interacting with tools/equipment/furniture to perform work tasks in a local workplace environment and a broader societal environment (Figure 5). Such a model can be useful to examine sitting as an occupational hazard and to identify potential influences on exposure and thus potential areas to change in the system of work. For example, changing the tools of an office worker from a seat and fixed height desk to a sit/stand workstation and changing organisational culture to accept and promote standing meetings.

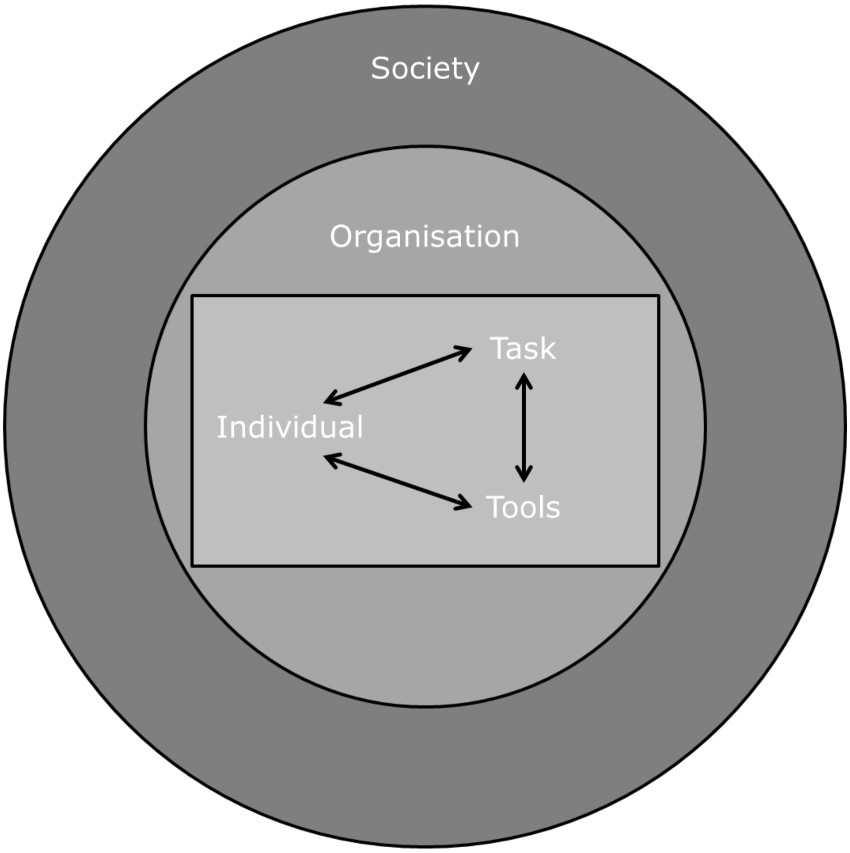

Figure 5. Conceptual model of occupational sitting (developed by the authors).

The World Health Organisation (World Health Organisation, 2010) has provided a model for action as a framework for employers, workers, policy makers and practitioners to develop continuous improvement processes that could be used to facilitate change in the elements of work systems in accordance with the hierarchy of risk controls. The framework suggests five critical keys to develop healthy workplaces:

(1) leadership commitment and engagement

(2) involving workers and their representatives

(3) business ethics and legality

(4) use of a systematic and comprehensive process to ensure effectiveness, and

(5) continual improvement and sustainability and integration.

Similarly, the US National Institute for Occupational Safety and Health WorkLife initiative identified four critical components to support effective employer employee partnerships to improve worker health (National Institute for Occupational Safety and Health, 2008):

(1) organisational culture and leadership

(2) program design

(3) program implementation and resources, and

(4) program evaluation.

These or similar frameworks can be valuable to assist organisations in developing feasible and sustainable changes to work systems to reduce occupational sitting exposure. For example, strong visible senior management support is likely to be important to encouraging new ways of working such as interrupting sedentary tasks regularly.

2.6 Measurement of sedentary behaviour

In order to understand the evidence for exposure and consequences of sedentary behaviour it is important to understand the various ways it can be measured.

To adequately characterise exposure, three aspects are required: the total amount of exposure (e.g. sedentary time per day), the pattern of sedentary behaviour exposure (e.g. accumulation of the total sedentary behaviour in prolonged bouts) and the nature/context of the behaviour (e.g. sitting in a truck delivery loads). Further, as noted in Section 2.2, the definition of sedentary behaviour includes both an energy expenditure and postural component, and a measure should ideally capture both elements.

While comprehensive measurement is possible in a laboratory setting, there is no ‘gold standard’ for measuring sedentary behaviour in field studies (Healy et al., 2011). Rather, a number of sub-optimal approaches are used to capture the various aspects of sitting exposure: self-reports, occupational coding and objective measurements.

A substantial proportion of currently available evidence on sedentary behaviour has been based on self-report questionnaires or diaries. While some questionnaires have been shown to have reasonable reliability, they typically have low validity in comparison to objective measures of sedentary time and suffer from random and systematic errors (Healy et al., 2011). Workers may under-estimate overall sedentary time and occupational exposure (Kwak, Proper, Hagstromer, & Sjostrom, 2011; A.A. Thorp et al., 2012).

The occupational coding method assumes that exposure can be reasonably estimated from occupational titles (e.g. dentist, manager). This method allows for the use of existing administrative databases to assess hazard exposure. However as it assumes homogeneity of hazard exposure within occupational codes (i.e. all workers with a similar occupational title have similar occupational sedentary exposure), it only provides a broad approximate assessment of exposure. This method also does not capture changing activity patterns within an occupational code.

Field objective measures include ‘activity monitors’ that incorporate accelerometer, inclinometer, gyroscopes and/or magnetometer functions. These small devices are typically worn on the hip, waist or thigh. Accelerometers measure movement and can be used to estimate energy expenditure – with very low movement considered sedentary time (Hagströmer, Oja, & Sjöström, 2007). Notably, with this method, standing (a common workplace activity; and a feasible alternative to sitting) can be misclassified as sedentary (Lyden, Kozey Keadle, Staudenmayer, & Freedson, 2012). Inclinometers measure angles with respect to gravity, and can thus estimate sitting/lying, standing and stepping time with very high accuracy - with sitting/lying considered sedentary behaviour (Grant, Ryan, Tigbe, & Granat, 2006). Gyroscopes and magnetometers are used to increase accuracy of movement and position sensing. Some monitors link with smart phone apps to provide user-friendly feedback. Monitors can be worn for several days to provide not only total exposure, but also patterns of exposure (when the sedentary time occurred, and duration of each sedentary bout). Additionally, some furniture has been equipped with sensors to determine how much time a chair is being sat on (Ryde, Gilson, Suppini, & Brown, 2012), how much time a sit/stand desk is set at each height, or when a person is within close proximity to a desk.

There is increasing evidence that patterns of exposure may be relevant for understanding associations with health. For example a total daily exposure of 4 hours of sedentary time is likely to be considered a low overall exposure. If this were accumulated in 10 minute bouts across the whole day then the associated risk is likely to be very low. However if this were accumulated in one prolonged bout of 4 hours duration the risk of adverse outcomes with regular exposure may be quite high.

Despite activity monitors providing considerable detail on total amount, and pattern of accrual, most provide no information on the context of sedentary behaviour, which is sometimes provided by a supplemental diary (Healy et al., 2011). A further limitation is that there are important variations in the methods used for objective monitoring, making synthesis of findings difficult. Nevertheless, the increasing use of activity monitors within the workplace setting has provided important knowledge on exposure to sedentary time, as well as the effectiveness of sitting exposure reduction initiatives.

Key messages covered in this section

- Sedentary behaviour refers to ‘any waking behaviour characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture’.
- Sedentary behaviour is conceptually different from ‘physical inactivity’, which is the lack of sufficient moderate/vigorous intensity physical activity.
- Sedentary behaviour can take place in transport, leisure, domestic and occupational domains.
- Occupational sitting is likely to be influenced by multiple elements in any work system and these provide opportunities to control the risks associated with the hazard of excessive exposure.
- Sedentary behaviour is often measured by self-report or occupational coding. More recently monitors have provided objective measurements considering the total duration, as well as the pattern of behaviour.

3. Methods

This report is an expert synthesis based on current evidence. The authors were drawn from four of the leading Australian research groups investigating sedentary behaviour. Thus the authors had access to the majority of widely published Australian and international evidence on this topic.

Literature already held by the authors was supplemented by a search of the most recent (January 2013-June 2015) occupational sedentary behaviour literature. The search was conducted on PubMed (Medline) with search terms comprising work (‘occupational’ or ‘work’) and sedentary behaviour (‘sedentary behaviour’ or ‘sedentary exposure’). This search strategy yielded a total of 311 unique research papers that were screened for relevance. Out of this total, only 9 papers focused on or included non-office based occupational groups. To supplement the limited published evidence, and capture contemporary data soon to be available, the authors reviewed studies presented at conferences in 2015, or in press/preparation, either from their own research projects, or from collaborating research groups. This approach yielded an additional 3 studies/projects for inclusion in the review.

Additionally, a search for initiatives of Australian and international work health and safety or related agencies addressing legislation, directives, guidelines and codes of practices relevant to occupational sitting was conducted. Information on this topic is presented in a supplementary report.

The current report is not intended to be exhaustive, but rather to illustrate the key constructs, contemporary understanding and potential implications of this rapidly developing field.

4. Sedentary behaviour exposure

In this section the sedentary behaviour exposure of the general population will be described. First, a description of sedentary behaviour in Australia will be given followed by a description of sedentary behaviour internationally. Also, the temporal changes in sedentary behaviour exposure over the last decades will be described.

4.1 Sedentary behaviour exposure in Australia

In Australia, a number of studies have investigated sedentary behaviour exposure in the general population.

Self-reported data from the Australian Health Survey (Australian Bureau of Statistics, 2013a) showed that adults spent on average 39 hours per week (5.6 hours per day) being sedentary with about 10 of these hours per week spent sitting at work. Other common sedentary behaviours were watching TV (13 hours) and using a computer (9 hours). In another study based on self-reports involving more than 200 000 Australian adults aged 45 years and older, 26% sat 0 to 4 hours per day, 48% sat 4 to 8 hours per day, 19% sat 8 to 11 hours per day and 6% sat 11 hours or more per day (van der Ploeg, Chey, Korda, Banks, & Bauman, 2012). In a third study, 2 581 Australia adults aged 18-65 self-reported an average of 4 hours sitting per day (median, with interquartile range 3 to 7) (Bauman et al., 2011). Similarly, 12 188 Australian young and middle aged women self-reported 5-6 hours sitting per day (interquartile range 4 to 8) (Clark, Peeters, Gomersall, Pavey, & Brown, 2014).

Using objective postural-based measurement in a sub-sample of 741 participants in the third wave of the Australian Diabetes, Obesity and Lifestyle (AusDiab3, 2011/2012) study, the estimated daily average exposure to sedentary time was 8.8 (SD 1.8) hours, or approximately 56% of awake time (Healy, Winkler, Owen, Anuradha, & Dunstan, 2015).

4.2 Sedentary behaviour exposure internationally

The self-report and objective findings from Australia are consistent with those reported internationally. Specifically, in a large study of almost 30 000 subjects in 32 European countries, average self-reported sitting time was 5 hours per day (median, interquartile range 3 to 7; Bennie et al., 2013). In another study comparing 20 countries (with almost 50 000 participants) using the same question, average self-reported sitting time was 5 hours per day (median, interquartile range 3 to 8) (Bauman et al., 2011).

The 2003-04 National Health and Nutrition Examination Survey (NHANES) study in the US measured sedentary time by a hip worn accelerometer on 6 329 participants, with a mean of 7.7 hours per day of sedentary time (54.9% of their awake time) (Matthews et al., 2008). The Canadian Health Measures Survey (CHMS) of 2 832 Canadian adults also collected hip worn accelerometer data (though not the same devices as the NHANES study) (Colley et al., 2011) and found average daily sedentary time was 9.6 hours for men and 9.8 hours for women.

Thus, national and international studies suggest daily exposure for adults of around 5 hours per day using self-report data, and 8-10 hours per day when using objective measures data. These findings illustrate the large volume of sedentary behaviour exposure and moreover highlight the under-reporting of sedentary behaviour when using self-report as compared to objective measures.

4.3 Changes in sedentary behaviour over recent years

Data described in the previous two sections provide insight into current levels of sedentary behaviour obtained from recent studies. This section provides some evidence from studies that aimed to describe the change in sedentary behaviour over the last decades.

Using Australian Time Use Survey data it was shown that non—occupational sedentary time had increased slightly from 1997 to 2007 (7.5 and 8.2 hours per day respectively; Chau, Merom, et al., 2012). This change was partly related to an increase in sedentary transport time (depicted by an increase from 1.0 to 1.1 hours of transport per day). Moreover, sedentary time due to leisure time computer use increased significantly over the given time period. This increase in sedentary behaviour was however partly offset by reduced time being sedentary while reading, listening to music or performing hobbies, arts and crafts. Also household and education-related sedentary behaviour increased significantly during the given time period. A study of 5 215 young women and 6 973 middle-aged Australian women found a change in self-reported sitting time of half an hour per day between 2000 and 2010 (Clark et al., 2014). However the direction of change was different for the two age groups. For middle-aged women, sitting time increased but for young women it decreased, with changes related to a range of work and personal life changes. Occupational sitting exposure was not reported.

A study conducted in various countries estimated the change in behaviour in occupation, leisure, travel and household domains using historical data on time allocation, occupation distribution and energy expenditure by activity (Ng & Popkin, 2012). In the US, sedentary behaviour increased from 26.4 hours per week in 1965 to 37.7 hours per week in 2009 (a 43% increase). In the UK, sedentary behaviour increased from 28.4 hours per week in 1961 to 41.7 hours per week in 2005 (a 47% increase to about 6 hours per day). These data were focussed on leisure time sedentary behaviour and are thus likely to be a gross underestimate of overall exposure. Several reasons for this change in sedentary behaviour were discussed by the authors including a change in work force, an increase in vehicle miles travelled and an increase in information technology use (computer and TV). In a large Danish study of 69 800 adults self-reported daily leisure time sitting (3.4 hours) and occupational sitting (4.4 hours) both increased by 13 minutes per day from 2007 and 2010 (Aadahl et al., 2013).

An increase in the use of information technology has been a commonly proposed reason for the apparent increase in sedentary behaviour over the last few decades. Studies have shown that although time spent watching TV has remained relatively stable over the last 20 years (Marshall, Gorely, & Biddle, 2006), increases in the use of other information technology devices over this time period (i.e., desktop computers, electronic games and more recently mobile touch screen devices) has meant that sedentary time has increased across the entire spectrum of daily living (Katzmarzyk, 2010; Owen, Sparling, Healy, Dunstan, & Matthews, 2010; Straker & Mathiassen, 2009). On the other hand, sedentary behaviours such as reading (i.e., paper based books and newspapers) and socializing has decreased substantially over the last thirty years, which has attenuated the overall increase in leisure sedentary time (van der Ploeg et al., 2013). More transport sedentary time arising from more time spent in vehicles (Brownson, Boehmer, & Luke, 2005) and more domestic sedentary time due to labour saving devices (Lanningham-Foster, Nysse, & Levine, 2003) have also been mentioned as contributors to an emerging sedentary society. The important role of occupational sitting in the total accumulation of sedentary behaviour will be described in the next section.

Key messages covered in this section

- Sedentary behaviour exposure is substantial in our society.
- Based on self-report, Australian adults, on average, spend an estimated 5 hours per day sitting, with a quarter of the population sitting for more than 8 hours per day.
- However, estimates of sedentary behaviour are even higher, 8-10 hours per day on average (≈50% of waking hours), when objective measures of sedentary behaviour are used.
- Estimates of sedentary behaviour exposure in Australia are comparable to Northern American and European estimates.
- Modern society has become increasingly sedentary over the last few decades. Important factors for this change are more information technology device use, more car travel and more occupational sitting.

5. Occupational sitting exposure

In this section exposure to occupational sitting will be described. As has been mentioned earlier in this report, the occupational setting is one of the key domains of sedentary behaviour. Following a description of current occupational sitting exposure in Australia, including across different industry sectors and occupations, the change in exposure over the last few decades will be described.

5.1 Exposure to occupational sitting in Australia

In 2008, Safe Work Australia conducted the National Hazard Exposure Worker Surveillance (NHEWS) in which 4 500 Australian workers self-reported on physical work demands (including sitting; Safe Work Australia, 2011c). While not a truly representative sample, it provides the best available national data and shows that 81% of Australian workers reported an exposure to sitting. High levels of exposure were reported by half of the workers; 23% reported working while sitting down 'all of the time' and a further 29% reported 'often' siting down while working. The prevalence of any exposure (81%) was substantially higher than any exposure to some of the more traditional occupational physical demands such as forward bending (74%), carying or lifting loads (63%), standing work (62%) and awkward postures (56%).

Studies are beginning to emerge which compare occupational and non-occupational exposure to sitting based on objective measurement. In a study of 193 Australian office workers using hip-worn accelerometry, the proportion of sitting time was higher on work days as compared to non-workdays (70% and 63% of the day respectively). Further, on work days, the proportion of sitting time was higher during work hours compared to non-work hours (77% and 63% of the work day respectively) (A.A. Thorp et al., 2012). In another study of 50 Australian office workers, participants accumulated 11.5 sedentary hours per day on work days, with 7.3 hours (63%) accumulated during working time, i.e. occupational sitting (Parry & Straker, 2013). Office workers accumulated half of their total weekly exposure at work, suggesting occupational exposure is likely to be a major contributor to the poor health outcomes associated with overall sedentary behaviour exposure.

Data from office workers contrasts with objectively measured data from transport workers. In a study of male bus drivers, total daily sedentary time was lower (7.8 hours) on work days than non-work days (8.9 hours) (Wong et al., 2014). Similarly these drivers spent only 44% of their time at work being sedentary compared with 60% outside of work time. Despite differences in the measurement methods, the occupational sitting exposure was considerable for all the groups measured.

The pattern of occupational exposure, in addition to total exposure, has also been explored with a particular focus on understanding time accrued in prolonged, unbroken bouts (typically defined as 20 or 30 minutes without interuption). Accelerometer studies on Australian office workers have found consistent evidence of greater exposure to prolonged sitting time at work compared to non-work. Parry and Straker (Parry & Straker, 2013) found that occupational time accounted for 58% of total weekly exposure to bouts of sedentary time greater than 30 minutes in duration. Similarly, Thorp et al (A.A. Thorp et al., 2012) found that 28% of occupational sitting exposure was in bouts of greater than 30 minutes duration. These findings are consistent with those from studies where postural based monitors have been used (that more accurately distinguish between sitting and standing) (Healy et al., 2013; Neuhaus, Healy, Dunstan, Owen, & Eakin, 2014). Parry and Straker also reported that office workers took breaks from sedentary time less frequently in occupational time compared with non-occupational time (5.1 vs 7.9 breaks per sedentary hour).

5.2 Exposure to occupational sitting internationally

A study of 83 office workers in the UK found 66% of work time was spent sitting using objective posture monitors (Ryan, Dall, Granat, & Grant, 2011). While there were no differences in overall occupational sitting time between 4 subgroups (lecturers, researchers, technicians and administrators), the technicians had a shorter mean longest sitting period than the researchers. An unpublished study of workers in Europe (under review) has assessed accelerometer measured prolonged sedentary bouts in a sample of male construction workers (n=38). These workers spent 7% of their work time in prolonged sedentary bouts of more than 30 minutes. This was substantially less than a comparative group of office workers (n=167) who spent 30% of their work time in prolonged sedentary bouts, suggesting that some occupational groups are likely to be at greater risk than others.

Thus occupational exposure in terms of both total accumulation and pattern of accumulation appears to be highly prevalent in some Australian workplaces.

5.3 Sitting exposure in different industry sectors and occupations

Data from the previously mentioned NHEWS study (Safe Work Australia, 2011c) show that exposure to any occupational sitting is high across major industry sectors (Figure 6). Sitting exposure can therefore be considered an issue of importance across all industries, though exposure is likely to vary between occupations.

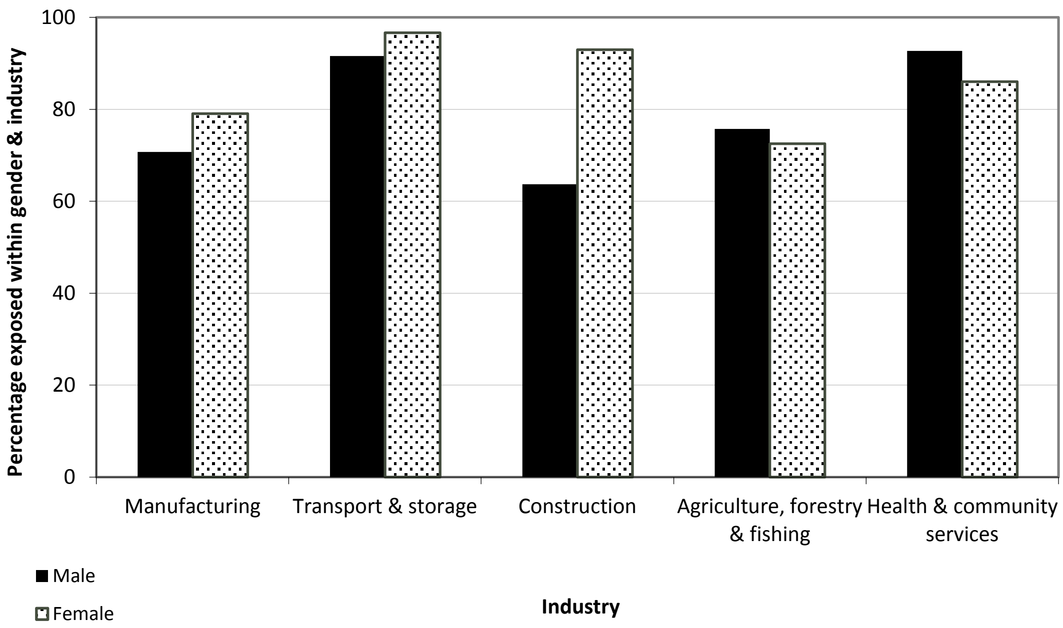

Figure 6. Exposure to any occupational sitting in different industries categorised by Australian and New Zealand Standard Classification of Occupations. (Source – NHEWS Safe Work Australia 2011)

As suggested by the model for occupational sitting (see section 2.6 with Figure 5), different work systems are likely to result in different sitting exposure. Thus, work system differences between industry sectors and occupations may result in different occupational sitting exposures. Further data from the NHEWS study illustrates this with considerable variety across industry sectors and skill levels in the proportions of workers exposed to any occupational sitting (Figure 7; Safe Work Australia, 2011c). Similarly, sitting 'often' or 'all the time' was reported by the majority of clerical and administrative workers (90%), professionals (66%), managers (64%) and, machinery operators and drivers (56%) but by only a minority of sales workers (40%), community and personal service workers (31%), technicians and trades workers (24%) and labourers (12%).

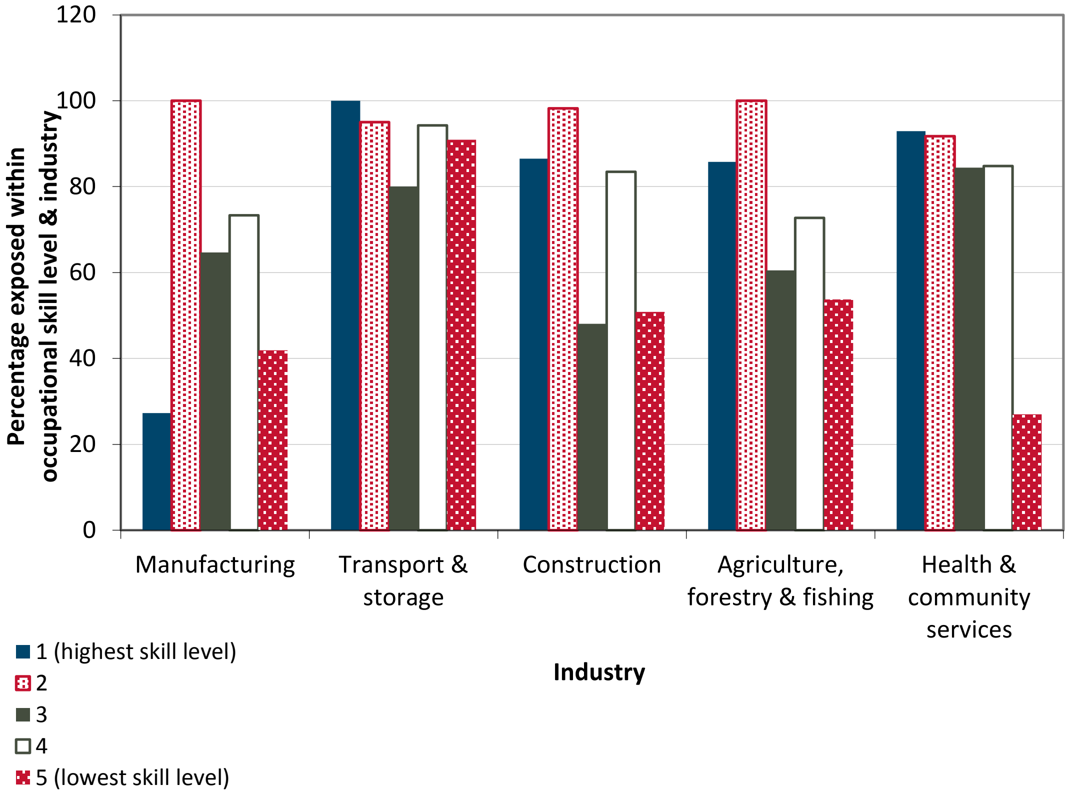

Figure 7. Exposure to any occupational sitting in different industries (coded by ANZ Standard Classifcation of Occuaptions) by five skill levels (highest to lowest). (Source – NHEWS Safe Work Australia 2011)

Among a sample of almost 1 000 workers in different industry sectors in Australia, sitting exposure was higher in those with higher education (tertiary studies; 4.10 hours per day) compared to those with lower education (no tertiary studies; 3.11 hours per day). Similarly, exposure was higher in those with higher income (≥$1500 per week; 4.10 hours per day) compared with those with lower income (<$1500 per week; 3.11 hours per day). Moreover, people who reported that they had limited decision making about when they had to sit at work reported higher sitting times than those who reported they had greater flexibility in deciding when they needed to sit (de Cocker, Duncan, Short, van Uffelen, & Vandelanotte, 2014). Shift work also appears to influence occupational sitting, with self-reported occupational sitting time lower in Australian shift workers (139 minutes/day) than non-shift workers (185 minutes/day) (Vandelanotte et al., 2013), while accelerometer measured sitting exposure in workers who had alternating night and day shifts was less than workers in daytime jobs (29 minutes per day less) in a study among more than 1500 workers in the US (Loprinzi, 2015).

5.4 Sitting exposure in 'blue' and 'white' collar occupations

A number of studies have presented sitting exposure data comparing occupational groups. Many of these conceptualised the occupational groups as 'white' (office) or ‘blue’ (non-office) collar workers. While this approach is simple, it does ignore the variation in job content *within* these large groups, and the changes in job content that have occurred over recent decades leading to more sedentary tasks in many classic ‘blue’ collar occupations, such as in construction.

In a telephone survey of 1194 regional Australians, Vandelanotte et al (Vandelanotte et al., 2013) found that ‘white’ collar workers (200 minutes per day) reported more at work sitting than ‘blue’ collar workers (88 minutes per day). Similarly, in a random sample of Australian households, ‘white’ collar workers reported more hours sitting at work (4.20 hours per day) than professionals (2.89 hours per day), and blue collar workers (2.17 hours per day) (de Cocker et al., 2014).

Internationally, similar differences in occupational sitting exposure have been reported between occupations. In a Dutch study using self-report data, senior managers were the most sedentary at work (on average 3.0 hours per day), followed by clerks (2.7 hours per day) and scientific/artistic professionals (2.1 hours per day) (Jans, Proper, & Hildebrandt, 2007). Furthemore, trade industrial or transport occupations (1.4 hours per day), agricultural occupations (1.2 hours per day) and service workers (0.8 hours per day) reported the lowest occupational sitting exposures. In a comparative study of self-reported workday sitting in UK employees, retail workers were the least sedentary (2 hours per day), while telecommunication workers were the most sedentary (8 hours per day) (Kazi, Duncan, Clemes, & Haslam, 2014).

Few studies have compared occupational sitting in ‘blue’ and ‘white’ collar occupations using objective measures. Tudor-Locke et al (Tudor-Locke, Craig, Thyfault, & Spence, 2013) suggested step counts can provide a proxy for sitting exposure. They outlined that sedentary time can be defined as a missed opportunity to accumulate steps from 1-120 every minute and reported that taking <5 000 steps/day was associated with spending between 522-577 min/day in sitting, compared with 348-412 min/day in those who take >10 000 steps/day. Thus earlier research comparing occupations using step counts, while not ideal, can provide some information on occupational sitting exposure. For example, Steele and Mummery (Steele & Mummery, 2003) showed that Australian university ‘blue’ collar workers (e.g. tradespersons and grounds staff) accumulated an average of 8,757 steps per day. This was around 5-6 000 more daily steps than university ‘white’ collar (e.g. clerical staff; 3 616 steps per day) and professional (e.g. administrators; 2 835 steps per day) workers. Similarly, in a New Zealand study, Schofield et al (Schofield, Badlands, & Oliver, 2005) reported similar steps per day for ‘blue’ collar workers (1 0334 steps/day) and lower values for ‘white’ collar general office (5 380 steps/day) and university academic (4 422 steps/day) workers.

More recently, studies using accelerometers have compared occupations. In a study among Australian rural men, office workers and farmers were compared regarding their objectively measured sitting. It was shown that office workers were more sedentary than farmers at work (6.6 and 4.3 hours per day, respectively) and in total (10.0 and 8.1 hours per day, respectively). Moreover, office workers had less ‘interruptions’ from sitting at work than farmers (Pontt et al., 2015). Even within an occupation there can be considerable inter- and intra-individual variability in sitting patterns (Ryde, Brown, Gilson, & Brown, 2014).

Internationally, occupational sitting was assessed over four consecutive days in a sample of 202 Danish ‘blue’ collar workers (Hallman, Gupta, Mathiassen, & Holtermann, 2015). Occupations with the lowest levels of occupational sitting exposure were garbage collectors (2.0 hours/day), manufacturing workers (2.3 hours/day) and cleaners (2.9 hours/day). Those with the highest exposure to sitting at work were construction workers (3.5 hours/day), assembly workers (3.7 hours/day) and mobile plant operators (4.5 hours/day). Similarly, analysis of accelerometer data from 1 112 US adults by occupational code found ‘engineers, architects and scientists’ had the largest proportion of their measured day being sedentary (65%), with ‘waiters and waitresses’ having the smallest proportion (40%) (Steeves et al., 2015). Other occupations with high sitting exposure were management (39%), artists (36%), secretaries (34%), technicians (32%), sales represenatives (31%) and teachers (30%).

Three other studies were found (two unpublished), which solely focused on objectively measuring occupational sitting exposure in non-office based workers; all three studies measured exposure in transport drivers. In a study of Australian male bus drivers, occupational sedentary time was 4.1 hours per day (Wong et al., 2014). Their total daily sedentary time was less on work days (7.8 hours) than on non-work days (8.9 hours). These drivers spent a lower proportion of their time sedentary while at work (44%) than outside of work time (60%). This study could have underestimated occupational sitting exposure, given that accelerometers may have classified time spent driving as light intensity activity (due to either vehicle vibrations or the upper body movement associated with driving given the wrist placement of the accelerometers). A UK study by Valela-Mato et al (Varela-Mato, Yates, Biddle, & Clemes, 2015) using posture monitors in bus drivers (n=28) found that drivers sat for a significantly greater proportion of their time on workdays (73%) compared to non-workdays (63%). Sitting time was also higher during work hours (85%) compared to non-work hours (70%). Gilson et al (N. D. Gilson, Pavey, et al., 2015) assessed patterns of workday sedentary time in Australian truck drivers. In this study, compared to local delivery drivers, long-haul drivers spent a significantly lower proportion of their day sedentary (38%; difference of 5% or 1.2 hours/day). This again highlights important variation in exposure even within a single occupation.

Thus, while emerging data suggests sitting exposure varies between occupations, and even within an occupational group, the evidence shows there are many occupations (including traditionally ‘blue’ collar occupations) in all industry sectors where occupational exposure to excessive sitting is likely to be an important occupational hazard.

5.5 Changes in occupational sitting exposure over years

While there is little direct Australian evidence relating to changes in occupational sitting exposure over recent decades, the international evidence does support the Australian anecdotal evidence. For example, self-report data from Denmark show a recent increase in the proportion of workers spending at least three-quarters of their work time sitting, from 33% in 1990 to 39% in 2010 (van der Ploeg, Moller, Hannerz, van der Beek, & Holtermann, 2015). A study from the US using employment statistics with occupational classification scheme codes has shown that the estimated average daily occupation related energy expenditure has decreased over the last 50 years by 100 calories (Church et al., 2011). This study also showed that whereas around 15% of the US workers worked in sedentary jobs in 1960, this had increased to around 25% by 2010. Part of this change is likely to be due to shifts from agriculture and manufacturing to service industries in the proportion of workforce employed (Church et al., 2011). However, this change is likely to be partly due to an increase in sedentariness within the same industry and occupation due to changes in job content (Lanningham-Foster et al., 2003; Straker & Mathiassen, 2009). For example, many mining workers now perform large parts of their work sitting in a vehicle or control room, where previously their jobs involved considerable heavy manual labour; construction workers spend parts of their workday seated completing administration tasks as well as seated using excavation machinery; and certain types of truck drivers are now precluded from manually loading and unloading deliveries due to health and safety concerns. Another reason for an increase in absolute sitting time at work is that the amount of time spent at the workplace has increased over recent decades (van der Ploeg et al., 2013).

5.6 Interaction of occupational and non-occupational sitting exposure

There is some evidence to suggest that occupational sitting exposure interacts with sedentary behaviour in other domains. Using data from the 2003-09 American Time Use Survey, Tudor-Locke et al (Tudor-Locke, Leonardi, Johnson, & Katzmarzyk, 2011) categorised respondents (n=30 758) into sedentary (e.g. financial managers, computer programmers, legal assistants), light (e.g. teachers, surveyors, musicians), moderate (e.g. paramedics, massage therapists, baggage porters) and vigorous (e.g. carpenters, construction workers, roofers) occupations. Those in sedentary occupations were the least sedentary outside of work (approximately 4 hours /day), while those in vigorous occupations spent more of their time outside of work being sedentary (almost 5 hours /day). Thus occupational sitting exposure may have additional implications for the whole sedentary exposure of individuals, suggesting a holistic approach is desirable.

While the limited available data shows important differences in sedentary exposure across different occupational groups, there is clearly a need for objectively measured occupational and non-occupational exposure data to ascertain exposure of Australian workers to this hazard.

Key messages covered in this section

- The exposure to occupational sitting is substantial with 81% of Australian workers reporting some exposure and half of workers reporting sitting at work ‘often’ or ‘all the time’.
- Occupational sitting exposure can account for half of total sedentary exposure for workers.
- Occupational exposure can be a hazard in both the total accumulation and the pattern of prolonged accumulation without interruptions.
- Exposure to occupational sitting occurs among many different industries and occupations.
- Certain occupational sub-groups are likely to be at greater risk of excessive occupational sitting.
- Exposure to occupational sitting has increased over the last decades, from workforce changes in occupation distribution as well as changes in job content.
- Occupational sitting exposure may influence non-occupational sedentary exposure.
- Better evidence of exposures of occupational groups using objective measures is needed.

6. Outcomes associated with overall sedentary behaviour

In this section, implications of overall sedentary behaviour on several health and work outcomes will be described. Most of the available evidence is from epidemiological studies which show associations and not causality. Section 9 provides an overview of potential mechanisms for causal pathways.

6.1 All-cause mortality

In a large study of more than 200 000 Australian adults aged 45 years and older, the association between sedentary behaviour and all-cause mortality within the subsequent 3 years was examined (van der Ploeg et al., 2012). Compared to those who reported sitting less than 4 hours per day, there was a 15% increase in the risk of death (from all causes) in those sitting 8 to 11 hours per day and a 40% increase in the risk of death in those sitting 11 or more hours per day. The increase in risk remained when participation in moderate/vigorous activity was also considered (accounted for in the analysis). This finding is consistent with those from several systematic reviews, which have also concluded that high levels of sitting time are associated with an increased risk of all-cause mortality (Biswas et al., 2015; J. Y. Chau et al., 2013; de Rezende, Rodrigues Lopes, Rey-Lopez, Matsudo, & Luiz Odo, 2014; A.A. Thorp, Owen, Neuhaus, & Dunstan, 2011).

6.2 Cardio-metabolic risk factors and outcomes

As early as 1967 objectively measured sedentary behaviour was shown to be linked to cardio-metabolic variables (Bloom & Eidex, 1967). Daily standing time (measured by a device attached to the leg) was about 3.5 hours less per day for obese participants than lean controls, providing indirect evidence of a potential positive association between sitting time and obesity.

More recent work supports the link between higher levels of sedentary behaviour and cardio-metabolic outcomes including: diabetes, the metabolic syndrome, weight gain and, fatal and non-fatal cardiovascular disease (de Rezende et al., 2014; Ford & Caspersen, 2012; A.A. Thorp et al., 2011). A recent review has confirmed that the increased risk of cardio-metabolic outcomes such as cardiovascular disease and type 2 diabetes associated with excessive sedentary behaviour, remains even after controlling for leisure time participation in moderate/vigorous physical activity (Biswas et al., 2015). Similarly, a systematic review has concluded that regardless of how the sedentary time was measured, those in the highest category of sedentary time had approximately twice the risk of developing diabetes or cardiovascular disease, or dying from cardiovascular disease, as those in the lowest sedentary time category (Wilmot et al., 2012).

Associations have also been found between sedentary behaviour and certain risk indicators for cardio-metabolic disease (Chau, Grunseit, et al., 2014), suggesting possible mechanisms through which sedentary behaviour is contributing to poorer health. Higher levels of sedentary behaviour appear to be linked with higher waist circumference (Healy, Wijndaele, et al., 2008), body mass index (BMI) (Mummery, Schofield, Steele, Eakin, & Brown, 2005) and disease risk biomarkers such as glucose and triglycerides (Brocklebank, Falconer, Page, Perry, & Cooper, 2015).

Prolonged sitting appears to be particularly detrimental for cardio-metabolic health. Studies that have investigated outcomes following imposed periods of prolonged sedentariness (e.g. bed rest studies) have found detrimental associations with insulin sensitivity, glucose and triglycerides levels (T. J. Saunders, Larouche, Colley, & Tremblay, 2012). In contrast, interruptions to prolonged sitting appears to have a beneficial impact on triglycerides (Brocklebank et al., 2015), and glucose and insulin levels following a meal (Dunstan et al., 2012; Peddie et al., 2013) in short term laboratory studies.

6.3 Cancer

Associations have also been found between sedentary behaviour and site-specific cancers. Higher levels of sedentary behaviour, such as TV viewing, have been shown to be associated with colon, endometrial and lung cancer risk (Schmid & Leitzmann, 2014) and breast cancer (Shen et al., 2014; Zhang, Jiang, Wu, & Jiang, 2014). A more recent review has confirmed an increased risk in breast, colon, colorectal, endometrial and epithelial ovarian cancers among those with higher sedentary behaviour exposure even after allowing for participation in moderate/vigorous physical activity (Biswas et al., 2015). Other reviews however have concluded that sedentary behaviour is not associated with a number of other cancers including rectum, ovarian, prostate, stomach, esophagus, testes, renal cell and non-Hodgkin lymphoid cancers, with mixed conclusions for breast cancer (Schmid & Leitzmann, 2014; Shen et al., 2014).

6.4 Musculoskeletal Disorders

Research suggests an increase in spinal load during sitting (Pope, Goh, & Magnusson, 2002). It is postulated that spinal loads are associated with rotation of the pelvis and spinal shrinkage and create a potential risk for the development of low back symptoms. However, a 2009 systematic review found no evidence for an association between leisure time sitting and low back pain (Chen, Liu, Cook, Bass, & Lo, 2009).

6.5 Mental Health

Higher levels of sedentary behaviour may also be associated with poorer mental health and increased risk of mental illness. Higher levels of sedentary behaviour appear to be associated with an increased risk of psychological distress (Hamer, Coombs, & Stamatakis, 2014; Kilpatrick, Sanderson, Blizzard, Teale, & Venn, 2013), reduced general mental well-being (Atkin, Adams, Bull, & Biddle, 2012) and post-natal depression (Teychenne & York, 2013). Sedentary behaviour also appears to be adversely associated with depression; a recent systematic review (Zhai, Zhang, & Zhang, 2015), found that those in the highest category of sedentary behaviour had a 25% increased risk of depression compared with those with the lowest levels of sedentary behaviour. There also appears to be moderate evidence that overall sedentary behaviour is linked with increased risk of anxiety symptoms (Teychenne, Costigan, & Parker, 2015).

6.6 Productivity

Sedentary behaviour outside of work has been associated with presenteeism, defined as lost productivity regarding time management, physical demands, mental-interpersonal demands and work output (Brown, Ryde, Gilson, Burton, & Brown, 2013). However conflicting evidence has also been reported in a study of 710 Australian workers which found no evidence of an association between non-work sitting time with self-reported presenteeism (Guertler et al., 2015).

Key messages covered in this section

- Overall sedentary behaviour exposure has been shown to be associated with a range of health outcomes.
- Sedentary behaviour has been shown to be detrimentally associated with all-cause mortality, cardio-metabolic outcomes (including cardiovascular disease, diabetes and obesity), some cancers, mental ill-health and health related quality of life.
- It is unclear whether non-occupational sedentary behaviour is associated with work outcomes such as reduced productivity.
- The majority of these associations remain even after allowing for the impact of physical inactivity, thereby underlining that sedentary behaviour and physical inactivity need to be considered as separate health hazards.

7. Outcomes associated with occupational sitting exposure

In this section an overview of the literature regarding health effects of occupational sitting will be given.

As early as the 17th century, occupational physician Bernadino Ramazzini acknowledged the detrimental health effects of excessive occupational sitting (Franco & Franco, 2001; Franco & Fusetti, 2004). In his 'De Morbis Artificum Diatriba' ('Diseases of Workers'), he stated that "*Sedentary workers who sit while they work at their job, become bent, hump-backed, and hold their heads down like people looking for something on the ground".* He recommended activity for sedentary workers "*so to some extent counteract the harm done by many days of sedentary life*" and "*First of all, to repair the damage that a sedentary life may bring on, physical exercise will be beneficial, but in moderation*". Since Ramazzini's insightful observations, considerable research into the potential health effects of different levels of occupational physical activity has been published. However, the evidence base linking occupational sitting, in particular, with health outcomes is scarce.

7.1 Mortality

While there is strong evidence that overall sedentary behaviour is associated with premature mortality, at this stage there is only suggestive evidence that high occupational sitting exposure may increase mortality risk. The only systematic review of occupational sitting and health outcomes conducted to date (van Uffelen et al., 2010) found six studies exploring this association. Four of these studies suggested an increased mortality risk with sitting occupations, one found no association and one found that sitting jobs were associated with a reduced risk of mortality.

Since this review, some additional evidence has accumulated. A large study (Stamatakis et al., 2013) involving over 10 000 workers in the UK found that women who had a sitting occupation had a lower risk of all-cause and cancer-related mortality compared with women in occupations involving standing or walking. However, no association with mortality was found among men. Similarly, an exploration of mortality risk among over 45 000 participants in a large Norwegian cohort study found a significantly increased mortality risk for those in self-reported sitting occupations compared with those in jobs requiring much walking, much walking and lifting, or heavy physical labour (J.Y. Chau et al., 2013). In contrast, a recent longitudinal study in Denmark (van der Ploeg et al., 2015) found no conclusive evidence linking self-reported occupational sitting with mortality risk.

7.2 Cardio-metabolic outcomes and risk factors

One of the earliest reports of empirical evidence for the health effects of occupational sitting was a study among workers in the London public transport sector (Morris, Heady, Raffle, Roberts, & Parks, 1953). Results showed that the bus or tram drivers (characterised as mainly sitting during their occupation) had higher rates of coronary heart disease and related death compared to their more active colleagues working as conductors. These early results, suggesting an association between occupational sitting and cardio-vascular disorders, have been supported by some of the more recent research, although the evidence is mixed.

Van Uffelen et al.'s (2010) review found conflicting findings relating to the association between self-reported occupational sitting and cardiovascular outcomes. Four studies found occupational sitting to be associated with increased risk of cardiovascular disease outcomes, while three showed no association. More recent evidence continues to be conflicting, with one study suggesting a reduced risk of heart failure in those with sitting occupations compared with those in moderate (e.g. standing, walking) and high (e.g. walking and lifting, heavy labour) physical activity occupations (Wang et al., 2010). Another study suggested a reduced risk of myocardial infarction (heart attack) in those with predominately walking, or walking and lifting jobs compared with predominately sitting (Held et al., 2012).

In terms of metabolic outcomes, there is mixed evidence for whether an association exists between sedentary work and obesity (van Uffelen et al., 2010). While some have found evidence to suggest a higher risk or prevalence of overweight/obesity among those with sitting/low activity jobs (Chau, van der Ploeg, Merom, Chey, & Bauman, 2012; Steeves, Bassett, Thompson, & Fitzhugh, 2012), others have found no evidence of an association (Pinto Pereira & Power, 2013; Pulsford, Stamatakis, Britton, Brunner, & Hillsdon, 2013). The majority of studies have utilised a cross-sectional study design which limits conclusions regarding the direction of causality. Of the prospective studies, two studies (Pinto Pereira & Power, 2013; Pulsford et al., 2013) found no association between levels of sitting at work and change in BMI (used as an estimate of obesity) over time, while one study (Eriksen, Rosthoj, Burr, & Holtermann, 2015) found that women who reduced their level of occupational sitting had a significantly lower BMI at follow up compared to those who had a large increase in their occupational sitting time.

There are some indications that occupational sitting may be associated with an increased risk of diabetes. Three prospective studies have found a lower risk of diabetes among those with more physically active jobs compared to those with sedentary jobs (Hu, Li, Colditz, Willett, & Manson, 2003; G. Hu et al., 2003; Probert, Tremblay, & Gorber, 2008). There is also evidence to suggest that occupational sitting may be associated with cardio-metabolic risk factors including lower levels of “good” HDL cholesterol and higher levels of triglycerides and insulin, even after adjusting for leisure-time sitting and physical activity (Pinto Pereira, Ki, & Power, 2012; Saidj, Jorgensen, Jacobsen, Linneberg, & Aadahl, 2013). This is supported by a small-scale laboratory trial with 10 office-based workers which found that blood glucose levels following a meal were improved when participants spent the afternoon standing rather than sitting (Buckley, Mellor, Morris, & Joseph, 2014).

Cancer

In 2010, a systematic review concluded that while there was some evidence for a detrimental association between occupational sitting exposure and cancer, the evidence was not definitive (van Uffelen et al., 2010). More recent reviews suggest a detrimental association between occupational sitting exposure with colon cancer (Schmid & Leitzmann, 2014) and breast cancer amongst women (Zhou, Zhao, & Peng, 2015).

7.3 Musculoskeletal disorders

Sitting has been associated with musculoskeletal disorders including lower extremity pain (Messing, Tissot, & Stock, 2008; Reid, Bush, Karwowski, & Durrani, 2010) and back pain (Al-Eisa, Egan, Deluzio, & Wassersug, 2006). In a study among bank tellers who either just sat, just stood or alternated sitting and standing every 30 minutes, it was shown that workers had more discomfort in the upper limbs while sitting, and workers had more discomfort in the lower limbs while standing (Roelofs & Straker, 2002). Occupational sitting has traditionally occurred with computer work, which in turn is associated with neck and upper extremity symptoms (Andersen, Fallentin, Thomsen, & Mikkelsen, 2011; Côté et al., 2008). However, while some systematic reviews confirmed these associations between occupational sitting and musculoskeletal disorders (Ariens, van Mechelen, Bongers, Bouter, & van der Wal, 2000; Côté et al., 2008), the evidence is inconsistent and other reviews have failed to find conclusive support for these associations (Bakker, Verhagen, van Trijffel, Lucas, & Koes, 2009; da Costa & Vieira, 2010; Janwantanakul, Sitthipornvorakul, & Paksaichol, 2012; Waersted, Hanvold, & Veiersted, 2010).

7.4 Mental Health

There is suggestive evidence that occupational sitting exposure may be associated with poorer mental health. This includes mental disorder symptoms (Hagger-Johnson et al., 2014), poorer mental well-being in highly active employees (Puig-Ribera et al., 2015) and burnout among women (Stenlund et al., 2007). Sitting for more than 6 hours per day for work has also been associated with increased psychological distress among Australian office-workers (Kilpatrick et al., 2013). However, other studies have found no evidence for associations between sitting for work with depression, stress and anxiety symptoms (Rebar, Vandelanotte, Van Uffelen, Short, & Duncan, 2014) or general mental health (Proper, Picavet, Bemelmans, Verschuren, & Wendel-Vos, 2012). Studies have mostly been cross-sectional in design so it is unclear if occupational sitting is likely causing poorer mental health or vice versa.

7.5 Work Outcomes

There is mixed evidence from epidemiological studies for associations between occupational sitting exposure and presenteeism or work engagement (Guertler et al., 2015; Munir et al., 2015; Puig-Ribera et al., 2015). Similarly, the evidence from intervention trials regarding the associations between occupational sitting exposure and work-related outcomes has also been mixed. For example, a review of studies (Karakolis & Callaghan, 2014) exploring the association between sit-stand workstations and productivity reported that of the eight studies included, three found increased productivity using the sit-stand workstation compared with sitting, four found no impacts on productivity, and one had mixed findings. In a more recent laboratory study involving 23 overweight/obese workers (A. A. Thorp, Kingwell, Owen, & Dunstan, 2014), productivity measures were compared between two conditions – either sitting all day for five days in a simulated office environment or alternating sitting and standing every 30 minutes for a five day period. They found a non-significant trend towards improved self-reported overall productivity in the stand-sit condition compared to the sitting condition. Fatigue was higher in the sitting condition, with reduced motivation and higher concentration problems reported. Another study (Dutta, Koepp, Stovitz, Levine, & Pereira, 2014) found no difference in productivity when workers used a sit-stand workstation compared to normal seated work. However, participants did report feeling more energetic, less tired and less sluggish when using the sit-stand workstation. A limitation of these studies is that they have generally used self-reported measures of productivity, or measured productivity using a simulated task. It is therefore uncertain whether these results would translate into measurable differences in real-life work outcomes.

7.6 Summary

To date, evidence for the health effects of occupational sitting exposure is not as strong as that for overall sedentary behaviour. Notably, few studies have captured occupational sitting exposure objectively. Sitting exposure has generally been assessed through categorical measures of occupational activity, e.g. comparing "mostly sitting" occupations to "mostly standing" or "heavy physical labour" occupations. Few studies have quantified the number of hours or proportion of work time spent sitting. Thus the lack of evidence of an association between occupational sitting exposure and various outcomes may be due to lack of precision in measuring occupational exposure.

While high quality longitudinal studies measuring health outcomes associated with occupational sitting exposure may be limited at this stage, the evidence base is developing rapidly and will continue to do so in the near future. In addition, emerging evidence from workplace intervention studies is providing useful insight into the mechanisms through which occupational sitting may be harmful to health.

Key messages covered in this section

- The health impact of occupational sitting has been acknowledged since as early as the 17th century.
- More recent studies have found modest evidence suggesting possible links between occupational sitting exposure and premature mortality, cardio-metabolic outcomes and certain cancers. The evidence for associations between occupational sitting exposure with musculoskeletal disorders and mental health outcomes is more mixed.
- The evidence for the health consequences of exposure to occupational sitting is not as strong as that for consequences from overall sedentary behaviour, but is developing rapidly.

8. Sitting exposure: what is excessive?

Sedentary behaviour is a hazard unlike tobacco smoking. For tobacco smoking, evidence suggests that there is a linear dose-response relationship between tobacco smoking and ill-health outcomes, and that even low exposure has a negative effect on health (Schane, Ling, & Glantz, 2010). Thus the risk threshold for tobacco smoking can be justifiably set at zero exposure – in both occupational and other domains. However some sedentary exposure is probably health promoting (aiding rest and recovery), suggesting a non-linear dose-response relationship between sitting exposure and ill-health outcomes. Thus sitting exposure is more akin to sun exposure – where too much exposure increases the risk of skin cancer and too little exposure increases the risk of Vitamin D deficiency and myopia (French, Ashby, Morgan, & Rose, 2013; Holick, 2014). In addition, there is evidence that risk is related to not only the total exposure but also the pattern of exposure. Nevertheless, evidence for a threshold for sitting exposure above which health risk increases is only just starting to accumulate.

All-cause mortality data from Australia suggests a minimal increase in risk of death with self-reported daily exposures of 4-8 hours compared with less than 4 hours (van der Ploeg et al., 2012). However mortality risk increased by 15% with 8-11 hours exposure and 40% with 11 or more hours of exposure. A meta-analysis of international studies found that there appeared to be no incremental increase in mortality risk for exposures of less than 7 hours per day, but that risk increased by 5% for every additional hour of exposure more than 7 hours per day, after adjustment for covariates including physical activity (J. Y. Chau et al., 2013). These findings suggest that, at least for mortality outcomes in adults, *excessive* could be considered somewhere near a 7 hour daily threshold (self-reported). The threshold for non-fatal health and work consequences (such as productivity) may be lower.

Direct evidence on what could be considered excessive *occupational* sitting exposure is more limited, making it difficult to determine a threshold level of occupational sitting above which exposure is harmful to health.

As this report has previously highlighted, the pattern of sitting exposure is another important consideration. While the importance of interrupting prolonged periods of sitting is supported by epidemiological studies (Healy, Dunstan, et al., 2008), what can be considered excessive in terms of insufficient interruptions is not yet clear. Metabolic (Dunstan et al., 2012) and musculoskeletal (Roelofs & Straker, 2002) outcome studies suggest that interrupting sedentary behaviour after 20 or 30 minutes has a positive effect on outcomes in the short term, suggesting that bouts longer than this duration may be sufficiently excessive to increase the risk of negative outcomes.

Further, the duration and the nature of the interruption from sitting that is required to reduce the increase in risk associated with a prolonged sitting exposure are not yet clear. However, initial evidence suggests that interruptions of light intensity activity (e.g. slow walking) and short duration (2 minutes) may be sufficient for beneficial metabolic effects to be observed short term in overweight/obese individuals (Dunstan et al., 2012). Providing an interruption of 30 minutes of standing after every 30 minutes of sitting has been shown to reduce musculoskeletal discomfort (Roelofs & Straker, 2002).

Whether it makes a difference where sedentary behaviour is accumulated, i.e. occupational or non-occupational domains, remains unclear. However principles of proportional attribution imply that where occupational exposures account for a half of an individual's overall exposure (Parry & Straker, 2013), the occupational exposure can be considered to be responsible for half the negative consequences (Straker, Healy, Atherton, & Dunstan, 2014).

Given legal action has already been taken in Australia which proposed that prolonged sitting was a cause of work-related compensable disease ("Schodde and Comcare (Compensation) [2015] AATA 598," 2015), clear evidence on what constitutes excessive occupational sitting is urgently needed.

Key messages covered in this section

- Sitting exposure is not all toxic; however, both the total exposure and the pattern of exposure are probably important.
- What should be considered excessive for occupational sitting is not clear.
- More than 7 hours overall sedentary behaviour per day (by self-report) is likely to be detrimental to health and therefore considered excessive.
- Prolonged sitting bouts of more than 20-30 minutes are likely to be detrimental to health and therefore considered excessive in both occupational and non-occupational settings.

9. Potential mechanisms for harm from occupational sitting

The mechanisms underlying the links between sedentary behaviour and poor health and productivity outcomes are not yet well understood. However a number of different mechanisms appear likely and provide a useful basis for considering potential control solutions.

Insufficient dynamic muscle activity is likely to be an underlying mechanism as it is linked to both insufficient energy expenditure and insufficient movement/lack of postural variety. Muscle activity directly contributes to energy expenditure but may also indirectly influence energy expenditure by altering metabolic pathways. In animal models, local muscle contractile activity influences maintenance of lipoprotein lipase activity — one of the key enzymes in glucose and lipid metabolism (M.T. Hamilton, Hamilton, & Zderic, 2004). In humans, muscle activity has beneficial effects on enhancing blood flow and skeletal muscle gene expression, including specific genes involved in carbohydrate metabolism (Latouche et al., 2013). Recently, low muscle activity has also been associated with cardio-metabolic risk biomarkers (Pesola et al., 2015). Muscle activity is also essential for movement and to enable changes in posture. For example changing from sitting to standing requires the use of large lower limb muscles and thus both energy expenditure and movement/posture variation.

It has been suggested that the association between sitting and adverse health outcomes such as obesity, metabolic syndrome, type 2 diabetes and cardiovascular disease may also be a consequence of the low amount of **energy expenditure** created by sitting (M. T. Hamilton, Hamilton, & Zderic, 2007). The increased premature mortality risk associated with higher sedentary behaviour is probably predominantly a consequence of the related metabolic changes on pathways to cardio-metabolic and cancer health outcomes.

Static postures, and thus a lack of movement and posture variation, have been proposed to increase musculoskeletal discomfort through prolonged stress on passive connective tissues such as ligaments and intervertebral discs, muscle fatigue and compromised circulation. Pain pathways can be stimulated by direct nerve pressure and by biochemical changes in tissues during fatigue or ischemia. Both standing and stepping increase skeletal muscle activity compared to a sitting or reclining posture (Tikkanen et al., 2013). While not likely to contribute to premature mortality, musculoskeletal pain disorders are often the most prevalent, burdensome and costly occupational health issues.

In addition to increases in muscular activity, transitioning from sitting to standing involves other physiological responses to counteract the effects of **gravity** on the body which may be beneficial. These include cardiovascular reflexes to restore mean arterial pressure and counteract pooling of blood in veins in the lower legs. In contrast, prolonged sitting has been shown to lead to a reduction in lower leg blood flow and blood vessel dilation (Restaino, Holwerda, Credeur, Fadel, & Padilla, 2015) which may have implications for cardiovascular risk. Evidence from studies on prolonged bed rest and space flight (both examples of reduced gravitational effects) suggests a number of detrimental health effects including decreased insulin sensitivity, increased levels of triglycerides in the blood and loss of muscle mass and strength (Bergouignan, Rudwill, Simon, & Blanc, 2011; Pavy-Le Traon, Heer, Narici, Rittweger, & Vernikos, 2007; Vernikos, 1996). Although these are extreme examples of sedentary behaviour, they suggest gravity may be an important mechanism.

Additional potential mechanisms for harm from occupational sitting relate to changes in circulation (blood pressure and plasma volume) (Jacob et al., 1998), sympathetic nervous system activity (Convertino & Cooke, 2002), endocrine function and low grade systemic inflammation. Several research groups are now dedicating significant attention to providing a better understanding of these mechanisms.

Recent attention has been devoted to undertaking trials to better understand the acute metabolic effects of **interrupting prolonged sitting time**. Studies undertaken have consistently observed improved post-meal blood glucose levels following the initiation of frequent (every 20-30 minutes) short (2-3 minutes) interruptions during prolonged sitting involving walking (Dunstan et al., 2012; Larsen et al., 2014). Furthermore, it has been reported that alternating sitting and standing work every 30 minutes leads to more favourable blood glucose levels and discomfort levels relative to prolonged seated work (Roelofs & Straker, 2002; A.A. Thorp et al., 2014). The studies have also shown beneficial effects of interrupting sitting time on blood pressure (Larsen et al., 2014) and fibrinogen (an important marker of cardiovascular risk (B. J. Howard et al., 2013)) and skeletal muscle gene expression) (Latouche et al., 2013).

Key messages covered in this section

- The harm associated with occupational sitting is potentially due to:
  - Insufficient dynamic muscle activity
  - Insufficient energy expenditure
  - Insufficient movement/lack of postural variety
  - Insufficient interrupting of prolonged sitting, and
  - Diminished gravitational resistance and a number of other mechanisms.

10. Key aims to minimise harm from occupational sitting

The evidence from health outcomes and potential mechanisms clearly supports the need for two aims to minimise the risk of harm associated with occupational sitting exposure:

1) to reduce the overall accumulation of occupational sitting when this is high by substitution, and

2) to interrupt prolonged bouts of occupational sitting.

Figure 8 illustrates these two aims using a sedentary work day timeline as an example – from starting the work shift in the morning through to end of the work shift. In the first line sitting is only interrupted with walking at morning, lunch and afternoon breaks. Substituting two periods of sitting with standing reduces the overall accumulation of sedentary time – thus addressing the first aim, but with little impact on the second aim. Interrupting sitting regularly with walking reduces the number of prolonged bouts of sitting – thus addressing the second aim, but with little impact on the first aim. Alternating sitting with standing every 30 minutes addresses both aims by substituting half of the sitting work time standing and providing an interruption to prolonged sitting. Finally, substituting some sitting with standing and interrupting both sitting and standing address both aims. Addressing both aims creates maximum task variety.

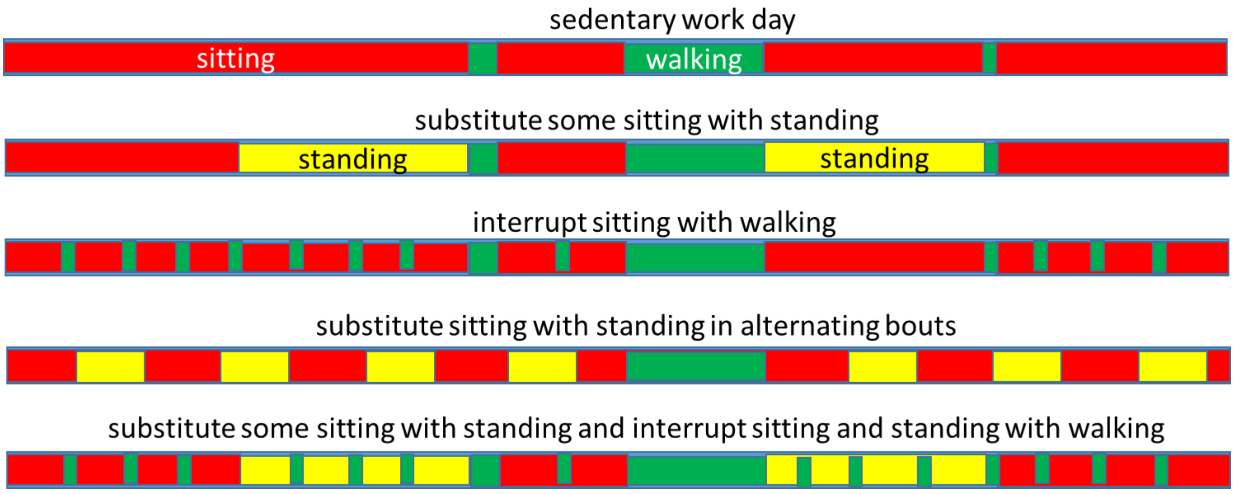

Figure 8 Illustration of how the hazard of sedentary work can be reduced by substitution and interruption of sitting time.

Section 11 reviews the potential alternatives to occupational sitting that could be used to address the first aim by substituting sedentary tasks with non-sedentary tasks. Section 12 reviews the options for addressing the second aim interrupting prolonged bouts of sitting.

10.1 Criteria for appropriate alternatives to sitting

In section 9 of this report, a number of underlying mechanisms that may play a role in the aetiology of adverse health effects of occupational sitting were outlined. These mechanisms suggest alternatives to sitting should satisfy at least one of the following criteria:

- Increase muscle activity
- Enhance energy expenditure, or
- Create movement/posture variation.

10.1.1 Increase muscle activity

Behaviour at the workplace that increases dynamic muscle activity might play an important role in counteracting the adverse health effects of sitting, particularly on musculoskeletal and metabolic health.

Muscle activation triggers a cascade of neural, circulatory and metabolic events which are important to health. The nature of the muscle activity plays a critical role in the consequences triggered. Prolonged isometric muscle activity (where tension is maintained at a similar level in a muscle without variation and without movement – often called ‘static’ muscle activity) is linked with reduced circulation, more rapid onset of muscle fatigue, and increased risk of musculoskeletal disorders. In contrast, dynamic muscle activity (where the level of tension varies to include either a rest phase or both low and high tension phases) typically induces movement and increases circulation. Muscles vary in their capacity to generate tension, with muscles with larger cross-sectional area able to generate higher tensions. Thus levels of muscle activity should be evaluated in terms of the relative capacity of the particular muscle, not the absolute tension generated. Muscles also vary in their capacity to resist fatigue. Large muscles involved in common anti-gravity activities such as standing typically have higher capacities for both tension generation and fatigue resistance and are thus typically good targets to increase muscle activity during occupational tasks.

Excessive static muscle activity and excessive repetitive or high levels of activity are likely to result in fatigue and poorer health and work outcomes.

10.1.2 Enhance energy expenditure

Behaviour at the workplace that enhances energy expenditure might play an important role in counterbalancing the adverse health effects of sitting, particularly cardio-metabolic health. Energy expenditure can obviously be increased by substituting sitting with either moderate to vigorous physical activity (MVPA) or light physical activity (Levine, Schleusner, & Jensen, 2000).

Within many occupational contexts, the feasibility of undertaking normal work tasks while expending more than 3 METs may be limited. Indeed the concept of *increasing* such physical demands in work tasks is contrary to the dominant paradigm of work design that developed in the mid 20th century (Straker & Mathiassen, 2009). While reducing MVPA may be an appropriate approach to risk reduction in jobs with high physical activity demands, it may be inappropriate in jobs with low physical demands. However substituting many hours of sedentary tasks with MVPA tasks would simply replace one hazard with another. Thus while introducing some MVPA into jobs may be appropriate, substitution of hours of sedentary tasks with hours of MVPA tasks is unlikely to be suitable in most situations.

Thus, within many occupational contexts, task substitution to increase energy expenditure is likely to be more feasible with light activity, as this can be sustained for greater proportions of the work day. Furthermore, replacing substantial amounts of occupational sedentary time with light physical activity could substantially increase the daily amount of energy expenditure. In addition to the likely greater feasibility, light physical activity is associated with favourable cardio-metabolic biomarkers (B. Howard et al., 2015), in particular blood pressure and cholesterol levels (Carson et al., 2013) and adiposity (Dowd, Harrington, Hanniga, & Donnelly, 2014) and is thus likely to have positive health impacts.

However excessive energy expenditure is likely to lead to fatigue and poorer health and work outcomes.

10.1.3 Create movement or variation in posture

Behaviour at the workplace that creates movement and variation in postures might play an important role in counteracting the adverse health effects of sitting, particularly on musculoskeletal and metabolic health.

Changing from one posture to another, for example sitting to standing, creates brief movement and also postural variety. Such variation has been shown to reduce musculoskeletal discomfort (especially in shoulders, upper back and lower back) without negatively affecting work productivity (Davis & Kotowski, 2014). Within static postures there are also variable amounts of small movement and posture variation possible, for example fidgeting. While postural variety has usually been encouraged in work system designs over the last 60 years, enhanced movement (fidgeting) was used as an indicator of *poor* seat design in early ergonomics research. Thus, criteria for optimal work design need to be revised to suit the emerging hazard of occupational sitting.

Dynamic activities, such as cycling and walking, create rhythmic movement, and thus varying muscle activity which reduces risks of static muscle overload and enhances circulation. Thus variability in movements and postures has been suggested to improve musculoskeletal health (Srinivasan & Mathiassen, 2012).

However, excessive movement, particularly repetitive motions, is likely to lead to tissue fatigue and poorer health and work outcomes.

Key messages covered in this section

- Key aims to reduce occupational sitting exposure are:
    - reduce the overall accumulation of occupational sitting when this is high by substitution, and
    - interrupt prolonged bouts of occupational sitting.
- Criteria for appropriate alternatives to sitting are:
    - Increase dynamic muscle activity
    - Enhance energy expenditure, and
    - Create movement/ postural variety.

11. Potential substitution alternatives to sitting

This section reviews the various potential alternatives to sitting, firstly examining static posture alternatives and then dynamic posture alternatives. These alternatives target the first aim of reducing overall occupational sitting exposure by enabling substitution during productive tasks[5]. Understanding the alternatives is important since the different alternatives available will have differential effects (Buman et al., 2014; Healy et al., 2015) and have different feasibility and implementation issues.

11.1 Static postures

Sitting, standing, kneeling and lying are postures that could be used for occupational tasks. Kneeling and lying have limited applicability in most workplaces, thus standing is the main potential static posture alternative to occupational sitting.

11.1.1 Standing

Standing behaviour has been shown to be negatively associated with mortality, suggesting it could be a healthy alternative to prolonged sitting (Katzmarzyk, 2014; van der Ploeg et al., 2014).

Thigh muscle activity during standing has been reported to be 2.5 times the level during sitting, at around 2.5% maximum voluntary contraction (Tikkanen et al., 2013). However this varied considerably between around 1% and 6% maximum voluntary contraction, on average. Patterning of thigh muscle activity during standing, related to small postural shifts commonly seen in standing, are likely to be important.

While there is consistent evidence that heart rate is higher during standing than sitting, there are mixed conclusions on whether standing results in higher energy expenditure than sitting based on the available studies (MacEwen, MacDonald, & Burr, 2015; Tudor-Locke, Schuna, Frensham, & Proenca, 2014). For example, working at a standing desk resulted in 1.36 kcal/min compared with 1.02 kcal/min working sitting at a desk (Reiff, Marlatt, & Dengel, 2012) but was similar in another study (~1.25 for both from graph; (Beers, Roemmich, Epstein, & Horvath, 2008)). A potential reason for the lack of clarity in findings is that there is a difference in energy expenditure in standing depending on whether the person is standing motionless or fidgeting while standing (Levine et al., 2000). A laboratory study of healthy adults found standing motionless to result in a 6.1% increase in energy expenditure compared to resting lying down, with sitting motionless resulting in a 5.6% increase: sitting while fidgeting resulted in a 8.2% increase and standing while fidgeting resulted in a 10.3% increase. Given workers are likely to fidget during standing, energy expenditure during standing at work is likely to be slightly greater than during sitting, and this slight increase may well have important health implications given the large accumulation possible.

Evidence on the metabolic effects of standing is also mixed but suggests beneficial effects. In overweight office workers, alternating sitting and standing every 30 minutes resulted in some modest beneficial effects on post-meal blood glucose (A.A. Thorp et al., 2014). However, a day of substantial standing was not able to change post-meal blood lipid markers in one short term trial, although 30 minutes of brisk walking was able to change blood lipids (Miyashita et al., 2013). Modelling of the

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[5] Productive tasks refers to tasks which contribute to a relevant work outcome and thus do not include tasks such as going to the bathroom.

effect of substituting sitting with standing in an epidemiological study suggests standing does contribute usefully to glucose and lipid metabolism, though not clearly to adiposity (Healy et al., 2015).

Thus the upright posture, greater thigh muscle activity, raised heart rate and probably slightly raised energy expenditure during standing, along with epidemiological evidence of beneficial relationships with biomarkers and health, suggest it meets the criteria to be a useful alternative to substitute for sitting.

As previously mentioned, excessive exposure to postures and movements other than sitting potentially creates other risks and there is evidence to suggest excessive occupational standing increases risks of musculoskeletal, venous and prenatal health and general fatigue.

Several studies have found some, although not conclusive, evidence that excessive occupational standing is associated with **musculoskeletal** disorders, particularly in the lower limbs (Allen et al., 2010; da Costa & Vieira, 2010; Irving, Cook, & Menz, 2006) and low back (Andersen, Haahr, & Frost, 2007; Roelen, Schreuder, Koopmans, & Groothoff, 2008; Tissot, Messing, & Stock, 2009). The increased low back discomfort risk may be due to greater compression loads (and greater spinal shrinkage) on the spine in standing posture as compared to sitting posture (van Deursen, van Deursen, Snijders, & Wilke, 2005). Although muscle fatigue has been suggested to be another potential mechanism for the development of low-back pain during prolonged standing, no conclusive evidence for such an aetiology has been found (Antle, Vézina, Messing, & Côté, 2013; D. E. Gregory & Callaghan, 2008).

An increase in discomfort in the lower limbs due to prolonged standing has been associated with an increase in lower limb volume and circumference, suggesting increased **venous** pooling) (Chester, Rys, & Konz, 2002). As such, long periods of occupational standing have been suggested to be associated with venous insufficiency and varicose veins (Beebe-Dimmer, Pfeifer, Engle, & Schottenfeld, 2005; Jawien, 2003; Pinto Pereira et al., 2012).

Several systematic reviews have found some evidence, although again limited, that excessive occupational standing was related to poorer **prenatal** health. For example, there was a 16% increase in relative risk of miscarriage with occupational standing ≥6–8 hours a day (Bonde, Jorgensen, Bonzini, & Palmer, 2013). Similarly, occupational standing was associated with preterm-delivery (van Beukering, van Melick, Mol, Frings-Dresen, & Hulshof, 2014), low birth weight and pre-eclampsia (high blood pressure during pregnancy) (Bonzini, Coggon, & Palmer, 2007). A third review found inconclusive results for the association of prolonged standing (in general, not just occupational) and pre-term birth (Domingues, Matijasevich, & Barros, 2009).

Excessive occupational standing has also been associated with general **fatigue** (Chester et al., 2002).

The implications of excessive occupational standing have been known for some time, and resulted in work system changes over the latter half of the 20th century to reduce occupational standing. Work changes which have included changing standing workstations to seated workstations and providing stools at standing workstations to enable sitting. However with increasing evidence on the health effects of prolonged sitting and increasing sitting exposure of many workers, a new approach may now be required to obtain a suitable balance between excessive sitting and excessive standing.

While it is clear excessive prolonged standing is not a suitable work design (Messing, Stock, Cote, & Tissot, 2015), the evidence supports alternating between sitting and standing. In a recent review, it was found that in general sit/stand workstations were able to reduce musculoskeletal discomfort and that sit/stand workstations did not reduce work productivity (Karakolis & Callaghan, 2014). For example, alternating between sitting and standing every 30 minutes over a day resulted in lower musculoskeletal discomfort in bank tellers compared to just sitting or just standing all day (Roelofs & Straker, 2002). Similarly, alternating between sitting and standing every 30 minutes had modest beneficial effects on post-meal glucose metabolism (A.A. Thorp et al., 2014). Alternating 45 minutes of standing with 15 minutes of sitting may not be a good substitution solution, as a laboratory study found that over half of participants had increasing low back discomfort (K.M. Gallagher, Campbell, & Callaghan, 2014). Given likely individual vulnerability to low back pain in standing, the optimal pattern of alternating standing and sitting is likely to vary between workers.

Prior studies have also provided evidence for a number of workstation design features which can be used to minimise the potential negative impacts of standing, including cushioned floor surface, soft shoe insoles, sloped floor surfaces and a foot rest bar (Cham & Redfern, 2001; K. M. Gallagher, Wong, & Callaghan, 2013; Ganesan, Lee, & Aruin, 2014; Hansen, Winkel, & Jorgensen, 1998; King, 2002).

Given many occupations previously required considerable standing, the **feasibility** of reintroducing some standing is high for many occupations. Thus, there is potential for office, factory/industrial, retail/sales, and some transport jobs to have productive tasks completed in both sitting and standing postures. For example, train drivers who have the option to stand during train operation and call centre workers who have the option to stand during customer calls. However substituting periods of standing for sitting may not be feasible for all jobs (e.g. long distance truck drivers).

Supporting the feasibility of using standing to substitute for sitting for some jobs is that work productivity during standing computer tasks appears to be equal to that of seated computer tasks (Husemann, Von Mach, Borsotto, Zepf, & Scharnbacher, 2009; MacEwen et al., 2015; Straker, Levine, & Campbell, 2009).

11.2 Dynamic 'postures'

Dynamic 'postures' – where some bodily movement occurs – include 'active' sitting and walking. 'Active' sitting postures include seats without a backrest, seats which are less stable, seats which move, doing exercises while seated and cycling while seated. Walking includes on a treadmill linked with a desk and free walking.

11.2.1 'Active' sitting

A number of different designs have been developed which attempt to increase the movement of workers while they remain seated. As noted previously, fidgeting while sitting results in small increases in energy expenditure than sitting motionless, though still with low levels (Levine et al., 2000). Most of these options would most likely not increase energy expenditure to more than 1.5 METS and would therefore remain classified as sedentary. Most of the research on 'active' sitting has been in office tasks, and although there is considerable research on transport seating, it has typically focussed on aspects such as vibration exposure.

Sitting without using the support of a back rest has been associated with an increase in trunk muscle activity. For example, an observational study monitoring back muscles over two hours found some back muscles were twice as active during periods of sitting when the back rest was not being used (Morl & Bradl, 2013). However, the level of back muscle activity was strongly related to lumbar posture, with activity declining to minimal in a slumped back (relative kyphosis) posture. Interestingly, the back rest was observed to be utilised for less than half of the time.

Thus while provision of a chair without a back rest is thought to enhance trunk movement and muscle activity, slumped sitting is likely to result in little trunk muscle activity.

Sitting on an unstable seat has been proposed to encourage trunk movement and muscle activity. Short term laboratory studies have shown that there are small increases in trunk movement, but often no increase in recorded muscle activity (Ellegast et al., 2012; O'Sullivan et al., 2006; van Dieen, de Looze, & Hermans, 2001). A different version of a passively unstable seat is the use of a large ball for a seat. A number of laboratory studies have examined the movement and muscle activity in comparison with a standard office chair, with most reporting minimal differences (D.E. Gregory, Dunk, & Callaghan, 2006).

Sitting in a radical chair design developed to enforce more trunk movement and muscle activity by using a small motor to repeatedly move the seat pan has been evaluated, but failed to create movement and muscle activity greater than a standard office chair (Ellegast et al., 2012).

Another approach to 'active' sitting that has been more successful in creating movement, muscle activity and thus energy expenditure is **under-desk cycling**. Laboratory studies have shown that heart rate is increased by around 20bpm when working at a computer while cycling compared with standard office chair computer work (Elmer & Martin, 2014; Straker et al., 2009). Elmer et al recorded an increase in energy expenditure from around 100kcal/hr (~1.3METS) in standard seating to around 250 kcal/hr (~3.3 METS) while cycling. In another laboratory study involving young people, it was shown that muscle activity was seven to eight times higher during desk cycling compared to regular sitting, with positive influences on a blood glucose metabolic marker, though not on other cardio-metabolic makers (Altenburg, Rotteveel, Dunstan, Salmon, & Chinapaw, 2013). Energy expenditure can obviously be varied enormously from just above resting levels to vigorous intensity levels. Generally the trials simulating workplace use have used very light intensity cycling, which could be performed without becoming breathless or sweating. These and other studies which have examined computer task performance have noted either no decrement or just a small decrement in typing and mouse performance (Commissaris et al., 2014). The feasibility relating to the long term use of desk cycling is yet to be determined, with issues related to localised discomfort, expense and noise noted (Baker et al., 2015).

A final approach to 'active' sitting is encouraging workers to undertake regular exercises while sitting, for example, shoulder 'shrugs', wrist stretches and head rolls. While this would take away from productive time for some tasks, some exercises may be possible and useful in very constrained workplaces such as machine operation cabins. Regular exercises while seated have been shown to reduce discomfort in call centre workers (Fenety & Walker, 2002). However the sustainability of such workplace exercises is questionable as most organisations which introduced similar interventions in the 1980s to help prevent Repetitive Strain Injury were not able to maintain adherence.

In summary, altering seat designs to create less support, less stability or more movement is conceptually attractive but yet to demonstrate significant trunk movement and muscle activation effects and increases in energy expenditure (Beers et al., 2008). Further, some of the designs have resulted in increased discomfort and some (fitballs) create new falling hazards, suggesting no benefit but some detriment. Additionally, none have demonstrated successful sustained workplace integration.

11.2.2 Walking

Walking is known to result in a useful increase in muscle activity, energy expenditure and body movement and therefore meets the criteria for a useful substitute for sitting.

There is good evidence that walking initiatives that encourage people to be less sedentary and more active have numerous health benefits including reduced blood pressure, body fat and total cholesterol and risk of depression (Hanson & Jones, 2015). Therefore, replacing sedentary occupational tasks with walking could counteract the adverse health effects of occupational sitting exposure.

Walking can be implemented in a work setting for productive tasks by either using a treadmill at a workstation for computer or other tasks, or by free walking during tasks that do not require a stationary workstation (e.g. discussion with a colleague).

In a work context, walking can be light intensity and not create breathlessness or sweating, yet still result in a substantial increase in energy expenditure. For example, walking at a gentle self-selected pace around 1.8kph while performing computer work at a treadmill workstation has been shown to result in an energy expenditure of around 190 kcal/hr compared with standard seated computer work of around 70 kcal/hr (Levine & Miller, 2007; Thompson, Foster, Eide, & Levine, 2008). Recent epidemiological modelling suggests that light activity, such as walking at a treadmill desk, is likely to have a stronger beneficial effect on lipid and glucose metabolism and on adiposity than standing (Buman et al., 2014; Healy et al., 2015).

Available evidence suggests that walking for some of the work day at treadmill workstations may be a feasible option for substitution of sedentary tasks (Thompson et al., 2008). Several laboratory studies have shown that the short term detrimental impact on typing performance is small, though more marked for fine computer mouse control performance (Commissaris et al., 2014; Straker et al., 2009). Other studies found no differences between desk based walking compared to sitting on higher cognitive functions (e.g., measured with attention, information processing, interference control and reading comprehension tests) (Alderman, Olson, & Mattina, 2014). Longer term field trials have shown promising effects on cardio-metabolic (e.g., resting heart rate and blood pressure, blood lipids and cholesterol) and anthropometric (e.g., weight and waist circumference) factors (MacEwen et al., 2015).

The long term feasibility of walking tasks and treadmill walking tasks, and thus the potential for large scale adoption in workplaces, is still unclear. Barriers to introduction of treadmill workstations include their expense, potential to create a fall hazard and noise if not well engineered. Treadmill workstations have mainly been trialled in office environments but may also be feasible in light industrial settings if fine motor control is not required.

'Free' walking, that is walking around the environment and not on a treadmill, may result in similar benefits to treadmill walking and may also have unique barriers including physical spaces and weather.

11.3 Substitution of work-related but non-productive work time sedentary tasks

The commute to work, as well as standard meal and formal breaks, are other periods where workers typically accumulate sedentary exposure. These work-related periods are opportunities for workplaces to assist workers to reduce their overall sedentary exposure.

The average time Australians spend in sedentary transport has increased in the last decades (Chau, Merom, et al., 2012), with an average of more than one hour of sedentary transport daily. This is potentially related to an increase in vehicle ownership (Australian Bureau of Statistics, 2013b) and an increase in vehicle kilometres travelled per year and per day (Brownson et al., 2005; Millard-Ball & Schipper, 2011).

Substituting some or all of the commute to and from work with standing, walking or cycling is a potentially feasible strategy for workers to decrease their daily sedentary behaviour exposure. Walking to work has significantly higher energy expenditure than driving to work (Lanningham-Foster et al., 2003) and cycling has greater energy expenditure than sitting (Elmer & Martin, 2014).

A systematic review found some evidence for improvement in health outcomes (i.e., reduction of the risk of all-cause mortality, hypertension, and type 2 diabetes) for active transport (walking and cycling) (L. E. Saunders, Green, Petticrew, Steinbach, & Roberts, 2013).

Being active during formal breaks and meal breaks, rather than being sedentary, is also a potentially feasible strategy organisations can support to reduce worker overall sedentary exposure. In an international study that included Australian office workers, an intervention over 10 weeks that used movement strategies during work breaks led to a reduction in occupational sitting by 15 minutes/day (N. D. Gilson et al., 2009). However, a linked qualitative study indicated that these workers found it difficult to frequently and consistently move more and sit less during work breaks, because of work pressures and time limitations (N. Gilson, McKenna, & Cooke, 2008).

Key messages covered in this section

- Standing, walking and desk-based cycling are potentially viable alternatives to sedentary postures to perform productive tasks.
- The long term feasibility and extent to which these alternatives can be used in ‘white’ and ‘blue’ collar workplaces is yet to be determined.
- Most ‘active’ sitting options probably provide little cardio-metabolic benefit, although they may provide some musculoskeletal benefit.
- Active commuting and being active during non-productive breaks at work are feasible alternatives to sitting and can reduce overall daily exposure.
- Substitution of work and non-work sitting tasks with standing and moving tasks throughout the day will reduce occupational sitting exposure.

12. Potential interruptions from occupational sitting

This section reviews the various potential options to interrupt occupational sitting and thus targets the second aim of minimising prolonged periods of sedentary behaviour.

An interruption in sedentary behaviour is created by a change to a different posture or energy expenditure level. Thus switching from sitting to performing a task in standing creates an interruption as does a brief walk to a water fountain, as illustrated in Figure 8, Section 10. The new activity can be a productive task, such as working on a computer at a treadmill workstation, or a non-productive task, such as walking to the bathroom.

The majority of workplace recommendations suggest prolonged sedentary work, typically computer work, should not be maintained for longer than 30-60 minutes. For example, the Comcare Guide to Health and Safety in the Office (Australian Government - Comcare, 2008) advises to: 'spend a maximum of 30 minutes at any one time in front of the computer screen'. Similarly, the Western Australian Code of Practice for Call Centre Workers (Western Australia Commission for Occupational Safety and Health, 2005) advises to put in place breaks from prolonged tasks of; five minutes for each 30 minutes or, 10 minutes each hour. Comparable advice has been given by in the European Union Checklist for Preventing Bad Working Postures (European Agency for Safety and Health at Work, 2008). These recommendations were based on mainly concerns related to musculoskeletal and visual discomfort.

Recently metabolic evidence has been reported which supports the desirability of keeping sustained sitting to no longer than 20-30 minutes. Laboratory studies have found that interrupting sitting every 20 or 30 minutes with either light or moderate intensity physical activity results in lower post-meal glucose and insulin levels (Dunstan et al., 2012; Peddie et al., 2013) and lower resting blood pressure (Larsen et al., 2014) compared to prolonged sitting.

The current evidence therefore indicates that avoidance of prolonged periods of sitting is beneficial. However it is not yet clear what the nature of any interruption needs to be to optimise health and work outcomes. Aspects which are likely to be important include the type and intensity of activity and the length and frequency of interruptions. Interruptions could involve intensities ranging from rest through to vigorous and involve stretching, resistance activities or dynamic activities. They could involve different muscles groups or the same muscle groups as were used during the sustained activity.

12.1 Task variation

Both substituting some sedentary productive time for non-sedentary productive time and using productive or non-productive interruptions to avoid prolonged sedentary periods create task variability. Given the variability in human physiology it is likely that there is no one best design in terms of optimised substitution and interruption of occupational sitting. Thus the current evidence that task variation can enhance health is mixed (Leider, Boschman, Frings-Dresen, & van der Molen, 2015; Luger, Bosch, Veeger, & de Looze, 2014; Srinivasan & Mathiassen, 2012). Despite this, it is relatively clear that work system designs which promote task variation, to ensure overall exposure to sitting is limited and exposure to prolonged periods of sitting is minimised, should be recommended.

Combining task substitution and interruptions using good job design (Safe Work Australia, 2015) can reduce sedentary exposure and thus minimise harm. Studies have identified a number of strategies office workers can use to substitute and interrupt sitting using productive tasks, work-related breaks, commuting and non-productive tasks (Australian Government - Comcare, 2014; N. D. Gilson, Ng, et al., 2015).

Key messages covered in this section

- Musculoskeletal and metabolic experimental and epidemiological evidence supports the benefits of keeping sedentary task bouts to no longer than 20-30 minutes.
- Prolonged sitting can be interrupted by either the substitution of sitting with a productive or non-productive non-sedentary task, or by a brief non-sedentary activity.
- Examples of substitution tasks to interrupt sedentary tasks include: switching to work on a computer at a standing or walking workstation, switching to stand to read a document, switching to a standing meeting, switching to a walk with friends at lunch time, switching to stand for some of the public transport work commute.
- Examples of brief activities which can act as interruptions include: standing while talking on the phone, walking to deliver a message to a colleague rather than emailing, walking to get a drink or visit the bathroom.
- Good job design can use substitution and interruption to minimise the harm from excessive occupational sitting exposure.

13. Effectiveness of interventions to reduce occupational sitting

Interventions targeting reductions in prolonged occupational sitting have traditionally been driven by the field of ergonomics, with the aim to modify job tasks or policies to ensure regular postural changes and with musculoskeletal outcomes being the primary focus (G.N. Healy et al., 2012). Indeed, in 2010, a systematic literature review which aimed to summarise the impact of workplace interventions on sedentary time found no studies that measured occupational sitting changes as their primary outcome measure (Chau et al., 2010). Since then, and as noted in Figure 1, this research field has rapidly developed, and there are now results published from several intervention trials that have evaluated the effectiveness of various strategies to reduce prolonged workplace sitting.

To date, the majority of interventions have been undertaken in the desk-based office workplace, and this evidence is described in the following section, using evidence summarised in recent reviews (Chau et al., 2010; G.N. Healy et al., 2012; Neuhaus, Eakin, et al., 2014; Prince, Saunders, Gresty, & Reid, 2014; Shrestha et al., 2015; Tew et al., 2015; Torbeyns et al., 2014), as well as original research reports. This is followed by a section on intervention evidence from other sectors.

13.1 Effectiveness of interventions to reduce occupational sitting in office workplaces

Office workers have been identified as a key target group for interventions to reduce prolonged sitting time for several reasons including their high rates of sitting time (see section 5) and the large proportion of office workers within the workforce (office work is the largest individual occupational sector in Australia).

The 2010 review by Chau and colleagues (Chau et al., 2010) was the first (from a broader public health / physical activity discipline) to systematically summarise the effectiveness of workplace interventions targeting physical activity and/or sedentary behaviour on sedentary behaviour outcomes. Although no significant reduction in sedentary behaviour was observed, key limitations of the studies were noted. Specifically, the primary aim of all six studies identified was to increase occupational physical activity; all used subjective sedentary behaviour measures; only one measured occupational sitting; and, all studies targeted interventions solely at the individual level. In 2014, a similar review was conducted by Prince and colleagues (Prince et al., 2014), which included 33 studies, six of which addressed sedentary behaviour only, with seven targeting physical activity and sedentary behaviour. The authors concluded that interventions with a focus on physical activity or that included both a physical activity and sedentary behaviour component produced less consistent findings and generally resulted in modest reductions in sedentary time. In contrast, there was consistent evidence that large and clinically meaningful reductions in sedentary time can be expected from interventions with a focus on reducing sedentary behaviours. This suggests that to reduce prolonged workplace sitting time, interventions should specifically target occupational sitting.

Five recent reviews have investigated the effectiveness of various strategies for reducing workplace sitting time (G.N. Healy et al., 2012; Neuhaus, Eakin, et al., 2014; Shrestha et al., 2015; Tew et al., 2015; Torbeyns et al., 2014). The applied intervention strategies identified across all the reviewed studies could be considered as targeting either one or a combination of the broader categories of: the organisation's physical and cultural environment; tools/equipment/furniture; and, the individual worker.

13.1.1 Interventions targeting the organisational physical and cultural environment

One integral element that can restrict or promote activity is the organisation's physical environment. Interventions that target building design have the potential to impact on the behaviour of all employees, and once built, the intervention remains ongoing. To date, there is minimal evidence on the impact of the macro-level physical environment on occupational sitting, with some preliminary evidence suggesting that there may be some benefit (Gorman et al., 2013). Further evidence on the importance of the built workplace environment (both by itself, and in combination with other strategies to reduce workplace sitting) is required.

Organisational cultural environment strategies for reducing sitting time include visible management support, enabling health promotion activities to occur during work hours, and providing resources and implementing policies to support the change. The level of organisational support has been highlighted as a key element within successful workplace interventions (Neuhaus, Healy, et al., 2014), as well as an important barrier to change (Parry, Straker, Gilson, & Smith, 2013). No studies to date have specifically examined the impact of implementing only organisational level support strategies on workplace sitting time. Although occupational sitting was not specifically measured in most of the ergonomic focussed interventions reviewed by Healy and colleagues, it was noted that the intervention strategies (which included policy changes to instigate regular postural shifts and breaks from sitting) resulted in reduced musculoskeletal discomfort (G.N. Healy et al., 2012). In their systematic review, Shrestha and colleagues (Shrestha et al., 2015) concluded that the evidence regarding the effects of organisational policy changes (to support cultural environments that encourage reducing and interrupting prolonged sitting) on reducing workplace sitting is currently inconsistent and that high quality evidence is required.

13.1.2 Interventions targeting the tools/equipment/furniture

The most commonly trialled modification to the tools/ equipment/furniture has been activity-promoting workstations. These have included sit-stand desks, treadmill desks and cycling workstations and have the potential to enable productive work to be performed in a non-sedentary manner. In terms of the risk control hierarchy model of the International Labour Organisation and Safe Work Australia, these changes in equipment are considered as engineering controls (International Labour Organisation, 1981; Safe Work Australia, 2011b). The three reviews evaluating their effectiveness (Neuhaus, Eakin, et al., 2014; Tew et al., 2015; Torbeyns et al., 2014) all concluded that activity-promoting workstations can be effective in reducing occupational sedentary time. This reduction can be substantial, with a meta-analysis reporting a pooled effect-size of a 77 minutes reduction in workplace sitting per eight-hour workday following intervention (Neuhaus, Eakin, et al., 2014). Intervention effects varied by the workstation design, with the impact on workplace sitting small and non-significant in a study which trialled the use of standing 'hot-desks' (i.e. not every participant had a standing desk) (N. D. Gilson, Suppini, Ryde, Brown, & Brown, 2012), and considerable (>2 hour reduction per 8 hour work day) in an intervention where the workstations were used in conjunction with organisational- and individual-level support strategies (Healy et al., 2013). No significant changes in health outcomes or work-related outcomes (such as work performance, absenteeism, and presenteeism) were observed across most outcomes reported. However, improvements in waist circumference and psychological well-being, and some detrimental impact on musculoskeletal outcomes, and short term work performance were noted (Neuhaus, Eakin, et al., 2014). Specifically, musculoskeletal outcomes worsened in 16/122 outcomes reports, of which two used standing desks without height adjustable chairs, three used standing desks with height adjustable chairs, and one used a height adjustable desk. Deleterious impacts on short term work performance was observed in 7/23 studies, of which six used a treadmill desk, and one used a cycle desk. No detrimental impact on work performance was observed following the installation of height-adjustable desks.

Studies with acceptability measures reported predominantly positive feedback (Neuhaus, Eakin, et al., 2014). Although specific information regarding the cost-effectiveness of interventions including activity-permissive workstations is yet to be reported, one case study observed a return on investment of 10 Euros for every Euro spent (G.N. Healy et al., 2012).

13.1.3 Interventions targeting the individual worker

Similar to the organisational level strategies, the evidence regarding the effects of strategies targeting the individual worker (such as through information and counselling or feedback and prompts) on reducing workplace sitting is currently inconsistent (Shrestha et al., 2015). For example, one study using hourly prompts found significant reductions in both overall sitting time (-6.6%), and time accrued in prolonged sitting bouts (-54%) (Swartz et al., 2014); whereas another study found no considerable effect of computer prompts on reducing sitting at work (mean difference -18 minutes) (Evans et al., 2012). It is likely that individual level strategies will need to be used in combination with higher level controls.

13.1.4 Multi-level interventions

Larger reductions in occupational sitting time were typically reported following interventions that targeted multiple aspects of the work system, compared to interventions that just targeted a single aspect (Healy et al., 2013). The potential impact of targeting multiple levels was specifically examined in one study. Here, the effectiveness of a sit-stand workstation-only intervention was compared to a multi-component intervention (including the same sit-stand workstation plus individual- and organisational-level support strategies) (Neuhaus, Healy, et al., 2014). This study reported a nearly three-fold greater reduction in workplace sitting time following the multi-component intervention (-89mins/8-hr workday vs. -33mins/8-hr workday) than what was observed following installation of just the activity-permissive workstations. This suggests that activity-permissive workstations can reduce workplace sitting time, however, additional support is likely to be required for more substantial change.

13.1.5 Qualitative evidence on barriers and facilitators for interventions in office workers

Studies that have utilised focus groups and interviews in their study design provide complementary data to support systematic review evidence, and most importantly, rich and meaningful insights into the barriers and facilitators that discourage or promote the uptake of sitting reduction strategies in office workers.

Since 2011, eight studies have qualitatively investigated worker, employer and practitioner experiences, perceptions and opinions around occupational sitting exposure (See Appendix 1 for summaries of studies). Most of these studies have taken place in Australia (Chau, Daley, et al., 2014; Cooley, Pedersen, & Mainsbridge, 2014; N. Gilson, Straker, & Parry, 2012; N. D. Gilson, Burton, van Uffelen, & Brown, 2011; Grunseit, Chau, van der Ploeg, & Bauman, 2013), with other studies contributing data from Belgium (de Cocker et al., 2015), Spain (Bort-Roig et al., 2014) and the US (Tudor-Locke, Hendrick, et al., 2014).

The studies by Chau et al (Chau, Daley, et al., 2014) and Grunseit et al (Grunseit et al., 2013) both examined post-intervention issues linked to sit-stand desks. Workers identified problems of using these desks in an open plan office, presumably because of privacy issues; the view that desks were benefitting health and productivity was perceived as a facilitator. Tudor-Locke et al (Tudor-Locke, Hendrick, et al., 2014) interviewed overweight or obese workers using treadmill desks; these workers highlighted that desks were difficult to use because of conflicts with work demands. Cooley et al (Cooley et al., 2014) qualitatively evaluated the impact of using a desk-based e-health intervention, which forced users to interrupt sitting by switching off computers. The requirement and inconvenience to interrupt work in progress was reported to be a major barrier.

Two studies have used focus groups as formative research to inform multi-component interventions (de Cocker et al., 2015; N. D. Gilson et al., 2011). Findings from both these studies identified productivity concerns as a major barrier to strategy uptake, and the importance of promoting combined responsibility for change (from workers, management and the company) as a key facilitator. A recent study by Bort-Roig et al (Bort-Roig et al., 2014) was valuable in capturing participant perspectives of ‘sit less and move more’ strategies during implementation; interviewees reported computer-based work to be the most significant barrier to change, while the most important facilitators were self-monitoring of sitting time, and providing workers with a menu of strategy options from which they could choose.

Lastly, a formative study by Gilson et al (N. Gilson et al., 2012) aimed to repeat worker focus group questions with Australian work health and safety practitioners. Similar to workers, practitioners considered productivity concerns, strategy contextualisation to job role, and balancing of choice with obligatory change as important factors influencing strategy adoption. Unique issues raised by this group included the importance of generating cross-disciplinary evidence to inform effective practice, and the need for multiple strategies that target regular changes in posture, as opposed to simply replacing sitting with standing, which was viewed as being equally as problematic as prolonged sitting.

13.2 Effectiveness of interventions to reduce occupational sitting in non-office workplaces

While searches yielded no published intervention studies that have directly measured changes in occupational sitting exposure in non-office based occupations, a recently completed Australian project has reported on objectively measured changes as part of an energy balance intervention in truck drivers (N. D. Gilson, Pavey, et al., 2015). The intervention used an activity tracker and smartphone application to encourage truck drivers to monitor, self-regulate and reduce sitting exposure through increases in standing and moving during driving breaks, administrative tasks and when waiting for trucks to be loaded and unloaded. On average, drivers reduced accelerometer measured sedentary, non-driving work time by 4% (or 27 minutes/day) at the end of the 5-month intervention, and these reductions were maintained at two months follow-up.

13.3 Work systems which are sustainable and do not result in excessive occupational sitting exposure

In summary, interventions to reduce sitting exposure can be targeted on organisational environment, tools/equipment/furniture and individual levels of the work system. While worker education and awareness are important to any work health and safety intervention, more substantial work system changes are likely to be more robust and sustainable. Indeed, interventions in general have been more effective when they consisted of multi-components targeting each aspect of the work system (Neuhaus, Eakin, et al., 2014). Interventions which specifically focus on reducing sitting exposure appear to be more effective than interventions also targeting physical activity (Prince et al., 2014; Swartz et al., 2014).

Using participative approaches that aim to engage workers and develop a sense of ownership and commitment to change by managers/supervisors and employees working as a team are important in developing, implementing and promoting effective sitting reduction interventions (Parry et al., 2013). Generating a social and physical environment that supports and facilitates employees to sit less, communicating the purpose and associated evidence for the intervention and, having champions to role model and support the intervention messages also appear to be important. Essential elements for occupational sitting interventions have been mapped to frameworks (National Institute for Occupational Safety and Health, 2008) to guide successful intervention development (G.N. Healy et al., 2012). Evidence is also developing on the practical problems and solutions based on the real world experiences of employers, employees and workplace health and safety practitioners (N. Gilson et al., 2012; N. D. Gilson et al., 2011). Further understanding of the barriers and facilitators of adoption and maintenance of change is also required.

Notably, the field is in its infancy and there is an urgent need for evidence, from a range of workplaces including non-office workplaces, on what work system changes can effectively reduce occupational sitting exposure and how such changes can be implemented to create sustainable work systems devoid of excessive occupational sitting exposure.

Key messages covered in this section

- Intervention trials have mainly been conducted on office workers.
- Interventions to reduce occupational sitting of office workers can be effective, and reduce exposure by over an hour each work day.
- Interventions which target multiple aspects of the office work system are likely to be more effective than those targeting just a single aspect.
- Qualitative studies suggest that concern about productivity is likely to be the most significant barrier to change.
- Preliminary data suggests interventions can successfully reduce sitting exposure in highly sedentary non-office based occupations such as truck drivers.
- Evidence on the implementation of changes to create sustainable work systems is limited.

14. Conclusion

Available evidence suggests that occupational sitting is likely to be a common hazard in Australian workplaces. Occupational sitting is linked to significant negative health and work outcomes, and is increasingly being recognised in the community and by international authorities as an important issue that needs attention.

There appear to be a number of initiatives that have demonstrated some success in reducing occupational sitting exposure in some industries and occupations. There is a need for consideration of the development of appropriate mechanisms to support the assessment and control the risks associated with this workplace health and safety hazard.

Appendix 1

Summary of qualitative studies (n=8 in reverse chronological order) examining perceived barriers and facilitators for uptake of strategies to reduce and interrupt occupational sedentary exposure in office workers

Authors	Participants	Study Methods	Key Findings
De Cocker et al 2015	34 workers and 21 executives from 3 companies; Belgium.	Formative research using focus groups	Barriers included productivity concerns, impracticality, awkwardness of standing in the office, and the habitual nature of sitting. Facilitators included raising awareness of the dangers of sitting, providing alternatives for standing, taking personal responsibility for change, and making some strategies obligatory.
Bort-Roig et al 2014	12 academics and administrators from 4 universities; Spain	Interviews conducted 3 times during a 5 month 'sit less, move more' intervention	Screen-based office work was perceived to be the most important barrier to change. The most important facilitators were self-monitoring of sitting time and providing workers with a menu of strategy options.
Chau et al 2014	42 workers from a non-government health agency; Australia	Focus groups following a 4 week trial of sit-stand desks	Working in an open plan office and office design were barriers to sit-stand desk use. A supportive work environment and perceptions of benefits to health and productivity were facilitators.
Cooley et al 2014	15 operational and non-operational police officers; Australia	Interviews following a 13 week e-health intervention to reduce sitting through non-purposeful physical activity	The requirement to interrupt important desk based work to be active was a major barrier.
Tudor-Locke et al 2014	41 overweight/obese workers; US	Interviews conducted during a 6 month treadmill desk intervention	Treadmill desks were difficult to use because of work conflict, time demands and busy schedules.

Authors	Participants	Study Methods	Key Findings
Grunseit et al 2013	13 workers from a government organisation: Australia	Interviews 3 months after installation of sit-stand desks	Factors facilitating use of sit-stand desks were perceptions of health benefits, positive impact on productivity and the practicality of desks.
Gilson et al 2012	34 occupational health and safety practitioners; Australia	Formative research using focus groups	Lack of contextualization of strategies to different occupations and work environments, and management perceptions of poor productivity were barriers. Focusing strategies on regular changes in posture, rather than simply replacing sitting with standing was identified as a key facilitator. Balancing choice with obligatory change and utilising cross-disciplinary evidence for advocacy, were also highlighted as important factors for promoting change.
Gilson et al 2011	20 workers from a government organisation: Australia	Formative research using focus groups	Barriers included concerns about the impact strategies would have on productivity and lack of organizational support. Facilitators included contextualization of strategies to different job roles and combined responsibility for change by workers and management.

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