safe work australia

NATIONAL HAZARD EXPOSURE WORKER SURVEILLANCE:

EXPOSURE TO BIOMECHANICAL DEMANDS, PAIN AND FATIGUE SYMPTOMS AND THE PROVISION OF CONTROLS IN AUSTRALIAN WORKPLACES

MARCH 2011

National Hazard Exposure Worker Surveillance: Exposure to biomechanical demands, pain and fatigue symptoms and the provision of controls in Australian workplaces

Acknowledgement
This report was commissioned and developed by the Australian Safety and Compensation Council (ASCC), which is now known as Safe Work Australia. The National Hazard Exposure Worker Surveillance (NHEWS) Survey was administered and collected by Sweeney Research in 2008. The data analyses were undertaken and the report written by Su Mon Kyaw-Myint and Fleur de Crespigny, Safe Work Australia. Paul Rothmore, University of Adelaide, provided a peer review of this report.

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Foreword

The Australian Safety and Compensation Council (ASCC), now Safe Work Australia, requested the development and fielding of the National Hazard Exposure Worker Surveillance (NHEWS) survey to determine the current nature and extent of Australian workers' exposure to selected occupational disease causing hazards. The survey also collected information from workers about the controls that were provided in workplaces to eliminate or reduce these hazards. The results of the NHEWS survey will be used to identify where workplace exposures exist that may contribute to the onset of one or more of the eight priority occupational diseases identified by the National Occupational Health and Safety Commission (NOHSC) in 2004. These diseases are; occupational cancer, respiratory diseases, noise-induced hearing loss, musculoskeletal disorders, mental disorders, cardiovascular disease, infectious and parasitic diseases and contact dermatitis.

The NHEWS survey was developed by the ASCC in collaboration with Australian work health and safety regulators and a panel of experts. These included Dr Tim Driscoll, Associate Professor Anthony LaMontagne, Associate Professor Wendy Macdonald, Dr Rosemary Nixon, Professor Malcolm Sim and Dr Warwick Williams. The NHEWS survey was the first national survey on exposure to workplace hazards in Australia.

In 2008, Sweeney Research was commissioned to conduct the NHEWS survey using computer assisted telephone interviews (CATI). The data, collected from 4500 workers, forms a national data set of occupational exposures across all Australian industries. The survey was conducted in two stages. The first stage (n=1900) focussed on the five national priority industries as determined by NOHSC in 2003 and 2005. These industries were selected to focus the work under the National Strategy 2002-2012 relating to reducing high incidence and high severity risks. The priority industries are Manufacturing, Transport and storage, Construction, Health and community services and Agriculture, forestry and fishing. The second stage (n = 2600) placed no restrictions on industry.

An initial report on the results of the NHEWS survey can be found on the Safe Work Australia website[1]. It contains a descriptive overview of the prevalence of exposure to the nine studied occupational hazards within industries and the provision of the various hazard control measures.

This report focuses on the exposure of Australian workers to specific biomechanical or physical demands (e.g. working in a twisted or awkward posture, repetitive hand or arm movements), their experience of pain and fatigue symptoms as a result of biomechanical demands and the control measures that are provided in workplaces to alleviate worker exposure to biomechanical demands. The aims of this report are threefold:

1. to describe the employment and demographic factors that distinguish workers who are highly exposed to biomechanical demands as a result of their work
2. to investigate the relationship between biomechanical demands and pain and fatigue symptoms, and to describe the employment and demographic characteristics associated with workers reporting pain and fatigue, and
3. to describe the employment, demographic and biomechanical demand exposure factors that affect the provision of controls for biomechanical demands in Australian workplaces.

Based on these findings, the report will make recommendations for policy and for future research in this field.

[1] http://www.safeworkaustralia.gov.au/swa/AboutUs/Publications/2008ResearchReports.htm

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Summary

Work-related musculoskeletal disorders (WMSDs) are collectively one of the eight priority occupational diseases for Australia. They account for the largest proportion of occupational disease workers' compensation claims in Australia. Exposure to biomechanical demands at work, such as repetitive hand or arm movements, and awkward postures are one of a number of work-related factors that are associated with the development or worsening of WMSDs.

In 2008, the National Hazard Exposure Worker Surveillance (NHEWS) survey was conducted to obtain a picture of occupational exposures to workplace hazards in Australia. Together with other hazard data, the NHEWS survey collected information on exposure to biomechanical demands, pain and fatigue symptoms and the provision of control measures for biomechanical demands. This report describes the prevalence of exposure to biomechanical demands in Australian workers. It examines the demographic and employment characteristics of people exposed to these demands and who experience pain and fatigue symptoms. Demographic and employment factors associated with the provision of particular control measures were also explored.

Main findings and recommendations of this report
• Exposure to biomechanical demands is very common in Australian workplaces. For each of nine biomechanical demands included in the survey, at least half and as many as 88% of the workers surveyed reported exposure.
• The majority of workers were exposed to multiple biomechanical demands and approximately 20% of workers reported exposure to all nine biomechanical demands.
• Young workers, male workers, night workers and lower skilled workers were most likely to report exposure to biomechanical demands and had the highest mean composite biomechanical demand exposure scores. It is recommended that workers in these groups be targeted in any intervention campaigns and be considered in policy development.
• Approximately 80% of workers reported experiencing fatigue and approximately 50% - 60% of workers reported experiencing pain symptoms as a result of the biomechanical demands of their work.
• The frequencies of pain and fatigue symptoms were strongly related to worker composite biomechanical demand exposure level. Workers with high composite biomechanical demand exposure were more likely to report experiencing pain and fatigue *all the time* or *often* than workers with lower biomechanical demand exposure.
• Workplace size (number of people working at a worksite) and composite biomechanical demand exposure level were the best predictors of biomechanical demand control provision. Workers in large workplaces and those with high biomechanical demand exposure were most likely to be provided with controls. Policy development needs to address the problems faced by smaller workplaces in the provision of biomechanical demand controls. Policy interventions should also seek to improve the provision of controls to workers exposed to intermediate levels of biomechanical demand.
• Although male workers typically were exposed to higher levels of biomechanical demands, female workers were more likely to report pain and fatigue symptoms and less likely to be provided with biomechanical demand controls than male workers. This potential link between reduced likelihood of control provision and increased reporting of pain and fatigue symptoms by female workers requires further, urgent investigation and attention by policy makers.
• More research on biomechanical demand control provision, use and efficacy is required in order to determine the size and characteristics of the Australian working population at risk of developing WMSDs as a result of biomechanical demand exposure. It is recommended that this aspect of the NHEWS survey be revised and improved for future surveys.

Findings in detail

Biomechanical demand exposure

Participants in the NHEWS survey were asked about their frequency of exposure to nine biomechanical demands while at work. These included: lifting or carrying heavy loads, repetitive hand or arm movements, working with the body bent forward, working in twisted or awkward posture, working with the hands raised above the head, working while sitting down, squatting or kneeling while working, pushing or pulling using some force, and working while standing in one place.

Almost all workers in the NHEWS survey reported some level of exposure to biomechanical demands:

- The percentages of workers who reported exposure to each individual biomechanical demand ranged from 50% for *working with the hands raised above the head* to 88% for *repetitive hand and arm movements* (refer to Table 4 for more detail).
- Fewer than 3% of workers reported exposure to only one biomechanical demand and more than 21% of workers reported exposure to all nine biomechanical demands (refer to Table 6 for more detail).

What were the employment and demographic characteristics of workers with high biomechanical demand exposure?

- Male workers, younger workers, lower skilled workers (skill levels three and five) and night workers were associated with high biomechanical demand exposure.
- Biomechanical demand exposure also depended on interactions between gender, occupational skill and industry. This was largely due to differences in the gender and occupational skill level of exposed workers in the Health and community services industry compared to the other national priority industries. In the Health and community services industry, females and higher skilled workers had higher biomechanical demand exposure than observed for females and higher skilled workers in the other industries.
- Workers in the Construction and the Agriculture, forestry and fishing industries recorded the highest mean composite biomechanical demand exposure of the national priority industries.
- The demographic and employment profiles of people who reported exposure to the majority of the surveyed biomechanical demands were similar. However, the profile of people *working while sitting down* was quite different to other biomechanical demands. This suggests that exposure to sedentary work behaviour is a unique biomechanical demand and the groups of workers at risk from this biomechanical demand are different from the at risk groups for the other biomechanical demands (refer to Table 5 for more detail).

Musculoskeletal pain and fatigue

Workers who reported some level of exposure to biomechanical demands were asked whether they experienced pain or fatigue symptoms as a result of the physical demands of their job. These symptoms included: tiredness, pain in the back or neck, pain in the shoulders, arms, wrists or hands, and/or pain in the hips, legs, knees or feet.

- Over 80% of workers reported experiencing tiredness in the last week and 88% reported experiencing some level of musculoskeletal pain or fatigue in the last week due to the biomechanical demands of their job. For each of the three pain symptoms, 50% to 60% of workers reported they experienced them rarely to all of the time (refer to Table 7 for more detail).

- Female workers were more likely to report fatigue and musculoskeletal pain than male workers.
- Young workers were less likely to report musculoskeletal pain symptoms than older workers.
- Workers from workplaces with fewer than 20 employees were less likely to report fatigue symptoms than larger workplaces.
- Workers who worked mostly at night (night workers) were more likely to report fatigue than workers who worked mostly during the day.
- Workers with higher exposure to biomechanical demands reported experiencing pain and fatigue symptoms more frequently than workers with low exposure to biomechanical demands.

The provision of biomechanical demand control measures

Workers exposed to biomechanical demands were surveyed about the provision of the following biomechanical demand controls: lifting equipment; trolleys; changing the layout of the job; changing the size or shape of loads; and manual handling training. These controls were grouped into three types of controls: engineering, redesign and training.

- 66% of workers were provided with engineering controls, 43% with redesign controls and 56% of workers received manual handling training.
- Approximately 22% of the workers surveyed reported that none of the biomechanical demand controls surveyed were provided. Around 17% of workers were provided with all five controls (refer to Table 10 for more detail).

What employment and demographic factors affected the provision of biomechanical demand controls?

- Workplace size - the number of people working at a worksite - was the most important factor affecting control provision. Workers in the smallest workplaces were least likely to be provided with controls and the likelihood of control provision increased with workplace size.
- Biomechanical demand exposure was the second best predictor of control provision. Workers with high exposure were more likely to be provided with biomechanical demand controls than those workers with lower levels of exposure.
- Male workers were more likely than female workers to be provided with controls generally and, specifically, engineering and redesign controls. There was no difference in the provision of manual handling training by worker gender.
- Night workers were more likely than day workers to be provided with at least one control measure for biomechanical demands and were also more likely to be provided with engineering controls. Night work was not associated with the provision of redesign or training controls.
- Of the national priority industries, workers in the Agriculture, forestry and fishing industry were most likely to be provided with controls generally and, specifically, most likely to be provided with engineering and redesign control measures.
- Workplace size and the level of biomechanical demand exposure were the only factors associated with the provision of manual handling training.
- More information on control provision can be found in Table 11 and Table 12.

Policy implications and future research recommendations

Policy implications

- Exposure to biomechanical demands is common in Australian workplaces. Ongoing surveillance of biomechanical demands is recommended. This will facilitate the development of targeted interventions and hazard controls. It will also enable work health and safety bodies to determine whether progress has been made on reducing biomechanical demand exposure at both the national / jurisdiction levels and by key worker demographics.
- Young workers, male workers, night workers and lower skilled workers were most likely to report exposure to biomechanical demands. Additionally, female workers were more likely to report pain and fatigue symptoms and less likely to be provided with biomechanical demand controls than male workers. It is recommended that these groups of workers are targeted in any intervention campaigns and be considered in policy development.
- Workplace size and composite biomechanical demand exposure were the best predictors of biomechanical demand control provision. Workers in large workplaces and those with high biomechanical demand exposure were most likely to be provided with controls. Policy development needs to address the problems faced by smaller workplaces in the provision of biomechanical demand controls. Policy interventions should also seek to improve the provision of controls to workers exposed to intermediate levels of biomechanical demand. This could improve the health outcomes of many workers, potentially including those of female workers (mentioned above) and other groups of workers, e.g. older workers, who may be more vulnerable to WMSDs.

Research recommendations

- The results presented in this report are based on cross-sectional survey data. While this type of data provides a useful source of information, further studies using observational or experimental designs are needed to better understand the causal relationships between a range of work factors and WMSDs. Future studies especially need to focus on hazards and risk factors in workplaces that are modifiable such as awkward postures, repetitive movements, and heavy lifting. To do this, it is important to understand the adverse effects of concurrent exposures to hazards in the workplace that are associated with WMSDs (such as biomechanical demands, psychosocial hazards and heat). As a first step, it is suggested that a follow up analysis of the NHEWS survey be conducted to determine the combined effect of exposure to biomechanical demands and psychosocial hazards on musculoskeletal symptoms.
- There is a lack of good quality intervention research in this field. Many of the currently available studies have limitations, such as targeting only one group of workers, small sample size, not accounting for confounding variables, no control groups and short follow-up periods. Many also target one specific hazard or risk factor rather than taking a multi-level systems approach. Future quality intervention research, addressing these limitations, is needed.
- Although male workers typically were exposed to higher levels of biomechanical demand, female workers were more likely to report pain and fatigue symptoms and less likely to be provided with biomechanical demand controls than male workers. This potential link between reduced likelihood of control provision and increased reporting of pain and fatigue symptoms by female workers requires further, urgent investigation.
- More research on biomechanical demand control provision, use and efficacy is required in order to determine the size and characteristics of the Australian working population at risk of developing WMSDs as a result of biomechanical demand exposure. It is recommended that this aspect of the NHEWS survey be revised and improved for future surveys.

Introduction

Musculoskeletal disorders are among one of the most common disorders in the general population worldwide (Woolf and Pfleger 2003). Population studies have shown that the point prevalence of back pain alone is 15%-30%, with a lifetime prevalence of 60-80% (Nachemson et al. 2000). In Australia, according to the 2001 National Health Survey, 6.1 million Australians were estimated to have arthritis and musculoskeletal disorders (Australian Institute of Health and Welfare 2005).

Musculoskeletal disorders are one of the leading causes of morbidity and disability and create a substantial burden to the individual and society (Brooks 2006). In the UK, the economic cost of back pain was estimated to be £12 300 million (over AU$21 000 million) (Maniadakis and Gray 2000). In Australia, they are the most common cause of a visit to the general practitioner and in 1993-1994 were estimated to cost AU$3 billion in health expenditure (Brooks and Hart 2000). This cost was comparable to that of circulatory diseases and respiratory diseases. A later study estimated that the direct (health costs) and indirect cost (loss in earnings or productivity) of low back pain alone was AU$9.7 billion in 2001 (Walker et al. 2003).

Similar to the general population, musculoskeletal disorders are also one of the most common disorders among the working population (National Research Council and The Institute of Medicine 2001; Jansen et al. 2004; Schneider et al. 2010). The term 'work related musculoskeletal disorders' (WMSDs) is used to describe a range of inflammatory and degenerative musculoskeletal disorders and diseases where work factors have been shown to be causal or contributing factors (Hagberg et al. 1995b; Buckle and Devereux 2002). WMSDs are collectively one of the eight priority occupational diseases for Australia (ASCC 2006). They include a variety of disorders such as back pain, repetitive strain injury, occupational overuse syndrome and shoulder pain.

Epidemiological evidence has shown a link between a range of work factors and WMSDs (Bernard 1997; van der Windt et al. 2000; David 2005; Nicholas et al. 2005). These work factors include physical work environment such as temperature and air quality, exposure to vibration, psychosocial working conditions such as high job demands, and biomechanical demands such as repetitive work, awkward posture, and carrying or lifting heavy loads (Keyserling 2000a, b; Miranda et al. 2001; Vieira and Kumar 2004; Côté et al. 2008; van Rijn et al. 2010). A 1993 study estimated that the burden of musculoskeletal disorders could be reduced by 30-40% if hazardous exposures at work were eliminated, suggesting that the work attributable fraction of musculoskeletal disorders could be 30-40% (Hansen 1993 as cited in Westgaard and Winkel 1997). A more recent study, in 2005, produced a similar figure, that as much as 37% of low back pain was attributable to occupational risk factors (Punnett et al. 2005). In terms of biomechanical demands, which are the focus of this report, a recent Swedish study of twins also showed that biomechanical demands were associated with a significant increase in low back and neck and shoulder pain, even after adjusting for genetic and environmental factors (Nyman et al. 2009).

When WMSDs became the focus of research and prevention activities in the early 1980s, it was thought that exposure to certain biomechanical demands, such as exposure to repetitive work and machine pacing would decline in developed countries and this would lead to reduced incidence of WMSDs among workers (Hagberg et al. 1995b). However, contrary to this early prediction, the incidence of WMSDs has been on the rise (Buckle and Devereux 1999; European Foundation for the Improvement of Living and Working Conditions 2007b). WMSDs are reported to be the most common type of occupational disease for the EU (Schneider et al. 2010).

In Australia, musculoskeletal disorders continue to represent a large proportion of workers' compensation claims. Australian workers' compensation data[2] showed that diseases of the musculoskeletal system and connective tissue made up 12.8% of the total workers' compensation claims during 2002 to 2008, and they accounted for the largest proportion of occupational disease claims. However, between 2004-05 and 2008-09 it appears that the incidence rates (claims per 1000 workers) of serious workers' compensation claims for diseases of the musculoskeletal system and connective tissues have stabilised or slightly declined (Table 1). However, it should be noted that workers' compensation data are sensitive to tightening in claim eligibility and changes in injury and disease definitions – both of which have occurred in recent years for WMSD s. This may have lead to an apparent stabilisation or decline in this disease grouping.

Table 1 and Table 2 present incidence rates by worker sex, age and industry, cost and time lost data for serious claims (claims requiring five days or more off work and fatal claims) for diseases of musculoskeletal system and connective tissues. On average, there were 18 464 serious compensated claims for WMSDs each year. The average cost of a serious compensation claim for musculoskeletal disorders was AU$19 658. The average total cost of claims for WMSDs per year was AU$361.5 million. Workers with WMSDs typically required six weeks off work. Based on the methodology and estimates from the 2009 cost of work related injury and illness report (ASCC 2009), it is estimated that there are 65 550 WMSD cases per year (compensated and non-compensated cases) (ASCC 2009). The 2009 report also enables estimation of the total economic cost of WMSDs based on compensation data. It is estimated that the cost to the economy from WMSDs per year, which includes cost to the employer, worker and society, assuming there are 65 550 cases per year, is AU$1910 million. These estimates confirm that WMSDs are a major occupational disease in Australia and are costly both in terms of human suffering and economic cost. This is also true internationally where, for example, the direct and indirect cost of WMSDs in the US is estimated to be US$54 billion per year (National Research Council and The Institute of Medicine 2001).

The workers' compensation data in Table 1 reveal higher rates of WMSDs in male workers and workers aged 35 years or more. The industries with the highest rates of WMSDs include Manufacturing, Agriculture, forestry and fishing, Construction, Wholesale trade, Health and community services, and Transport and storage.

In terms of data on the prevalence of exposure to biomechanical demands, the best available data come from the European Working Condition Surveys. Based on these surveys, the prevalence of exposure to biomechanical demands in the working population is high. For example, in 2005, over 60% of workers in the European Union reported exposure to repetitive hand or arm movements and approximately 45% reported exposure to painful and tiring positions for at least a quarter of their time at work (European Foundation for the Improvement of Living and Working Conditions 2007a). Moreover, approximately 40% of workers reported working while standing or walking all or nearly all of their time at work and over a third of the workers reported carrying or lifting heavy loads for at least a quarter of their time at work. The European Working Conditions Survey also found gender and age differences in exposure to biomechanical demands, as well as multiple and concurrent exposure to several biomechanical demands (Schneider et al. 2010).

In addition to the European Working Conditions Survey data, some information on the prevalence of exposures in selected populations is available from epidemiological studies. In a study of Danish workers, 37% reported repetitive work for 10 minutes or more per hour and 53% reported lifting at work (Andersen et al. 2007). Sitting for more than 30 minutes per hour was reported by 21% of workers whereas standing for more than 30 minutes per hour was

[2] National Data Set for Compensation-based Statistics (NDS). The data are also available online through the Safe Work Australia Online Statistics Interactive National Workers' Compensation Statistics Databases at http://nosi.ascc.gov.au/.

reported by 8% of workers. Approximately one in five workers in this Danish study reported squatting for more than five minutes an hour at work. In a Swedish cohort study of workers aged 20 to 25 years, 39% of workers reported mostly sitting still at work and 7.6% reported mostly standing at work (Love et al. 2010). Approximately 14% of workers reported that their work involved mostly walking, lifting and carrying a lot and one in twenty workers reported that their work involved heavy physical work.

Table 1. Incidence rates (claims per 1000 workers) of serious compensated claims for diseases of the musculoskeletal system and connective tissue by sex, age and industry, 2004-05 to 2008-09. Note that the 2008-09 data are preliminary and subject to change.

	YEAR				
Characteristic	**2004-05**	**2005-06**	**2006-07**	**2007-08**	**2008-09**
SEX					
Female	1.7	1.9	1.7	1.5	1.4
Male	2.2	2.8	2.3	2.1	1.9
AGE					
<20 years	0.5	0.7	0.6	0.5	0.5
20-24 years	1.1	1.5	1.1	1	1
25-29 years	1.5	1.9	1.5	1.4	1.1
30-34 years	1.9	2.4	1.9	1.7	1.5
35-39 years	2.3	2.8	2.2	2	1.8
40-44 years	2.5	2.9	2.4	2.4	2.1
45-49 years	2.6	3.1	2.7	2.5	2.3
50-54 years	2.5	3	2.8	2.6	2.4
55-59 years	2.4	2.8	2.6	2.4	2.2
60-64 years	2.1	2.5	2.3	2.2	1.8
65+ years	1.3	1.2	1.2	1.3	1
INDUSTRY					
Agriculture, forestry and fishing	2.3	3.1	2.5	2.6	2.4
Mining	0.9	1.7	1.4	1	0.8
Manufacturing	3.9	4.8	4.4	3.8	3.2
Electricity, gas and water supply	0.6	0.9	0.9	0.8	0.6
Construction	2.5	3.4	2.5	2.4	2.4
Wholesale trade	2.6	3.3	2.5	2.6	2.5
Retail trade	1.4	1.5	1.3	1.1	1.1
Accommodation, cafes and restaurants	1	1.4	1.1	1	1
Transport and storage	3.3	4.2	3.8	3.4	3.2
Communication services	0.6	1.1	0.8	0.9	0.6
Finance and insurance	0.6	0.7	0.5	0.6	0.5
Property and business services	1.4	1.4	0.9	0.9	0.8
Government administration and defence	1.5	2.3	1.7	1.6	1.6
Education	0.9	0.9	1	0.8	0.7
Health and community services	2.6	3.1	2.7	2.5	2.2
Cultural and recreational services	1.2	1.5	1.4	1.4	0.9
Personal and other services	1.9	2.5	2.2	1.8	2
Total number of claims per year	**17 261**	**21 712**	**18 999**	**17 936**	**16 414**
Overall incidence rate per year	**1.9**	**2.4**	**2.0**	**1.8**	**1.7**
Source: Safe Work Australia National Workers' Compensation Statistics Databases					

Table 2. Payment and time lost from work for serious compensated claims for diseases of musculoskeletal system and connective tissue, 2004-05 to 2007-08. Data for 2008-09 are not yet available.

	YEAR			
	2004-05	**2005-06**	**2006-07**	**2007-08**
Average payment per case ($)	$20 102	$22 839	$20 881	$20 141
Total payments ($'m)	$347.0	$495.9	$396.7	$332.8
Median time lost from work (weeks)	6	5.5	6.2	6.7
Source: Safe Work Australia National Workers' Compensation Statistics Databases				

In Australia, some information is also available on the prevalence of exposure to biomechanical demands. For example, in a study of public servants, it was found that 34% of females reported exposure to sitting in one position for a prolonged period of time (Strazdins and Bammer 2004). The prevalence of this exposure in males was 21%. Almost a third (30%) of females in the study reported exposure to repetitive movements all the time and the figure was 16% for males.

Additional information on exposures to biomechanical demands in Australia can be obtained from workers' compensation data. The majority of claims for diseases of the musculoskeletal system and connective tissues were due to body stressing. Body stressing includes biomechanical demands such as manual handling, repetitive movements and prolonged or awkward postures. Body stressing accounts for approximately 41% of all workers' compensation claims each year. Cases of body stressing (a mechanism of injury/disease for WMSDs) can be further broken down into one of the four types of occurrence classification categories in workers' compensation data that can be related back to specific biomechanical demands. These are:

1. repetitive movement, low muscle loading
2. muscular stress with no objects being handled
3. muscular stress while handling objects other than lifting, carrying or putting down, and
4. muscular stress while lifting, carrying or putting down objects.

Category two includes bending down, twisted posture, working in cramped or unchanged positions and prolonged standing. Category three includes pushing or pulling objects and handling objects where force or power is required. The majority of body stressing claims were due to category three and category four (see Table 3), suggesting that these were the biomechanical hazards most associated with WMSD claims in Australia (assuming there is no difference in the likelihood of making a workers' compensation claim based on the type of biomechanical hazard involved). With this latter consideration in mind, it should be noted that the pattern of exposures to biomechanical demand indicated by workers' compensation claims may not be truly reflective of the actual pattern of exposures associated with WMSDs in Australia (Safe Work Australia 2009). WMSDs often arise as a result of long term cumulative load rather than single events, and these sorts of long latency illnesses, where there are no single causative factors, are harder to obtain compensation for. Furthermore, not all workers with WMSDs lodge a workers' compensation claim especially when the disorder is minor or did not require significant time off from work. Other reasons for not lodging a workers' compensation claim include concerns about negative effect on employment and that claims require too much effort and are inconvenient.

There is some evidence that interventions in the workplace, especially when multilevel, can reduce exposure to biomechanical demands, and subsequently, the prevalence of WMSDs (Westgaard and Winkel 1997; Buckle and Devereux 2002). Interventions such as ergonomic redesign (to improve work stations) and reduction in muscular load, for example, have been shown to reduce the incidence of neck and back pain, workers' compensation claims and numbers of days lost due to physical restriction (Smith et al. 1999; Boocock et al. 2007).

Prevention of WMSDs is important not only because of the pain and suffering to the individual worker but because of the large economic and societal costs.

Table 3. Types of body stressing claims, 2002-03 to 2007-08

Mechanism of Injury or Disease	% of body stressing claims					
	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08p
Repetitive movement, low muscle loading	9	9	8	8	7	6
Muscular stress with no objects being handled	11	11	12	12	12	14
Muscular stress while handling objects other than lifting, carrying or putting down	32	33	35	35	36	37
Muscular stress while lifting, carrying, or putting down objects	48	47	45	45	45	43
Source: Safe Work Australia Online Statistics Interactive National Workers' Compensation Statistics Databases, p means provision data						

A first step in a more effective prevention of WMSDs is to better understand the proportion and types of workers exposed to causal or contributing work hazards relating to WMSDs. However, no national picture of exposure to biomechanical demands exists in Australia. Available data from individual studies and the workers' compensation dataset while providing essential information for prevention are limited. This is because they do not provide a national picture (in the case of small, targeted epidemiological studies) or a complete picture of current exposures in Australian workers (in the case of workers' compensation data as not all workers are entitled to workers compensation claims or workers may be reluctant to lodge a claim). In contrast, data on the national prevalence of exposure to specific biomechanical demands will provide an estimate of the extent of potential exposure to these hazards. Moreover, information on factors that influence exposure, provision of control and identification of key at-risk groups will provide and guide policy and other intervention initiatives to reduce exposure to these hazards. This report aims to fill some of this existing information gap by presenting the findings related to biomechanical demands and related pain and fatigue symptoms from the first National Hazard Exposure Worker Surveillance (NHEWS) Survey conducted in 2008 across Australia.

Research questions

The research questions for this report are:

1. What is the prevalence of exposure to specific biomechanical demands?
2. What employment and demographic characteristics are associated with self-reported exposure to specific biomechanical demands?
3. What is the prevalence of concurrent exposure to multiple biomechanical demands?
4. What demographic and employment factors are associated with exposure to concurrent and multiple biomechanical demands?
5. What is the prevalence of pain and fatigue symptoms in the exposed population?
6. What employment, demographic and biomechanical demand exposure factors are associated with reporting of pain and fatigue symptoms?
7. What control measures are provided at workplaces for biomechanical demands?
8. What demographic, employment factors and biomechanical demand exposure factors affect how many or the types of controls provided?

Overview of the survey and data analysis methodology

The NHEWS survey collected information from 4500 Australian workers about their work-related exposure to each of the following nine biomechanical demands:

- lifting or carrying heavy loads
- repetitive hand or arm movements
- working with the body bent forward
- working in twisted or awkward posture
- working with the hands raised above the head
- working while sitting down
- squatting or kneeling while working
- pushing or pulling using some force, and
- working while standing in one place.

Responses were collected on a five point scale (1= Never, 2= Rarely, 3= Sometimes, 4= Often, 5= All the time).

Overall biomechanical demand exposure was estimated by calculating a composite biomechanical demand exposure *z* score. This score reflected both the number of demands a worker reported exposure to and the intensity of the exposures. High *z* scores correspond with high levels of exposure. Refer to Appendix A for a detailed explanation of how the *z* score was calculated.

Workers who reported some level of exposure to at least one biomechanical demand were then asked whether they experienced pain or fatigue symptoms as a result of the physical demands of their job. These symptoms included: tiredness, pain in the back or neck, pain in the shoulders, arms, wrists or hands, and/or pain in the hips, legs, knees or feet.

Workers who reported some level of exposure to at least one biomechanical demand were also asked whether or not specific controls were provided in their workplaces to prevent pain associated with the biomechanical demands of their job. The specific controls surveyed included: lifting equipment, trolleys, changing the layout of the job, changing the size and shape of loads, and manual handling training. Survey participants sometimes volunteered additional control measures provided in their workplaces but these were not included in the analyses because not all participants were prompted to describe other control measures in their workplaces.

The biomechanical demands, pain and fatigue symptoms and controls data were collected alongside detailed employment and demographic data for each survey participant. The majority of these data were analysed in logistic regressions, which describe the likelihood (in the form of odds ratios) of reporting exposure, the presence of pain and fatigue symptoms or the provision of controls, with respect to the employment and demographic characteristics of the workers. Most of the analyses were restricted to workers in the five national priority industries (Manufacturing, Construction, Agriculture, forestry and fishing, Transport and storage, and Health and community services) owing to small sample sizes in the remaining industries. This means that the conclusions and results drawn from some of the analyses in this report do not present a complete picture of exposure to biomechanical demands for all Australian workers. Furthermore, the data presented in this report are unweighted and are therefore only representative of the survey sample.

Full details of the survey design, fielding methodology and the data analysis methodology can be found in Appendix A.

Results

Biomechanical demands

All but two participants in the NHEWS survey reported exposure to at least one of the nine biomechanical demands surveyed in this study. Table 4 presents the numbers and percentages of workers who reported exposure to any of the nine biomechanical demands. The percentage of workers who were exposed to a particular biomechanical demand ranged from a high of 88% for *repetitive hand or arm movements* to a low of 50% for *working with the hands raised above the head*.

Table 4. The percentage of workers who reported exposure to each of the nine biomechanical demands

Type of biomechanical demands	Not exposed (n)	Exposed (n)	% exposed
Carrying or lifting heavy loads	1655	2845	63.2
Repetitive hand or arm movements	520	3980	88.4
Work with the body bent forward	1148	3352	74.5
Work in a twisted or awkward posture	1961	2539	56.4
Work with the hands raised above the head	2253	2249	50.0
Work while sitting down	835	3665	81.4
Squatting or kneeling while working	1683	2817	62.6
Pushing or pulling, using some force	1584	2916	64.8
Work standing in one place	1712	2788	62.0

Employment and demographic characteristics of workers who reported exposure to biomechanical demands

Logistic regression analyses were undertaken to determine the demographic and employment characteristics of workers that were associated with reporting exposure to each of the nine biomechanical demands. For consistency, the same demographic and employment factors were included in the analyses of all biomechanical demands where possible. Interaction terms were also included in the models. Interaction terms show that certain employment and demographic factors depend on others in terms of how they affect the likelihood of a worker reporting exposure to biomechanical demands. For instance, the likelihood of a female worker reporting carrying or lifting heavy loads is dependent on the industry in which she is employed.

The full statistical output of the logistic regression models for the individual biomechanical demands are presented in Appendix B, Table 17 to Table 30, together with post-hoc tests involving interaction terms and graphical representations of the significant interactions. Table 5, in this section of the report, presents an overview of the findings of the models and shows only the statistically relevant findings. The table outlines which employment and demographic characteristics of workers were associated with increased or decreased likelihoods (odds ratios) of reporting exposure to each of the biomechanical demands.

Table 5. Summary of the results of the logistic regressions examining the factors affecting exposure to each of the nine biomechanical demands

Employment and demographic factors included in the models	Carrying or lifting heavy loads	Repetitive hand or arm movements	Work with the body bent forward	Work in a twisted or awkward posture	Work with the hands raised above the head	Work while sitting down	Squatting or kneeling while working†	Pushing or pulling, using some force	Work standing in one place
Gender (reference group = Female)									
Male						↑	↑		
Age (reference group = 55 years or more)									
15-24 years	↑	↑↑	↑↑	↑			↑↑	↑↑	↑↑
25-34 years	↑↑	↑	↑	↑↑			↑	↑	↑
35-44 years	↑	↑	↑	↑			↑	↑	↑
45-54 years	↑	↑	↑	↑			↑	↑	↑
Other language spoken at home (reference group = No)									
Yes						↓			
Occupational skill level (reference group = 5 – lowest level)									
1 (highest skill level)		↓			↓	↑↑	↓		
2					↓↓	↑	↓↓		
3						↑	↑		
4						↑			
Workplace size (reference group = 200 or more employees)									
Less than 5 employees						↓	↑		
5 – 19 employees				↓					
20 – 199 employees									
Night work (reference group = Did not work at night)									
Worked at night	↑		↑	↑	↑		↑	↑	↑
Industry (reference group = Health & community services)									
Manufacturing						↑	↓↓		
Transport & storage						↑↑	↓	↓↓	
Construction						↑	↓	↓	
Agriculture, forestry & fishing						↑			
Interaction terms									
Industry * Gender	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**No**
Industry * Occupational skill level	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**N/A**	**Yes**	**Yes**
Tables and figures in Appendix B that present model statistical output and examination of interactions	Table 15 Table 16 Figure 7 Figure 8	Table 17	Table 18 Table 19 Figure 9 Figure 10	Table 20 Table 21 Figure 11 Figure 12	Table 22 Table 23 Figure 13 Figure 14	Table 24 Table 25 Figure 15 Figure 16	Table 26	Table 27 Table 28 Figure 17 Figure 18	Table 29 Table 30 Figure 19

† The results presented for this biomechanical demand are from a main-effects only model whereas, for the other biomechanical demands, the models included interaction terms. ↓ indicates the odds of having a particular exposure were significantly decreased. ↑ indicates the odds of having a particular exposure were significantly increased. ↑↑ or ↓↓ indicate the factor level with the greatest increase / decrease in odds.

The employment and demographic characteristics that affected the likelihood of reporting exposure to any of the nine biomechanical demands were similar for eight of the biomechanical demands. The exception was the biomechanical demand; *work while sitting down*. Unlike most of the other demands, there was no effect of worker age on the odds of reporting exposure to *work while sitting down*. Furthermore, in contrast to all other demands there was an effect of language spoken at home on the likelihood of *working while sitting down*. Those who spoke another language at home had significantly lower odds of reporting exposure to *working while sitting down* compared to those who only spoke English at home. Also, the odds of reporting exposure to *work while sitting down* were significantly increased for those workers in the highest occupational skill level compared to the lowest. Although workplace size was not a good predictor of exposure to biomechanical demands, the models indicated that people in workplaces with less than five employees were significantly less likely to report exposure to *work while sitting down*.

The likelihood of reporting exposure to most biomechanical demands was increased by working at night. The exceptions to this finding were the biomechanical demands *repetitive hand or arm movements* and *work while sitting down*.

Worker age had a consistent and statistically significant effect on the likelihood of reporting exposure to seven of the nine biomechanical demands. For five of these, workers aged 15-24 years had the greatest likelihood of reporting exposure. The likelihood of reporting exposure to the remaining two biomechanical demands were greatest for 25-34 year olds. These models strongly indicate that young workers have increased likelihood of exposure to biomechanical demands in comparison to older workers.

Worker gender, on its own, did not affect the likelihood of reporting exposure to most of the nine biomechanical demands. *Work while sitting down* was again an exception to this rule, with male workers recording increased odds of reporting exposure to this biomechanical demand. Male workers were also significantly more likely than female workers to report exposure to *squatting or kneeling while at work.* Although, there were few main effects of gender on the likelihood of reporting exposure to biomechanical demands, there was a significant interaction between industry and gender in six of the eight biomechanical models. This means that the effect of gender on the likelihood of reporting exposure to biomechanical demands differed depending on the industry of employment. For these six biomechanical demands, the interaction between gender and industry was probably driven by differences between the Health and community services industry and the other four priority industries. A typical example is shown in Figure 1, where within the Health and community services industry a greater percentage of the female workers reported exposure to *work in a twisted and awkward posture.* In contrast, in the other four industries, a larger percentage of male workers reported exposure to this biomechanical demand.

Like gender, industry of employment on its own was not usually a statistically important predictor of the likelihood of reporting exposure to biomechanical demands. However for three biomechanical demands, the odds of reporting *work while sitting down* were increased in each priority industry when compared to the Health and community services industry, with workers in the Transport and storage industry recording the most increased odds of *work while sitting down*. In contrast, the odds that a worker reported *squatting or kneeling while at work* were significantly decreased by working in the Manufacturing, Transport and storage and Construction industries in comparison to the Health and community services industry. Likewise, the odds of a worker reporting that they *push or pull using some force* were decreased by working in the Transport and storage and Construction industries in comparison to working in the Health and community services industry.

Figure 1. The percentage of workers who reported exposure to the biomechanical demand *work in a twisted or awkward posture* within gender and industry

In addition to the interaction with gender, the relationship between industry and exposure to most of the biomechanical demands depended on occupational skill. This relationship is more complex and the reader is recommended to consult the statistical output of the models in Appendix B for details on individual models / biomechanical demands. As an example, Figure 2 shows the relationship between industry and occupational skill for *work in a twisted or awkward posture*. As with Figure 1, this is a crude illustration of the relationship because, unlike the model, it does not take into account the impact of other demographic or employment factors. Despite this, it is evident from the graph that there is relatively little difference between occupational skill levels in the percentages of workers who reported exposure to this biomechanical demand within the Agriculture, forestry and fishing and Health and community services industries. However, in contrast, workers in occupational skill level three typically recorded much greater percentages of workers who reported exposure to *work in a twisted or awkward posture* in the remaining industries. The model itself indicated that workers in occupational skill level one (the highest level) and the Manufacturing, Construction or Transport and storage (marginally not significant) industries had decreased odds of reporting exposure to this biomechanical hazard compared to the occupational skill level five in Health and community services.

It should be noted that the parameter estimates of this (and the other models) strongly depend on the model reference groups. For interaction terms such as these, establishing the best reference group is highly complicated and the parameter estimates should only be treated as a guide. The main finding should be the knowledge that industry and occupational skill together affect the likelihood of reporting exposure to biomechanical demands.

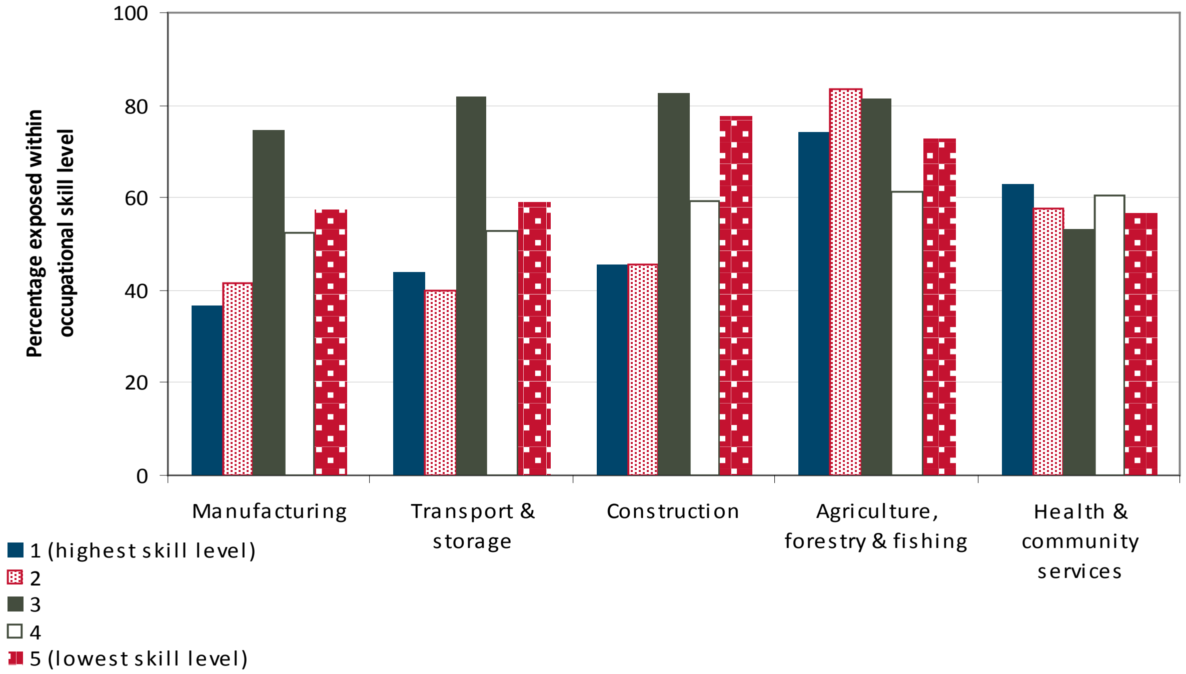

Figure 2. The percentage of workers who reported exposure to the biomechanical demand *work in a twisted or awkward posture* within occupational skill level and industry

Exposure to multiple biomechanical demands

So far, only the factors affecting self reported exposure to single biomechanical demands have been considered and presented in this report. However, as can be seen in Table 6, the majority of workers (98%) in the NHEWS survey reported exposure to two or more biomechanical demands. Less than three per cent of workers reported exposure to only one biomechanical demand while one in five workers reported exposure to all nine biomechanical demands measured in the NHEWS survey. Only two survey participants reported that they were not exposed to any biomechanical demands.

Table 6. The number of biomechanical demands workers reported they were exposed to

Number of biomechanical demands worker reported exposure to	Number of workers exposed	Percentage of workers exposed
Exposure to only **one** biomechanical demand	106	2.4
Exposure to **two** biomechanical demands	431	9.6
Exposure to **three** biomechanical demands	414	9.2
Exposure to **four** biomechanical demands	429	9.5
Exposure to **five** biomechanical demands	413	9.2
Exposure to **six** biomechanical demands	451	10
Exposure to **seven** biomechanical demands	571	12.7
Exposure to **eight** biomechanical demands	720	16
Exposure to **all nine** biomechanical demands	963	21.4

Figure 3 shows the percentages of male and female workers who reported being exposed to different numbers of biomechanical demands. Larger percentages of male workers reported exposure to seven, eight or nine biomechanical demands than female workers. For example, 26% of male workers reported exposure to all nine biomechanical demands compared to 16% of female workers.

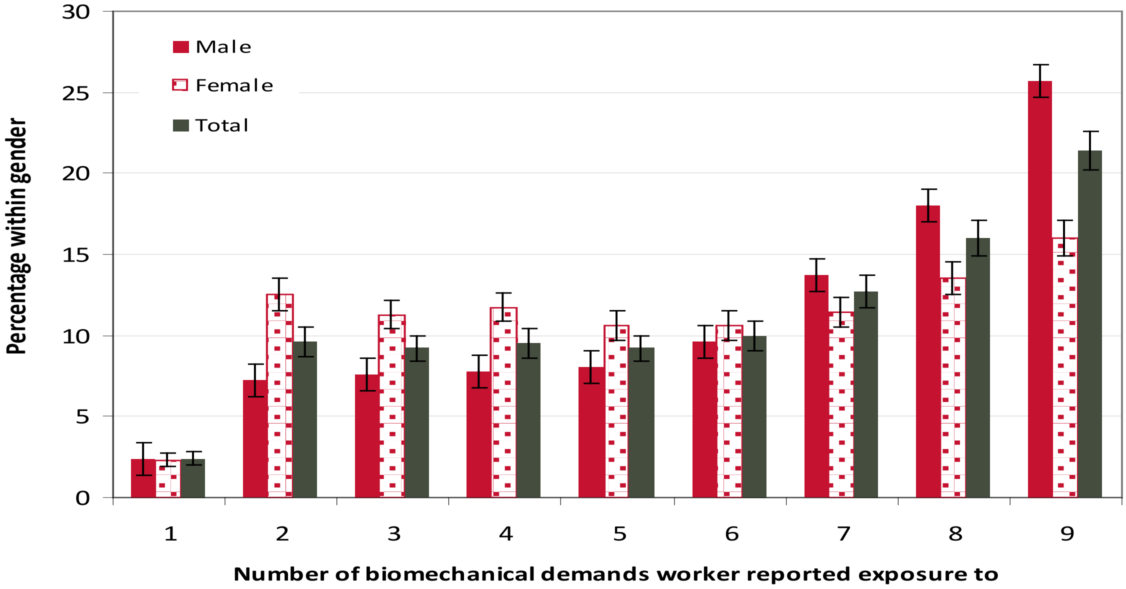

Figure 3. Exposure to multiple biomechanical demands by worker gender (percentage and 95% confidence intervals)

Exposure to combined biomechanical demands: The composite biomechanical demand exposure score (*z*)

As the majority of workers reported multiple exposures to biomechanical demands, it was decided that a composite measure reflecting both the intensity (frequency of exposure) and the number of concurrent exposures would be used for further analysis. For information on the construction of this composite measure, please refer to Appendix A. However, please note that the composite *z* score excludes the biomechanical demand working while sitting down due to its low inter-item correlation with other biomechanical hazards during reliability analysis. A *z* score of zero indicates median exposure and a negative score indicates lower than median exposure. A positive *z* score indicates higher than median exposure.

Several factors affected workers' composite biomechanical demand exposure score (*z*) (Appendix C Table 31). These were gender, age, industry, occupational skill level and night work. Additionally, there was a significant three-way interaction between gender, occupational skill level and industry, meaning that the effect of each of these factors on the *z* score was dependent on the other two factors. This model only included workers from the five priority industries but the relationships observed in the model between each of the following factors; gender, age, night work and occupational skill, and the *z* score were consistent with the pattern observed for the whole data set (refer to Appendix C Table 32). One thing of particular interest was that although workplace size did not affect the composite biomechanical demand exposure score within the priority industry analysis, in the whole data analysis biomechanical demands were highest for workers from the smallest workplaces (< five employees), and the level of biomechanical demand declined with increasing workplace size (Table 32).

Male workers had a higher mean composite exposure score than female workers and mean composite exposure score declined with age. Therefore biomechanical demands were highest for male workers and the youngest workers. Furthermore, workers who reported working at night had a higher mean composite biomechanical demand exposure score than workers who did not work at night.

As mentioned previously, gender, industry and occupational skill level depended on each other in terms of their effect on the composite exposure score. In all industries except Health and community services, males recorded a higher mean composite exposure score than females (Figure 4). This indicates that females in the Health and community services industry typically experienced higher biomechanical demands than males, which is in contrast to the overall pattern. The genders also differed in terms of the occupational skill level with the highest mean composite exposure score (Figure 5). For male workers, workers in occupational skill level three had the highest composite exposure score. In contrast, female workers in the lowest skill level (five) recorded the highest composite exposure score. There was little difference between the sexes in the composite exposure score recorded by workers in the highest occupational skill levels (one and two).

Figure 4. The combined effect of gender and industry on mean (± standard error) composite exposure score

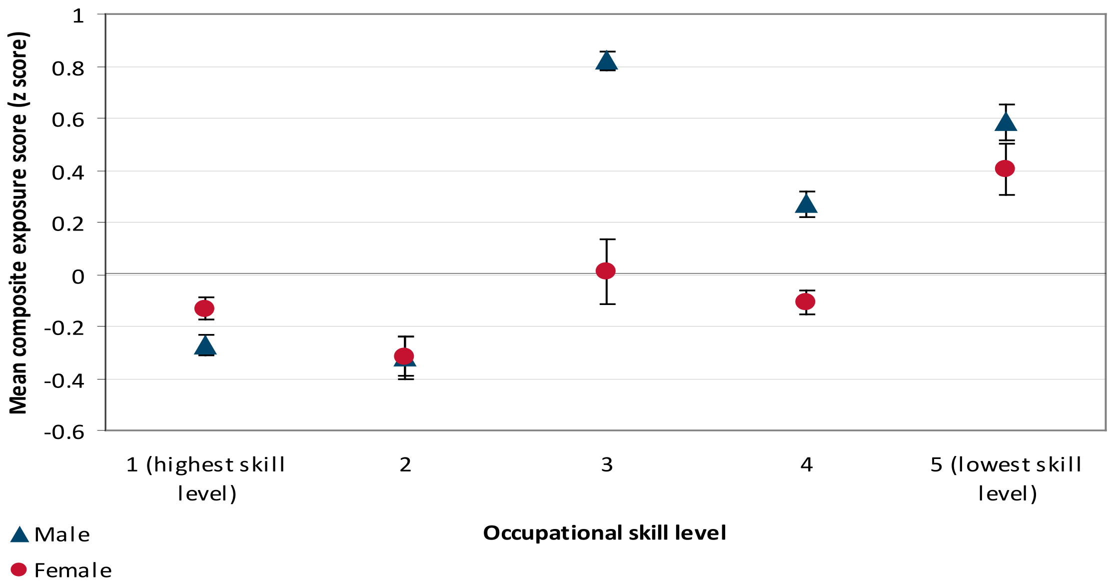

Figure 5. The combined effect of gender and occupational skill on mean (± standard error) composite exposure score

The effect of occupational skill level on mean composite exposure score also depended on industry of employment. As can be seen in Figure 6, workers in occupational skill level three had the highest mean exposure score in the Transport and storage, Construction and Agriculture, forestry and fishing industries and close to the highest score in the Manufacturing industry. In the Health and community services industry, workers in occupational skill level five and four both had higher mean exposure scores than workers in occupational skill level three. When considering industry on its own, Construction industry workers had the highest mean composite exposure scores, followed by workers in the Agriculture, forestry and fishing industry. Health and community services industry workers had the lowest mean composite exposure score.

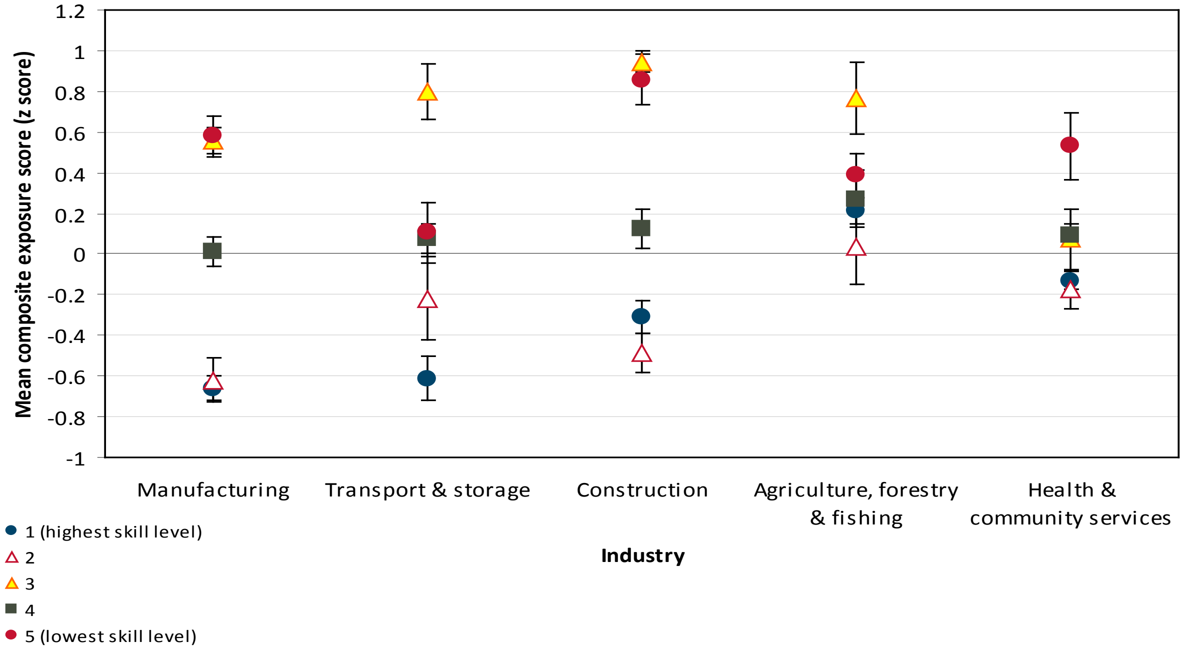

Figure 6. The combined effect of industry and occupational skill on mean (± standard error) composite exposure score

Pain and fatigue symptoms

The NHEWS survey participants were asked four questions about the pain and fatigue symptoms they experienced in the survey reference week that were a result of the physical demands of their job. As shown in Table 7, less than 20% of respondents said they never experienced tiredness in the last week due to the physical demands of their job. In comparison, approximately 40-50% of survey participants reported they never experienced each of the three groups of pain symptoms. About 5% of survey participants said they experienced each of the three groups of pain symptoms all the time.

Table 7. The percentage of workers who reported pain and fatigue symptoms by how often they experienced pain and fatigue symptoms (unweighted data)

Pain and fatigue symptoms	Never	Rarely	Sometimes	Often	All the time
Tiredness	19.4	14.0	32.8	21.3	12.5
Pain in back or neck	41.8	15.7	25.6	12.0	4.8
Pain in shoulders, arms, wrists or hands	44.9	16.4	22.9	11.0	4.7
Pain in hips, legs, knees or feet	51.3	14.9	19.4	9.8	4.7

Only 12% (n = 541) of respondents said they ‘never’ experienced any of the four pain and fatigue symptoms during the reference week. Less than one per cent of workers (n = 40) reported experiencing all four symptoms ‘all the time’ in the past week. When only considering the three groups of pain symptoms, 27.8% (n = 1250) of workers reported they experienced no pain symptoms in the last week. Approximately one third (34%) of workers reported they experienced all three pain symptoms (‘rarely’ to ‘all the time’).

Demographic and employment characteristics associated with reporting pain and fatigue symptoms

To obtain a better understanding of the employment, demographic and biomechanical demand exposure factors associated with the reporting of pain and fatigue symptoms, logistic regression analyses were carried out, with pain and fatigue analysed separately.

Pain symptoms

This analysis classified workers as having experienced pain as a result of the biomechanical demands of their work if workers said they rarely, sometimes, often or all the time had any of the three pain symptoms in the last week. How often these symptoms occurred and how many types of pain were experienced were not taken into account in this analysis. Exposure to biomechanical demands was modelled using the composite biomechanical demand exposure z score groups (low, medium-low, medium-high and high), rather than individual biomechanical demands. A summary of the model is presented in Table 8 and the full statistical details of the model can be found in Appendix C, Table 33.

Only three factors predicted whether or not a worker experienced pain as a result of the biomechanical demands of their work. These were the level of biomechanical demands they were exposed to, worker gender and age. When controlling for the effects of other factors in the model, workers with high composite biomechanical demand exposure were almost 23 times more likely to report experiencing pain relative to the workers with low composite biomechanical demand exposure. Workers with medium-high and medium-low composite biomechanical demand exposure were also more likely to report experiencing pain than workers with low composite biomechanical demand exposure. The likelihood of reporting pain declined with decreasing biomechanical demand exposure.

Worker gender and age also affected whether or not workers reported experiencing pain symptoms as a result of the biomechanical demands of their job. Male workers were less likely to report experiencing pain than female workers. The youngest workers (15-24 years old) were also less likely to report experiencing pain than the oldest workers (55 years or more). However, there were no differences in the likelihood of reporting pain based on age for workers between 25 and 54 years and those 55 years or more.

Table 8. The factors predicting whether or not worker experienced pain as a result of the biomechanical demands they were exposed to: summary of logistic regression results

MODEL FACTORS The model reference group is *experiencing no pain symptoms*	The likelihood* of experiencing pain symptoms (as opposed to not) was…	… by a factor of (odds ratio) relative to the reference group
Composite biomechanical demands exposure group		
Medium-low	Increased	2.235
Medium-high	Increased	6.243
High	Increased	22.529
Low	Reference group	
Gender		
Male	Decreased	0.665
Female	Reference group	
Age		
15-24 years	Decreased	0.532
25-34 years		
35-44 years		
45-54 years		
55+ years	Reference group	

* Only statistically significant differences in odds are presented

Fatigue symptoms

Similar to the previous examination of the factors affecting whether or not workers experienced pain symptoms, an analysis of the factors affecting whether or not workers experienced fatigue as a result of the biomechanical demands of their work was undertaken. As in the previous model, exposure to biomechanical demands was modelled using the composite biomechanical demand exposure *z* score groups (low, medium-low, medium-high and high), rather than individual biomechanical demands. A summary of the model is presented in Table 9 and the full statistical details of the model can be found in Appendix C, Table 34.

Four employment and demographic factors affected the likelihood of a worker reporting they experienced tiredness as a result of the biomechanical demands of their work. Similar to the model examining pain symptoms, biomechanical demand level and gender affected the reporting of fatigue symptoms, as did night work and workplace size.

When controlling for the effects of the other factors in the model, males were less likely than females to report fatigue symptoms as a result of their work. Workers from workplaces with fewer than 20 employees were also less likely to report fatigue as a result of the biomechanical demands of their work. In contrast, workers who had high composite biomechanical demand exposure were over eight times more likely to report fatigue symptoms than workers in the low composite biomechanical demand exposure group. Like for pain symptoms, the odds of reporting fatigue symptoms increased with increasing level of biomechanical demand exposure. In addition to biomechanical demand, working at night increased the likelihood of a worker reporting fatigue symptoms.

Table 9. The factors predicting whether or not worker experienced fatigue as a result of the biomechanical demands they were exposed to: summary of logistic regression results

MODEL FACTORS **The model reference group is *experiencing no fatigue symptoms***	**The odds* of experiencing fatigue symptoms (as opposed to not) were…**	**… by a factor of (odds ratio) relative to the reference group**
Composite biomechanical demands exposure group		
Medium-low	Increased	2.128
Medium-high	Increased	3.709
High	Increased	8.059
Low	Reference group	
Gender		
Male	Decreased	0.755
Female	Reference group	
Night work		
Worked at night	Increased	1.688
Did not work at night	Reference group	
Workplace size		
Less than 5 employees	Decreased	0.638
5-19 employees	Decreased	0.618
20-199 employees		
200 or more employees	Reference group	

* Only statistically significant differences in odds are presented

Provision of control measures at workplaces

As stated previously, all but two workers were exposed to at least one biomechanical demand (‘rarely’ to ‘all the time’). Workers who reported exposure to biomechanical demands were asked a question on employer provided control measures. This question was asked at the end of questions on exposure to biomechanical demands and associated pain and fatigue questions. Workers were asked ‘what does your employer do to prevent this kind of pain?’ Interviewers then read out a list of five options; provide lifting equipment; provide trolleys; change layout of job; change the size and shape of loads, and; provide manual handling training. Because only one control measure question was asked and there were nine biomechanical demands, it was difficult to ascertain whether responses given by the respondents were appropriate control measures for their reported exposures. It was also apparent that the majority of intervention responses that were read out by the interviewer were more applicable to certain biomechanical demands (e.g. lifting or carrying heavy loads) than others (e.g. work while sitting down). Therefore, the adequacy of interventions provided could not be assessed in this report and this should be kept in mind when reading this section of the report.

The provision of control measures were examined in three ways. First, in terms of the number of controls provided and second in terms of whether or not any form of control was provided. The third way controls were investigated was by grouping them according to whether or not they were engineering controls, redesign controls or training. Table 10 shows the number and percentage of workers who reported they were provided with each of the controls surveyed and in terms of control grouping and number of controls provided. Over 60% of workers exposed to biomechanical hazards were provided with trolleys but only 32% were able to change the size and shape of loads. Indeed, engineering controls were the most commonly reported control group, followed by training and then redesign controls.

Of the workers exposed to biomechanical demands, 78% were provided with at least one type of control and many workers reported having access to more than one type of control. Over 17% were provided with all five of the surveyed control measures.

Table 10. Provision of controls for biomechanical demands: The number and percentage of all workers surveyed who reported the control was provided by type of control, group of controls and number of controls provided

Surveyed control measure	Percentage of workers who were provided with control
Provide lifting equipment	49%
Provide trolleys	61%
Change the layout of the job	34%
Change the size and shape of loads	32%
Provide manual handling training	56%
Grouped control measures*	**Percentage of workers who were provided with control**
Engineering controls	66%
Redesign controls	43%
Training	56%
Number of surveyed controls provided	**Percentage of workers who were provided each number of controls**
0	21.7%
1	17.1%
2	15.0%
3	16.8%
4	12.3%
5	17.1%
Total**	100.0%

* Engineering controls included the provision of lifting equipment and/or trolleys
Redesign controls included changing the layout of the job and/or the size or shape of loads

** Only two workers, of the 4500 surveyed, reported they were not exposed to any biomechanical demand. These workers were not asked the control measures question.

What employment and demographic factors predict the provision of controls?

As mentioned previously the provision of controls was examined in three ways. The full statistical output of these models is presented in Appendix C, Table 35 (number of controls provided), Table 36 (at least one control provided), Table 37 (engineering controls), Table 38 (redesign controls) and Table 39 (training).

Factors affecting the number of controls provided and the provision of at least one biomechanical hazard control

There were five common employment and demographic factors that were important predictors of (a) how many controls were provided and (b) the provision of at least one biomechanical demand control to workers to help them cope with the pain associated with the biomechanical demands of their work. An additional employment factor (night work) was associated with the provision of at least one biomechanical demand control. Table 11 presents a summary of the findings of the two analyses.

Table 11. Summary of model findings: Factors that affected (a) how many controls were provided and (b) whether or not any control was provided

MODEL FACTORS AND LEVELS The model reference group is 'no controls provided'	The likelihood of being provided with *x* number of controls as opposed to NO controls was increased / decreased by being in *y* factor level relative to the factor reference group					
	1 control	2 controls	3 controls	4 controls	5 controls	Any number of controls
Composite biomechanical demand exposure						
Medium-Low			Increased	Increased	Increased	Increased
Medium-High	Increased	Increased	Increased	**Increased**	**Increased**	Increased
High	**Increased**	**Increased**	**Increased**	Increased	Increased	**Increased**
Low	Reference	Reference	Reference	Reference	Reference	Reference
Gender						
Male				**Increased**	**Increased**	**Increased**
Female	Reference	Reference	Reference	Reference	Reference	Reference
Industry						
Manufacturing				Increased	**Increased**	Increased
Transport & storage						
Construction						
Agriculture, forestry & fishing				**Increased**	Increased	**Increased**
Health & community services	Reference	Reference	Reference	Reference	Reference	Reference
Workplace size						
Less than 5 employees	**Decreased**	**Decreased**	**Decreased**	**Decreased**	**Decreased**	**Decreased**
5 to 19 employees	Decreased	Decreased	Decreased	Decreased	Decreased	Decreased
20 to 199 employees	Decreased		Decreased	Decreased	Decreased	Decreased
200 or more employees	Reference	Reference	Reference	Reference	Reference	Reference
Occupational skill level						
1 (highest skill level)			Increased	Increased	Increased	Increased
2				Increased		
3		**Increased**	**Increased**	**Increased**	**Increased**	**Increased**
5 (lowest skill level)						
4	Reference	Reference	Reference	Reference	Reference	Reference
Night work*						
Worked at night						**Increased**
Did not work at night						Reference

Bold signifies the factor level with the greatest increase or decrease in odds ratio within the factor

* Night work did not predict control provision in the multinomial model examining the number of controls provided

The Agriculture, forestry and fishing and Manufacturing industries were more likely than the Health and community service industries to provide four or five biomechanical demand controls and overall, any number of controls. However, it should be noted that one of the controls – changing the size and shape of loads – is generally not practical in the Health and community services industry, whether the main load is the patient. This effectively reduces the number of controls available in this sector within this study. Despite this, there was no statistical difference in the likelihood of providing four or five controls between the Health and community services industry and either the Construction or Transport and storage industries, where presumably, all surveyed types of control measures are available. This suggests that the adequacy of control provision in these latter two industries may require further investigation.

Occupational skill level was also a predictor of biomechanical demand control provision. Workers that typically had the greatest exposure to biomechanical demands – those in occupational skill level three – were also associated with the most increased likelihood of being provided with two, three, four or five controls (as opposed to none) than workers in skill level four. The likelihood of being provided with three, four or five controls was also increased for workers in the highest skill level (one).

The odds of being provided with at least one biomechanical demand control were increased by working at night relative to not working at night. However, this factor did not affect the provision of each number of controls.

Workplace size was consistently the best predictor of biomechanical demand control provision. Workers in the smallest workplaces were always least likely to report that any number of controls were provided and, overall, least likely to report that any control was provided. The likelihood that biomechanical demand controls were provided were significantly reduced for all workplaces smaller than 200 or more employees. However, the reduction in likelihood became smaller as workplace size increased.

After workplace size, the second best predictor of the provision of biomechanical demand controls was composite biomechanical demand exposure score. Compared to workers with low biomechanical demand score, workers with higher demands were more likely to be provided with each number of controls. Overall, the workers most likely to be provided with any number of controls were workers with high biomechanical demand exposure. However, it should be noted that the likelihood that workers were provided with four or five controls (as opposed to none) was greatest for workers with Medium-High biomechanical demand exposure.

Male workers were more likely than female workers to be provided with at least one biomechanical demand control. However, when the number of controls provided was examined it can be seen that this relationship is driven by males being more likely to be provided with four or five controls compared to females. There was no difference in the likelihood of provision of one, two or three biomechanical demand controls between male and female workers.

Groups of biomechanical demand controls

The same employment and demographic factors that were important predictors of the number of controls tended to be important predictors of the three groups of controls; engineering, redesign and training. However, there were differences, in particular between the provision of training and the two other control types, in terms of the factors that predicted the provision of each of these controls. The results of these analyses are presented in summary in Table 12.

Table 12. Summary of model findings: Factors affecting the provision of (a) engineering controls, (b) redesign controls and (c) training

MODEL FACTORS AND LEVELS	The likelihood of being provided with each type of control, as opposed to NOT being provided with the control, was *increased / decreased* by being in *x* factor level relative to the factor reference group		
The model reference group is 'control not provided'	**Engineering controls**	**Redesign controls***	**Training****
Gender			
Male	**Increased**	**Increased**	
Female	Reference	Reference	
Workplace size			
Less than 5 employees	**Decreased**	**Decreased**	**Decreased**
5 to 19 employees	Decreased	Decreased	Decreased
20 to 199 employees	Decreased	Decreased	Decreased
200 or more employees	Reference	Reference	Reference
Composite biomechanical demand exposure			
Medium-Low	Increased		Increased
Medium-High	Increased	**Increased**	**Increased**
High	**Increased**		Increased
Low	Reference	Reference	Reference
Occupational skill level			
1 (highest skill level)		Increased	
2		**Increased**	
3	**Increased**	Increased	
5 (lowest skill level)	Increased		
4	Reference	Reference	
Industry			
Manufacturing	Increased	Increased	
Transport & storage	Increased	Increased	
Construction	Increased	Increased	
Agriculture, forestry & fishing	**Increased**	**Increased**	
Health & community services	Increased	Increased	
Electricity, gas & water supply			
Wholesale & Retail trade	Increased	Increased	
Accommodation, cafes & restaurants	Increased	Increased	
Communication services			
Finance & insurance			
Mining	**Increased**	**Increased**	
Government administration & defence	Increased	Increased	
Education	Increased		
Cultural, recreational & personal services			
Property & business services	Reference	Reference	
Night work			
Worked at night	**Increased**		
Did not work at night	Reference		

Bold indicates the factor level with the greatest increase or decrease in odds ratio within the factor

Bold indicates the national priority industry with the greatest increase in odds ratio

* Night work did not predict the provision of redesign controls and was removed from the model

** Only two factors, workplace size and composite biomechanical demand exposure, predicted the provision of training.

Unlike the previous controls analyses, workers from all industries were included in the groups of biomechanical demand analyses. The likelihoods of the provision of both the engineering and the redesign controls were increased for workers in each of the national priority industries compared to workers in the Property and business services industry. Within the national priority industries, the industry associated with the greatest likelihoods of provision of these controls was the Agriculture, forestry and fishing industry. Across the board, however, the likelihoods of being provided with engineering or redesign controls were most increased for workers in the Mining industry. Unlike, engineering and redesign controls, industry of employment did not affect the provision of training.

Like industry, worker gender had a consistent effect on the provision of engineering and redesign controls. For both types of controls, male workers were more likely to be provided with the control than female workers. Another factor with a consistent effect on the likelihood of control provision was workplace size. This factor was one of only two factors that affected the provision of training. For each control, the likelihood that the control was provided was decreased most for workers in the smallest workplaces (< five employees) relative to the largest workplaces (220 or more employees). Although all workplaces with less than 200 employees were significantly less likely to provide these controls than the largest workplaces, the reduction in likelihood decreased as workplace size increased.

The other factor that affected the provision of training controls – and engineering and redesign controls – was worker composite biomechanical demand exposure score. However, there were different patterns within this factor for each of the biomechanical demand control groups. The level of biomechanical demand exposure that was associated with the most increased odds of provision of engineering controls was high exposure. In contrast, the likelihood of redesign controls being provided was only increased for workers in the medium-high biomechanical demand exposure group. Workers with other levels of exposure had the same odds of being provided with redesign controls as workers with low biomechanical demand exposure. The likelihood of being provided with training was also most increased for workers with medium-high biomechanical demand exposure. However, workers with medium-low and high biomechanical demand exposure were also more likely to be provided with manual handling training than workers with low biomechanical demand exposure.

Occupational skill level also affected the likelihood of control provision, but only the provision of engineering and redesign controls. These controls differed in terms of the occupational skill levels associated with increased odds of control provision. The likelihood of provision of engineering controls was most increased for workers in skill level three but also increased for workers in skill level five (the lowest skill level) relative to workers in skill level four. Workers in occupational skill levels three and five recorded the highest mean composite biomechanical demand exposure scores. In contrast, workers in skill level two were associated with the greatest increase in likelihood of being provided with redesign controls relative to skill level four. Workers in skill levels one and three were also associated with increased odds of provision of this biomechanical demand control. It is possible that awareness of redesign controls is greater in the higher skill levels because workers in these levels have more responsibility in their jobs for making decisions about these controls.

The final employment factor that affected the provision of engineering controls was night work. Workers who worked at night were more likely than those who did not to be provided with engineering controls. This factor did not affect the provision of redesign controls or training.

Summary of results

A summary of the main findings of this report is presented in Table 13. This table describes the relationships between the main employment and demographic characteristics of workers and biomechanical demand exposure, self-reported pain and fatigue symptoms, and biomechanical demand control provision.

Table 13. Summary of the main findings of the analyses contained in this report

SUMMARY OF LOGISTIC REGRESSION MODEL RESULTS			Pain and fatigue symptoms		Provision of biomechanical demand controls			
Employment / demographic characteristic	Individual biomechanical demands	Composite biomechanical demand exposure	Pain	Fatigue	Number of controls / at least one control	Engineering	Redesign	Training
Gender								
Male	Males were more likely to report work while sitting down and squatting or kneeling while working than females	Males had a higher mean composite biomechanical demand exposure score than females (except in Health & community services)	Males were less likely to report pain symptoms than females	Males were less likely to report fatigue than females	Males were more likely than females to be provided with 4 or 5 controls - or controls generally	Males were more likely than females to be provided with engineering controls	Males were more likely than females to be provided with redesign controls	
Female								
Age								
15-24	The youngest workers (15 - 34) were consistently most likely to report exposure to biomechanical demands	Young workers recorded the highest mean composite biomechanical demand exposure while older workers recorded the lowest exposure	The youngest workers were least likely to report pain					
25-34								
35-44								
45-54								
55+								
Workplace size								
Less than 5 employees	Inconsistent and small effect on exposure to biomechanical demands. Effect depended on demand.			2nd least likely to report	The smallest workplaces were least likely to be provided with controls. Provision increased with workplace size.	The smallest workplaces were least likely to be provided with engineering controls. Provision increased with workplace size.	The smallest workplaces were least likely to be provided with redesign controls. Provision increased with workplace size.	The smallest workplaces were least likely to be provided with training. Provision increased with workplace size.
5 to 19 employees				Least likely to report				
20 to 199 employees								
200 or more employees								
Composite biomechanical demand								
Low			Least likely to report	Least likely to report	Least likely to report	Least likely		Least likely
Medium-Low								
Medium-High			2nd most likely to report	2nd most likely to report	2nd most likely to report	2nd most likely	Most likely	Most likely
High			Most likely to report	Most likely to report	Most likely to report	Most likely		2nd most likely
Occupational skill								
1 (highest skill level)	Lowest skill levels most likely to report exposure to the biomechanical demands (except for work while sitting down). Effect depended on industry and type of biomechanical demand.	Occupational skill levels 3 & 5 had the highest composite biomechanical demand exposure score (except in Health & community services)			Skill level 3 was most likely to be provided with 2, 3, 4 and 5 controls, and controls in general. Skill level 1 also more likely to report controls provided		3rd most likely	
2							Most likely	
3						Most likely	2nd most likely	
4								
5 (lowest skill level)						2nd most likely		
Industry								
Manufacturing	Effect depended on gender and occupational skill and specific biomechanical demand				Most likely 5 controls	2nd most likely	2nd most likely	
Transport & storage						Least likely	4th most likely	
Construction		Highest				4th most likely	3rd most likely	
Agriculture, forestry & fishing		2nd Highest			Most likely 4 controls & at least 1 control	Most likely	Most likely	
Health & community services		Lowest				3rd most likely	Least likely	
Night work								
Worked at night	Night work increased likelihood of exposure to 7 of 9 biomechanical demands	Mean composite biomechanical demand exposure was higher for night workers		Night work increased likelihood of reporting fatigue	Night work increased likelihood of reporting at least one control	Night work increased likelihood of reporting engineering controls		
Did not work at night								
Other language spoken at home								
Yes	Only affected work while sitting down - those who spoke other language at home were less likely to report exposure							
No (English only)								
Interaction terms								
Gender*Industry* Occupational skill		Interaction largely a result of differences in gender and occupational skill level of exposed workers in the Health and community services industry compared to the other industries						
Industry*Gender	Affected all biomechanical demands except Repetitive hand or arm movements, Squatting or kneeling while at work and Work while standing in one place							
Industry*Occupational skill	Affected all biomechanical demands except Repetitive hand or arm movements and Squatting or kneeling while at work							
KEY	[light shading]	Factor modelled but had no effect	[dark shading]	Factor not modelled				

Discussion

Prevalence of exposure to biomechanical demands

This report found that self-reported exposure to biomechanical demands among Australian workers was high. Between 50% and 89% of workers said they were exposed, at least some of the time, to each of the nine biomechanical demands included in this survey. Similar prevalence rates have also been observed in other industrialised countries. In a French survey of workplace exposures, 40% of workers reported handling heavy loads, with 30% of workers reported handling heavy loads for at least two hours a week (Grégoire 2006). In the same survey, one in 10 workers reported doing repetitive movements for 10 hours or more a week (European Foundation for the Improvement of Living and Working Conditions 2007b). Approximately three quarters of workers in Europe reported standing or walking during work for at least a quarter of the time in the 2005 European Working Conditions Survey (European Foundation for the Improvement of Living and Working Conditions 2007a).

A second key finding of this report is that the majority of workers were exposed to at least two biomechanical demands. This finding is similar to that reported by a surveillance study of upper extremity WMSDs in French workers (Roquelaure et al. 2006). Approximately half of all workers in this French study reported exposure to at least two risk factors for WMSDs.

As this is the first national survey of workplace exposures in Australia, there is no data to compare to determine whether the prevalence of exposure to these hazards has been declining or increasing. Trend data from the French Sumer Survey as well as those from the European Working Conditions Survey suggest that prevalence is increasing or similar to previous surveys despite a declining workforce in physically demanding industries such as Manufacturing and Agriculture (European Foundation for the Improvement of Living and Working Conditions 2007a, b). Australian workers' compensation data indicate a stabilisation or decline in claim rates for diseases of the musculoskeletal system and connective tissue. However workers' compensation data may not properly reflect exposure to biomechanical demands because workers' compensation authorities restrict eligibility for claims, definitional changes in workers' compensation data may have generated apparent declines, and, for a variety of reasons, workers do not always seek workers' compensation for their WMSDs. It is therefore possible that the prevalence of exposures to biomechanical demands has also been increasing in Australia. Time series data is needed to determine patterns of biomechanical demand exposure prevalence.

It is important to note that European (and possibly Australian) workers' exposures to biomechanical demands have not declined despite several decades where work health and safety agencies have invested significant resources in addressing WMSDs, particularly in relation to biomechanical demands at work. A review of existing codes of practice and guidelines for the International Labour Organisation (ILO) by an expert group of researchers found 33 international standards, codes of practice and guidance materials that were relevant to risk management of WMSDs (Macdonald et al. 2004; Niu 2010). Despite the wide prevalence of these materials, and efforts by Australian and international work health and safety agencies, the authors noted that little was known about the effectiveness of such information and guidance in reducing hazardous exposures that could lead to the development or exacerbation of WMSDs. It has been suggested that the use of inconsistent terminology, inadequate exposure assessment tools, lack of usability of available documents, failure to take into account cumulative and concurrent exposure to similar biomechanical demands, failure to adopt a 'systems' approach to risk management may have acted as barriers to better control of hazards associated with WMSDs (Macdonald et al. 2004; Whysall et al. 2004; Macdonald et al. 2006). It is clear that these barriers need to be addressed to reduce the prevalence of exposure to biomechanical demands in Australian workers.

Identification of workers exposed to biomechanical demands

This report identified workers exposed to biomechanical demands using two approaches to classifying exposure:

1) for each biomechanical demand: exposed ('rarely' to 'all the time') and non exposed ('never'), and

2) composite biomechanical demand exposure *z*-score taking into account the number and frequency of biomechanical demands.

Regardless of the approach taken, certain demographic and employment characteristics of workers were consistently identified as associated with exposed workers. The workers most likely to report exposure to biomechanical demands were generally young (< 34 years) and/or male and/or worked at night and/or had low occupational skill. Specifically, workers in occupational skill levels three and five (the lowest skill level) had the highest mean composite biomechanical demand exposure score, indicating greatest exposure.

There was a three way interaction between industry, gender and occupational skill on composite biomechanical demand exposure score. This means that these factors depended on each other in terms of their effect on composite biomechanical demand exposure. The main driver of this relationship seems to be the Health and community services industry where different skill levels and females had higher biomechanical demand scores than the same demographics in other industries. Similar results were found for two-way interactions between gender and industry, and occupational skill level and industry, when each individual biomechanical demand was modelled.

A summary of the findings of the biomechanical demand exposure analyses, together with pain and fatigue symptoms and biomechanical demand control provision, is presented in Table 13.

Young workers

For the majority of biomechanical demands examined in this report, there were clear age related differences in exposure, with younger workers having a higher likelihood of exposure. The exceptions were the biomechanical demands: *work while sitting down;* and *work with the hands raised above the head*. Similar findings of increased exposure in young workers for biomechanical demands, such as repetitive work, have been reported elsewhere (Gauthy 2006; Grégoire 2006). This may be due to younger workers starting out in lower paid and more manual jobs while they are completing their education and training. It is also likely that older workers move out of jobs with extreme biomechanical demands either because of associated injury (the healthy worker effect) or because they have become physically unsuited to the job.

Although young workers were more likely to report exposure to biomechanical demands, young workers (15-24 years old) were the least likely to report pain symptoms as a result of the biomechanical demands of their job. Workers 25 to 54 years in age were equally likely as workers aged 55 years or more to report pain symptoms as a result of the biomechanical demands of their work. This finding contrasts with the overall result that workers with high composite biomechanical demand scores were more likely to report pain (in all bodily locations) all the time or often and least likely to report they never experienced pain relative to the workers with low, medium-low and medium-high levels of biomechanical demand exposure. However, the finding may be explained by the presumably better physical capabilities of the youngest workers and/or higher rates of part-time work amongst young workers. These possibilities require further investigation.

Worker age did not affect the likelihood of a worker reporting fatigue symptoms. Nor did worker age affect the likelihood of biomechanical demand control provision. Despite this, young and/or newly employed workers who were exposed to physically demanding tasks have been found to have a high risk of developing WMSDs (Haekkaenen et al. 2001). This stresses the importance of having prevention initiatives aimed at young and new workers. It is essential that young workers are given a proper induction/education of safe work procedures and are provided with the appropriate controls for the biomechanical demands of their work.

Worker gender

The effect of worker gender on exposure to the individual biomechanical demands depended on industry of employment. However, on the whole, larger proportions of male workers reported exposure to biomechanical hazards than females and males had a higher mean composite biomechanical demand exposure score than females. The gender based differences in biomechanical demand exposure found in this study are consistent with the findings of other studies (Nordander et al. 1999; Hooftman et al. 2005). Despite males typically having greater exposure to biomechanical demands than females, males were less likely to report pain and fatigue symptoms than females. Differences in self reported pain and fatigue symptoms by gender are discussed further below in the *Prevalence of pain and fatigue symptoms* section.

Males were, however, more likely to be provided with biomechanical demand controls. This was true of controls generally and the provision of four or five of the five controls surveyed. Males were also more likely to be provided with engineering and redesign controls. There was no difference between males and females in terms of the likelihood of being provided with manual handling training. It should be borne in mind that the control measures questions were somewhat limited in the sense that they were not linked to specific biomechanical demands and were biased towards particular biomechanical demands. However, this finding raises the possibility that gender differences in the reporting of pain and fatigue are due to gender differences in the provision of controls. An alternative explanation of this finding is that biomechanical demand exposure level is a better predictor of control provision than gender and that this factor has driven the observed relationship. Workers with higher composite biomechanical demand exposure were most likely to be provided with all forms of biomechanical demand control and the workers with the highest mean biomechanical demand exposure were male. Nevertheless, it should be noted that females, with lower levels of biomechanical demand, reported associated pain and fatigue symptoms. This warrants further investigation.

Workplace size

Workplace size had an inconsistent and small effect on exposure to individual biomechanical demands and was not a predictive factor for composite biomechanical demand exposure score in the model examining only the priority industries. This implies that workers from small work places were as likely as large workplaces to be exposed to biomechanical demands. In contrast, when the whole data set was examined, there were significant differences in biomechanical demand exposure by workplace size and the mean composite biomechanical demand level declined with increasing workplace size (Table 32). This means that workers from the smallest workplaces had, on average, the greatest biomechanical demand exposure. This relationship requires further investigation, particularly since the relationship between workplace size (number of workers at a worksite / location) and company size has not been determined in this study.

Although workplace size may or may not have affected exposure to biomechanical demands, workplace size predicted fatigue symptoms (but not pain), with workers from the smallest workplaces (< 20 employees) being less likely than workers from the largest workplace (200 or more employees) to report fatigue as a result of the biomechanical demands of their work.

Workplace size was the best predictor of control provision. The smallest workplaces were least likely to be provided with controls and the likelihood of control provision increased with increasing workplace size. This finding is consistent with other research where smaller businesses were found to have less work health and safety risk assessment and controls compared to larger businesses. This was thought to be due to a number of factors, such as lack of awareness and time and resource constraints and having a lower level of work health and safety expertise (Dorman 2000; Lin and Mills 2001; Champoux and Brun 2003).

The findings of this study indicate that biomechanical demand control provision probably needs improvement in smaller workplaces, and this is especially pertinent if small workplaces are associated with higher biomechanical demand exposure. Relatively reduced control provision in small workplaces is not a new finding and addressing the work health and safety issues of smaller workplaces remains an objective of regulatory authorities. It is recognised that, due to their limited human and capital resources, smaller workplaces may need additional help and support from stakeholders involved in prevention of workplace injuries and diseases (Access Economics 2009). However, since a large proportion of Australian businesses are smaller sized businesses (Australian Bureau of Statistics 2010), it seems imperative that priority be given to improving provision and access to controls for biomechanical demands in these smaller workplaces.

Night work

Night work increased the likelihood of a worker reporting exposure to seven of the nine individual biomechanical demands and the mean composite biomechanical demand exposure score was higher for night workers than for those who did not work at night. Not surprisingly, night workers were more likely than day workers to report the biomechanical demands of their job caused fatigue. There was no difference between night workers and day workers in terms of the likelihood of reporting pain symptoms. Although it seems likely that the biomechanical demand exposure was greater for night workers, these workers were also more likely to be provided with at least one control measure than day workers. Furthermore, the likelihood that engineering controls were provided was increased for workers who worked at night. Night work had no effect on the provision of redesign controls or training. Further research is required to determine the adequacy and suitability of the biomechanical demand control measures provided to this highly exposed group of workers.

Occupational skill

Workers in the lowest skill levels and those in occupational skill levels three and five, in particular, were the most likely to report exposure to biomechanical demands and recorded the highest mean composite biomechanical demand exposure scores. Interestingly, occupational skill level was not associated with self reported fatigue or pain symptoms as a result of biomechanical demands. Workers in occupational skill level three were most likely to be provided with controls overall, however the type of control affected the odds of control provision. Workers in occupational skill level three were most likely to be provided with engineering controls but workers in skill level two were more likely to be provided with redesign controls. This difference may be attributable to differences in job control, responsibility and control awareness between the occupational skill levels. Workers in higher skill levels may have more awareness of or ability to utilise redesign controls for their biomechanical demands.

Industry

The effect of industry on exposure to individual biomechanical demands depended on worker gender and occupational skill and the specific biomechanical demand concerned. Overall, Construction industry workers had the highest composite biomechanical demand score, followed by workers in the Agriculture, forestry and fishing industry. Workers in the Health and community services industry had the lowest mean biomechanical demand score of the priority industries. Industry of employment was not associated with self reported pain and fatigue symptoms. However, industry did effect biomechanical demand control provision. The odds of workers being provided with four controls or at least one control were increased for workers in the Agriculture, forestry and fishing industry. This industry was also the most likely, of the priority industries, to be provided with engineering or redesign controls. The Construction industry, where workers had the highest biomechanical demand exposure, recorded the second and third lowest likelihoods of the priority industries of providing these controls. Biomechanical demand control provision in the Construction industry therefore requires further investigation. However, it should be remembered that these likelihoods are all relative. Across the board, all the national priority industries had increased odds of providing engineering and redesign controls compared to the reference industry (Property and business services).

Prevalence of pain and fatigue symptoms

This study provides a first estimate of self-reported pain and fatigue symptoms in Australian workers. Approximately half of those surveyed had self-reported pain in either neck or back, and/or shoulder/arm/wrists or hands, and/or hips, legs, knees or feet. Due to the use of different instruments to assess pain and fatigue symptoms in the literature, absolute comparisons could not be made with other studies. However, the rates (sometimes to all the time) observed in this study for back/neck pain and pain shoulders/arms/wrists/hands were slightly higher compared to the French prevalence rates for upper extremity symptoms in the last week, which assessed symptoms using the Nordic questionnaire (Hagberg et al. 1995a; Roquelaure et al. 2006). In a 2008 systematic review of neck pain, one week prevalence of neck pain varied between 10.6% and 19.6% (Côté et al. 2008).

Analyses in this report showed the highest odds of reporting pain were associated with the highest exposure to biomechanical demands. Workers with high composite biomechanical demand exposure were over 20 times more likely to report pain symptoms than workers with low composite biomechanical demand exposure. Younger workers and males were less likely to report pain compared to older and female workers. Other studies have also found that females experienced more pain and other musculoskeletal symptoms than males (de Zwart et al. 1997; Treaster and Burr 2004; Collins and O'Sullivan 2009). The reason for higher rates of musculoskeletal symptoms in women is not yet known. Several factors, such as differences in physical load capacity, muscular activity, the double work and home burden of female workers, issues in workplace design which are based on anthropometric measures of men and differences in types of occupations, have been suggested but the evidence is still unclear (de Zwart et al. 1997; Nordander et al. 2008).

Biomechanical demand control measures

The NHEWS study only investigated the provision of biomechanical demand controls in a limited way. The findings of this study cannot be used to draw conclusions about the provision of controls, beyond indicative trends. This important aspect of hazard exposure requires considerable further research, both in terms of basic provision and use of controls (as attempted by the NHEWS survey) but also in terms of the efficacy of the individual control measures. There is mixed evidence so far regarding the effectiveness of control measures to reduce exposure to biomechanical demands. Meta-analyses and systematic reviews of intervention studies have found that single factor interventions such as providing lifting training or postural adjustment alone have little or no impact on subsequent musculoskeletal health (Westgaard and Winkel 1997; Hignett 2003; Gerr et al. 2005; Côté et al. 2008; Driessen et al. 2010). These reviews suggest that a ‘systems’ approach that incorporates training, equipment provision, work redesign and changes in work practices have a better chance of success. All stakeholders need to improve their awareness of the complex interplay between different characteristics of the work and worker to ensure appropriate control measures are being provided at the workplace, not just the measures that are most convenient and cost effective.

Good quality intervention research, especially research which considers and targets multiple hazards associated with WMSDs, is quite limited. Many currently available studies also have other limitations such as targeting only one group of workers, small sample size, not accounting for confounding variables, no control groups or having short follow-up periods. Future quality intervention research that addresses the limitations of current research is gravely needed.

Limitations of this report and directions for future research

This report must be read with a number of limitations in mind. Firstly, the data used in this report is self-reported data. While self-reported assessment of exposure to biomechanical demands is a common and widely accepted method of exposure assessment (Stock et al. 2005), the wide number of instruments used in self-report studies makes it difficult to make direct comparisons across studies. Many self-reported exposure assessment measures take a more quantitative approach by asking for more specific details on frequency or duration of exposure to biomechanical demands. For example, in the case of lifting, information on the amount of load (e.g. standing in position for 30 minutes, lifting 11-30 times a hour, trunk flexion over 45°) might be collected (Pope et al. 2001; Jansen et al. 2004; Roquelaure et al. 2006). The NHEWS survey did not attempt to quantify exposure. It only collected information on the frequency of exposures on a five point 'never' to 'all the time' scale.

Secondly, all analyses presented in this report were based on cross-sectional data. Cross-sectional data cannot be used to identify causal relationships. Although regression and other analyses presented in this report identified the key demographic and employment characteristics of workers associated with self-reported exposure to biomechanical demands or pain and fatigue symptoms, further research using longitudinal datasets is needed to confirm such reported relationships. In addition, in terms of associations between exposure to biomechanical demands and musculoskeletal pain, this report did not consider all work hazards that could potentially contribute to the development or exacerbation of musculoskeletal symptoms. Other work related factors, such as temperature, vibration and psychosocial working conditions, have also been found to be associated with the development of WMSDs (e.g. Keyserling 2000b; van Rijn et al. 2010). It is recommended that a short follow-up report of the NHEWS survey be conducted to examine the combined effect of exposure to biomechanical demands and psychosocial hazards on self-reported musculoskeletal pain. It is also suggested that further studies of exposure to work related factors associated with musculoskeletal disorders, including biomechanical and psychosocial hazards, are conducted, using observation and experimental study designs (rather than cross-sectional surveys).

Despite musculoskeletal disorders being a highly prevalent occupational disease, there is little information in Australia on the burden of these disorders, other than estimates based on workers' compensation dataset. Future studies on the population attributable fraction of these disorders due to occupational exposures, on the economic cost (including the cost of presenteeism, absenteeism and the cost to the society) should provide a more complete picture of the true cost and burden of this preventable occupational disease in Australia.

Lastly, additional intervention research, using a 'systems' approach, will provide useful information to more effectively prevent exposure to biomechanical demands, and subsequently, prevent the development of work related musculoskeletal disorders.

Policy implications

The following are the main policy implications arising from this research:

- Exposure to biomechanical demands is common in Australian workplaces. Ongoing surveillance of biomechanical demands is recommended. This will facilitate the development of targeted interventions and hazard controls. It will also enable work health and safety bodies to determine whether progress has been made on reducing biomechanical demand exposure at both the national / jurisdiction levels and by key worker demographics.
- Young workers, male workers, night workers and lower skilled workers were most likely to report exposure to biomechanical demands. It is recommended that these workers in these groups be targeted in any intervention campaign and be considered in policy development.

- Although male workers typically were exposed to higher levels of biomechanical demand, female workers were more likely to report pain and fatigue symptoms and less likely to be provided with biomechanical demand controls than male workers. This potential link between reduced likelihood of control provision and increased reporting of pain and fatigue symptoms by female workers requires further, urgent investigation.
- Workplace size and composite biomechanical demand exposure were the best predictors of biomechanical demand control provision. Workers in large workplaces and those with high biomechanical demand exposure were most likely to be provided with controls. Policy development needs to address the problems faced by smaller workplaces in the provision of biomechanical demand controls. Policy interventions should also seek to improve the provision of controls to workers exposed to intermediate levels of biomechanical demand. This may improve the health outcomes of many workers, potentially including those of female workers (mentioned above) and other groups of workers e.g. older workers, who may be more vulnerable to WMSDs.
- More research on biomechanical demand control provision, use and efficacy is required in order to determine the size and characteristics of the Australian working population at risk of developing WMSDs as a result of biomechanical demand exposure. It is recommended that this aspect of the NHEWS survey be revised and improved for future surveys.

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Appendix A: NHEWS survey methodology

The first National Hazard Exposure Worker Surveillance (NHEWS) survey was conducted in 2008. The NHEWS survey aimed to provide an estimate of the prevalence of exposure to priority occupational hazards (which include biomechanical demands in the workplace) and obtained data on the provision of selected controls in the workplace. It was the first time a nationwide survey of workplace hazard exposures was undertaken. A total of 4500 workers from all industries across Australia were interviewed.

The NHEWS survey instrument was developed by the Office of the Australian Safety and Compensation Council (now Safe Work Australia) and Victorian WorkCover, with substantial input from topic experts and other state and territory OHS authorities. In particular, expert input was provided by Dr Tim Driscoll, Associate Professor Anthony LaMontagne, Associate Professor Wendy Macdonald, Dr Rosemary Nixon and Dr Warwick Williams.

The survey was conducted by Sweeney Research using the computer assisted telephone interviewing (CATI) method. For full details regarding the NHEWS survey and its methodology, please refer to the survey handbook at http://www.safeworkaustralia.gov.au/NR/rdonlyres/F2FD697E-2854-40BF-9F4A-0077CC901B8E/0/dm2433774ASCCNHEWSHandbook17Sept2008.pdf. For more details on the sample, please consult the appendix of the NHEWS Survey 2008 results report at http://www.safeworkaustralia.gov.au/NR/rdonlyres/A86582B6-F3B9-42F8-AE48-EB46CA92AB46/0/NationalHazardExposureWorkerSurveillanceREVISED_March09.pdf.

Assessment of exposure to individual biomechanical demands

Worker exposure to individual biomechanical demands was measured in the NHEWS survey by asking respondents about the specific biomechanical demands involved in their work. Responses were on a five point frequency scale (1= Never, 2= Rarely, 3= Sometimes, 4= Often, 5= All the time). Respondents were asked about nine biomechanical demands. These were:

- lifting or carrying heavy loads
- making the same hand or arm movements over and over again (repetitive hand movements)
- work with the body bent forward
- work in a twisted or awkward posture
- work with the hands raised above the head
- work while sitting down
- squatting or kneeling while working
- pushing or pulling using some force, and
- work while standing in one place.

These nine biomechanical demands are similar to the biomechanical demands covered in the European Working Conditions Survey, Work Environment Survey (Sweden) and National Exposures at Work Survey (National Institute for Occupational Safety and Health, USA) (Australian Safety and Compensation Council 2008).

Currently, there is no 'gold standard' way of defining who is exposed to biomechanical demands using a self-report questionnaire as different studies tend to use different questions and rating scales. Within the NHEWS survey, exposure to biomechanical demands was assessed using a five-point 'never' to 'all the time' frequency scale. Information on exposure to the majority of other hazards in the NHEWS survey was collected by asking respondents to nominate the length of time spent working with a particular hazard (hours per day or week). For analyses of exposure to these other hazards (e.g. noise, airborne hazards, and vibration) collected in the NHEWS survey, if a person reported any exposure during the past week, he/she was classified as 'exposed'. Therefore, to keep analyses in this report as consistent as possible with analyses of other exposures from the NHEWS survey, workers were classified as 'exposed' to a particular biomechanical demand if they reported 'any' exposure, that is if their responses ranged from 'rarely' to 'all the time'. All workers who said 'never' to a biomechanical demand item were classified as 'not-exposed' for that item. This simple classification means that workers who stated that they were exposed to a biomechanical demand 'rarely' were grouped in the same category as those who reported a more frequent exposure (sometimes, often, all the time). However, as there was no information available for a more scientific cut off point, it was decided to proceed with this simple classification of exposed and non-exposed workers. However, additional analyses were also carried out using a composite exposure measure to take into account the frequency of exposure (see section below).

There were very little missing data on exposure to the nine biomechanical demands. Due to the very small number of missing items, no treatment of missing data was undertaken.

Measurement of exposure to combined biomechanical demands score - The composite biomechanical demand exposure score

In addition to exposure to single biomechanical demands, a composite measure reflecting both the intensity and the number of concurrent biomechanical demand exposures was constructed for this report. This was undertaken because in actual workplaces it is likely that workers are exposed to more than one type of biomechanical demand in their job. This means that information on co-exposures would provide valuable additional information for prevention initiatives. This composite measure provides a way of identifying workers with the greatest exposure to a combination of different types of biomechanical demands. The composite exposure score, which was based on a similar analysis conducted for the EU Working Conditions Survey (European Foundation for the Improvement of Living and Working Conditions 2007a), was created in two steps:

1) The raw composite score for each respondent was calculated by taking the mean of the responses to the nine biomechanical demands. As all the nine biomechanical demand items in the NHEWS survey were measured using the same five point scale (from 5 'all of the time' to 1 'never'), the average exposure on a scale of 1–5 is calculated for a composite variable representing combined exposure. The greater the exposure to multiple biomechanical demands and the more intense the exposure, the higher an individual's composite score would be.

2) For easier interpretation, a standardised score (z-score) was then calculated across the distribution: 0 represents median exposure, a positive score is greater than median exposure and a negative score is less than median exposure, measured in standard deviation units. A positive score indicates higher exposure and can be considered a negative from a worker health and safety perspective. The formula for calculation of z-score is (Gravetter and Wallnau 2009):

$$z = \frac{(x - \mu)}{\sigma}$$

The variables in the z-score formula are:

z= z score

x= raw score

μ= mean of the population

σ = standard deviation of the population.

Although it was originally intended to include all nine biomechanical demand items in this composite measure, reliability analysis showed that the Cronbach's alpha for the 9-item scale was less than ideal (0.653). Generally, an alpha of 0.7 or more is considered acceptable

(Nunnally and Bernstein 1978). It was found that removing the item, 'working while sitting down', increased the Cronbach's alpha to 0.809. Therefore, a decision was made to exclude 'work while sitting down' from the composite exposure scale. The final composite score, therefore contained eight items and excludes 'sitting down', a measure of sedentary behaviour.

It should be noted that this methodology assumes that all biomechanical demands contribute equally to biomechanical hazards and the likelihood of injury. This may not be the case in reality. Furthermore, the presence of multiple biomechanical demands may have a multiplicative effect on injury risk, rather than a summative effect as calculated (by taking the mean) here. Therefore, in terms of the latter assumption, the *z* score may confer an underestimate of the biomechanical demand exposure health risks of workers.

In addition to the standardised composite score, a categorical variable was also created for descriptive and regression analyses. This was based on the standardised composite *z* score that contained eight biomechanical demands (excluding 'work while sitting down'). Four groups were created by cutting off the score at the 25th, 50th and 75th percentiles. Those with a score in the first 25th percentile were coded as Low, those with a score between 26th to 50th percentiles were coded as Medium-low, those with a score between 51st and 75th percentiles were coded as Medium-high and those with a score above the 75th percentile were coded as High.

Demographic and employment variables

The NHEWS survey collected information on several demographic and employment factors. A list of variables examined in this report is presented in Table 14. These variables were examined to see if they were associated with exposure to biomechanical demands, pain and fatigue symptoms or if they were associated with the provision of control measures.

Rather than occupation, occupational skill levels were used in the analyses contained in this report. Respondents' occupation and main tasks at work were used to code occupations down to the six digit level of the Australian and New Zealand Standard Classification of Occupations (ANZSCO). This information was then used to group respondents into skill levels as defined in the ANZSCO first edition (Australian Bureau of Statistics and Statistics New Zealand 2006). Occupational skill level one is the highest skill level and skill level five is the lowest skill level.

Although 'occupational skill level' may at first not appear a useful way of identifying at-risk groups for prevention activities compared to 'occupation', it is chosen for detailed analyses in this report for three reasons:

1. It consists of only five skill categories and makes it more feasible for cross-tab or logistic regression analyses (analyses including occupation have to be restricted to the nine broad occupational groupings [ANZSCO-1]).
2. The ANZSCO publication provides simple identification of occupations within each occupational skill level, thus, in terms of identifying workers at-risk, information on skill level was considered more complete (a reference table of skill level by occupation is also provided in this report, see Table 40 in Appendix D).
3. Within each industry, occupational skill level provides a proxy measure of seniority and income (LaMontagne et al. 2008) and level of education.

Table 14. Demographic and employment variables examined in this report

Independent / explanatory variable	Response categories	n (%*)
Gender	Male	2515 (55.9%)
	Female	1985 (44.1%)
Age	15-24 years	250 (5.6%)
	25-34 years	627 (14.0%)
	35-44 years	1149 (25.7%)
	45-54 years	1462 (32.8%)
	55+ years	976 (21.9%)
Night work - working most of the time at night between 10pm and 6am	Worked at night	263 (6.8%)
	Did not work at night	4233 (94.2%)
Industry	Manufacturing	714 (15.9%)
	Transport and storage	391 (8.7%)
	Construction	655 (14.6%)
	Agriculture, forestry and fishing	317 (7.0%)
	Health and community services	956 (21.2%)
Workplace size - number of employees at workplace	Less than 5	977 (21.8%)
	5 to 19	956 (21.4%)
	20 to 199	1512 (33.8%)
	200 or more	1027 (22.8%)
Occupational skill level	1 (Highest skill level)	1529 (34.0%)
	2	413 (9.4%)
	3	803 (18.3%)
	4	1164 (26.5%)
	5 (Lowest skill level)	483 (11.0%)
Language other than English spoken at home?	Yes	336 (7.5%)
	No (only English)	4164 (92.5%)
Interaction terms	Gender x industry	
	Industry x occupational skill level	

* Percentages provided are valid percentages, that is, they exclude missing responses. For example 36 respondents did not provide information on their age, so percentages for age are based on a total of 4464 respondents.

Assessment of pain and fatigue symptoms

Self-reported pain and fatigue symptoms associated with the physical demands of work were measured in the NHEWS survey. Respondents were asked ‘As a result of the physical demands of your job last week, how often did you experience..?

- tiredness
- pain in your back or neck
- pain in your shoulders, arms, wrists or hands, and/or
- pain in your hips, legs, knees or feet?’

Response categories were on a one to five scale of ‘never’, ‘rarely’, ‘sometimes’, ‘often’ or ‘all the time’. As such, symptoms reported were those experienced last week as a result of biomechanical demands of their job.

There were little missing data on pain and fatigue symptoms. There were five missing cases for tiredness and pain in shoulders, arms, wrists, or arms, nine missing cases for pain in neck or back, and 10 missing cases for pain in hips, legs, knees and feet. As these missing data made up a very small proportion of the entire sample (n = 4500), no treatment of missing data was undertaken.

For logistic regression analysis, dichotomous variables for pain and fatigue were created to determine the factors associated with self-reported musculoskeletal pain. For the dichotomous pain variable, workers were given a score of 0 if they said they ‘never’ had any of the three pain symptoms in the last week and they were assigned a score of 1 if they had pain (‘rarely’ to ‘all the time’) to any of the three pain symptoms. For the dichotomous variable on fatigue, workers were given a score of 0 if they ‘never’ had tiredness in the last week and a score of 1 if they were ‘rarely’ to ‘all the time’ tired in the last week.

Control measures for biomechanical demands

Workers who reported they were exposed to at least one biomechanical demand were asked whether or not specific controls were provided in their workplaces to prevent pain associated with the biomechanical demands of their job. The specific controls surveyed included: lifting equipment, trolleys, changing the layout of the job, changing the size and shape of loads, and manual handling training. Participants sometimes volunteered information about additional controls provided in their workplaces. These data were not included in the analyses contained in this report because not all participants were prompted or given the opportunity to provide additional control information.

The control measures were analysed in terms of the number of controls provided (one to five) and in terms of whether or not any (at least one) controls were provided. Furthermore, the controls data were analysed with respect to the provision of each of three types of controls: engineering controls, redesign controls and training. Engineering controls included lifting equipment and trolleys. Redesign controls included changing layout of jobs and the size and shape of loads. Only one question related to training so that particular type of control consisted of only one element. For the analyses, engineering or redesign controls were considered ‘provided’ if the worker said that at least one of the elements of these control types were provided.

Data analyses

This report presents the results of analyses of the NHEWS survey data relating to exposure to biomechanical demands, experience of pain and fatigue symptoms and provision of biomechanical demand controls. The majority of the data analyses were undertaken using logistic regression models. These models describe the demographic and employment factors (listed in Table 14) that affected the likelihood of workers reporting exposure to biomechanical demands, experiencing pain and fatigue symptoms and the provision of biomechanical demand controls. Only workers in the national priority industries (Manufacturing, Construction, Transport and storage, Agriculture, forestry and fishing and Health and community services) were included in the logistic regression models of the individual biomechanical demands, experiencing pain and fatigue symptoms and some of the control measures models. The data was restricted in this way to increase the stability of the models. However, workers from all industries were included in the models of engineering, redesign and training control provision. This means that the conclusions and results drawn from some of the logistic regression analyses in this report do not present a complete picture of exposure to biomechanical demands for all Australian workers but are limited to workers in the five priority industries.

Logistic regression models for individual biomechanical demands

Logistic regression analyses were undertaken to determine the demographic and employment factors that affected the likelihood of reporting exposure to each of the nine biomechanical demands. For consistency, the same demographic and employment factors were included in the analyses of all biomechanical demands where possible. Interaction terms were included in eight of the nine biomechanical demand models however they were excluded from the model of the demand *squatting or kneeling while working* because their inclusion resulted in an unstable model. An interaction occurs between two variables if the effect of one variable on the dependent variable (in this case, exposure to a particular biomechanical demand) depends on the different levels (or groups) of the second variable. Post-hoc cross tab analyses of statistically significant interaction terms were undertaken in an effort to partially explore the effect of these factors. These analyses are presented in Appendix B. It should, however, be noted that these cross-tab analyses do not accurately demonstrate the true interaction effect as, unlike the regression model, the cross tab analysis does not take into account the effects of other factors.

Other logistic regression models

For the remaining logistic regression analysis, all predictor variables were included in the model initially. Variables were removed following backwards stepwise deletion to obtain the final minimal model, with only statistically significant predictor variables remaining.

General linear model of composite biomechanical demand exposure

A general linear model was used to determine the factors that affected the composite biomechanical demand exposure score (z). Non-significant terms were removed from the model following backwards step-wise deletion as in the regression models. The model residuals were inspected to confirm the fit of the model.

Presentation of model statistical output and other data analyses

All the findings presented in the main body of the report are supported by formal statistical analyses and are statistically significant at the $P = 0.05$ level. To keep the report concise, details of statistical tests or models are not included in the main results section of this report. Full statistical details (model output, test statistics and p-values) are presented in Appendices B and C.

Appendix B includes the model outputs of the analysis of each biomechanical demand. For each biomechanical demand Appendix B also includes post-hoc tests of interaction term factors, graphical representation of the interactions and a short description of the model findings. The reader is encouraged to refer to this section for specific findings regarding particular biomechanical demands. An overview of the trends for the nine biomechanical demands is presented in the results section in the main body of this report.

Appendix C contains the statistical output of all other analyses underpinning the findings of this report. This includes the general linear model examining the factors that affected composite biomechanical demand exposure score and the logistic regressions of self-reported pain and fatigue symptoms and the provision of control measures. The reader is encouraged to refer to this section for specific odds ratios – however, the main findings from these models are presented in the results section.

Appendix B: Regression models for individual biomechanical demands

Appendix B presents the statistical output of the logistic regressions examining the factors that affected exposure to each of the biomechanical demands. Most of the models included interaction terms that had a significant effect on the likelihood of reporting exposure to the biomechanical demands. This means that the effect of one variable on exposure to the biomechanical demand depends on the other variable in the interaction term. Exploration of the nature of each statistically significant interaction has been undertaken in two ways. First, for each interaction, a simple cross-tabulation of the percentage of workers who reported exposure to each biomechanical demand within each interaction factor is presented in graphical format. Second, differences in the percentages of workers who reported exposure to the biomechanical demands by each interaction factor have been examined with post-hoc Chi-square tests and the results presented in a table.

It is important to note that, unlike the model, the effects of other factors are not controlled in any of these figures or post-hoc tests. They should therefore be treated as a guide only in all cases. Furthermore, the parameter estimates generated for the interaction terms in the logistic models are difficult to manipulate in the analysis process and difficult to interpret upon completion of analysis. The parameter estimates depend on the reference group to which all other factor levels are compared. Therefore, the statistically significant differences in odds ratios for the interaction term levels, presented in these tables, should not be considered the only differences. There could be other statistically significant differences in odds ratios if a different reference group was used. The main conclusion to draw from these models is the overarching effect of the interaction term. These are not affected by the reference groups.

Exposure to carrying or lifting heavy loads

The statistical output of the model examining exposure to *carrying or lifting heavy loads* is presented in Table 16. This model showed that, while accounting for all the other factors in the model:

- Compared to the oldest workers (55+ years), younger workers had higher odds of exposure to *carrying or lifting heavy loads*, with the highest odds reported for workers in the 25-34 years age group.
- The odds of reporting exposure to *carrying or lifting heavy loads* were increased by a factor of 1.7 by working at night relative to not working at night.
- There was a significant interaction between gender and industry on reporting exposure to *carrying or lifting heavy loads*. See below, Table 15 and Figure 7 for more detail.
- There was also a significant interaction between industry and occupational skill level on reporting exposure to *carrying or lifting heavy loads*. See below, Table 15 and Figure 8 for more detail.

Figure 7 and the post-hoc tests in Table 15 partially illustrate the interaction between industry and gender on exposure to *carrying or lifting heavy loads*. In all industries except the Health and community services industry, a significantly greater percentage of male workers reported being exposed to *carrying or lifting heavy loads* compared to females.

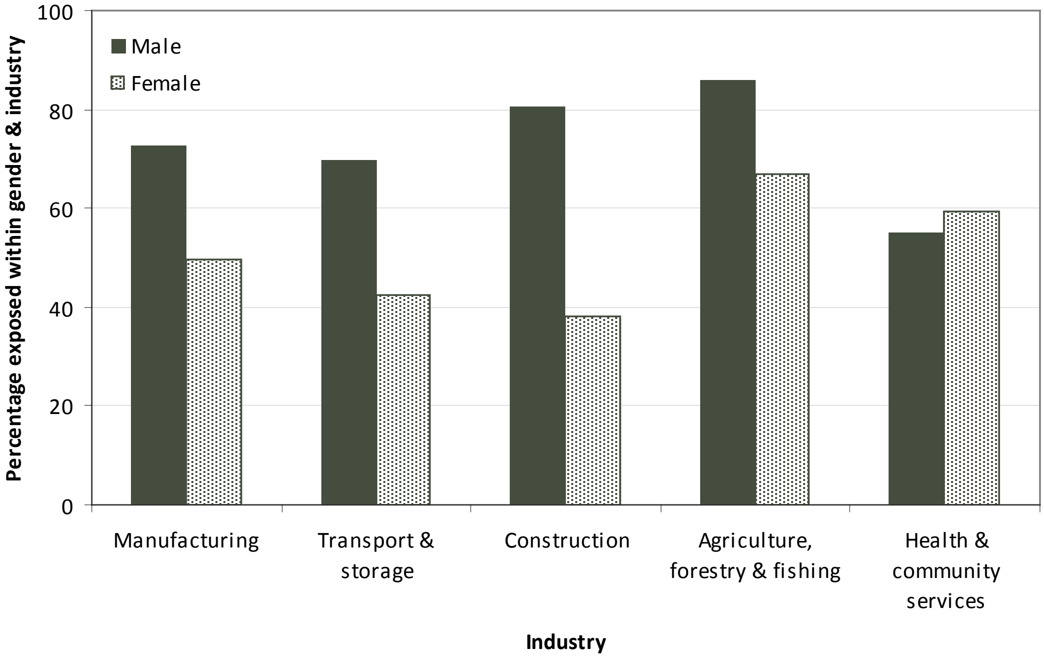


Figure 7. The percentage of workers who reported exposure to *carrying or lifting heavy loads* within industry and gender

Figure 8 and the post-hoc tests in Table 15 partially illustrate the interaction between industry and occupational skill level on exposure to *carrying or lifting heavy loads*. The post-tests indicate that there were significant differences within all industries, except the Agriculture, forestry and fishing industry, in the percentage of workers exposed to *carrying or lifting heavy loads* by occupational skill level. In these industries, occupational skill level three recorded the greatest percentage of workers who reported exposure to *carrying or lifting heavy loads*, followed by occupational skill level five.

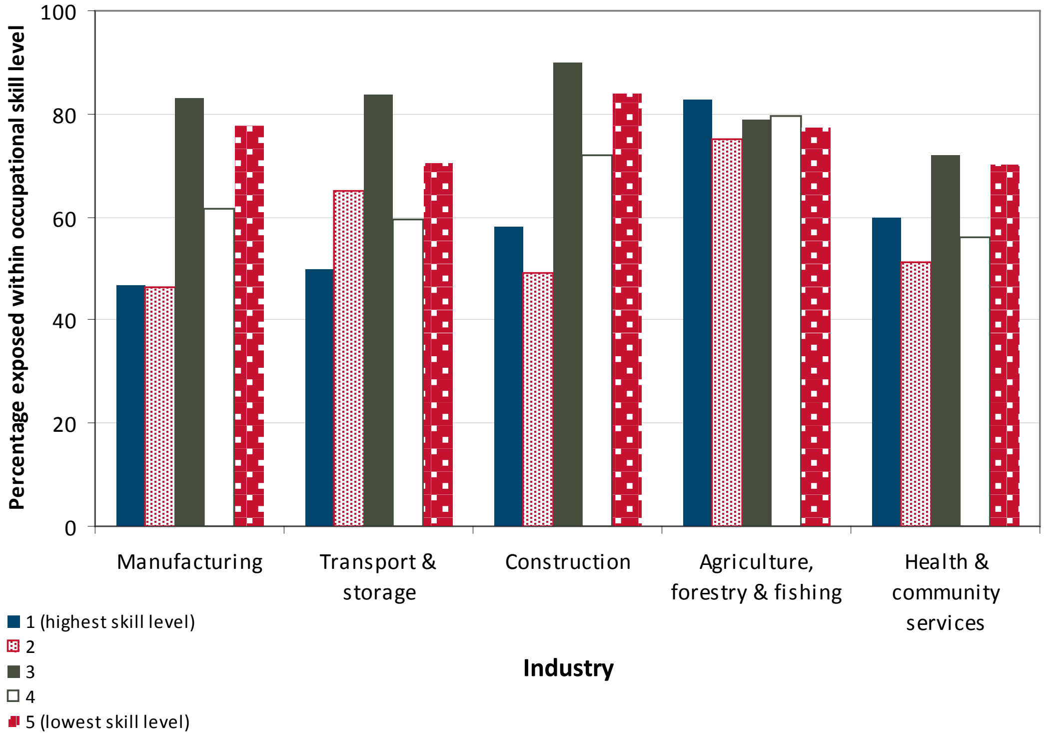


Figure 8. The percentage of workers who reported exposure to *carrying or lifting heavy loads* within industry and occupational skill level

Table 15. Post-hoc Chi-square test statistics for exposure to *carrying or lifting heavy loads* by industry, gender and occupational skill

Differences in the percentage of workers exposed to *carrying or lifting heavy loads* by gender within industry	Pearson Chi-square	*p*
Manufacturing	31.798	<0.001
Transport and storage	22.950	<0.001
Construction	62.153	<0.001
Agriculture, forestry and fishing	14.586	<0.001
Health and community services	1.284	0.264
Differences in the percentage of workers exposed to *carrying or lifting heavy loads* by occupational skill within industry	**Pearson Chi-square**	***p***
Manufacturing	68.758	<0.001
Transport and storage	15.948	0.003
Construction	80.007	<0.001
Agriculture, forestry and fishing	1.091	0.896
Health and community services	15.948	0.003

Table 16. Parameter estimates of the logistic regression model examining exposure to *carrying or lifting heavy loads*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	393.311	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	9.369	8	0.312
Nagelkerke Pseudo R Square	0.175		

Whether or not worker reported exposure to lifting or carrying heavy loads								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	-0.264	0.167	2.498	1	0.114	0.768	0.554	1.065
Female	0[b]			0				
Age			**31.304**	**4**	**0.000**			
15-24 years	0.571	0.224	6.466	1	0.011	1.770	1.140	2.748
25-34 years	0.688	0.150	21.177	1	0.000	1.990	1.485	2.668
35-44 years	0.570	0.122	22.020	1	0.000	1.769	1.394	2.245
45-54 years	0.373	0.113	10.911	1	0.001	1.452	1.164	1.812
55+ years	0[b]			0				
Night work								
Worked at night	0.552	0.182	9.233	1	0.002	1.736	1.216	2.478
Did not work at night	0[b]			0				
Industry			**3.672**	**4**	**0.452**			
Manufacturing	-0.402	0.474	0.720	1	0.396	0.669	0.264	1.694
Transport & storage	-0.851	0.532	2.561	1	0.110	0.427	0.151	1.211
Construction	-0.919	0.578	2.525	1	0.112	0.399	0.128	1.239
Agriculture, forestry & fishing	-0.458	0.514	0.793	1	0.373	0.633	0.231	1.733
Health & community services	0[b]			0				
Workplace size			**3.209**	**3**	**0.360**			
Less than 5 employees	0.072	0.140	0.262	1	0.609	1.074	0.816	1.414
5-19 employees	0.019	0.130	0.022	1	0.882	1.020	0.790	1.316
20-199 employees	-0.130	0.115	1.266	1	0.260	0.878	0.701	1.101
200 or more employees	0[b]			0				
Occupational skill level			**7.474**	**4**	**0.113**			
1 (highest skill level)	-0.609	0.389	2.455	1	0.117	0.544	0.254	1.165
2	-0.924	0.424	4.741	1	0.029	0.397	0.173	0.912
3	-0.079	0.546	0.021	1	0.885	0.924	0.317	2.696
4	-0.718	0.395	3.303	1	0.069	0.488	0.225	1.058
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.048	0.159	0.092	1	0.762	0.953	0.698	1.302
No (only English spoken)	0[b]			0				

Table 16 continued

Whether or not worker reported exposure to lifting or carrying heavy loads								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**49.937**	**4**	**0.000**			
Manufacturing* gender	1.268	0.266	22.628	1	0.000	3.552	2.107	5.989
Transport & storage*gender	1.410	0.315	20.092	1	0.000	4.098	2.212	7.592
Construction*gender	1.938	0.338	32.807	1	0.000	6.942	3.577	13.471
Agriculture, forestry & fishing*gender	1.280	0.342	14.021	1	0.000	3.595	1.840	7.023
Health & community services*gender	0[b]							
Industry*skill level			**40.868**	**16**	**0.001**			
Manufacturing* skill level 1	-0.938	0.509	3.398	1	0.065	0.391	0.144	1.061
Manufacturing* skill level 2	-0.567	0.601	0.890	1	0.345	0.567	0.175	1.842
Manufacturing* skill level 3	0.106	0.640	0.027	1	0.868	1.112	0.317	3.899
Manufacturing* skill level 4	-0.015	0.503	0.001	1	0.976	0.985	0.367	2.643
Transport and storage * skill level 1	-0.504	0.602	0.700	1	0.403	0.604	0.186	1.965
Transport and storage * skill level 2	0.734	0.734	1.001	1	0.317	2.083	0.495	8.773
Transport and storage * skill level 3	0.575	0.762	0.570	1	0.450	1.777	0.399	7.910
Transport and storage * skill level 4	-0.021	0.549	0.001	1	0.970	0.979	0.334	2.871
Construction * skill level 1	-0.614	0.558	1.212	1	0.271	0.541	0.181	1.615
Construction * skill level 2	-0.493	0.629	0.615	1	0.433	0.611	0.178	2.094
Construction * skill level 3	0.446	0.683	0.427	1	0.514	1.562	0.409	5.961
Construction * skill level 4	0.265	0.585	0.205	1	0.651	1.303	0.414	4.103
Agriculture, forestry & fishing * skill level 1	1.009	0.541	3.480	1	0.062	2.743	0.950	7.915
Agriculture, forestry & fishing * skill level 2	0.977	0.862	1.285	1	0.257	2.656	0.491	14.375
Agriculture, forestry & fishing * skill level 3	0.042	0.749	0.003	1	0.956	1.043	0.240	4.525
Agriculture, forestry & fishing * skill level 4	0.849	0.631	1.808	1	0.179	2.337	0.678	8.056
Health and community services * skill level 5	0[b]							
Intercept	0.660	0.392	2.837					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to repetitive hand or arm movements

The logistic regression analysis showed that age and occupational skill were the main factors affecting self-reported exposure to *repetitive hand or arm movements*. Gender, working at night, number of employees at the workplace, industry and language spoken at home did not significantly affect the odds of self-reported exposure to *repetitive hand or arm movements*. Accounting for all factors in the model, the findings of this model, presented in Table 17, include the following:

- Compared to workers aged 55 years and over, younger workers had significantly greater odds of reporting exposure to *repetitive hand or arm movements*, and the odds of exposure to *repetitive hand or arm movements* declined with age.
- Compared to workers of the lowest occupational skill level (level 5), those who were most skilled (skill level 1) had approximately half the odds of reporting exposure to *repetitive hand or arm movements*. There were no significant differences in the odds of reporting exposure to *repetitive hand or arm movements* between skill levels 2, 3, 4 and the reference group (skill level 5).
- This biomechanical demand is one of the only hazards for which there were no statistically significant interaction effects between gender and industry and occupational skill level and industry.

Table 17. Parameter estimates of the logistic regression model examining exposure to *repetitive hand or arm movements*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	139.225	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	4.808	8	0.778
Nagelkerke Pseudo R Square	0.092		

Whether or not worker reported exposure to repetitive hand or arm movements								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Sex								
Male	-0.228	0.216	1.120	1	0.290	0.796	0.521	1.215
Female	0[b]			0				
Age			**29.261**	**4**	**0.000**			
15-24 years	1.306	0.437	8.914	1	0.003	3.690	1.566	8.696
25-34 years	0.716	0.210	11.677	1	0.001	2.047	1.357	3.087
35-44 years	0.782	0.171	20.810	1	0.000	2.186	1.562	3.058
45-54 years	0.427	0.149	8.217	1	0.004	1.533	1.145	2.054
55+ years	0[b]			0				
Night work								
Worked at night	-0.042	0.237	0.031	1	0.860	0.959	0.603	1.525
Did not work at night	0[b]			0				
Industry			**4.983**	**4**	**0.289**			
Manufacturing	0.160	1.264	0.016	1	0.899	1.173	0.099	13.970
Transport & storage	-1.075	1.218	0.779	1	0.378	0.341	0.031	3.716
Construction	-0.744	1.239	0.361	1	0.548	0.475	0.042	5.387
Agriculture, forestry & fishing	-1.595	1.127	2.003	1	0.157	0.203	0.022	1.847
Health & community services	0[b]			0				
Workplace size			**0.957**	**3**	**0.812**			
Less than 5 employees	0.085	0.199	0.181	1	0.670	1.088	0.737	1.607
5-19 employees	0.079	0.188	0.175	1	0.676	1.082	0.748	1.564
20-199 employees	-0.063	0.164	0.147	1	0.702	0.939	0.681	1.294
200 or more employees	0[b]			0				
Occupational skill level			**11.477**	**4**	**0.022**			
1 (highest skill level)	-2.113	1.024	4.254	1	0.039	0.121	0.016	0.900
2	-1.878	1.052	3.189	1	0.074	0.153	0.019	1.201
3	-0.926	1.254	0.545	1	0.460	0.396	0.034	4.626
4	-1.566	1.033	2.298	1	0.130	0.209	0.028	1.582
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.113	0.226	.251	1	0.616	0.893	0.574	1.390
No (only English spoken)	0[b]			0				

Table 17 continued								
Whether or not worker reported exposure to repetitive hand or arm movements								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**1.318**	**4**	**0.858**			
Manufacturing* gender	0.090	0.402	0.051	1	0.822	1.095	0.498	2.408
Transport & storage*gender	0.257	0.517	0.246	1	0.620	1.293	0.469	3.560
Construction*gender	-0.384	0.595	0.416	1	0.519	.681	0.212	2.187
Agriculture, forestry & fishing*gender	0.313	0.447	0.488	1	0.485	1.367	0.569	3.284
Health & community services*gender	0^b							
Industry*skill level			**15.168**	**16**	**0.512**			
Manufacturing* skill level 1	-0.327	1.268	0.067	1	0.796	.721	0.060	8.659
Manufacturing* skill level 2	-0.287	1.340	0.046	1	0.831	.751	0.054	10.381
Manufacturing* skill level 3	-0.430	1.467	0.086	1	0.769	.650	0.037	11.520
Manufacturing* skill level 4	0.504	1.293	0.152	1	0.697	1.655	0.131	20.859
Transport and storage * skill level 1	0.847	1.241	0.465	1	0.495	2.332	0.205	26.577
Transport and storage * skill level 2	2.309	1.589	2.112	1	0.146	10.061	0.447	226.413
Transport and storage * skill level 3	1.137	1.520	0.559	1	0.455	3.117	0.158	61.289
Transport and storage * skill level 4	1.711	1.233	1.928	1	0.165	5.537	0.494	61.998
Construction * skill level 1	1.665	1.154	2.080	1	0.149	5.285	0.550	50.784
Construction * skill level 2	1.534	1.236	1.541	1	0.214	4.637	0.412	52.246
Construction * skill level 3	1.577	1.371	1.323	1	0.250	4.841	0.329	71.123
Construction * skill level 4	1.582	1.196	1.752	1	0.186	4.867	0.467	50.684
Agriculture, forestry & fishing * skill level 1	1.809	1.125	2.587	1	0.108	6.104	0.674	55.329
Agriculture, forestry & fishing * skill level 2	21.165	11533.165	0.000	1	0.999	1.556E9	0.000	.
Agriculture, forestry & fishing * skill level 3	1.561	1.507	1.072	1	0.300	4.763	0.248	91.410
Agriculture, forestry & fishing * skill level 4	1.798	1.229	2.139	1	0.144	6.037	0.542	67.177
Health and community services * skill level 5	0^b							
Intercept	3.174	1.026	9.563					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to working with the body bent forward

The statistical output of the logistic regression model examining exposure to *working with the body bent forward* is presented in Table 19. When other factors in the model were accounted for, this model showed that:

- The youngest workers had the greatest odds of reporting exposure to *working with the body bent forward*. The likelihood of working in this manner declined with increasing age.
- Those who worked at night had almost twice as likely to report *working with the body bent forward* compared to those workers who did not work at night.
- There was a significant interaction between gender and industry on reporting exposure to *working with the body bent forward*. See below, Table 18 and Figure 9 for more detail.
- There was a significant interaction between occupational skill level and industry on reporting exposure to *working with the body bent forward*. See below, Table 18 and Figure 10 for more detail.

Figure 9 and the post-hoc tests presented in Table 18 partially illustrate the interaction between industry and gender on self reported exposure to *working with the body bent forward.* As can be seen in Figure 9, in all industries except the Health and community services industry, a significantly greater percentage of male workers reported exposure to *working with the body bent forward* than female workers. The reverse was true for workers in the Health and community services industry.

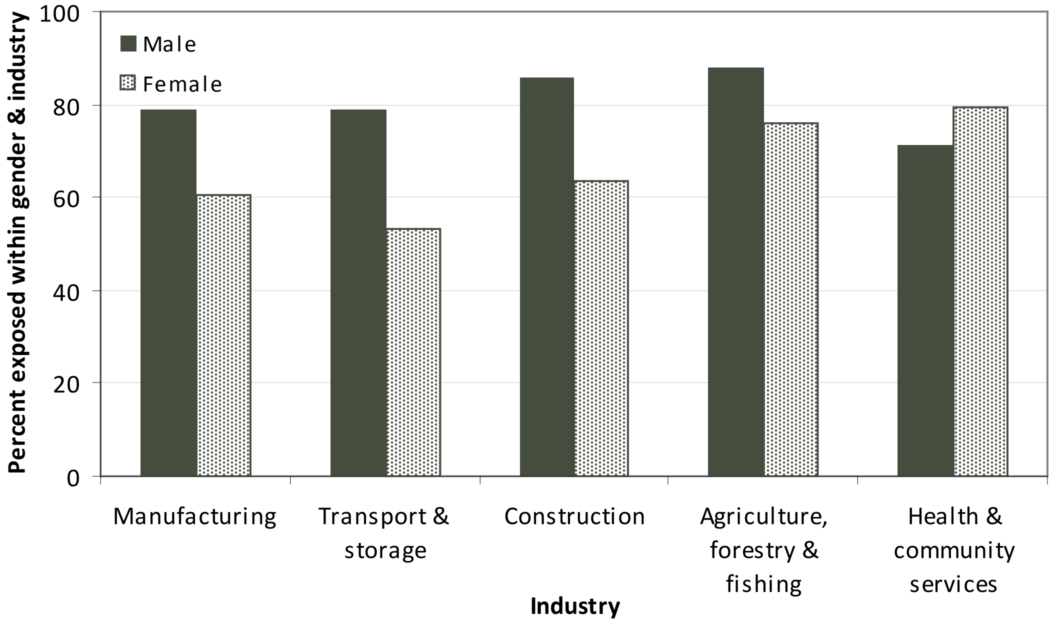


Figure 9. The percentage of workers who reported exposure to *working with the body bent forward* within industry and gender

The interaction between industry and occupational skill level on exposure to *working with the body bent forward* is more complex. Only in three of the industries, Manufacturing, Transport and storage, and Construction, were there significant differences by occupational skill level within industry (Figure 10, Table 18). In these industries, occupational skill level three recorded the greatest percentages of workers who reported exposure to *working with the body bent forward*. There was little difference in the percentage of workers who reported exposure to this biomechanical demand across occupational skill levels in the Agriculture, forestry and fishing and Health and community services industries.

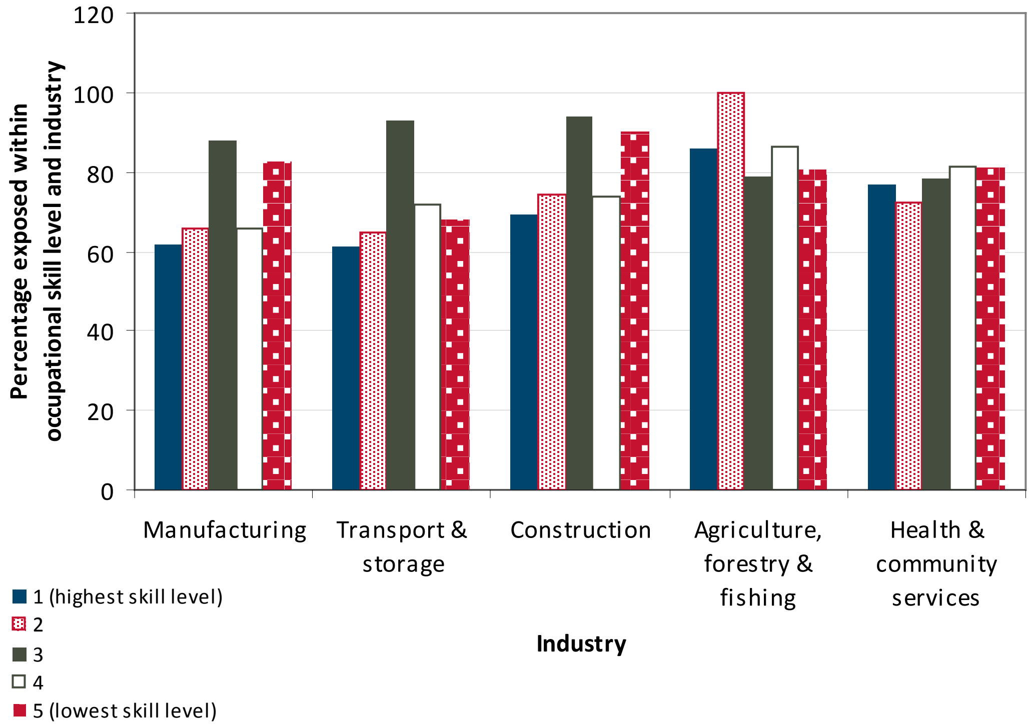


Figure 10. The percentage of workers who reported exposure to *working with the body bent forward* within industry and occupational skill level

Table 18. Post-hoc Chi-square test statistics for exposure to *working with the body bent forward* by industry, gender and occupational skill

Differences in the percentage of workers exposed to *working with the body bent forward* by gender within industry	Pearson Chi-square	*p*
Manufacturing	23.916	<0.001
Transport and storage	23.274	<0.001
Construction	22.831	<0.001
Agriculture, forestry and fishing	7.332	0.010
Health and community services	5.831	0.018
Differences in the percentage of workers exposed to *working with the body bent forward* by occupational skill within industry	**Pearson Chi-square**	***p***
Manufacturing	46.510	<0.001
Transport and storage	15.498	0.004
Construction	54.341	<0.001
Agriculture, forestry and fishing	4.152	0.386
Health and community services	4.175	0.383

Table 19. Parameter estimates of the logistic regression model examining exposure to *working with the body bent forward*

Model information	**Chi-square**	***d.f.***	***p***
Omnibus test of model coefficients	237.777	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	11.533	8	0.173
Nagelkerke Pseudo R Square	0.120		

Whether or not worker reported exposure to working with body bent forward								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	-0.332	0.189	3.095	1	0.079	0.717	0.495	1.039
Female	0[b]			0				
Age			**21.401**	**4**	**0.000**			
15-24 years	0.782	0.273	8.232	1	0.004	2.186	1.281	3.731
25-34 years	0.576	0.165	12.115	1	0.001	1.778	1.286	2.459
35-44 years	0.485	0.133	13.270	1	0 .000	1.625	1.251	2.109
45-54 years	0.350	0.124	8.013	1	0 .005	1.419	1.114	1.809
55+ years	0[b]			0				
Night work								
Worked at night	0.658	0.222	8.773	1	0.003	1.931	1.249	2.984
Did not work at night	0[b]			0				
Industry			**7.242**	**4**	**0.124**			
Manufacturing	-0.407	0.526	0.598	1	0.439	0.666	0.237	1.868
Transport & storage	-1.353	0.564	5.750	1	0.016	0.258	0.086	0.781
Construction	-0.167	0.660	0.064	1	0.801	0.847	0.232	3.085
Agriculture, forestry & fishing	-0.618	0.565	1.195	1	0.274	0.539	0.178	1.632
Health & community services	0[b]			0				
Workplace size			**3.464**	**3**	**0.326**			
Less than 5 employees	0.129	0.157	0.673	1	0.412	1.137	0.836	1.546
5-19 employees	0.004	0.145	0.001	1	0.975	1.005	0.755	1.336
20-199 employees	-0.126	0.128	0.963	1	0.326	0.882	0.686	1.134
200 or more employees	0[b]			0				
Occupational skill level			**4.381**	**4**	**0.357**			
1 (highest skill level)	-0.226	0.441	0.262	1	0.609	0.798	0.336	1.893
2	-0.472	0.478	0.975	1	0.324	0.624	0.244	1.592
3	-0.182	0.605	0.090	1	0.764	0.834	0.255	2.732
4	0.052	0.452	0.013	1	0.908	1.053	0.434	2.554
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.019	0.180	0.011	1	0.916	0.981	0.690	1.395
No (only English spoken)	0[b]			0				

Table 19 continued

Whether or not worker reported exposure to working with body bent forward								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			26.654	4	0.000			
Manufacturing* gender	1.054	0.285	13.731	1	0.000	2.870	1.643	5.013
Transport & storage*gender	1.347	0.328	16.822	1	0.000	3.844	2.020	7.316
Construction*gender	1.253	0.351	12.743	1	0.000	3.502	1.760	6.969
Agriculture, forestry & fishing*gender	1.101	0.378	8.467	1	0.004	3.008	1.433	6.315
Health & community services*gender	0^b							
Industry*skill level			35.591	16	.003			
Manufacturing* skill level 1	-0.907	0.560	2.628	1	0.105	0.404	0.135	1.209
Manufacturing* skill level 2	-0.318	0.656	0.235	1	0.627	0.727	0.201	2.631
Manufacturing* skill level 3	0.379	0.706	0.288	1	0.591	1.461	0.366	5.830
Manufacturing* skill level 4	-0.895	0.560	2.552	1	0.110	0.409	0.136	1.225
Transport and storage * skill level 1	-0.246	0.634	0.151	1	0.698	0.782	0.226	2.708
Transport and storage * skill level 2	0.379	0.760	0.249	1	0.618	1.460	0.329	6.474
Transport and storage * skill level 3	1.617	0.874	3.426	1	0.064	5.037	0.909	27.911
Transport and storage * skill level 4	-0.057	0.587	0.010	1	0.922	0.944	0.299	2.985
Construction * skill level 1	-1.084	0.646	2.819	1	0.093	0.338	0.095	1.199
Construction * skill level 2	-0.382	0.724	0.278	1	0.598	0.683	0.165	2.821
Construction * skill level 3	0.529	0.784	0.455	1	0.500	1.697	0.365	7.892
Construction * skill level 4	-1.092	0.669	2.663	1	0.103	0.336	0.090	1.245
Agriculture, forestry & fishing * skill level 1	0.681	0.593	1.320	1	0.251	1.975	0.618	6.311
Agriculture, forestry & fishing * skill level 2	20.459	11466.594	0.000	1	0.999	7.676E8	0.000	.
Agriculture, forestry & fishing * skill level 3	-0.020	0.796	0.001	1	0.980	0.980	0.206	4.670
Agriculture, forestry & fishing * skill level 4	0.431	0.711	0.367	1	0.544	1.538	0.382	6.194
Health and community services * skill level 5	0^b							
Intercept	1.149	0.442	6.751					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to working in a twisted or awkward posture

The results of the model examining the factors that affected exposure to *working in a twisted or awkward posture* are presented in Table 21. All factors in the regression model, except other language spoken at home, had a significant impact on exposure to *working in a twisted or awkward posture*. The main findings are summarised briefly below:

- Younger workers had significantly higher odds of reporting exposure to *working in a twisted or awkward posture* compared to the oldest workers (55 years and older).
- Night workers had almost 2.5 times the odds of reporting exposure to *working in a twisted or awkward posture* compared to non-night workers.
- There were no significant differences in the odds of reporting exposure to *working in a twisted or awkward posture* by gender or language spoken at home.
- Compared to workers in workplaces with 200+ employees, those in workplaces with 5-19 employees had significantly lower odds of reporting exposure to *working in a twisted or awkward posture*.
- There were significant interactions between industry and gender and industry and occupational skill level on reporting exposure to *working in a twisted or awkward posture*.

The interaction between industry and gender on exposure to working in a twisted or awkward posture is partially illustrated in Figure 11 and post-hoc tests presented in Table 20. This figure and table show that within the Health and community services industry, a higher (but not statistically significantly higher) percentage of females reported *working in a twisted or awkward posture* compared to males. In contrast, significantly larger percentages of males reported exposure to *working in a twisted or awkward posture* compared to females in the rest of the priority industries.

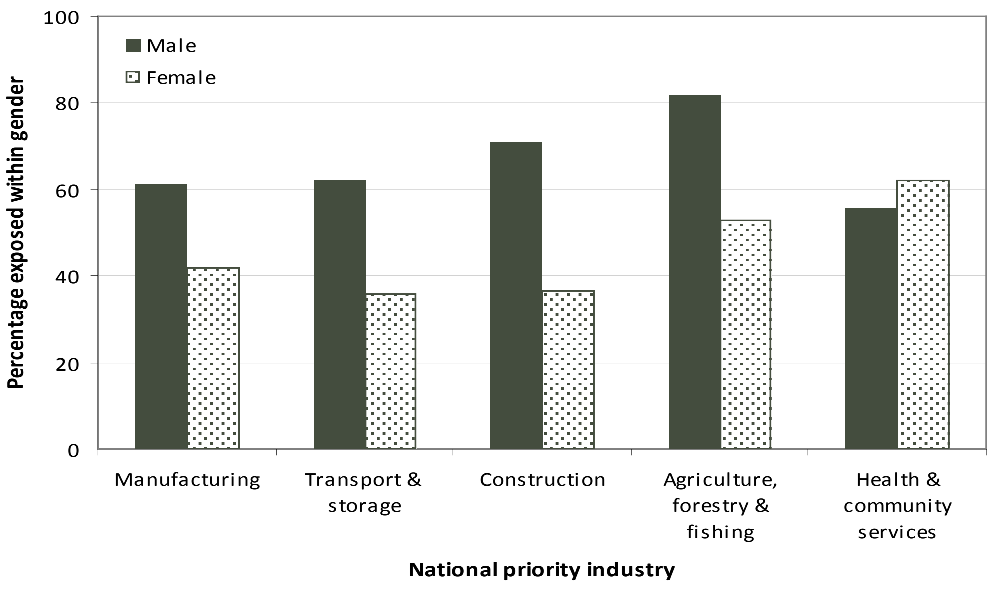
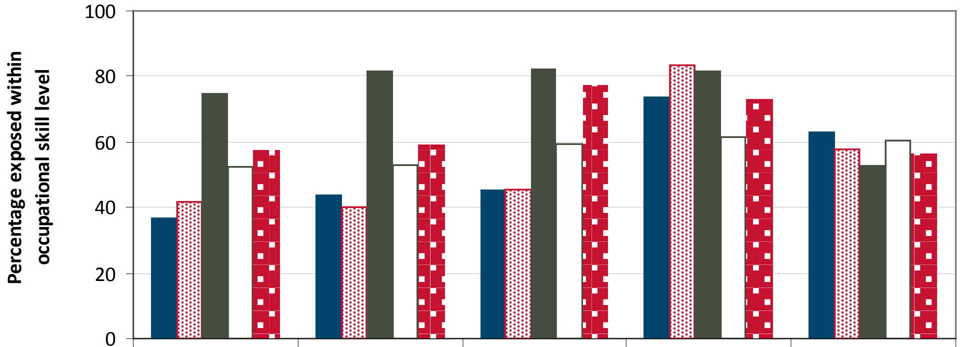


Figure 11. The percentage of workers who reported exposure to *working in a twisted or awkward posture* within gender and industry

The interaction between industry and occupational skill level on reporting exposure to *working in a twisted or awkward posture* is partially illustrated in Figure 12 and post-hoc tests presented in Table 20. There were significant differences in the percentage of workers who reported exposure to *working in a twisted or awkward posture* by occupational skill level for the Manufacturing, Transport and storage and Construction industries. The model results, which control for the effects of other variables indicated that workers in occupational skill level one in the Manufacturing and Construction industries (and occupational skill level two in the Construction industry) were significantly less likely to report exposure to *working in a twisted or awkward posture* than workers in occupational skill level 5 in the Health and community services industry.



	Manufacturing	Transport & storage	Construction	Agriculture, forestry & fishing	Health & community services
1 (highest skill level)	37	44	45	74	63
2	42	40	46	83	58
3	75	82	83	82	53
4	52	53	59	61	61
5 (lowest skill level)	58	59	78	73	57

Figure 12. The percentage of workers who reported exposure to *working in a twisted or awkward posture* within industry and occupational skill level

Table 20. Post-hoc Chi-square test statistics for exposure to *working in a twisted or awkward posture* by industry, gender and occupational skill level

Differences in the percentage of workers exposed to *working in a twisted or awkward posture* by gender within industry	**Pearson Chi-square**	***p***
Manufacturing	20.502	<0.001
Transport and storage	19.284	<0.001
Construction	33.718	<0.001
Agriculture, forestry and fishing	27.980	<0.001
Health and community services	2.800	0.107
Differences in the percentage of workers exposed to *working in a twisted or awkward posture* by occupational skill level within industry	**Pearson Chi-square**	***p***
Manufacturing	58.649	<0.001
Transport and storage	20.903	<0.001
Construction	79.169	<0.001
Agriculture, forestry and fishing	5.198	0.268
Health and community services	2.393	0.664

Table 21. Parameter estimates of the logistic regression model examining exposure to *working in a twisted or awkward posture*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	346.233	38	<.001
Hosmer and Lemeshow chi-square test of goodness of fit	3.707	8	.883
Nagelkerke Pseudo R Square	0.152		

Whether or not worker reported exposure to working with a twisted or awkward posture								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**Upper**
Sex								
Male	-0.262	0.168	2.436	1	0.119	0.770	0.554	1.069
Female	0[b]			0				
Age			**29.339**	**4**	**0.000**			
15-24 years	0.534	0.207	6.643	1	0.010	1.706	1.136	2.560
25-34 years	0.665	0.143	21.732	1	0.000	1.944	1.470	2.570
35-44 years	0.510	0.117	18.933	1	0.000	1.665	1.323	2.095
45-54 years	0.326	0.110	8.836	1	0.003	1.385	1.117	1.718
55+ years	0[b]			0				
Night work								
Worked at night	0.849	0.184	21.275	1	0.000	2.338	1.630	3.355
Did not work at night	0[b]			0				
Industry			**2.655**	**4**	**0.617**			
Manufacturing	-0.512	0.426	1.443	1	0.230	0.599	0.260	1.382
Transport & storage	-0.533	0.496	1.156	1	0.282	0.587	0.222	1.551
Construction	-0.041	0.528	0.006	1	0.938	0.960	0.341	2.701
Agriculture, forestry & fishing	-0.096	0.478	0.040	1	0.842	0.909	0.356	2.321
Health & community services	0[b]			0				
Workplace size			**4.627**	**3**	**0.201**			
Less than 5 employees	-0.091	0.134	0.463	1	0.496	0.913	0.703	1.186
5-19 employees	-0.262	0.126	4.347	1	0.037	0.770	0.602	0.984
20-199 employees	-0.132	0.113	1.380	1	0.240	0.876	0.702	1.093
200 or more employees	0[b]			0				
Occupational skill level			**2.026**	**4**	**0.731**			
1 (highest skill level)	0.261	0.355	0.540	1	0.463	1.298	0.647	2.602
2	0.098	0.394	0.062	1	0.803	1.103	0.510	2.388
3	-0.146	0.494	0.088	1	0.767	0.864	0.328	2.276
4	0.244	0.361	0.456	1	0.500	1.276	0.628	2.592
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.047	0.153	0.093	1	0.760	0.954	0.708	1.287
No (only English spoken)	0[b]			0				

Table 21 continued

Whether or not worker reported exposure to working with a twisted or awkward posture								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**41.360**	**4**	**0.000**			
Manufacturing* gender	0.931	0.261	12.759	1	0.000	2.538	1.522	4.230
Transport & storage*gender	1.262	0.316	15.972	1	0.000	3.533	1.903	6.562
Construction*gender	1.392	0.333	17.514	1	0.000	4.022	2.096	7.717
Agriculture, forestry & fishing*gender	1.725	0.327	27.815	1	0.000	5.611	2.956	10.651
Health & community services*gender	0[b]							
Industry*skill level			**44.209**	**16**	**0.000**			
Manufacturing* skill level 1	-1.093	0.459	5.671	1	0.017	0.335	0.136	0.824
Manufacturing* skill level 2	-0.621	0.560	1.229	1	0.268	0.537	0.179	1.611
Manufacturing* skill level 3	0.858	0.568	2.280	1	0.131	2.359	0.774	7.187
Manufacturing* skill level 4	-0.354	0.453	.612	1	0.434	0.702	0.289	1.705
Transport and storage * skill level 1	-1.071	0.566	3.585	1	0.058	0.343	0.113	1.038
Transport and storage * skill level 2	-0.830	0.696	1.422	1	0.233	0.436	0.111	1.707
Transport and storage * skill level 3	1.084	0.702	2.383	1	0.123	2.956	0.747	11.701
Transport and storage * skill level 4	-0.687	0.507	1.838	1	0.175	0.503	0.186	1.358
Construction * skill level 1	-1.604	0.502	10.219	1	0.001	0.201	0.075	0.538
Construction * skill level 2	-1.315	0.578	5.173	1	0.023	0.268	0.086	0.834
Construction * skill level 3	0.357	0.604	0.348	1	0.555	1.429	0.437	4.669
Construction * skill level 4	-0.976	0.521	3.507	1	0.061	0.377	0.136	1.047
Agriculture, forestry & fishing * skill level 1	-0.195	0.502	0.151	1	0.698	0.823	0.308	2.201
Agriculture, forestry & fishing * skill level 2	0.677	0.944	0.513	1	0.474	1.967	0.309	12.521
Agriculture, forestry & fishing * skill level 3	0.531	0.725	0.536	1	0.464	1.700	0.410	7.046
Agriculture, forestry & fishing * skill level 4	-0.910	0.574	2.511	1	0.113	0.403	0.131	1.240
Health and community services * skill level 5	0[b]							
Intercept	-0.007	0.358	0.000	1				

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to working with the hands raised above the head

The statistical output of the model examining worker reports of exposure to *working with the hands raised above the head* is presented in Table 23. This model showed that, when accounting for the other factors in the model:

- The odds of reporting exposure to *working with the hands raised above the head* were increased by a factor of 1.6 by working at night, relative to not working at night.
- Workers in the highest occupational skill levels (one and two) were associated with significantly lower odds of reporting exposure to *working with the hands raised above the head* than workers in the lowest skill level (five).
- There were significant interactions between gender and industry, and occupational skill level and industry on exposure to *working with the hands raised above the head*. Refer to Table 20, Figure 13 and Figure 14 and see below for more detail on the interactions.

Consistent with other biomechanical demands, the interaction between gender and industry on exposure to *working with the hands raised above the head* is caused by a different pattern of exposure in the Health and community services industry compared to the other priority industries (Figure 13, Table 20). There was no difference between the percentages of male and female workers who reported exposure to this biomechanical hazard in the Health and community services industry. In the other industries, significantly larger percentages of male workers reported exposure to *working with the hands raised above the head* than female workers.

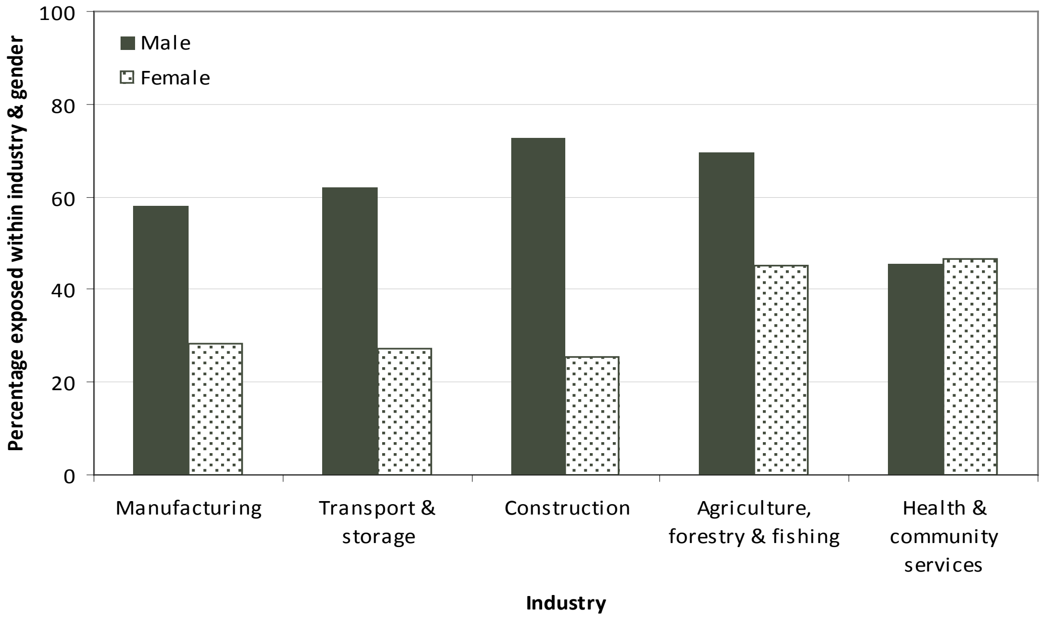


Figure 13. The percentage of workers who reported *working with the hands raised above the head* by gender and industry

As with other biomechanical demands the interaction between industry and occupational skill level is complicated. The model (Table 23) revealed significant increases in the odds of reporting exposure to *working with the hands raised above the head* for workers in occupational skill level three in the Transport and storage, and Construction industries, relative to occupational skill level five in the Health and community services industry. Occupational skill level one workers in the Agriculture, forestry and fishing industry also had significantly increased odds of reporting exposure to this biomechanical demand. Figure 14 shows the percentages of workers within each occupational skill level and industry that reported exposure to *working with* *the hands raised above the head*. Occupational skill level three recorded the greatest percentages of workers exposed in the Manufacturing, Transport and storage and Construction industries. Cross tab analyses showed that there were significant differences by skill level for all priority industries except the Agriculture, forestry and fishing industry (Table 22).

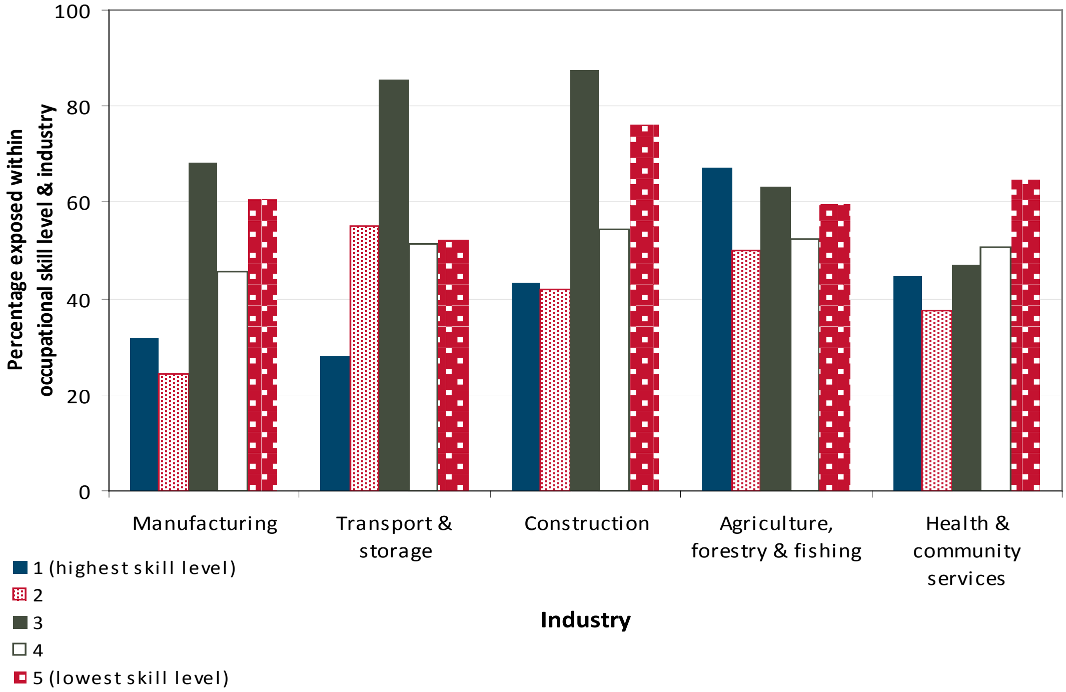


Figure 14. The percentage of workers who reported exposure to *working with the hands raised above the head* within industry and occupational skill level

Table 22. Post-hoc Chi-square test statistics for exposure to *working with the hands raised above the head* by industry, gender and occupational skill level

Differences in the percentage of workers exposed to *working with the hands raised above the head* by gender within industry	**Pearson Chi-square**	***p***
Manufacturing	47.461	<0.001
Transport and storage	34.070.	<0.001
Construction	64.406	<0.001
Agriculture, forestry and fishing	16.492	<0.001
Health and community services	0.079	0.813
Differences in the percentage of workers exposed to *working with the hands raised above the head* by occupational skill level within industry	**Pearson Chi-square**	***p***
Manufacturing	65.421	<0.001
Transport and storage	36.063	<0.001
Construction	116.922	<0.001
Agriculture, forestry and fishing	4.381	0.357
Health and community services	36.063	<0.001

Table 23. Parameter estimates of the logistic regression model examining exposure to *working with the hands raised above the head*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	455.738	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	4.577	8	0.802
Nagelkerke Pseudo R Square	0.193		

Whether or not worker reported exposure to working with their hands raised above their head								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	0.064	0.165	0.150	1	0.699	1.066	0.771	1.474
Female	0[b]			0				
Age			**8.294**	**4**	**0.081**			
15-24 years	0.486	0.211	5.279	1	0.022	1.626	1.074	2.461
25-34 years	0.253	0.139	3.293	1	0.070	1.288	0.980	1.692
35-44 years	0.189	0.117	2.613	1	0.106	1.208	0.961	1.518
45-54 years	0.064	0.110	0.337	1	0.561	1.066	0.860	1.322
55+ years	0[b]			0				
Night work								
Worked at night	0.453	0.164	7.619	1	0.006	1.572	1.140	2.168
Did not work at night	0[b]			0				
Industry			**6.895**	**4**	**0.142**			
Manufacturing	-0.865	0.438	3.900	1	0.048	0.421	0.178	0.994
Transport & storage	-1.289	0.511	6.376	1	0.012	0.275	0.101	0.749
Construction	-0.796	0.543	2.148	1	0.143	0.451	0.155	1.308
Agriculture, forestry & fishing	-0.779	0.470	2.742	1	0.098	0.459	0.183	1.154
Health & community services	0[b]			0				
Workplace size			**3.992**	**3**	**0.262**			
Less than 5 employees	-0.093	0.133	0.492	1	0.483	0.911	0.702	1.182
5-19 employees	-0.245	0.125	3.811	1	0.051	0.783	0.612	1.001
20-199 employees	-0.091	0.112	0.667	1	0.414	0.913	0.734	1.136
200 or more employees	0[b]			0				
Occupational skill level			**12.054**	**4**	**0.017**			
1 (highest skill level)	-0.837	0.363	5.329	1	0.021	0.433	0.213	0.881
2	-1.054	0.403	6.827	1	0.009	0.349	0.158	0.769
3	-0.707	0.499	2.009	1	0.156	0.493	0.185	1.311
4	-0.490	0.369	1.765	1	0.184	0.613	0.297	1.262
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	0.168	0.153	1.203	1	0.273	1.183	0.876	1.597
No (only English spoken)	0[b]			0				

Table 23 continued

Whether or not worker reported exposure to working with their hands raised above their head								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**35.280**	**4**	**0.000**			
Manufacturing* gender	1.183	0.270	19.142	1	0.000	3.264	1.921	5.545
Transport & storage*gender	1.286	0.330	15.146	1	0.000	3.618	1.893	6.912
Construction*gender	1.520	0.353	18.500	1	0.000	4.573	2.287	9.142
Agriculture, forestry & fishing*gender	1.008	0.309	10.670	1	0.001	2.740	1.497	5.017
Health & community services*gender	0[b]							
Industry*skill level			**60.792**	**16**	**0.000**			
Manufacturing* skill level 1	-0.582	0.474	1.503	1	0.220	0.559	0.221	1.416
Manufacturing* skill level 2	-0.599	0.601	0.992	1	0.319	0.549	0.169	1.785
Manufacturing* skill level 3	0.640	0.575	1.241	1	0.265	1.897	0.615	5.853
Manufacturing* skill level 4	-0.143	0.464	0.095	1	0.758	0.867	0.349	2.154
Transport and storage * skill level 1	-0.501	0.590	0.719	1	0.396	0.606	0.191	1.928
Transport and storage * skill level 2	1.274	0.704	3.280	1	0.070	3.577	0.901	14.203
Transport and storage * skill level 3	1.960	0.714	7.538	1	0.006	7.099	1.752	28.763
Transport and storage * skill level 4	0.217	0.512	0.179	1	0.672	1.242	0.455	3.388
Construction * skill level 1	-0.531	0.506	1.098	1	0.295	0.588	0.218	1.587
Construction * skill level 2	-0.209	0.586	0.127	1	0.721	0.811	0.257	2.560
Construction * skill level 3	1.398	0.613	5.203	1	0.023	4.045	1.217	13.443
Construction * skill level 4	-0.316	0.524	0.364	1	0.546	0.729	0.261	2.037
Agriculture, forestry & fishing * skill level 1	1.155	0.480	5.784	1	0.016	3.174	1.238	8.134
Agriculture, forestry & fishing * skill level 2	0.674	0.767	0.772	1	0.380	1.962	0.436	8.825
Agriculture, forestry & fishing * skill level 3	0.860	0.666	1.666	1	0.197	2.364	0.640	8.729
Agriculture, forestry & fishing * skill level 4	0.107	0.549	0.038	1	0.845	1.113	0.379	3.265
Health and community services * skill level 5	0[b]							
Intercept	0.463	0.366	1.599					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to working while sitting down

The statistical output of the model examining exposure to *working while sitting down* is presented in Table 25. When controlling for the effects of other factors, the main findings of this model were as follows:

- The odds that a worker reported *working while sitting down* were increased by a factor of two for male workers in comparison to female workers.
- Workers in the smallest workplaces (< five employees) had significantly lower odds of reporting exposure to *working while sitting down* compared to the largest workplaces (200 or more employees).
- The odds that a worker reported *working while sitting down* were decreased by a factor of 0.57 for workers who spoke a language other than English at home in comparison to workers who spoke English at home. This is the only biomechanical hazard where the language spoken at home had a significant effect on the odds of reporting exposure.
- There were significant interactions between gender and industry, and occupational skill level and industry on the likelihood of reporting exposure to *working while sitting down*. See below and refer to Table 24, Figure 15 and Figure 16 for more information on these interactions and the main effects of industry and occupational skill.

On its own, industry of employment affected the likelihood of reporting exposure to *working while sitting down*. Workers in the Transport and storage industry were 64 times more likely than workers in the Health and community services industry to report *working while sitting down*. The other priority industries (Manufacturing, Construction, Agriculture, forestry and fishing) were also more likely to report exposure to *working while sitting down* than the Health and community services industry.

There were different patterns of exposure to this biomechanical demand by gender across these industries. The interaction between these factors is partially illustrated in Figure 15, where it can be seen that larger percentages of female workers reported exposure to *working while sitting down* than male workers in the Manufacturing, Transport and storage and Construction industries. In contrast, smaller percentages of female workers reported exposure to *working while sitting down* than male workers in the Agriculture, forestry and fishing and Health and community services industries. This is a different pattern of exposure by worker gender and industry to most other biomechanical demands. Within industries, the difference in the percentages of male and female workers exposed was statistically significant for the Manufacturing, Construction and Health and community services industries (Table 24).

Occupational skill level also had a main effect on the likelihood of reporting exposure to *working while sitting down*. Compared to the lowest skill level (five), all higher skill levels were significantly more likely to report exposure to *working while sitting down*. The odds ratios for reporting exposure to *working while sitting down* were increased most dramatically (by factors of 33 and 29) for occupational skill levels one and two respectively, which are the highest occupational skill levels.

The pattern of exposure to *working while sitting down* across occupational skill levels varied dramatically within and between industries (Table 24, Figure 16). For example, occupational skill level one recorded the smallest percentage of workers who reported exposure to this demand in the Manufacturing industry, but the highest percentages of workers who reported exposure to this demand in the Transport and storage and Health and community services industries. Occupational skill level two recorded the greatest percentages of workers who reported exposure to *working while sitting down* in the remaining industries.

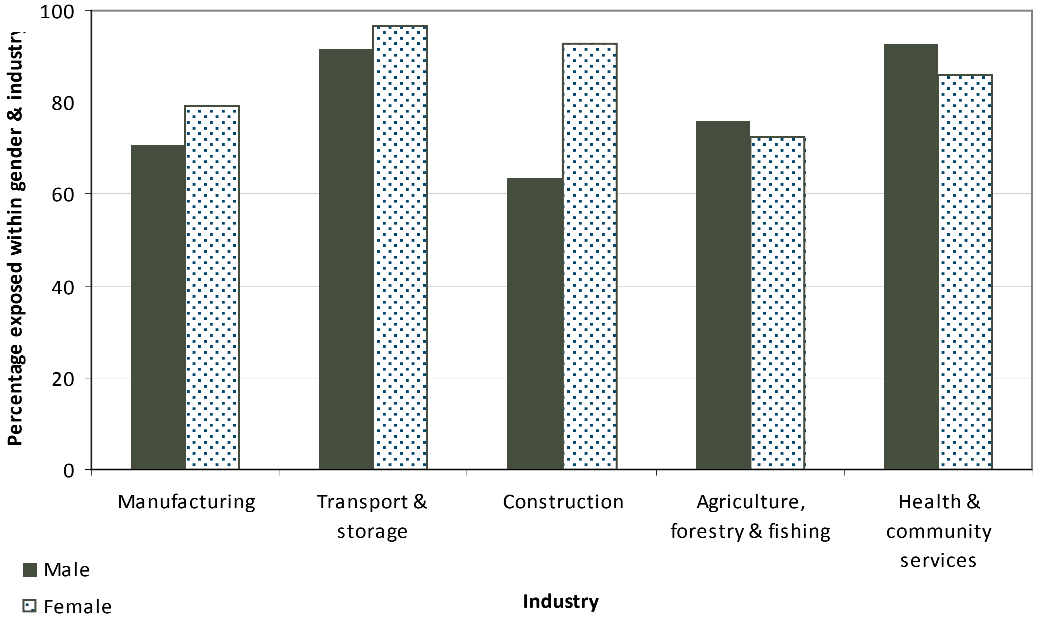


Figure 15. The percentage of workers who reported exposure to *working while sitting down* within gender and industry

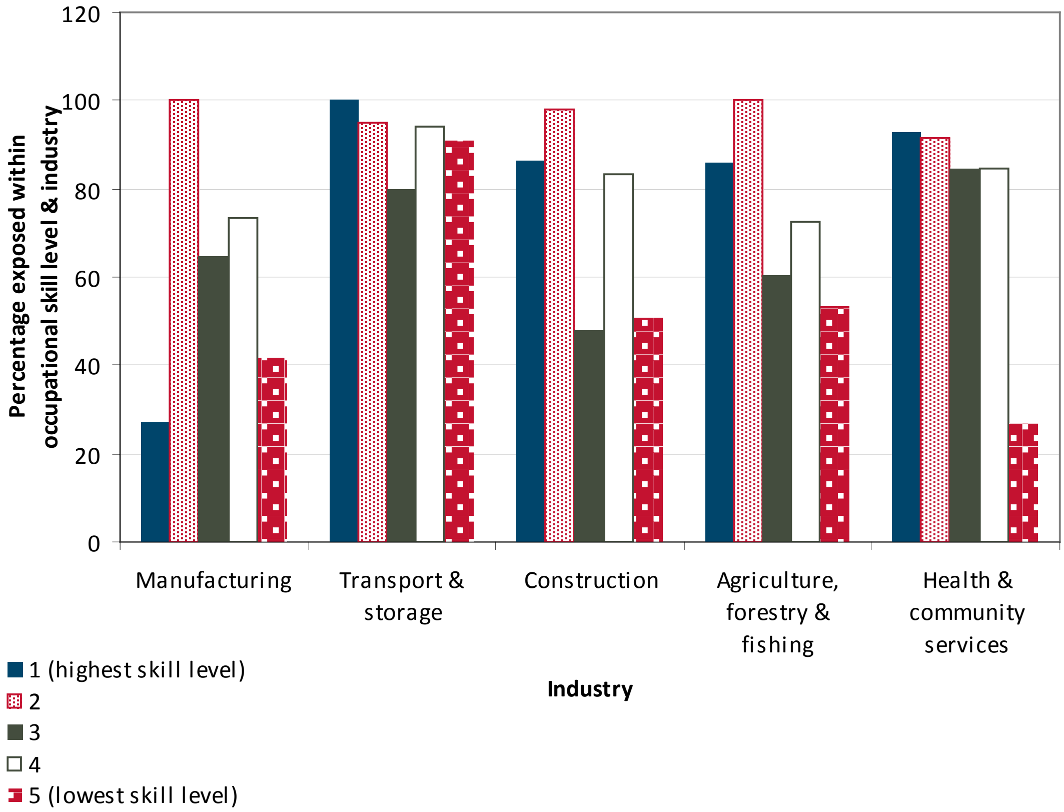


Figure 16. The percentage of workers who reported exposure to *working while sitting down* by industry and occupational skill level

Table 24. Post-hoc Chi-square test statistics for exposure to *working while sitting down* by industry, gender and occupational skill

Differences in the percentage of workers exposed to *working while sitting down* by gender within industry	Pearson Chi-square	*p*
Manufacturing	4.726	0.032
Transport and storage	2.753	0.110
Construction	24.463	<0.001
Agriculture, forestry and fishing	0.338	0.570
Health and community services	6.516	0.009
Differences in the percentage of workers exposed to *working while sitting down* by occupational skill level within industry	**Pearson Chi-square**	***p***
Manufacturing	100.522	<0.001
Transport and storage	18.140	0.001
Construction	114.293	<0.001
Agriculture, forestry and fishing	33.884	<0.001
Health and community services	18.140	0.001

Table 25. Parameter estimates of the logistic regression model examining exposure to *working while sitting down*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	602.765	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	3.888	8	0.867
Nagelkerke Pseudo R Square	0.289		

Whether or not worker reported exposure to working while sitting down								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**Upper**
Sex								
Male	0.704	0.325	4.675	1	0.031	2.021	1.068	3.826
Female	0[b]			0				
Age			**2.632**	**4**	**0.621**			
15-24 years	-0.192	0.221	0.749	1	0.387	0.826	0.535	1.274
25-34 years	0.077	0.176	0.192	1	0.661	1.080	0.766	1.523
35-44 years	-0.007	0.151	0.002	1	0.961	0.993	0.738	1.335
45-54 years	0.118	0.146	0.650	1	0.420	1.125	0.845	1.497
55+ years	0[b]			0				
Night work								
Worked at night	-0.122	0.213	0.327	1	0.568	0.885	0.583	1.344
Did not work at night	0[b]			0				
Industry			**28.954**	**4**	**0.000**			
Manufacturing	1.147	0.468	5.995	1	0.014	3.149	1.257	7.886
Transport & storage	4.155	0.908	20.926	1	0.000	63.744	10.748	378.063
Construction	2.555	0.662	14.890	1	0.000	12.868	3.515	47.105
Agriculture, forestry & fishing	1.243	0.503	6.114	1	0.013	3.465	1.294	9.280
Health & community services	0[b]			0				
Workplace size			**10.796**	**3**	**0.013**			
Less than 5 employees	-0.562	0.172	10.732	1	0.001	0.570	0.407	0.798
5-19 employees	-0.325	0.170	3.649	1	0.056	0.722	0.517	1.008
20-199 employees	-0.295	0.158	3.482	1	0.062	0.745	0.546	1.015
200 or more employees	0[b]			0				
Occupational skill level			**71.631**	**4**	**0.000**			
1 (highest skill level)	3.494	0.420	69.138	1	0.000	32.906	14.442	74.977
2	3.383	0.516	42.951	1	0.000	29.466	10.713	81.046
3	2.596	0.619	17.589	1	0.000	13.412	3.986	45.124
4	2.857	0.416	47.051	1	0.000	17.405	7.694	39.372
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.569	0.182	9.759	1	0.002	0.566	0.396	0.809
No (only English spoken)	0[b]			0				

Table 25 continued								
Whether or not worker reported exposure to working while sitting down								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**19.985**	**4**	**0.001**			
Manufacturing* gender	-1.381	0.411	11.294	1	0.001	0.251	0.112	0.562
Transport & storage*gender	-1.757	0.835	4.425	1	0.035	0.173	0.034	0.887
Construction*gender	-2.078	0.593	12.263	1	0.000	0.125	0.039	0.401
Agriculture, forestry & fishing*gender	-0.492	0.443	1.232	1	0.267	0.612	0.257	1.457
Health & community services*gender	0[b]							
Industry*skill level			**47.140**	**16**	**0.000**			
Manufacturing* skill level 1	-0.032	0.622	0.003	1	0.959	0.968	0.286	3.277
Manufacturing* skill level 2	18.161	6287.258	0.000	1	0.998	7.715E7	0.000	.
Manufacturing* skill level 3	-1.404	0.680	4.268	1	0.039	0.246	0.065	0.930
Manufacturing* skill level 4	-1.509	0.503	8.979	1	0.003	0.221	0.082	0.593
Transport and storage * skill level 1	15.479	5656.478	0.000	1	0.998	5.27E6	0.000	.
Transport and storage * skill level 2	-2.713	1.274	4.538	1	0.033	0.066	0.005	0.805
Transport and storage * skill level 3	-3.133	0.896	12.222	1	0.000	0.044	0.008	0.252
Transport and storage * skill level 4	-2.058	0.746	7.599	1	0.006	0.128	0.030	0.552
Construction * skill level 1	-1.729	0.554	9.751	1	0.002	0.177	0.060	0.525
Construction * skill level 2	0.336	1.167	0.083	1	0.773	1.399	0.142	13.766
Construction * skill level 3	-2.628	0.682	14.865	1	0.000	0.072	0.019	0.275
Construction * skill level 4	-1.501	0.561	7.157	1	0.007	0.223	0.074	0.669
Agriculture, forestry & fishing * skill level 1	-1.814	0.540	11.278	1	0.001	0.163	0.057	0.470
Agriculture, forestry & fishing * skill level 2	17.541	11554.463	0.000	1	0.999	4.148E7	0.000	.
Agriculture, forestry & fishing * skill level 3	-2.370	0.750	9.975	1	0.002	0.094	0.021	0.407
Agriculture, forestry & fishing * skill level 4	-2.026	0.593	11.672	1	0.001	0.132	0.041	0.422
Health and community services * skill level 5	0[b]							
Intercept	-0.803	0.408	3.872					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to squatting or kneeling while working

The statistical output of the model examining self-reported exposure to *squatting or kneeling while working* is presented in Table 26. This is a main effects only model because including interaction terms resulted in unacceptable model fit. The main findings of this model, when controlling for other factors, include:

- The odds of reporting exposure to *squatting or kneeling while working* were increased by a factor of 1.78 for male workers relative to female workers.
- The likelihood of reporting exposure *squatting or kneeling while working* declined with increasing age. The youngest workers (15-24 years) were 2.3 times more likely than the oldest workers (55 and older) to report exposure to this hazard.
- The odds of reporting exposure to *squatting or kneeling while working* were increased by a factor of 1.6 for night workers relative to non-night workers.
- Compared to workers in the Health and community services industry, workers in the Manufacturing, Transport and storage and Construction industries had significantly reduced odds of reporting exposure to *squatting or kneeling while working*.
- Occupational skill level significantly affected the likelihood of reporting exposure to *squatting or kneeling while working*. Workers in occupational skill level three were twice as likely to report exposure to this biomechanical demand as workers in occupational skill level five. However, workers in occupational skill levels one, two and four were significantly less likely to report exposure to *squatting or kneeling while working* than workers in skill level five.
- The odds of reporting exposure to *squatting or kneeling while working* were increased by a factor of 1.4 for workers in the smallest workplaces (< five employees) relative to the workers from the largest workplaces (200 or more employees).

Table 26. Parameter estimates for the logistic regression model examining exposure to *squatting or kneeling while working* (main effects only model)

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	252.851	18	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	8.228	8	0.411
Nagelkerke Pseudo R Square	0.115		

Whether or not worker reported exposure to squatting or kneeling								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Sex								
Male	0.579	0.102	32.315	1	0.000	1.784	1.461	2.178
Female	0[b]			0				
Age			**26.766**	**4**	**0.000**			
15-24 years	0.827	0.227	13.296	1	0.000	2.287	1.466	3.568
25-34 years	0.581	0.144	16.287	1	0.000	1.788	1.348	2.371
35-44 years	0.431	0.118	13.432	1	0.000	1.538	1.222	1.937
45-54 years	0.319	0.110	8.416	1	0.004	1.376	1.109	1.708
55+ years	0[b]			0				
Night work								
Worked at night	0.491	0.177	7.709	1	0.005	1.633	1.155	2.310
Did not work at night	0[b]			0				
Industry			**73.295**	**4**	**0.000**			
Manufacturing	-1.000	0.128	60.703	1	0.000	0.368	0.286	0.473
Transport & storage	-0.873	0.149	34.210	1	0.000	0.418	0.312	0.560
Construction	-0.416	0.145	8.197	1	0.004	0.660	0.496	0.877
Agriculture, forestry & fishing	-0.263	0.169	2.427	1	0.119	0.769	0.553	1.070
Health & community services	0[b]			0				
Workplace size			**13.778**	**3**	**0.003**			
Less than 5 employees	0.350	0.136	6.626	1	0.010	1.418	1.087	1.851
5-19 employees	-0.121	0.126	0.924	1	0.336	0.886	0.693	1.134
20-199 employees	0.040	0.113	0.128	1	0.721	1.041	0.835	1.299
200 or more employees	0[b]			0				
Occupational skill level			**80.709**	**4**	**0.000**			
1 (highest skill level)	-0.499	0.153	10.643	1	0.001	0.607	0.450	0.819
2	-0.534	0.193	7.678	1	0.006	0.587	0.402	0.855
3	0.685	0.174	15.474	1	0.000	1.984	1.410	2.792
4	-0.293	0.153	3.665	1	0.056	0.746	0.552	1.007
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	-0.207	0.154	1.820	1	0.177	0.813	0.601	1.098
No (only English spoken)	0[b]			0				
Intercept	0.611	0.189	10.395					
b. This parameter is the reference category and is set to zero because it is redundant								

Exposure to pushing or pulling using some force

The statistical output of the model examining exposure to *pushing or pulling using some force* is presented in Table 28. While accounting for other factors in the model, this model showed that:

- The odds of reporting exposure to *pushing or pulling using some force* were increased by a factor of 3.0 for night workers relative to non-night workers.
- The likelihood of reporting exposure to *pushing or pulling using some force* declined with increasing age. The youngest workers (15-24 years) were 2.6 times more likely than the oldest workers (55 and older) to report exposure to this hazard.
- There were significant interactions between gender and industry, and occupational skill level and industry on the likelihood of reporting exposure to *pushing or pulling using some force*. See below and refer to Table 27, Figure 17 and Figure 18 for more explanation of these interactions and the main effect of industry.

Relative to the Health and community services industry, the Transport and storage and the Construction industries had decreased odds of reporting exposure to *pushing or pulling using some force*. However, the effect of industry on exposure to this biomechanical demand depended on the gender of the worker. Similar to what was observed for exposure to other biomechanical demands, larger percentages of male workers reported exposure to *pushing or pulling using some force* compared to females in most priority industries (Figure 17). The only exception was in the Health and community services industry where a larger percentage of females reported this exposure compared to males. The differences observed between males and females were statistically significant within each industry (Table 27).

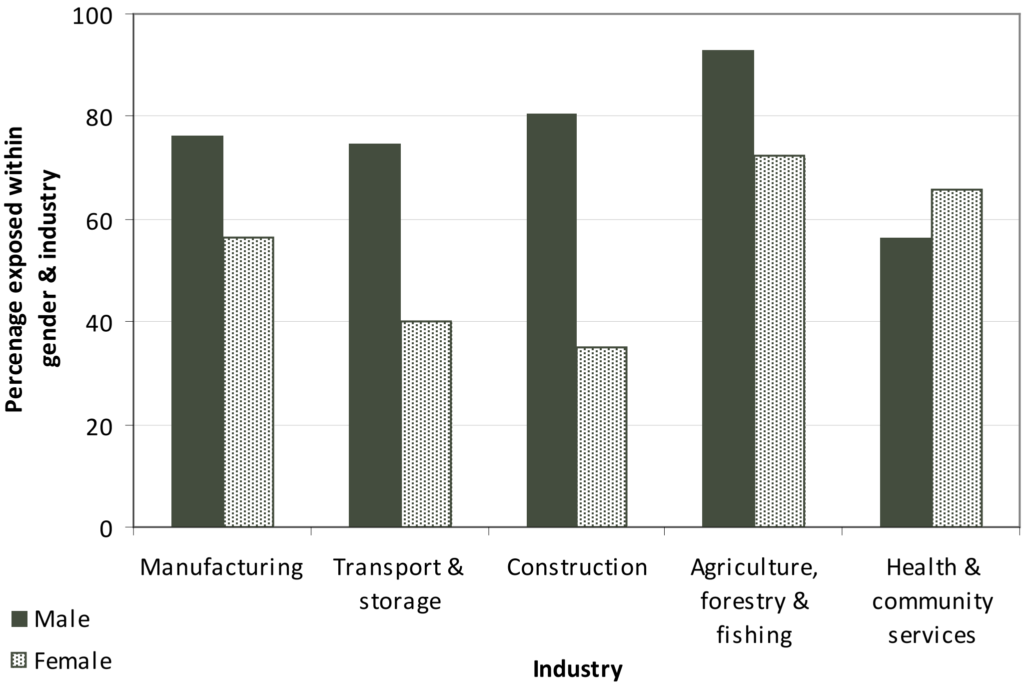


Figure 17. The percentage of workers who reported exposure to *pushing or pulling using some force* within industry and gender

The effect of industry on exposure to *pushing or pulling using some force* was also dependent on occupational skill level. As can be seen in Table 27 and Figure 18, workers in occupational skill levels three, four and five typically recorded the highest percentages of workers who reported exposure to this biomechanical demand. The difference between these lower skill levels and the highest skill levels (one and two) were statistically significant for the Manufacturing, Transport and storage and Construction industries, but not for the Agriculture, forestry and fishing or Health and community services industries. In these latter industries, there was no difference in the percentage of workers who reported exposure to *pushing or pulling using some force* by occupational skill level. In the Agriculture, forestry and fishing industry, more than 83% of workers in each occupational skill level reported exposure to this biomechanical demand.

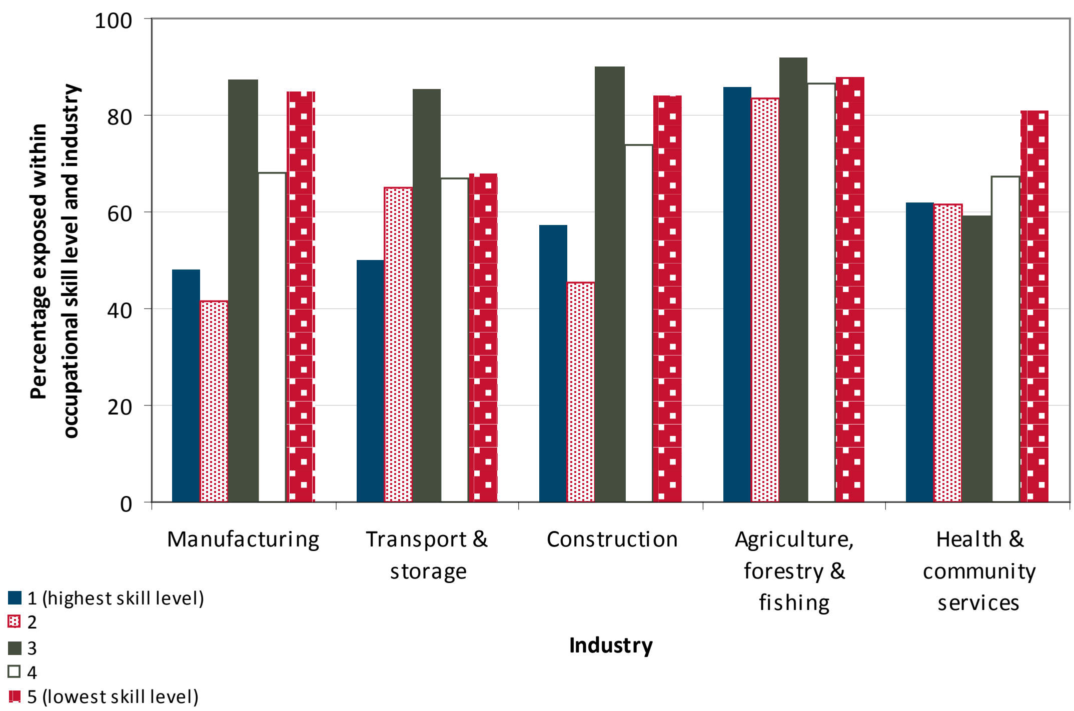


Figure 18. The percentage of workers who reported exposure to *pushing or pulling using some force* within industry and occupational skill level

Table 27. Post-hoc Chi-square test statistics for exposure to *pushing or pulling using some force* by industry, gender and occupational skill level

Differences in the percentage of workers exposed to *pushing or pulling using some force* by gender within industry	**Pearson Chi-square**	***p***
Manufacturing	25.010	<0.001
Transport and storage	38.167	<0.001
Construction	71.105	<0.001
Agriculture, forestry and fishing	23.791	<0.001
Health and community services	5.894	0.017
Differences in the percentage of workers exposed to *pushing or pulling using some force* by occupational skill level within industry	**Pearson Chi-square**	***p***
Manufacturing	93.941	<0.001
Transport and storage	15.143	0.004
Construction	87.589	<0.001
Agriculture, forestry and fishing	1.324	0.857
Health and community services	7.581	0.108

Table 28. Parameter estimates of the logistic regression model examining exposure to *pushing or pulling using some force*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	455.340	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	5.067	8	0.750
Nagelkerke Pseudo R Square	0.206		

Whether or not worker reported exposure to pushing or pulling using some force								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	-0.327	0.170	3.697	1	0.055	0.721	0.517	1.006
Female	0^b			0				
Age			**25.850**	**4**	**0.000**			
15-24 years	0.950	0.266	12.791	1	0.000	2.585	1.536	4.350
25-34 years	0.644	0.159	16.492	1	0.000	1.905	1.396	2.599
35-44 years	0.374	0.126	8.782	1	0.003	1.453	1.135	1.861
45-54 years	0.232	0.118	3.878	1	0.049	1.261	1.001	1.590
55+ years	0^b			0				
Night work								
Worked at night	1.113	0.223	24.855	1	0.000	3.044	1.965	4.714
Did not work at night	0^b			0				
Industry			**13.915**	**4**	**0.008**			
Manufacturing	-0.487	0.557	0.765	1	0.382	0.614	0.206	1.830
Transport & storage	-1.724	0.589	8.562	1	0.003	0.178	0.056	0.566
Construction	-1.589	0.634	6.287	1	0.012	0.204	0.059	0.707
Agriculture, forestry & fishing	-0.445	0.618	0.517	1	0.472	0.641	0.191	2.154
Health & community services	0^b			0				
Workplace size			**1.887**	**3**	**0.596**			
Less than 5 employees	-0.009	0.146	0.004	1	0.951	0.991	0.744	1.320
5-19 employees	-0.164	0.135	1.473	1	0.225	0.848	0.651	1.106
20-199 employees	-0.070	0.121	0.338	1	0.561	0.932	0.735	1.182
200 or more employees	0^b			0				
Occupational skill level			**8.413**	**4**	**0.078**			
1 (highest skill level)	-1.158	0.463	6.260	1	0.012	0.314	0.127	0.778
2	-1.125	0.495	5.166	1	0.023	0.325	0.123	0.857
3	-1.268	0.581	4.760	1	0.029	0.282	0.090	0.879
4	-0.897	0.469	3.657	1	0.056	0.408	0.163	1.023
5 (lowest skill level)	0^b			0				
Other language spoken at home								
Yes	0.041	0.168	0.060	1	0.806	1.042	0.750	1.448
No (only English spoken)	0^b			0				

Table 28 continued

Whether or not worker reported exposure to pushing or pulling using some force								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**62.509**	**4**	**0.000**			
Manufacturing* gender	1.191	0.276	18.598	1	0.000	3.291	1.915	5.655
Transport & storage*gender	1.764	0.321	30.265	1	0.000	5.836	3.113	10.940
Construction*gender	2.081	0.345	36.371	1	0.000	8.014	4.075	15.763
Agriculture, forestry & fishing*gender	1.882	0.394	22.827	1	0.000	6.570	3.035	14.221
Health & community services*gender	0[b]							
Industry*skill level			**40.614**	**16**	**0.001**			
Manufacturing* skill level 1	-0.759	0.587	1.674	1	0.196	0.468	0.148	1.478
Manufacturing* skill level 2	-1.041	0.673	2.392	1	0.122	0.353	0.094	1.321
Manufacturing* skill level 3	1.265	0.694	3.324	1	0.068	3.544	0.909	13.814
Manufacturing* skill level 4	-0.011	0.585	0.000	1	0.986	0.989	0.314	3.114
Transport and storage * skill level 1	0.086	0.657	0.017	1	0.896	1.090	0.301	3.950
Transport and storage * skill level 2	1.084	0.786	1.904	1	0.168	2.957	0.634	13.789
Transport and storage * skill level 3	1.895	0.802	5.582	1	0.018	6.651	1.381	32.026
Transport and storage * skill level 4	0.537	0.608	0.781	1	0.377	1.712	0.520	5.637
Construction * skill level 1	-0.089	0.614	0.021	1	0.885	0.915	0.274	3.049
Construction * skill level 2	-0.431	0.681	0.400	1	0.527	0.650	0.171	2.469
Construction * skill level 3	1.643	0.713	5.309	1	0.021	5.170	1.278	20.911
Construction * skill level 4	0.586	0.643	0.832	1	0.362	1.798	0.510	6.338
Agriculture, forestry & fishing * skill level 1	0.944	0.656	2.071	1	0.150	2.571	0.711	9.301
Agriculture, forestry & fishing * skill level 2	0.818	1.028	0.633	1	0.426	2.266	0.302	16.999
Agriculture, forestry & fishing * skill level 3	1.553	0.937	2.745	1	0.098	4.724	0.753	29.644
Agriculture, forestry & fishing * skill level 4	0.675	0.768	0.774	1	0.379	1.964	0.436	8.843
Health and community services * skill level 5	0[b]							
Intercept	1.376	0.466	8.712					

b. This parameter is the reference category and is set to zero because it is redundant.

Exposure to working while standing in one place

The statistical output of the model examining exposure to *working while standing in one place* is presented in Table 30. Accounting for other factors in the model, the main findings of the model included:

- The likelihood of reporting exposure to *working while standing in one place* declined with increasing age. The youngest workers (15-24 years) were 2.1 times more likely than the oldest workers (55 and older) to report exposure to this hazard.
- The odds of reporting exposure to *working while standing in one place* were increased by a factor of 1.8 for night workers relative to non-night workers.
- There was a significant interaction between industry and occupational skill level on exposure to working while standing in one place. See below and refer to Table 29 and Figure 19 for more detail.

As can be seen in Figure 19, workers in occupational skill level three recorded the highest percentage of workers who reported exposure to *working while standing in one place* in all priority industries except the Health and community services industry. In this latter industry there was no statistical difference between the occupational skill levels in terms of the percentage of workers who reported exposure to this biomechanical demand (Table 29).

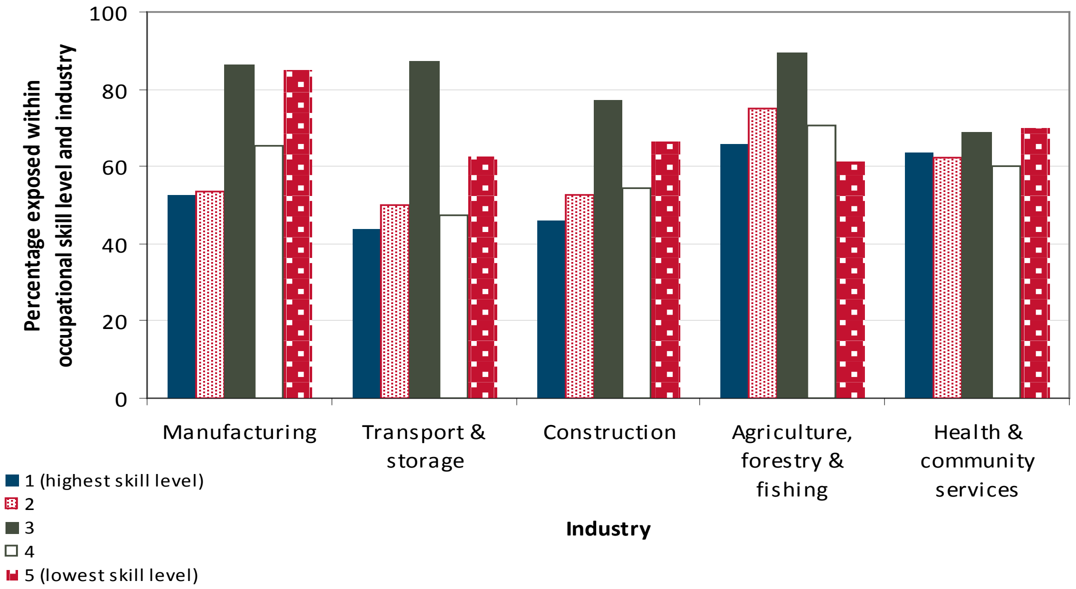


Figure 19. The percentage of workers who reported exposure to *working while standing in one place* within industry and occupational skill level

Table 29. Post-hoc Chi-square test statistics for exposure to *working while standing in one place* by industry and occupational skill level

Differences in the percentage of workers exposed to *working while standing in one place* by occupational skill level within industry	Pearson Chi-square	*p*
Manufacturing	67.229	<0.001
Transport and storage	31.991	<0.001
Construction	47.802	<0.001
Agriculture, forestry and fishing	10.336	0.035
Health and community services	2.566	0.633

Table 30. Parameter estimates of the logistic regression model examining exposure to *working while standing in one place*

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	269.665	38	<0.001
Hosmer and Lemeshow chi-square test of goodness of fit	9.639	8	0.291
Nagelkerke Pseudo R Square	0.121		

Whether or not worker reported exposure to working while standing in one place								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	0.140	0.172	0.666	1	0.415	1.150	0.822	1.611
Female	0[b]			0				
Age			**26.474**	**4**	**0.000**			
15-24 years	0.755	0.220	11.780	1	0.001	2.127	1.382	3.273
25-34 years	0.607	0.143	17.896	1	0.000	1.834	1.385	2.429
35-44 years	0.410	0.116	12.426	1	0.000	1.507	1.200	1.893
45-54 years	0.267	0.109	5.996	1	0.014	1.306	1.055	1.617
55+ years	0[b]			0				
Night work								
Worked at night	0.598	0.181	10.966	1	0.001	1.819	1.277	2.592
Did not work at night	0[b]			0				
Industry			**9.459**	**4**	**0.051**			
Manufacturing	0.540	0.489	1.218	1	0.270	1.716	0.658	4.475
Transport & storage	-0.663	0.514	1.663	1	0.197	0.515	0.188	1.411
Construction	-0.629	0.522	1.452	1	0.228	0.533	0.192	1.483
Agriculture, forestry & fishing	-0.519	0.483	1.153	1	0.283	0.595	0.231	1.535
Health & community services	0[b]			0				
Workplace size			**3.963**	**3**	**0.266**			
Less than 5 employees	-0.256	0.134	3.673	1	0.055	0.774	0.596	1.006
5-19 employees	-0.106	0.128	0.691	1	0.406	0.899	0.700	1.155
20-199 employees	-0.069	0.115	0.356	1	0.551	0.933	0.745	1.170
200 or more employees	0[b]			0				
Occupational skill level			**1.322**	**4**	**0.858**			
1 (highest skill level)	-0.313	0.379	0.684	1	0.408	0.731	0.348	1.537
2	-0.239	0.418	0.327	1	0.567	0.787	0.347	1.786
3	-0.071	0.531	0.018	1	0.894	0.932	0.329	2.638
4	-0.352	0.385	0.835	1	0.361	0.703	0.330	1.496
5 (lowest skill level)	0[b]			0				
Other language spoken at home								
Yes	0.114	0.157	0.530	1	0.467	1.121	0.825	1.523
No (only English spoken)	0[b]			0				

Table 30 continued

Whether or not worker reported exposure to working while standing in one place								
MODEL FACTORS	**Parameter Estimates**							
							95% CI for Exp (B)	
The reference group in the model is 'not exposed'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**Lower**	**Upper**
Industry*gender			**5.094**	**4**	**0.278**			
Manufacturing* gender	0.457	0.272	2.823	1	0.093	1.580	0.927	2.693
Transport & storage*gender	0.585	0.317	3.413	1	0.065	1.795	0.965	3.340
Construction*gender	0.450	0.324	1.925	1	0.165	1.568	0.831	2.961
Agriculture, forestry & fishing*gender	0.355	0.320	1.233	1	0.267	1.426	0.762	2.668
Health & community services*gender	0[b]							
Industry*skill level			**33.388**	**16**	**0.007**			
Manufacturing* skill level 1	-1.323	0.520	6.481	1	0.011	0.266	0.096	0.738
Manufacturing* skill level 2	-1.272	0.611	4.336	1	0.037	0.280	0.085	0.928
Manufacturing* skill level 3	0.076	0.647	0.014	1	0.907	1.079	0.303	3.837
Manufacturing* skill level 4	-0.707	0.516	1.873	1	0.171	0.493	0.179	1.357
Transport and storage * skill level 1	-0.654	0.581	1.267	1	0.260	0.520	0.167	1.623
Transport and storage * skill level 2	-0.207	0.700	0.088	1	0.767	0.813	0.206	3.204
Transport and storage * skill level 3	1.181	0.749	2.484	1	0.115	3.258	0.750	14.152
Transport and storage * skill level 4	-0.496	0.526	0.890	1	0.345	0.609	0.217	1.707
Construction * skill level 1	-0.401	0.497	0.651	1	0.420	0.670	0.253	1.774
Construction * skill level 2	-0.114	0.574	0.039	1	0.843	0.892	0.290	2.749
Construction * skill level 3	0.581	0.613	0.899	1	0.343	1.788	0.538	5.940
Construction * skill level 4	-0.035	0.515	0.005	1	0.945	0.965	0.352	2.646
Agriculture, forestry & fishing * skill level 1	0.627	0.489	1.643	1	0.200	1.872	0.718	4.886
Agriculture, forestry & fishing * skill level 2	0.973	0.835	1.359	1	0.244	2.646	0.515	13.594
Agriculture, forestry & fishing * skill level 3	1.593	0.795	4.016	1	0.045	4.920	1.036	23.368
Agriculture, forestry & fishing * skill level 4	0.735	0.571	1.653	1	0.198	2.085	0.680	6.386
Health and community services * skill level 5	0[b]							
Intercept	0.509	0.382	1.777					

b. This parameter is the reference category and is set to zero because it is redundant.

Appendix C: Statistical output of analyses of multiple biomechanical demand exposure, pain and fatigue symptoms and biomechanical demand control provision

Mean composite biomechanical demand exposure z-scores

Table 31 Statistical output of general linear model examining the factors affecting workers' composite biomechanical demand score (*z* score)

GENERAL LINEAR MODEL Composite biomechanical demand score: *z* score	F	*df*	*p*
Corrected model*	**18.115**	**54**	**0.000**
Intercept	20.496	1	0.000
Gender	37.495	1	0.000
Age	13.655	4	0.000
Night work	25.914	1	0.000
Occupational skill level	31.545	4	0.000
Industry	6.882	4	0.000
Industry * Gender * Occupational skill level	5.407	40	0.000
R Squared = 0.252 (Adjusted R Squared = 0.238)			

* The model is restricted to workers in the five national priority industries

Table 32. Differences in the mean composite z-scores within the whole survey sample by gender, age, occupational skill level, industry and workplace size

Employment & demographic factors and statistical tests of differences in *z* score		
Gender	**Mean composite score**	**Standard deviation**
Males (N=2514)	0.13	1.03
Females (N=1984)	-0.170	0.93
T-test results	**t**	***p***
df: 4420	10.452	<0.01
Age groups	**Mean composite score**	**Standard deviation**
15-24 years (N=250)	0.37	1.06
25-34 years (N=626)	0.24	1.08
35-44 years (N=1149)	-0.00	0.99
45-54 years (N=1462)	-0.05	0.96
55 and older (N=975)	-0.15	0.95
F-test results	**F**	***p***
df: 4	25.128	<0.01
Occupational skill level	**score**	**Standard deviation**
1 (highest skill level) (N=1528)	-0.34	0.88
2 (N=413)	-0.34	0.86
3 (N=803)	0.63	0.97
4 (N=1164)	-0.02	0.96
5 (lowest skill level) (N=482)	0.46	0.97
F-test results	**F**	***p***
df: 4	186.625	<0.01
Workplace size	**Mean composite score**	**Standard deviation**
Less than 5 employees (N=976)	0.18	1.00
5-19 employees (N=956)	0.03	1.02
20-199 employees (N=1511)	-0.05	0.97
200 or more employees (N=1027)	-0.14	1.00
F-test results	**F**	***p***
df: 3	19.744	<0.01
Industry	**Mean composite score**	**Standard deviation**
Manufacturing (N=714)	0.08	1.03
Transport and storage (N=391)	0.06	1.04
Construction (N=655)	0.40	1.07
Agriculture, forestry and fishing (N=316)	0.32	0.89
Health and community services (N=956)	-0.04	0.94
F-test results	**F**	***p***
df: 4	23.006	<0.01

Pain and fatigue symptoms

Table 33. Parameter estimates of the logistic regression model examining the factors affecting worker experience of pain symptoms

Model information	**Chi-square**	***d.f.***	***p***
Omnibus test of model coefficients	522.053	8	<.001
Hosmer and Lemeshow chi-square test of goodness of fit	1.311	7	0.988
Nagelkerke Pseudo R Square	0.235		

Whether or not worker reported experiencing pain								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'did not experience fatigue'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	-0.408	0.097	17.695	1	0.000	0.665	0.550	0.804
Female	0^b			0				
Composite biomechanical demand exposure level			**420.019**	**3**	**0.000**			
Medium-Low	0.804	0.132	36.923	1	0.000	2.235	1.724	2.896
Medium-High	1.831	0.117	245.011	1	0.000	6.243	4.964	7.852
High	3.115	0.173	323.327	1	0.000	22.529	16.043	31.637
Low	0^b			0				
Age			**9.578**	**4**	**.048**			
15-24 years	-0.631	0.224	7.952	1	0.005	0.532	0.343	0.825
25-34 years	-0.151	0.164	0.854	1	0.355	0.859	0.623	1.185
35-44 years	-0.208	0.133	2.440	1	0.118	0.812	0.626	1.054
45-54 years	-0.052	0.127	0.171	1	0.679	0.949	0.740	1.216
55+ years	0^b			0				
Intercept	0.015	0.130	0.013					

b. This parameter is the reference category and is set to zero because it is redundant.

Table 34. Parameter estimates of the logistic regression model examining the factors affecting worker experience of fatigue symptoms

Model information	Chi-square	*d.f.*	*p*
Omnibus test of model coefficients	231.629	8	0.000
Hosmer and Lemeshow chi-square test of goodness of fit	5.427	7	0.608
Nagelkerke Pseudo R Square	0.121		

Whether or not worker reported experiencing fatigue								
MODEL FACTORS	**Parameter Estimates**							
The reference group in the model is 'did not experience fatigue'	**B**	**Std. Error**	**Wald**	**df**	***p***	**Odds ratio Exp(B)**	**95% CI for Exp (B) Lower**	**95% CI for Exp (B) Upper**
Sex								
Male	-0.281	0.104	7.275	1	0.007	0.755	0.616	0.926
Female	0[b]			0				
Composite biomechanical demand exposure level			**196.577**	**3**	**0.000**			
Medium-Low	0.755	0.145	27.285	1	0.000	2.128	1.603	2.826
Medium-High	1.311	0.123	114.274	1	0.000	3.709	2.917	4.717
High	2.087	0.164	162.395	1	0.000	8.059	5.847	11.109
Low	0[b]			0				
Night work								
Worked at night	0.523	0.255	4.229	1	0.040	1.688	1.025	2.779
Did not work at night	0[b]			0				
Workplace size			**12.473**	**3**	**0.006**			
Less than 5 employees	-0.449	0.153	8.584	1	0.003	0.638	0.473	0.862
5-19 employees	-0.482	0.153	9.883	1	0.002	0.618	0.457	0.834
20-199 employees	-0.243	0.144	2.842	1	0.092	0.784	0.591	1.040
200 or more employees	0[b]			0				
Intercept	0.887	0.144	38.162	1	0.000	2.429		

b. This parameter is the reference category and is set to zero because it is redundant.

Biomechanical demand control measure provision

Table 35. Parameter estimates of the multinomial logistic regression model examining the factors affecting how many controls were provided to workers

ONE, TWO, THREE, FOUR OR FIVE CONTROLS

MODEL INFORMATION	Chi-square	*df*	*P*
Final model	611.974	75	0.000
Goodness of fit - Deviance	2587.756	2595	0.536
Nagelkerke pseudo R Square	0.192		
LIKELIHOOD RATIO TESTS			
Factor	**Chi-square**	***df***	***P***
Intercept	0.000	0	.
Composite biomechanical demand	176.082	15	0.000
Gender	12.779	5	0.026
Industry	91.111	20	0.000
Workplace size	219.952	15	0.000
Occupational skill level	48.472	20	0.000

Number of controls, model factors and levels The model reference group is NO controls provided	B	Wald	*df*	*P*	Odds ratio Exp(B)	95.0% C.I. for Exp(B) Lower	Upper
ONE CONTROL PROVIDED							
Gender							
Male	0.114	0.509	1	0.475	1.120	0.820	1.530
Female							
Workplace size							
Less than 5 employees	-0.936	17.844	1	0.000	0.392	0.254	0.605
5 to 19 employees	-0.609	7.746	1	0.005	0.544	0.354	0.835
20 to 199 employees	-0.568	6.999	1	0.008	0.566	0.372	0.863
200 or more employees							
Composite biomechanical demand							
Medium-Low	0.148	0.518	1	0.472	1.160	0.775	1.735
Medium-High	0.746	17.377	1	0.000	2.108	1.485	2.994
High	0.903	19.490	1	0.000	2.467	1.652	3.683
Low							
Occupational skill							
1 (highest skill level)	0.332	3.758	1	0.053	1.393	0.996	1.949
2	0.077	0.092	1	0.762	1.080	0.655	1.781
3	0.201	0.780	1	0.377	1.223	0.783	1.910
5 (lowest skill level)	0.275	1.226	1	0.268	1.316	0.809	2.140
4							
Industry							
Manufacturing	-0.001	0.000	1	0.997	0.999	0.650	1.536
Transport & storage	0.265	1.401	1	0.237	1.304	0.840	2.024
Construction	-0.275	1.600	1	0.206	0.760	0.496	1.163
Agriculture, forestry & fishing	0.481	3.664	1	0.056	1.618	0.989	2.650
Health & community services							
Intercept	-0.383	2.376	1	0.123			

TWO CONTROLS PROVIDED	B	Wald	*df*	*P*	Exp (B)	Lower	Upper
Gender							
Male	0.152	0.828	1	0.363	1.165	0.839	1.617
Female							
Workplace size							
Less than 5 employees	-1.247	30.205	1	0.000	0.287	0.184	0.448
5 to 19 employees	-0.767	11.884	1	0.001	0.464	0.300	0.718
20 to 199 employees	-0.381	3.214	1	0.073	0.683	0.451	1.036
200 or more employees							
Composite biomechanical demand							
Medium-Low	0.347	2.111	1	0.146	1.415	0.886	2.259
Medium-High	1.392	48.649	1	0.000	4.022	2.720	5.948
High	1.698	60.392	1	0.000	5.464	3.560	8.385
Low							
Occupational skill							
1 (highest skill level)	0.067	0.135	1	0.713	1.069	0.749	1.525
2	0.263	1.066	1	0.302	1.301	0.790	2.143
3	0.700	10.819	1	0.001	2.014	1.327	3.057
5 (lowest skill level)	0.214	0.724	1	0.395	1.238	0.757	2.025
4							
Industry							
Manufacturing	0.221	1.020	1	0.313	1.248	0.812	1.918
Transport & storage	0.184	0.611	1	0.434	1.202	0.758	1.906
Construction	-0.338	2.222	1	0.136	0.713	0.458	1.112
Agriculture, forestry & fishing	0.413	2.396	1	0.122	1.512	0.896	2.551
Health & community services							
Intercept	-0.870	10.641	1	0.001			
THREE CONTROLS PROVIDED							
Gender							
Male	0.190	1.411	1	0.235	1.209	0.884	1.655
Female							
Workplace size							
Less than 5 employees	-2.055	87.134	1	0.000	0.128	0.083	0.197
5 to 19 employees	-1.289	37.613	1	0.000	0.275	0.182	0.416
20 to 199 employees	-0.593	9.293	1	0.002	0.552	0.377	0.809
200 or more employees							
Composite biomechanical demand							
Medium-Low	0.759	11.456	1	0.001	2.136	1.376	3.314
Medium-High	1.726	77.789	1	0.000	5.621	3.830	8.249
High	1.880	75.295	1	0.000	6.554	4.286	10.021
Low							
Occupational skill							
1 (highest skill level)	0.385	5.189	1	0.023	1.469	1.055	2.046
2	-0.156	0.337	1	0.561	0.855	0.505	1.449
3	0.634	9.177	1	0.002	1.886	1.251	2.842
5 (lowest skill level)	0.433	3.280	1	0.070	1.542	0.965	2.463
4							
Industry							
Manufacturing	0.367	3.216	1	0.073	1.443	0.967	2.154
Transport & storage	-0.413	2.880	1	0.090	0.662	0.411	1.066
Construction	-0.232	1.167	1	0.280	0.793	0.521	1.208
Agriculture, forestry & fishing	0.334	1.630	1	0.202	1.397	0.836	2.334
Health & community services							
Intercept	-0.623	6.030	1	0.014			

FOUR CONTROLS PROVIDED	B	Wald	*df*	*P*	Exp (B)	Lower	Upper
Gender							
Male	0.443	6.671	1	0.010	1.557	1.113	2.179
Female							
Workplace size							
Less than 5 employees	-1.782	58.643	1	0.000	0.168	0.107	0.265
5 to 19 employees	-1.326	33.189	1	0.000	0.265	0.169	0.417
20 to 199 employees	-0.547	6.813	1	0.009	0.579	0.384	0.873
200 or more employees							
Composite biomechanical demand							
Medium-Low	0.643	7.336	1	0.007	1.902	1.195	3.030
Medium-High	1.583	59.493	1	0.000	4.869	3.257	7.280
High	1.333	32.353	1	0.000	3.791	2.395	6.001
Low							
Occupational skill							
1 (highest skill level)	0.396	4.470	1	0.034	1.486	1.029	2.146
2	0.535	4.162	1	0.041	1.708	1.021	2.857
3	0.728	10.507	1	0.001	2.071	1.334	3.217
5 (lowest skill level)	0.421	2.668	1	0.102	1.524	0.919	2.527
4							
Industry							
Manufacturing	0.677	9.424	1	0.002	1.968	1.277	3.032
Transport & storage	-0.025	0.009	1	0.924	0.976	0.585	1.626
Construction	-0.201	0.717	1	0.397	0.818	0.514	1.302
Agriculture, forestry & fishing	1.067	16.383	1	0.000	2.908	1.734	4.876
Health & community services							
Intercept	-1.209	19.016	1	0.000			
FIVE CONTROLS PROVIDED							
Gender							
Male	0.480	8.970	1	0.003	1.616	1.180	2.211
Female							
Workplace size							
Less than 5 employees	-2.598	133.992	1	0.000	0.074	0.048	0.116
5 to 19 employees	-1.670	63.087	1	0.000	0.188	0.125	0.284
20 to 199 employees	-0.855	19.905	1	0.000	0.425	0.292	0.619
200 or more employees							
Composite biomechanical demand							
Medium-Low	0.509	6.180	1	0.013	1.663	1.114	2.485
Medium-High	1.315	53.350	1	0.000	3.724	2.617	5.300
High	0.971	21.132	1	0.000	2.641	1.745	3.995
Low							
Occupational skill							
1 (highest skill level)	0.683	15.406	1	0.000	1.980	1.408	2.785
2	0.440	3.079	1	0.079	1.553	0.950	2.539
3	0.903	18.380	1	0.000	2.467	1.633	3.728
5 (lowest skill level)	0.329	1.676	1	0.195	1.390	0.844	2.288
4							
Industry							
Manufacturing	1.044	25.959	1	0.000	2.842	1.901	4.246
Transport & storage	0.279	1.354	1	0.245	1.322	0.826	2.116
Construction	0.337	2.459	1	0.117	1.401	0.919	2.135
Agriculture, forestry & fishing	0.784	8.213	1	0.004	2.190	1.281	3.743
Health & community services							
Intercept	-0.713	8.255	1	0.004			

Table 36. Parameter estimates of the binary logistic regression model examining the factors affecting the provision of any / at least one biomechanical demand control

ANY / AT LEAST ONE CONTROL

MODEL INFORMATION	Chi-square	*df*	*P*
Omnibus test of model coefficients	308.633	16	0.000
Hosmer & Lemeshow test	9.168	8	0.328
Nagelkerke R Square	0.160		

Model factors and levels The model reference group is NO controls provided	B	Wald	*df*	*P*	Odds ratio Exp(B)	95.0% C.I. for Exp(B) Lower	Upper
Gender							
Male	0.260	4.490	1	0.034	1.297	1.020	1.650
Female							
Workplace size		112.079	3	0.000			
Less than 5 employees	-1.695	92.756	1	0.000	0.184	0.130	0.259
5 to 19 employees	-1.115	40.981	1	0.000	0.328	0.233	0.461
20 to 199 employees	-0.593	12.438	1	0.000	0.552	0.397	0.768
200 or more employees							
Composite biomechanical demand		110.127	3	0.000			
Medium-Low	0.451	8.940	1	0.003	1.570	1.168	2.110
Medium-High	1.289	88.585	1	0.000	3.630	2.775	4.747
High	1.315	68.048	1	0.000	3.724	2.725	5.090
Low							
Occupational skill		16.225	4	0.003			
1 (highest skill level)	0.377	8.133	1	0.004	1.457	1.125	1.888
2	0.226	1.425	1	0.233	1.253	0.865	1.815
3	0.631	13.615	1	0.000	1.879	1.344	2.628
5 (lowest skill level)	0.327	2.803	1	0.094	1.386	0.946	2.032
4							
Industry		26.952	4	0.000			
Manufacturing	0.490	8.979	1	0.003	1.632	1.185	2.249
Transport & storage	0.082	0.209	1	0.647	1.085	0.765	1.538
Construction	-0.130	0.643	1	0.423	0.878	0.639	1.207
Agriculture, forestry & fishing	0.630	9.724	1	0.002	1.878	1.264	2.792
Health & community services							
Night work							
Worked at night	0.519	3.885	1	0.049	1.680	1.003	2.813
Did not work at night							
Constant	0.916	22.467	1	0.000	2.500		

Table 37. Parameter estimates of the binary logistic regression model examining the factors affecting the provision of engineering biomechanical demand controls

ENGINEERING CONTROLS

MODEL INFORMATION	Chi-square	*df*	*P*
Omnibus test of model coefficients	609.989	26	0.000
Hosmer & Lemeshow test	13.634	8	0.092
Nagelkerke R Square	0.181		

Model factors and levels The model reference group is control not provided	B	Wald	*df*	*P*	Odds ratio Exp(B)	95.0% C.I. for Exp(B) Lower	Upper
Gender							
Male	0.325	16.153	1	0.000	1.384	1.181	1.621
Female							
Workplace size		208.210	3	0.000			
Less than 5 employees	-1.531	172.176	1	0.000	0.216	0.172	0.272
5 to 19 employees	-0.956	73.710	1	0.000	0.385	0.309	0.478
20 to 199 employees	-0.348	11.864	1	0.001	0.706	0.579	0.861
200 or more employees							
Composite biomechanical demand		99.769	3	0.000			
Medium-Low	0.267	6.236	1	0.013	1.306	1.059	1.611
Medium-High	0.799	72.348	1	0.000	2.224	1.850	2.674
High	0.956	68.803	1	0.000	2.601	2.075	3.260
Low							
Occupational skill		23.702	4	0.000			
1 (highest skill level)	-0.025	0.072	1	0.788	0.975	0.814	1.169
2	0.156	1.439	1	0.230	1.169	0.906	1.510
3	0.453	13.983	1	0.000	1.573	1.241	1.995
5 (lowest skill level)	0.404	8.744	1	0.003	1.498	1.146	1.958
4							
Industry		139.370	14	0.000			
Manufacturing	1.373	63.856	1	0.000	3.948	2.819	5.528
Transport & storage	0.588	10.360	1	0.001	1.800	1.259	2.575
Construction	0.649	14.992	1	0.000	1.914	1.378	2.658
Agriculture, forestry & fishing	1.472	55.758	1	0.000	4.359	2.962	6.414
Health & community services	0.660	17.441	1	0.000	1.935	1.419	2.637
Electricity, gas & water supply	0.712	2.519	1	0.113	2.037	0.846	4.906
Wholesale & Retail trade	1.223	33.456	1	0.000	3.397	2.244	5.140
Accommodation, cafes & restaurants	1.046	12.933	1	0.000	2.845	1.609	5.030
Communication services	-0.121	0.124	1	0.725	0.886	0.451	1.739
Finance & insurance	0.251	0.933	1	0.334	1.285	0.773	2.136
Mining	2.102	10.959	1	0.001	8.179	2.357	28.386
Government admin. & defence	0.398	3.984	1	0.046	1.488	1.007	2.200
Education	0.648	11.987	1	0.001	1.912	1.325	2.759
Cultural, recreational & personal services	0.042	0.026	1	0.873	1.043	0.622	1.749
Property & business services							
Night work							
Worked at night	0.337	3.942	1	0.047	1.401	1.004	1.953
Did not work at night							
Constant	-0.267	2.254	1	0.133	0.765		

Table 38. Parameter estimates of the binary logistic regression model examining the factors affecting the provision of redesign biomechanical demand controls

REDESIGN CONTROLS

MODEL INFORMATION	Chi-square	*df*	*P*
Omnibus test of model coefficients	252.552	25	0.000
Hosmer & Lemeshow test	12.853	8	0.117
Nagelkerke R Square	0.076		

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Model factors and levels The model reference group is control not provided	B	Wald	*df*	*P*	Odds ratio Exp(B)	95.0% C.I. for Exp(B) Lower	Upper
Gender							
Male	0.163	4.716	1	0.030	1.177	1.016	1.364
Female							
Workplace size		27.888	3	0.000			
Less than 5 employees	-0.540	26.876	1	0.000	0.583	0.475	0.715
5 to 19 employees	-0.330	11.158	1	0.001	0.719	0.593	0.873
20 to 199 employees	-0.210	5.887	1	0.015	0.810	0.684	0.960
200 or more employees							
Composite biomechanical demand		33.253	3	0.000			
Medium-Low	0.165	2.416	1	0.120	1.179	0.958	1.452
Medium-High	0.468	26.996	1	0.000	1.597	1.339	1.906
High	0.167	2.489	1	0.115	1.181	0.960	1.453
Low							
Occupational skill		11.335	4	0.023			
1 (highest skill level)	0.199	5.135	1	0.023	1.220	1.027	1.449
2	0.296	5.895	1	0.015	1.344	1.059	1.706
3	0.293	7.844	1	0.005	1.340	1.092	1.645
5 (lowest skill level)	0.116	0.975	1	0.323	1.123	0.892	1.415
4							
Industry		125.903	14	0.000			
Manufacturing	1.004	36.903	1	0.000	2.729	1.974	3.772
Transport & storage	0.413	5.116	1	0.024	1.511	1.057	2.161
Construction	0.803	22.629	1	0.000	2.231	1.603	3.106
Agriculture, forestry & fishing	1.026	29.811	1	0.000	2.790	1.931	4.033
Health & community services	0.378	5.447	1	0.020	1.460	1.063	2.006
Electricity, gas & water supply	0.764	3.667	1	0.056	2.146	0.982	4.690
Wholesale & Retail trade	0.767	14.925	1	0.000	2.154	1.459	3.179
Accommodation, cafes & restaurants	0.569	4.656	1	0.031	1.766	1.054	2.960
Communication services	-0.006	0.000	1	0.987	0.994	0.495	1.995
Finance & insurance	0.070	0.065	1	0.799	1.073	0.625	1.840
Mining	1.389	12.867	1	0.000	4.012	1.878	8.572
Government admin. & defence	0.466	5.486	1	0.019	1.594	1.079	2.354
Education	-0.293	2.205	1	0.138	0.746	0.507	1.098
Cultural, recreational & personal services	-0.173	0.370	1	0.543	0.841	0.482	1.468
Property & business services							
Constant	-1.094	37.815	1	0.000	0.335		

Table 39. Parameter estimates of the binary logistic regression model examining the factors affecting the provision of training

TRAINING

MODEL INFORMATION	Chi-square	*df*	*P*
Omnibus test of model coefficients	354.485	6	0.000
Hosmer & Lemeshow test	5.850	8	0.664
Nagelkerke R Square	0.150		

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Model factors and levels The model reference group is training not provided	B	Wald	*df*	*P*	Odds ratio Exp(B)	95.0% C.I. for Exp(B) Lower	Upper
Workplace size		290.734	3	0.000			
Less than 5 employees	-1.998	253.789	1	0.000	0.136	0.106	0.173
5 to 19 employees	-1.332	111.971	1	0.000	0.264	0.206	0.338
20 to 199 employees	-0.748	39.335	1	0.000	0.473	0.375	0.598
200 or more employees							
Composite biomechanical demand		46.600	3	0.000			
Medium-Low	0.263	3.777	1	0.052	1.301	0.998	1.697
Medium-High	0.724	41.705	1	0.000	2.062	1.655	2.568
High	0.537	19.976	1	0.000	1.712	1.352	2.167
Low							
Constant	0.931	55.908	1	0.000	2.537		

Appendix D: Occupation and occupational skill level

Table 40. Reference table for occupational skill level by ANZSCO 3-digit occupations

ANZSCO code	Occupation	Skill level
111	Chief Executives, General Managers and Legislators	1
121	Farmers and Farm Managers	1
131	Advertising and Sales Managers	1
132	Business Administration Managers	1
133	Construction, Distribution and Production Managers	1
134	Education, Health and Welfare Services Managers	1
135	ICT Managers	1
139	Miscellaneous Specialist Managers	1
141	Accommodation and Hospitality Managers	2
142	Retail Managers	2
149	Miscellaneous Hospitality, Retail and Service Managers	2
211	Arts Professionals	1
212	Media Professionals	1
221	Accountants, Auditors and Company Secretaries	1
222	Financial Brokers and Dealers, and Investment Advisers	1 and 2
223	Human Resource and Training Professionals	1
224	Information and Organisation Professionals	1
225	Sales, Marketing and Public Relations Professionals	1
231	Air and Marine Transport Professionals	1
232	Architects, Designers, Planners and Surveyors	1
233	Engineering Professionals	1
234	Natural and Physical Science Professionals	1
241	School Teachers	1
242	Tertiary Education Teachers	1
249	Miscellaneous Education Professionals	1
251	Health Diagnostic and Promotion Professionals	1
252	Health Therapy Professionals	1
253	Medical Practitioners	1
254	Midwifery and Nursing Professionals	1
261	Business and Systems Analysts, and Programmers	1
262	Database and Systems Administrators, and ICT Security Specialists	1
263	ICT Network and Support Professionals	1
271	Legal Professionals	1
272	Social and Welfare Professionals	1
311	Agricultural, Medical and Science Technicians	2
312	Building and Engineering Technicians	2
313	ICT and Telecommunications Technicians	2
321	Automotive Electricians and Mechanics	3
322	Fabrication Engineering Trades Workers	3
323	Mechanical Engineering Trades Workers	3
324	Panel beaters, and Vehicle Body Builders, Trimmers and Painters	3
331	Bricklayers, and Carpenters and Joiners	3
332	Floor Finishers and Painting Trades Workers	3
333	Glaziers, Plasterers and Tilers	3
334	Plumbers	3
341	Electricians	3
342	Electronics and Telecommunications Trades Workers	3
351	Food Trades Workers	3

ANZSCO code	Occupation	Skill level
361	Animal Attendants and Trainers, and Shearers	3
362	Horticultural Trades Workers	3
391	Hairdressers	3
392	Printing Trades Workers	3
393	Textile, Clothing and Footwear Trades Workers	3
394	Wood Trades Workers	3
399	Miscellaneous Technicians and Trades Workers	3
411	Health and Welfare Support Workers	2
421	Child Carers	4
422	Education Aides	4
423	Personal Carers and Assistants	4
431	Hospitality Workers	4 and 5
441	Defence Force Members, Fire Fighters and Police	2 and 3
442	Prison and Security Officers	4 and 5
451	Personal Service and Travel Workers	4
452	Sports and Fitness Workers	3 and 4
511	Contract, Program and Project Administrators	2
512	Office and Practice Managers	2
521	Personal Assistants and Secretaries	3
531	General Clerks	4
532	Keyboard Operators	4
541	Call or Contact Centre Information Clerks	4
542	Receptionists	4
551	Accounting Clerks and Bookkeepers	4
552	Financial and Insurance Clerks	4
561	Clerical and Office Support Workers	5
591	Logistics Clerks	4
599	Miscellaneous Clerical and Administrative Workers	3 and 4
611	Insurance Agents and Sales Representatives	4
612	Real Estate Sales Agents	3
621	Sales Assistants and Salespersons	5
631	Checkout Operators and Office Cashiers	5
639	Miscellaneous Sales Support Workers	5
711	Machine Operators	4
712	Stationary Plant Operators	4
721	Mobile Plant Operators	4
731	Automobile, Bus and Rail Drivers	4
732	Delivery Drivers	4
733	Truck Drivers	4
741	Store persons	4
811	Cleaners and Laundry Workers	5
821	Construction and Mining Labourers	4 and 5
831	Food Process Workers	4 and 5
832	Packers and Product Assemblers	5
839	Miscellaneous Factory Process Workers	4 and 5
841	Farm, Forestry and Garden Workers	5
851	Food Preparation Assistants	5
891	Freight Handlers and Shelf Fillers	5
899	Miscellaneous Labourers	4 and 5

Source: (Australian Bureau of Statistics and Statistics New Zealand 2006)