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FOREWORD

The Australian Safety and Compensation Council (ASCC) leads and coordinates national efforts to prevent workplace death, injury and disease in Australia and aims to improve national workers' compensation arrangements and return to work of injured employees.

Through the quality and relevance of the information it provides, the ASCC seeks to influence the awareness and activities of every person and organisation with a role in improving Australia's occupational health and safety (OHS) performance.

The *National OHS Strategy 2002-2012*, (the National Strategy) which was endorsed by the Workplace Relations Ministers' Council on 24 May 2002, records a commitment by all Australian, State and Territory governments, the Australian Chamber of Commerce and Industry and the Australian Council of Trade Unions, to share the responsibility of ensuring that Australia's performance in work-related health and safety is continuously improved.

The National Strategy sets out five 'national priorities' to achieve short-term and long-term improvements.

The priorities are to:

- reduce high incidence and high severity risks
- improve the capacity of business operators and worker to manage OHS effectively
- prevent occupational disease more effectively
- eliminate hazards at the design stage, and
- strengthen the capacity of government to influence OHS outcomes.

In March 2004 it was agreed by the then National Occupational Health and Safety Commission (NOHSC) that, under the national priority to prevent occupational disease more effectively, eight disease categories would be considered for particular focus under any national action plan. These are work-related musculoskeletal disorders; mental disorders, noise-induced hearing loss; respiratory diseases; occupational cancers; contact dermatitis; infectious and parasitic diseases, and cardiovascular disease.

To assist the setting of national action priorities to prevent these diseases, reports were prepared for members on each disease category. The following report is an extract of the information provided to members on the causes and risk factors for cardiovascular disease, the available data on the magnitude and severity for the disease category within Australia, approaches to prevention and evidence for their effectiveness.

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EXECUTIVE SUMMARY

Background

In line with a decision of the National Occupational Health and Safety Commission (NOHSC) 67 meeting in March 2004 a report has been provided on work-related musculoskeletal disorders (WMSDs) in Australia. This provides information on the causes and prevention of WMSDs, and data on the magnitude and severity of these disorders in Australia.

Scale of the problem

In Australia, like most other industrialised countries, WMSDs are the most common condition for which workers' compensation claims are currently lodged. These conditions result in health problems for many employees and a very significant social and economic burden for Australians. The number of workers' compensation claims for acute and chronic musculoskeletal disorders reported for the year 2003 was over 76,000 claims representing 43% of all injury and disease-related claims made.

According to the National Data Set (NDS), the most common mechanism of injury for WMSDs was 'body stressing'. Body stressing is coded as due to *repetitive movements, muscle loading, muscular stress with no objects being handled, muscular stress while handling objects other than lifting, carrying or putting down and muscular stress while lifting, carrying or putting down objects.*

Absolute numbers of workers' compensation claims provides one indicator of the magnitude of the WMSD problem. Industries with the highest number of body stressing cases reported in 2003 were *Manufacturing, Construction, Retail trade, Transport & Storage and Health & Community Services*, which have already been designated as priority industries under the National OHS strategy. Another indicator is incidence rate (claims per 1,000 employees). When this is examined for these priority industries by sub-category, the highest incidence rate is found for the *Storage* sub-category. The next highest rates were for *Food, Beverage and Tobacco, Wood and Paper Products, and Non-metallic metal* manufacturing sub-categories. Since high *incidence* rates reflect relatively poor performance in injury control, prevention campaigns targeting these high-incidence sub-categories clearly have substantial scope to yield significant benefits in injury reduction.

Within 'high claim' industries, differences between different occupational groups can also be identified. The highest number of cases was recorded for *Labourers and related workers*, followed by *Tradespersons and related workers* and *Intermediate production and transport workers*. For all occupational groups, injury claims attributed to body stressing constituted the largest percentage of 'mechanism of injury or disease' (32 - 44%). Among body stressing claims, the largest group was recorded as due to *muscular stress while lifting, carrying or putting down objects*, and the

smallest group was attributed to *repetitive movement, low muscle loading*.

NDS data for 2001-02 shows that the number of body stressing cases varies with age, peaking at 40-44 years. The proportion of cases due to *muscular stress while lifting, carrying or putting down objects* declines with age, whereas the proportion due to *muscular stress while handling objects other than lifting, carrying or putting down* increases with age.

Body stressing cases had longer recorded periods of time lost, and higher direct costs, than all other types of injury and disease cases. Using the NDS data for 2001-02, it was found that although the number of cases due to *repetitive movement, low muscle loading* was low, median time lost due to this mechanism was the highest at 5.4 weeks. This indicates the high severity of cases reported due to this mechanism, and explains why median direct costs are the highest for such cases. It is suggested that interventions to reduce time lost and direct costs could usefully be directed to reducing exposure to this injury mechanism.

Prevention of work-related musculoskeletal disorders

Effective prevention of WMSDs is achieved by the elimination or reduction of exposure to the major mechanisms of injury. As most WMSDs result from chronic exposures, prevention activities designed to eliminate acute injuries should in time also reduce the overall magnitude and severity of these conditions.

Historically, there has been considerable attention paid to programs to reduce strains and sprains which are more commonly associated with tasks requiring high muscle force and awkward body postures. A stocktake of current or recently completed programs reveal that all OHS jurisdictions are undertaking a large number of activities which specifically target the prevention of musculoskeletal disorders primarily through 'strains and strain prevention' programs.

Examination of NDS data has shown that the following industries have been identified as having a high numbers and or incidence of Body Stressing claims. National actions may therefore have the biggest effect if they target the following:

- Industries: Manufacturing sector (specifically Food, beverage and tobacco, Wood and paper products and metal production manufacturing, and Non-metallic minerals and metal products), Health industry, Retail trade, Construction, and the Storage industry.
- Occupations: Labourers and related workers (especially Factory labourers and Other labourers and related workers), Tradespersons and related workers (second highest incidence) (especially Skilled agricultural and horticultural workers); and Intermediate productions and transport workers.

1. INTRODUCTION

In March 2004, the National Occupational Health and Safety Commission (NOHSC) 67 meeting endorsed an occupational disease prevention framework for planned action, according to which the NOHSC Office should provide a report on each priority disease category, to inform the process of prioritising national strategies for occupational disease prevention.

Accordingly, this report provides data on the magnitude and severity of work-related musculoskeletal disorders (WMSDs) in Australia, and reviews evidence concerning the workplace hazards that are major contributors to their development, and on this basis, the kinds of workplace interventions that constitute the most effective means of prevention.

Most of the information presented here is based on published, peer-reviewed literature. Other relevant information from on-line sources has been included where appropriate. No new investigations were undertaken to obtain general information on exposure or risk. Quantitative information on work-related musculoskeletal disorders in Australia was obtained primarily from the National Data Set (NDS).

It is acknowledged that WMSDs arise from exposure to multiple hazards and associated risk factors, including some beyond the workplace. However, WMSDs are a significant problem for employers regardless of whether *all* causal factors are occupational. Tanaka *et al.* (2001) estimated that about 40% (n>500,000) of all upper limb WMSDs in the US working population were to some degree 'caused' by exposures to occupational hazards and risk factors, and therefore in theory are controllable, to a significant degree, by reducing or eliminating such exposures.

2. DEFINITIONS AND RELEVANT ISSUES AND CONCEPTS

2.1 Definitions

Musculoskeletal disorders include a wide range of inflammatory and degenerative conditions affecting the muscles, tendons, ligaments, joints, peripheral nerves, and supporting blood vessels (Punnet and Wegman 2004; Kumar 2001). This comprises over 100 diseases and syndromes, which are usually progressive and are associated with pain.

The term 'disorder' gives an indication of the multifactorial nature of these conditions, which often develop from exposure to more than one risk factor and do not always fit neatly into an 'injury' or 'disease' category. This group includes labels (and colloquial terms) such as 'repetitive strain injuries', 'occupational overuse syndrome', 'back injury', 'osteoarthritis', 'backache', 'sciatica', 'slipped disc', 'carpal; tunnel syndrome' and others. Systemic diseases such as rheumatoid

arthritis, gout, lupus and diabetes can also affect the musculoskeletal and peripheral nerve tissues but are usually not work-related as so are not considered here.

2.2 Health Effects

Globally, musculoskeletal conditions are one of the leading causes of morbidity and disability, giving rise to enormous healthcare expenditures and loss of work (WHO 2003), and reducing the quality of life of affected employees and their families. WMSDs exert a substantial economic burden in health care and compensation costs, lost salaries and productivity borne not only by the employers and employees, but also by the community. As the conditions become more serious and impinge on the person's functional capacity, their work performance and productivity are also likely to decrease.

The underlying damage or changes to tissue that cause discomfort or pain and disability may involve the soft tissue structures (muscles, nerves, tendons) and/or the joints or bones (including the ligaments, cartilage, discs) and/or associated connective tissue. WMSDs include a wide range of inflammatory and degenerative conditions and diseases affecting the muscles, tendons, ligaments, joints, peripheral nerves and supporting blood vessels, such as:

- myalgias, i.e. pain and functional impairments of muscles, occurring predominantly in the shoulder-neck region, that occur in occupations with large static work demands;
- inflammations of tendons and related conditions (eg epicondylitis, tendinitis, stenosing tenosynovitis of the finger and tenosynovitis), especially in the forearm, wrist, elbow and shoulder, evident in occupations involving prolonged periods of repetitive and static work where there is reduced lubrication, high peak loads and cumulative strain;
- compromised nerve function occurring especially in the wrist, forearm or low back (eg carpal tunnel syndrome, sciatica) where there are increased hydrostatic pressure, direct compression, impingement or stretch on nerves; and
- degenerative disorders (eg osteoarthritis) occurring in the spine (usually in the neck or lower back), but which may also occur in the hip or knee joints especially in those performing manual handling or heavy physical work (Buckle and David 2000; Punnet and Wegman 2004).

The health effects of musculoskeletal disease range from intermittent pain and discomfort that may or may not seriously affect work life, through to severe debilitation where pain and loss of functional capacity make even the most basic of daily living activities difficult. The progression of tissue deterioration is influenced by the extent of ongoing exposure to hazards and associated protective activities. Of

note are that problems that are reversible in their early stages can become permanently disabling if exposure to the hazard is not reduced or eliminated. On the other hand, there is some evidence that activities such as maintaining physical fitness and flexibility (Dul *et al.* 2004) may have some protective effect.

In situations where repeated exposure to risk factors results in increasing level of tissue damage and symptom severity, the allocation of a presenting disorder to 'acute injury' or 'chronic condition' can be somewhat arbitrary, especially in the earlier stages. Some WMSDs exhibit well-defined signs and symptoms (for example, rotator cuff tendinitis, and carpal tunnel syndrome). However, many conditions (such as the myalgic disorders characterised by pain, discomfort, numbness and tingling sensations throughout the neck shoulders, upper limbs and lower back) are much less well defined. Further, WMSDs often cannot be diagnosed with respect to a clinical pathology, but they may still result in physical impairment and disability (Buckle and David 2000). The pathology of such MSDs are identical, whether or not they are work-related.

Symptoms of WMSDs may include:

- local or generalised pain, aching or discomfort;
- loss or hypersensitivity of sensation to touch, heat or pressure;
- loss of muscle strength, endurance and/or flexibility;
- loss of ability to perform controlled movements, postural or balance reactions; and/or
- physical changes to muscle tone or bulk (atrophy, hypertrophy¹ etc), skin colour and temperature, inflammation, abnormal alignment of joints, loss of joint range of motion or stability (Punnet and Wegman 2004; Riihimaki 1995)

These symptoms can themselves increase the risk of further injury, since in various ways they reduce both the physical and psychological performance capacity of sufferers. Most obviously, muscle weakness and neural damage will make the performance of manual tasks more physically difficult, and also more dangerous as speed and accuracy of movements deteriorate. Both pain and restrictions to normal ranges of movements tend to cause people to change their actions, often resulting in awkward, unnatural postures, which can themselves cause additional pain. Finally, pain can seriously reduce cognitive performance capacities, resulting in a loss of concentration and reduced capacity to process information, which in time-pressured work is likely to increase stress levels; further, pain itself can be a significant cause of psychological stress.²

¹ hypertrophy may result from one muscle working harder to compensate for the weakness of another.

² These latter factors are important, since elevated stress levels have been clearly demonstrated to increase people's susceptibility to WMSDs (see Section 3 and Appendix A).

3. RISK FACTORS ASSOCIATED WITH THE DEVELOPMENT OF WMSDs

3.1. Work-related Risk Factors³

Musculoskeletal disorders may result from a single event, or from cumulative exposure to one or more hazards over an extended period of time. However, they are commonly *attributed* to an event close to the time at which the injury is reported – not least, because of the format of injury reporting forms. Since official injury statistics are derived from information reported on forms whose design focuses the respondent's attention on events or hazards observable at the time of the report rather than on cumulative exposures, it is highly likely that the role of such factors is over-estimated by such statistics. In contrast, the important role of cumulative exposures and the interacting effects of several hazards are now well demonstrated by research, as outlined below.

The main categories of WMSD hazards are outlined below. Unfortunately, the most widely used methods of WMSD hazard identification and risk assessment are based on 'snapshot' observations of workplace tasks and activities, and while these are adequate for hazards such as frequent 'heavy lifting' or poor workstation design, they do not address most other types of hazard. Importantly, they do not support effective hazard identification and risk assessment related to cumulative exposure to less severe physical hazards, or to cognitive task demands (which strongly influence the time pressures that people are likely to experience), or to the hazards that may be inherent in work organisation and job design, or in a poor workplace 'safety climate', or in more general management practices. As a consequence, the most commonly implemented WMSD control measures address only a subset of the wide range of hazards that have been documented as potentially important in WMSD development, and by implication – as important to control, if WMSDs are to be prevented

Occupational hazards or risk factors that may cause or contribute to the development of musculoskeletal disorders – either alone or in varying combinations and to varying degrees – are now well documented (Armstrong et al. 1993; Buckle and Devereux 2002; Chaffin 1997; Dugan and Frontera 2000; Forde et al. 2002; Keyserling 2000; Kumar 2001; Hagberg *et al.* 1995; Punnet and Wegman 2004, National Research Council and Institute of Medicine, 2001; National Research Council, 1998; NIOSH, 1997). WMSD hazards are summarised immediately below.

Hazards are categorised here as those inherent in the performance of specific work tasks, those due to work and job design factors, those

³ According to the Macquarie Dictionary, a 'hazard' is "a potential source of harm, injury", while 'risk' is "the degree of probability of such loss". If all other factors are equal, then risk is proportional to hazard. In practice, however, other factors are rarely equal so the relationship between hazard severity and risk is variable.

due to characteristics of the workplace environment (including psychosocial factors and 'safety climate'), and those associated with the personal characteristics of people in the workplace, including supervisors and managers. While there is some overlap between these categories, they provide a useful basis for the development of control strategies.

- ***Hazards Inherent in Specific Work Tasks.*** The most widely recognised WMSD hazards are *physical* characteristics of actions entailed in performing work tasks. Hazardous physical task characteristics include movement characteristics (high frequencies, velocities, accelerations, durations), exertion of force (high frequencies, magnitudes), joint angles and postures (duration; how extreme or awkward), body part compression (frequency, magnitude), and exposure to whole body or body part vibration. These widely recognised physical task factors can directly damage body tissues and thereby increase the risk of WMSDs. They are controllable by changes to the design of workstations, tools and related equipment, and of the tasks themselves.
- In addition, some *psychological* task factors constitute hazards for WMSDs because they tend to increase people's stress levels, and the physiological correlates of 'stress' can directly damage body tissues in ways that increase the risk of WMSDs (see Appendix A). Tasks that require a substantial amount of cognitive 'information processing', to a degree that slows down the rate at which it is possible to work effectively, constitute a *cognitive* hazard. Such tasks include those that require things to be sorted or categorised (e.g. mail sorting; product inspection), as well as those entailing more complex decision making. The key factor determining whether or not such tasks will be stressful and therefore hazardous, is whether or not adequate time is available for their performance. In addition to such *cognitive* hazards, there may be *emotional* hazards – for example, for call centre operators who have to deal with abusive customers. In this case also, the hazard stems from the stressful nature of such work.
- ***Hazards arising from the Design, Organisation and Management of Work and Jobs.*** As with task-specific hazards, those in this category include both physical and psychological factors. Arguably, two of the most important are high workloads and long working hours, since these are likely to increase people's exposure to hazards of *all* types. Also of potential importance are work processes, procedures or job designs that result in people having to work at a very fast pace; this will increase the severity of task-related cognitive hazards, and possibly also of some task-related physical hazards since working fast is likely to increase movement velocities and accelerations. Also hazardous are systems of work organisation that result in highly repetitious or psychologically

monotonous jobs, and shift systems that provide inadequate recovery times; these can increase the risk of WMSDs both directly (via increased levels of exposure to some physical hazards and higher levels of physical fatigue), and indirectly (via elevated stress levels, which increase people's physiological susceptibility to WMSDs {see below}).

- Another important hazard for WMSDs are job designs and/or work organisation/ management systems that fail to provide workers with adequate control and autonomy in relation to the work they are required to perform (e.g. when people are not able to vary their work rate because it is determined by production line speeds or by the rate at which machines operate). Also hazardous are jobs that provide inadequate opportunities for people to utilise and further develop their own skills.
- ***Hazards Arising from the Physical Environment and from the Organisational Climate.*** Physical environments that subject people to extreme cold can increase their susceptibility to developing WMSDs. Also, lighting levels that are inadequate for some tasks may cause people to adopt hazardous postures as they struggle to see essential information as they perform these tasks, thus increasing WMSD risk.
- Aspects of the organisational climate and the management systems that create and sustain them may also be hazardous, whether related specifically to safety issues ('safety climate'), or to more general, values and social behaviours. A poor safety climate does not support compliance with safe workplace procedures, and a more generally poor psychosocial 'climate' promotes conditions that tend to generate stress, with a consequent increase in the risk of WMSDs. Hazardous environments of this kind include those:
 - that do not provide adequate opportunities for people to 'have a say' in decisions affecting their work;
 - that do not provide adequate recognition or reward for people's work-related effort, commitment and achievements;
 - that do not promote social cohesion and good relationships between coworkers; and
 - in which levels of support from supervisors and/or managers are perceived as inadequate.
- ***Hazards Arising from Personal Factors Specific to the Workplace.*** A wide range of personal factors may be related to individual injury risk, including age, gender, physical dimensions and strength, physical fitness, personality, some systemic diseases, obesity, smoking, ethnicity and/or socio-economic status. Such factors may influence people's capacity to cope with their work demands, and/or their attitudes to discomfort (Moon *et al.* 1996; Punnett and Wegman 2004), and they may interact with

other types of hazard. Most relevant here, however, are personal factors specific to the workplace; in particular, individuals' knowledge of work-related hazards and associated risk control strategies relevant to their own situation, and their motivation to act appropriately in managing such risks at work.

There is a very large body of peer-reviewed, scientific research supporting the above summary of WMSD hazards and risk factors. While no single document can be recommended as fully comprehensive, one of the best in its coverage is that of the US National Research Council and Institute of Medicine (2001), which encompasses both physical and psychosocial hazards. The earlier (1997) report by the US National Institute of Occupational Safety and Health (NIOSH) is probably more widely cited, but it focused only on the *physical* characteristics of work tasks and of the workplace environment, providing no coverage of the many other variables that have now been clearly demonstrated to have a major influence. As discussed below in section 5, a strong case can now be made that further substantial progress in reducing the incidence and severity of WMSDs will be dependent on the development and implementation of strategies that go beyond purely physical hazards to encompass the way in which work is organised and managed.

Task-specific hazards. Purely physical hazards associated with the performance of specific tasks remain important sources of risk, and much remains to be done in eliminating or reducing the severity of such hazards. In particular, based on a range of evidence including that presented in Section 4 below, there is a need for more effective control of the effects of exposure or 'dose' to less severe and therefore less obvious hazards. In the case of several physical factors, dose-response relationships have been demonstrated, and the pathophysiological links between such hazards and injuries are supported by considerable evidence. The Washington State Department of Labor and Industries (2000, p 1) stated that:

"There is strong scientific evidence that the greater the intensity, duration and frequency of exposure to physical risk factors at work, the greater the risk of having a WMSD. There is also strong evidence that reductions in exposure will reduce the development of WMSDs. In particular, applying the principles and tools of ergonomics to known risk factors can effectively reduce the hazards to workers and thereby prevent many WMSDs."

NIOSH (1997) reviewed evidence linking physical task factors (repetition, force, posture and vibration) to the development of WMSD of the neck, upper extremity, and low back, and classified such as evidence into one of the following categories: strong evidence of work-relatedness (+++); evidence of work-relatedness (++) ; insufficient evidence of work-relatedness (+/0); evidence of no effect of work factors (-). Table 1 summarises the classification of

results by body part and specific risk factor from this review. The report concludes there is a substantial body of credible epidemiologic research providing strong evidence of an association between WMSDs and certain work-related physical factors when there are high levels of exposure and especially in combination with exposure to more than one physical factor. The researchers also found that individual factors may influence the degree of risk from specific exposure, but that they did not interact synergistically with physical factors. They also noted these disorders can be caused by non work exposures. Importantly, exposure to multiple risk factors can have synergistic or multiplicative effects, thus inflating the overall risk of developing MSDs.

Table 1. Review of Epidemiological Evidence for Upper Extremity and Low Back WMSDs (from NIOSH, 1997)

MSD Location or Diagnostic	Number of Studies	Force	Static or Extreme Postures	Repetition	Vibration (Segmental)	Combination
Neck and Neck/Shoulder	> 40	++	+++	++	+/0	(--)
Shoulder	> 20	+/0	++	++	+/0	(--)
Elbow	> 20	++	+/0	+/0	(--)	++ +
Carpal Tunnel	> 30	++	+/0	++	++	++ +
Hand/Wrist Tendinitis	8	++	++	++	(--)	++ +
Hand-Arm Vibration Syndrome	20	(--)	(--)	(--)	+++	(--)
Low Back	> 40	++	+++	+/0	++	++ +

Note: +/0 = insufficient evidence; ++ = evidence for causal relationship; +++ = strong evidence of a causal relationship; (--) = association is not found by NIOSH

Historically, prevention initiatives have often focused on single, physical risk factors such as forceful exertion, especially associated with lifting, probably because such factors are immediately obvious and 'heavy lifting' seems likely, at an intuitive level, to be hazardous injury. Consistent with this viewpoint, muscular exertion involving relatively low weights or forces is typically seen as much less hazardous than very forceful actions. In fact, low forces that are sustained for extended periods, or high levels of repetition of

movements entailing only low forces, may be more hazardous than the occasional exertion of much higher forces. As discussed in section 5 below, while the risks associated with lifting and forceful movements should of course be addressed, there is substantial scope to reduce WMSDs by broadening OHS prevention interventions to focus also on eliminating or minimising 'static work postures' and low force, high frequency actions.

Moving beyond evidence showing relationships between purely physical hazards (characteristics of work tasks and of the workplace environment), and the incidence of WMSDs, empirical research has shown that the development of musculoskeletal conditions is also caused by hazards stemming from the way work and jobs are designed, organised and managed, as outlined above (Buckle and Devereux, 2002; Cox 1995; Keyserling, 2000; Moon & Sauter, 1996; Macdonald 2003; Warren et al, 2000). In addition, high levels of cognitive or emotional demands on workers performing some tasks can constitute WMSD hazards. For example, sorting mail can impose a high cognitive demand due to processing a large amount of information under time pressure (Hoffmann et al, 1993); if insufficient time is allowed for the performance of such tasks, increased stress (which is an MSD hazard) will be a likely consequence. Similarly, call centre operators sometimes need to deal with distressed or angry customers, which imposes a high emotional demand; without adequate resources to help them cope, they are likely to experience increased stress and an associated increase in WMSD risk (Holman, 2002).

Work organisation and job design hazards. These are important because they directly affect the overall workload and associated time pressures, with which people have to cope in order to perform their jobs satisfactorily. As noted above, high workloads and long working hours increase people's exposure to hazards of *all* types. In addition, they tend to increase fatigue levels, with associated potential to increase both the risk of acute injuries due to performance degradation, and the risk of cumulative injuries due to higher stress levels.

As noted above, the negative effects of all types of hazards on health may be mediated via psycho-physiological, stress-related mechanisms, as well as directly in the case of physical hazards (Aptel et al. 2002; Bongers et al. 2002; Blair 1996; Buckle and Devereux 2002; Carayon et al. 1999; Cox and Griffith 1995; Kuorinka and Forcier 1998; Macdonald 2003; 2004; National Research Council and Institute of Medicine 2001; Westgaard 1996). In the case of WMSDs in particular, a number of possible pathways have been identified, linking the physiological correlates of increased stress with increased MSD risk. These pathways entail increases in muscle tone, vasoconstriction, oedema due to disruption of mineral balance, increased levels of circulating pre-inflammatory cytokines, and

changes in the acid-base equilibrium; they are described in more detail in Appendix A.

Workplace environment hazards. Hazards stemming from physical environment factors are relatively straightforward to identify and control. Those related to organisational 'climate' in the social sense, are often categorised together with work organisation and job design factors, since both may act as 'stressors' (factors that tend to increase stress levels), with negative consequences for WMSD risk.

Hazards related to personal variables. Most relevant here are factors specific to the workplace: in particular, individuals' knowledge of work-related hazards and associated risk control strategies relevant to their own situation, and their motivation to act appropriately in managing such risks at work. These are discussed at greater length in Section 5. However, there has been considerable research on relationships between WMSD risk and some more general personal factors, and this is briefly outlined below.

The issue of differences in WMSDs incidence between the genders and with ageing employees warrant particular comment. Differences in the incidence of MSD between the genders are commonly reported; for example, women suffer more often from Carpal Tunnel Syndrome but men experience more low back pain (see Section 4). This is attributed to a range of factors including differences in body dimensions and strength, differences in occupational exposures (different types of work tasks, jobs and associated hazards), different domestic responsibilities and associated stressors and fatigue levels, and different attitudes and behavioural responses to discomfort.

The WDLAI (2000) report noted that a biologically plausible explanation for differences in MSD rates between the genders is that women's weaker upper limb muscle force exposes them to higher proportional loads of their maximal capacity than men during the same task. They noted a higher incidence of low back disorders among men, and suggested that this may be due to men's longer and heavier trunks such that, when bent, the load on the back muscles tends to be higher – a difference compounded by men undertaking heavier 'manual handling' work tasks.

Age can also have a substantial effect on individual risk. As people age, their back, shoulder and wrist tissues become more vulnerable to the harmful effects of repeated exertions and awkward postures, due to ageing-related changes such as decreased blood flow, impaired nutrition and tissue degeneration (Ilmarinen and Tuomi 1992), and the cumulative exposure to hazards of all sorts, both within and outside the workplace. As a result, the likelihood of an MSD diagnosis increases with age (Ilmarinen 1999). However, a recent report by Comcare (2003) on ageing workers in the public sector notes some evidence that older individuals who are able to maintain an active, 'healthy' lifestyle may have the physical

functioning of sedentary adults 15 years their junior. Further, many physiological changes associated with ageing can be simply accommodated for by small, inexpensive changes which facilitate safer work for all employees, regardless of age.

While personal characteristics clearly may play some role in the development of work-related WMSDs, the focus of this report is on the prevention or minimisation of exposure to work-related hazards. Accordingly, only interventions related to workplace-specific hazards are reviewed in Section 5.

4. MAGNITUDE AND SEVERITY OF WMSDs IN AUSTRALIA

The numbers and severity of WMSDs in Australia have been determined by examination of two data sources. The first set of data reported is that collected by the Australian Institute of Health and Welfare (AIHW) from the BEACH dataset (Bettering the Evaluation and Care of Health). This provides information about work-related aspects of patient presentations to general practitioners in each jurisdiction. The second set is from the National Data Set (NDS) for compensation-based statistics (2001-2 and 2002-3).

However, neither of these sets of data is likely to provide a full picture of the true incidence and cost of work-related musculoskeletal disorders. This is because:

- Not all of the working population make, or are eligible to make, compensable claims, due to a range of reasons. For example, employees may not claim if they think it would threaten their job security, or believe that pain is an ordinary consequence of work activities, or of ageing;
- Employees move between jobs, so cumulative WMSDs may be due to exposure to a wide variety of hazards in different workplaces;
- Datasets such as these provide most information about industries with the largest number of claims. There may be smaller industries (not identified) with not many claims, but a very high incidence rate; and
- As opposed to other occupational disorders/diseases (such as noise induced hearing loss, where there is one main exposure factor), musculoskeletal disorders usually develop from exposure to a *combination* of work-related hazards: for example, working in an awkward posture, and repeating or sustaining muscular actions entailing some degree of force; at an individual level the risk might be exacerbated by factors unrelated to work, such as obesity (Pransky *et al.* 1999).

Nevertheless, both datasets provide useful information. Readers are directed to the National Health Survey for data regarding the statistics related to the general population (Australian Bureau of Statistics 2001).

4.1 BEACH Data Set

The prevalence of musculoskeletal disorders, both work and non work-related, within the general population is quite high.⁴ Internationally, MSDs are the largest group of reported work-related compensated injuries in developed countries, with neck and back pain as the most frequent area of injury within this category; injury patterns in Australia are consistent with this general pattern.

The BEACH dataset describes data from visits by patients (63% male, 37% female) to a random sample of 984 general practitioners (GP), representing all jurisdictions throughout Australia, between April 1998 and end of March 1999 (AIHW 2000). It is reported that during this time 96,901 encounters occurred; of these, 3,659 (3.8%) were work-related. Of the work-related encounters, it was reported that workers' compensation would cover 49% of these with 44% covered by Medicare.

For the 3,659 work-related encounters, patients gave 5,038 separate reasons for the consultations; GPs could record up to four problems at each encounter, and it was not always possible to determine which reasons were specifically work-related. For all encounters (both work and non-work related), 44.9% of were for "*musculoskeletal problems*", with "*general-other*" (e.g. chronic pain, fatigue) being the next most common category (8%). Of the 44.9% encounters related to "*musculoskeletal problems*", 57% of these were attributed to back, neck and shoulder problems, demonstrating a high prevalence of MSDs in the general community.

For those encounters that were recorded as work-related, a similar trend was observed where the most commonly stated reasons for the encounter were "*musculoskeletal problems*" (45%) with "*general-other*" (e.g. chronic pain, fatigue) problems being the next most common category (8%). It was of note that workers compensation was paid for only 48% of encounters that were considered work-related by the patient.

4.2 Australian National Data Set for Compensation-based Statistics (NDS)

The NDS enables the production of national and nationally comparable workers' compensation-based data. This data provides an important indicator of the magnitude and severity of the occupational death, injury and disease in Australia.

Within the NDS, there is a differentiation between *acute* MSDs – that is, "sprains and strains of joints and adjacent muscles", which are classified as 'injuries' – and *cumulative* MSDs, or more generalised tissue damage that is coded under "diseases of the musculoskeletal

⁴ In 2001, 32% (6 million) of the population reported having a disease of the musculoskeletal system and connective tissue as a long-term condition, where the condition lasted, or was expected to last, six months or more (ABS National Health Survey, 2001).

systems and connective tissues". However, under the Type of Occurrence Classification System (TOOCS), the most commonly reported *mechanism* for both types of MSD is termed *Body stressing*. Therefore, strategies that effectively reduce the incidence and severity of *Body stressing* will reduce not only acute incidence on strains and sprains but also cumulative MSDs.

Body stressing is a mechanism of incident classification used in TOOCS to describe actions, exposures or events that are deemed (by those completing the initial injury report forms) to be the direct cause of injuries or disorders; the term implies that the injuries or disorders result from physical stress placed on muscles, tendons, ligaments and bones. This category includes:

- muscular stress while lifting, carrying or putting down objects;
- muscular stress while handling objects other than lifting, carrying or putting down (eg pushing, pulling, throwing, handling objects where muscle power is required);
- muscular stress with no objects being handled (eg bending, reaching, turning, working cramped or unchanging positions etc); and
- repetitive movement, low muscle loading (eg repetitive movement with low muscle loads, occupational overuse or repetitive movement occurrences).

The term 'body stressing' has been criticised by some, since it focuses attention on only a subset of the hazards that are known to contribute to WMSDs, as summarised in Section 3 above. However, the term is used here since it is one of the central categories of the NDS. There have been some recent changes in coding for data collection and insurance purposes in Victoria, where some conditions traditionally coded as 'injuries' (acute) are now coded as 'MSDs' (cumulative). Where this affects the reported data (usually only for 2003-04), the data for 2001-02 is used. These changes will be progressively adopted by the other jurisdictions by 2007.

4.2.1. MSDs and Body Stressing – Number of Claims

The number of claims gives an indication of the magnitude of the problem as measured by the NDS. Australian NDS data for 2001-02 indicated there were over 5,300 *musculoskeletal disorder* cases (including arthropathies and related disorders of the joints; dorsopathies – disorders of the spinal column; disorders of muscle, tendons and other soft tissues; osteopathies, chondropathies and acquired musculoskeletal deformities). These represented 4.1% of all compensated conditions but did not include acute MSDs (sprains and strains). This increased to 13,448 in 2002-03 due to coding changes, described in the footnote to Table 2. In 2001-02, there were 76,990 claims for *Sprains and strains of joints and adjacent muscles* (acute

MSDs) which dropped to 63,130 in 2002-03, associated with the coding changes.

Table 2 shows (below) the number of *sprains and strains of joints and adjacent muscles* and of *MSD* claims between 1998-2003. The majority of conditions reported were for disorders of the muscles, tendons and other soft tissues.

Table 2. Number of claims for sprains and strains, and for diseases of the musculoskeletal system and connective tissue 1998-2003⁵

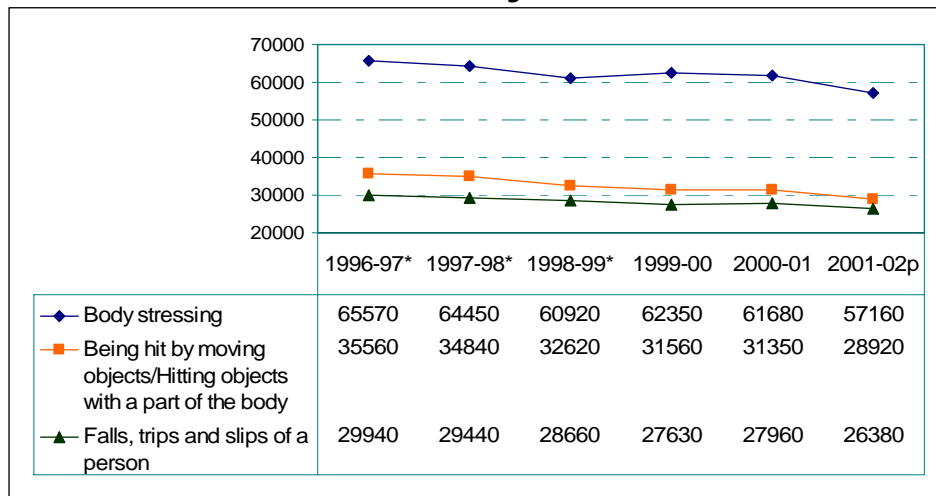
	Year					
	1998	1999	2000	2001	2002	2003
Sprains and strains of joints and adjacent muscles	81,020	79,120	80,770	81,950	76,990	63,130
Arthropathies & related disorders	143	156	171	208	257	619
Dorsopathies	963	1123	1166	1206	1255	5826
Disorders of muscle, tendons & other soft tissue	3673	4170	4257	4186	4246	6934
Osteopathies, chondropathies & acquired musculoskeletal deformities	89	66	77	66	66	69
Grand Total	85888	84635	86411	87616	82814	76578

For these groups, the most common mechanism of injury was *body stressing*. In 2002-03, there were nearly 55,000 cases of *body stressing* (41% of all workers' compensation cases), representing mainly work-related sprains and strains of joints and adjacent muscles, hernias and of musculoskeletal disorders. Among the 2002-03 *Body stressing* cases, 74% were coded as *injury and poisoning* (implying that a single incident had occurred) and 18.6% as *diseases of the musculoskeletal system and connective tissue* (implying cumulative processes).

Figure 2 (next page) shows the number of new cases by mechanism of injury over the last six years. In percentage terms, this has remained unchanged over the past six years despite a decrease in the total number of compensation cases.

⁵ due to a change in coding practices in Victoria many claims previously coded as strains and sprains are now coded as diseases of the musculoskeletal system and connective tissue and hence there has been a large increase in claim numbers in 2002-03 for this nature of injury/disease.

Figure 2. Number of new cases by mechanisms of injury or disease for the six years to 2002



4.2.2. Body Stressing and Mechanisms of Injury

Figure 3 (below) shows the number of cases attributed to *Body stressing* over the period from 1998 to 2003 (2003 data is provisional). From this NDS data, it was evident that for all 6 years, the majority (approximately 50 %) of such cases were associated with *muscular stress while lifting, carrying or putting down objects*. The second most commonly attributed cause of body stressing (attributed mechanism of injury) was *muscular stress while handling objects other than lifting, carrying or putting down*, accounting for approximately one-third of all body stressing cases. The mechanism *repetitive movements, low muscle loading* was least often the attributed cause of body stressing cases.

Figure 3. Number of body stressing claims by Mechanism, 1998-2003

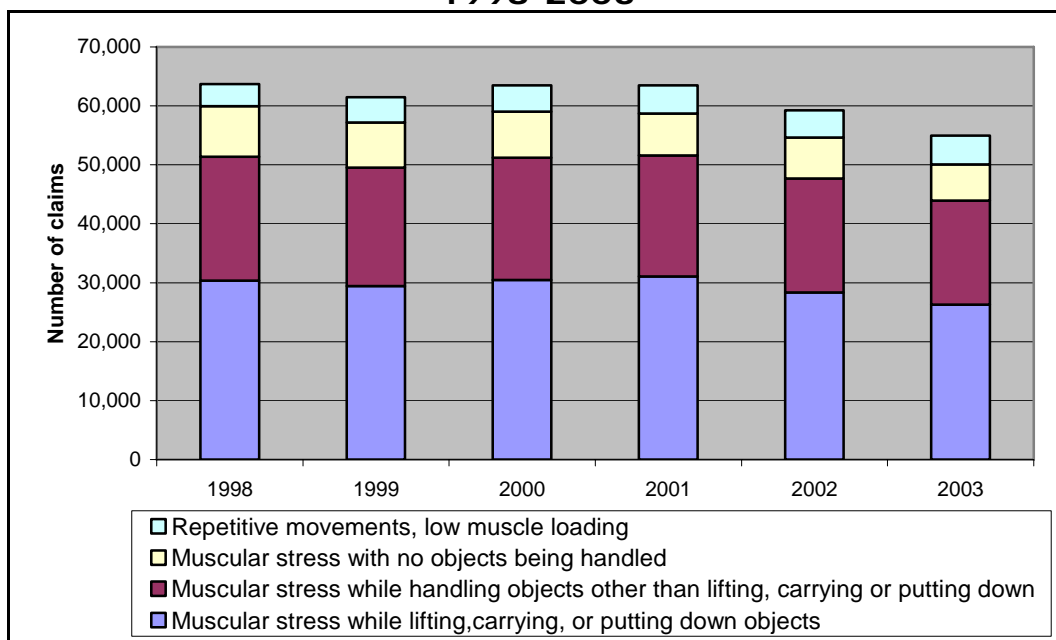


Table 3 (below) illustrates that the number of claims attributed to 'body stressing' has decreased during the period of 1998-2003 from 63,680 to 54,960. Examination of mechanisms for this period revealed that apart from *repetitive movements, low muscle loading*, the number of claims related to all other mechanisms has consistently decreased over this six-year period. It should be noted that the number of body stressing claims attributed to *repetitive movements, low muscle loading* has increased in recent years.

Table 3. Body Stressing Claims by Mechanism 1998-2003

YEAR	Body stressing claims by mechanism				Total
	41	42	43	44	
1998	30,370	21,010	8,560	3,740	63,680
1999	29,460	20,060	7,650	4,280	61,450
2000	30,470	20,750	7,810	4,430	63,470
2001	31,070	20,520	7,110	4,790	63,500
2002	28,350	19,350	6,910	4,620	59,220
2003	26,290	17,620	6,170	4,880	54,960
Total	176,010	119,310	44,220	26,740	366,280

41 = Muscular Stress while lifting, carrying, or putting down objects

42 = Muscular stress while handling objects other than lifting, carrying or putting down

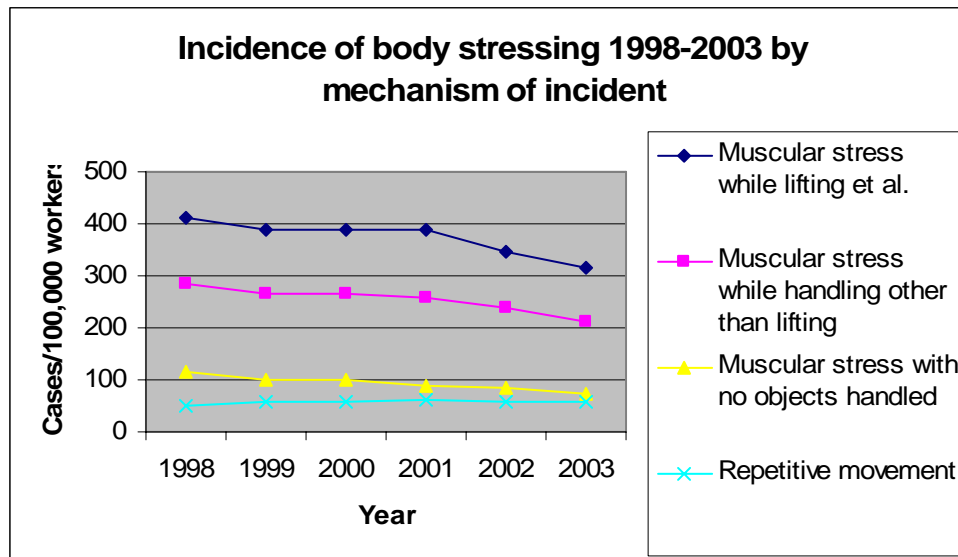
43 = Muscular stress with no objects being handled

44 = Repetitive movements, low muscle loading

A similar trend was seen when examining the incidence rate⁶ of body stressing. While not easily apparent from visual inspection of Figure 4 (below), there was a significant, 16-29%, reduction in the incidence of three attributed mechanisms between 1998 and 2003, with a 19% increase in cases attributed to "*Repetitive movement, low muscle loading*" during the same period.

⁶ Number of occurrences expressed as a rate per 1,000 wage and salary earners employed

Figure 4. Incidence of body stressing cases by mechanism, 1998 to 2003



From these data, it appears that both the number and incidence of body stressing cases is decreasing, except for those attributed to *Repetitive movement, low muscle loading*, for which incidence rates are increasing. However, based on epidemiological data such as the above, it is not possible to determine the *causes* for shifts in the incidence rates of this mechanism. It is important to bear in mind that the validity of 'injury mechanisms' documented in the above datasets is highly questionable.

Validity of the data about causal mechanisms is limited first by workplace respondents' knowledge of the full range of likely WMSD hazards and associated injury mechanisms (as outlined in Section 3). For example, many people would be more likely to attribute their back pain to an immediately obvious 'cause' such as lifting a heavy box, rather than to factors such as long working hours spent driving a truck with a poorly designed seat that does little to ameliorate whole-body vibration, in a sedentary posture that is maintained for long periods with few breaks. In fact, research evidence indicates that the latter factors are likely to be more significant hazards. Second, the validity of current data is limited by the design of reporting forms, and perhaps also by the circumstances in which they are completed, such that most people would be inhibited from recording anything other than very brief and simplistic information about injury precursors.

Therefore, there is a need for the collection of more 'in depth' data concerning WMSDs and their work-related precursors, to provide a more reliable basis for identifying the effects on WMSDs in Australian workplaces of the different types of hazards and risk factors identified by researchers and outlined in Section 3. Only with higher quality data will it be possible to determine the underlying causes for

the trends in incident rates described above. For example, are these attributable to changes in industry practice that have reduced heavy 'manual handling' requirements but increased the incidence of work entailing low force, high frequency movements? Or to higher workloads, time pressures and other such stressors? Or to more sophisticated and accurate reporting of mechanisms of injury?

Bearing in mind the significant limitations of the current data, it is still worthwhile to review injury patterns and reported causal mechanisms in relation to different industries and occupations. These are described in the following sections.

4.2.3. Body Stressing by Industry

Different industries have different numbers of employees, types of hazard and associated exposure patterns. The numbers of *Body stressing* claims by industry and by mechanism for 2002-2003 are shown below (Table 4). Those sectors with the highest numbers of body stressing cases correspond to those identified as priority industries/sectors under the National OHS Strategy (*Construction; Manufacturing; Retail and Wholesale Trade; Transport and Storage; and Health and Community*).

Within these industry sectors, the highest number of cases were reported for the *Manufacturing* industry (12,190), followed by the *Health and community services* (8,164) and *Retail trade* (5,892) industries. *Construction* and *Transport and storage* industries reported a similar numbers of claims, 4,485 and 4,425 respectively. The industry category which recorded the lowest number of cases due to *Body stressing* was *Electricity, gas and water supply*.

Table 4. Number of body stressing claims by industry, 2002-

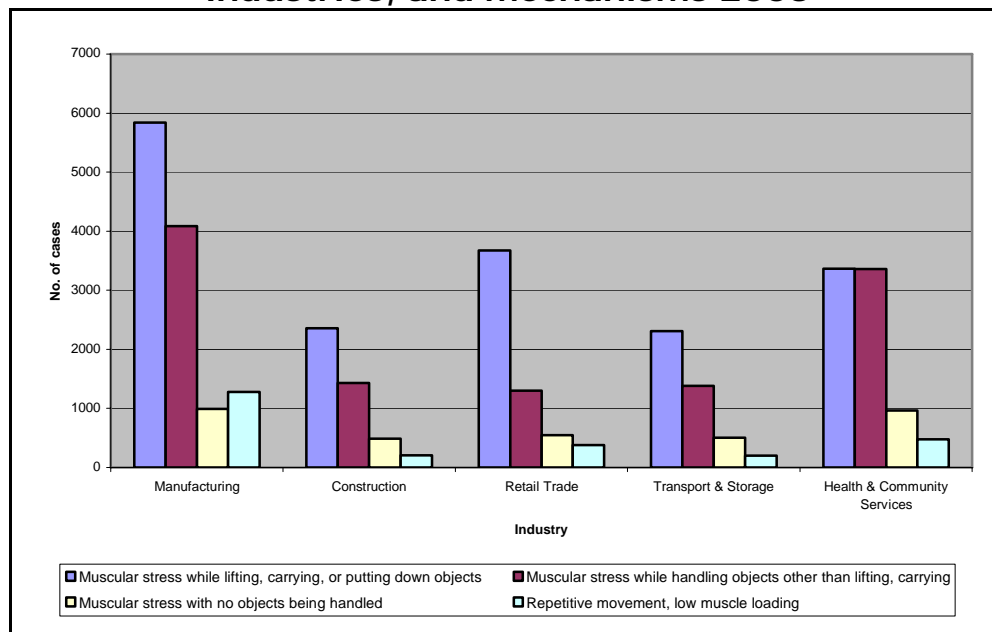
2003, p7

ANZSIC2	Number of Body stressing claims by industry	Incidence rate
Ag, forest, fish	1609	8.8
Mining	599	7.2
Manuf	12190	11.9
Elec,gas,water	280	3.9
Construction	4485	9.8
Wholesale Trade	2734	6.8
Retail Trade	5892	4.5
Accom/cafes	2273	5.1
Transport/storage	4425	12.6
Communication	636	5.0
Finance/insurance	517	1.6
Property/business	3908	3.8
Govt,admin/defence	2419	5.4
Education	1973	2.9
Health/comm services	8164	9.0
Cultural and Rec	1008	4.6
Personal/other	1841	5.8
Grand Total by mechanism	54953	

The five industries with the highest number of cases by mechanism are graphically represented in Figure 5. For most industries, *muscular stress while lifting, carrying or putting down objects* contributed to the largest number of body stressing cases followed by *muscular stress while handling objects other than lifting, carrying or putting down* then *muscular stress with no objects being handled* and finally *repetitive movement, low muscle loading*.

⁷ Numbers still provisional and subject to rounding

Figure 5. Number of body stressing cases by priority industries, and mechanisms 2003



Numbers of cases are likely to be higher in industries with the most employees, but the incidence rate helps to identify those who are the poorest performers. Table 4 shows that while the number of claims was high for the retail industry, its incidence rate was much lower compared to other "high claims industries" such as *manufacturing, construction, transport & storage* and *health & community services*. In contrast, although *Ag, forest, fish* industry reported a relatively low number of body stressing cases, its incidence rate was among the five highest incidence rates reported for 2003. When the incidence rates of four priority industries were considered by sub-categories, quite significant differences between some sub-category became apparent (see Table 5).

The highest incidence rate was reported for the *storage* sub-category. The next highest rates were in the *Food, Beverage and Tobacco* manufacturing followed by the *Wood and Paper Products* and *Non-Metallic Mineral* sub-categories. Clearly, prevention interventions targeting these sub-categories have the greatest potential for yielding significant benefits.

Table 5. Incidence rate for 2003 of 'body stressing' by selected priority industry sub categories

Industry Sub Groups	Incidence rates
MANUFACTURING	
Food, Beverage & Tobacco	20
Non-Metallic Mineral	12.3
Wood & Paper Products	14.6
Metal Product	12.0
Machinery Equipment	10.6
Textiles et al	9
Manufacturing other	11.8
Petroleum, Coal, Chemical	7.8
Printing et al.	5.1
CONSTRUCTION	
Trade services	10.1
General	9.3
TRANSPORT	
Storage	27.1
Road	11.8
Air & Space	11.2
Services to transport	11.2
Rail	9.2
Water	4.7
HEALTH & COMMUNITY SERVICE	
Health	9.4
Community	7.8

4.2.4. Body Stressing and Occupations

Exposure to WMSD hazards varies considerably between occupational groups. Preliminary data for 2003 (see Figure 6) indicates that the group recording the highest number of cases involving *Body stressing* was *Labourers and related workers*. This is followed by *Tradespersons and related workers* and *Intermediate production and transport workers*. The lowest number of cases are reported by *Advanced clerical and service workers*.

Examination of claim percentages reveals an interesting trend. For all occupational groups, body stressing comprised the largest percentage of mechanism of injury or disease, varying from 32 % to 44.2 % of claims for each occupational group. Although the number of cases for *Advanced clerical and service workers* were low, body stressing claims comprised 41 % of all claims by this occupation in 2003.

The highest percentage of body stressing claims were attributed to *muscular stress while lifting, carrying or putting down objects* (47.8 %), with *labourers and related workers* accounting for the highest percentage of body stressing claims with this mechanism.

Figure 6. Number of body stressing claims by occupation and mechanism (1998-2003)

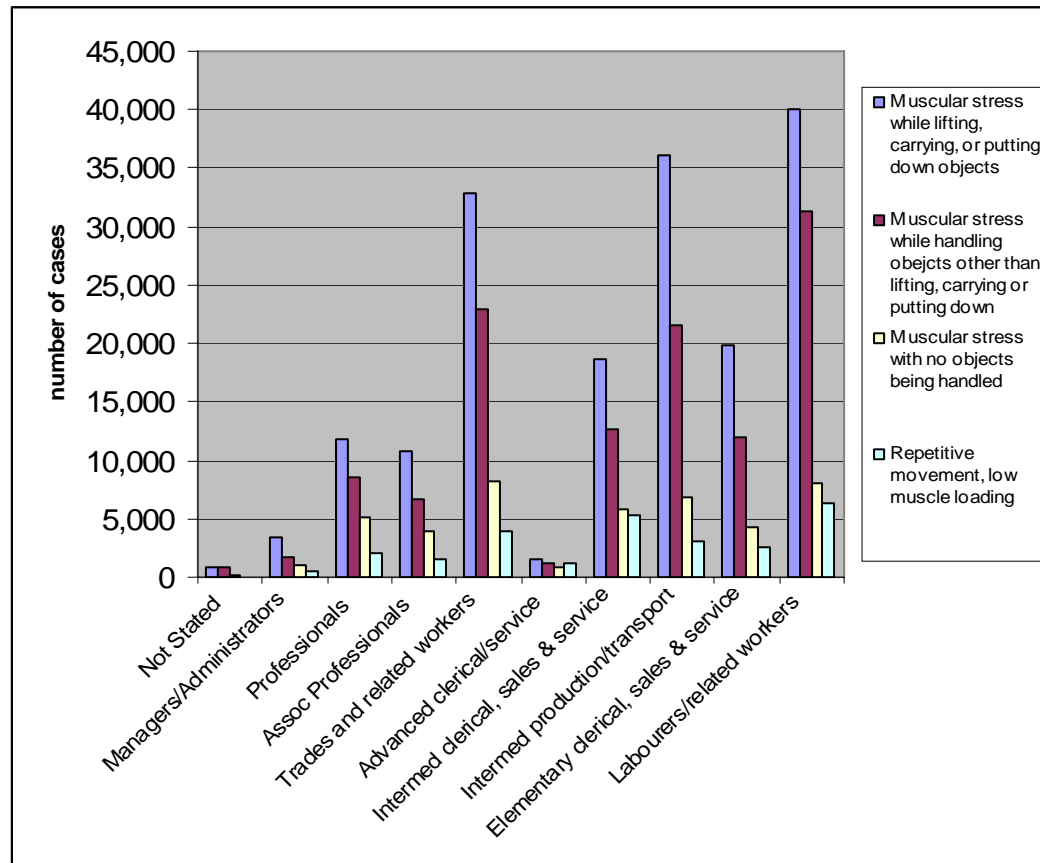


Table 6 shows the 2003 incidence rates of *Body stressing* for different occupational category. The highest rates (in red) were for *Labourers and related workers* (19.2), followed by *Intermediate production and transport workers* (13.6), then *Tradespersons and related workers* (10.6). The lowest incidence rate was observed for *Advanced clerical and service workers* (1.6).

For the *Labourers and related workers*, the highest incidence rate was for the sub-occupation *Factory Labourers* with males higher than females. For the *Tradespersons and related workers*, sub-occupations the *Skilled Agricultural and Horticultural Workers* (25.3), *Food Tradespersons* (15.2), and *Construction Tradespersons* (14) were the highest.

For the *Intermediate production and transport workers* occupational group, the highest *Body stressing* incidence rates were observed for *Other Intermediate Production and Transport Workers*.

Table 6. Incidence of 'body stressing' by occupational category (2003)

Occupation	Total
MANAGERS AND ADMINISTRATORS	2.3
PROFESSIONALS	2.6
ASSOCIATE PROFESSIONALS	3.6
TRADESPERSONS AND RELATED WORKERS	10.6
Mechanical & Fabrication Engineering Tradespersons	13.2
Automotive Tradespersons	5.6
Electrical and Electronics Tradespersons	5
Construction Tradespersons	11.7
Food Tradespersons	11.6
Skilled Agricultural and Horticultural Workers	18.6
Other Tradespersons and Related Workers	13.1
ADVANCED CLERICAL AND SERVICE WORKERS	1.6
INTERMEDIATE CLERICAL, SALES & SERVICE WORKERS	4.1
INTERMEDIATE PRODUCTION & TRANSPORT WORKERS	13.6
Intermediate Plant Operators ⁸	14.8
Intermediate Machine Operators ⁹	14.1
Road and Rail Transport Drivers	10.1
Other Intermediate Production and Transport Workers	16
ELEMENTARY CLERICAL, SALES AND SERVICE WORKERS	4.3
LABOURERS AND RELATED WORKERS	19.2
Cleaners	11.3
Factory Labourers	24.8
Other Labourers and Related Workers	20.1
TOTAL	6.6

4.2.5. Body Stressing by Age and Gender

The prevalence of MSDs in the general population (ABS 2001) increases with age with the condition reported by 43% of people in the 65-74 year age group and over half (52%) of people aged 75 and over. The NDS data for 2001-02 shows the number of *body stressing* cases increases with age to a peak at the *40-44 years* age group and then declines again. The *40-44 years* age group also recorded the

⁸ operate large, complex mechanical equipments- fully or partially automated (ASCO 2nd edition)

⁹ operate stationary processing machines- tasks include fixing attachments to machines, setting controls, loading materials to be processed, starting machinery, and maintaining production records. (ASCO 2nd edition)

highest number of cases in all four sub-groups. This might be attributable to a 'healthy worker effect' and those with MSDs which impede their work capacity work begin leaving the workforce in larger numbers. In this age group, nearly half of all injury and disease cases were due to *body stressing*. At the other end of the scale, the *less than 20 years* age group were the least likely to record an injury due to *body stressing* (2001-02).

The proportion of cases due to *muscular stress while lifting, carrying, or putting down objects* decreased with age, while the proportion due to *muscular stress while handling objects other than lifting, carrying, or putting down objects* increased with age. For example, in the *Less than 20 years* age group, the proportions of cases due to *muscular stress while lifting, carrying, or putting down objects* was 59%, whereas in the *55 years and over* group, it was only 43 %. On the other hand, the youngest group recorded 28% of its cases for *muscular stress while handling objects other than lifting, carrying, or putting down objects* compared to the oldest group which recorded 38 % of its cases for this sub-group.

The incidence of body stressing claims (per 1,000 employees with one week or more absence) by gender steadily increases from 2.9 at *less than 20 years age* group, to a peak of 8.9 for those between *50-54 years age* group before it reduces again to 5.2 for those over 55 years of age. This reduction in incidence rate could be due to those affected workers leaving the workforce.

Overall, the NDS data shows that the *body stressing* incidence rate (per 1,000 employees with 1 week of more absence) for females is less across all age groups than that for males, reflecting amongst other things the tendency for males to be employed in more physically demanding occupations.

While males accounted for 69 % of all cases, they accounted for slightly less of the *Body stressing* cases (66 %). This proportion has remained steady for the past six years. The subgroup with the highest proportion of males was *muscular stress while lifting, carrying, or putting down objects* (70 % of cases) whereas the subgroup with the highest proportion of females was *repetitive movement, low muscle loading* (at around 60% of cases).

Reliable interpretation of the above data is not possible without additional information concerning age-related variation in types of work and associated hazard exposures. It is likely that differences between different age groups in injury patterns are due, at least in part (and possibly a very large part) to differences in the type of work, jobs and working conditions to which people of different ages are exposed, rather than to age-related differences in personal characteristics.

4.2.6. Body Stressing by type of occurrence classification

Bodily location of injury is related to the mechanism of injury and disease. For the past six years, locations of injuries have remained consistent, with cases affecting the *Trunk* comprising over 50 % of all cases, followed by *upper limbs* (29 %). Table 8 demonstrates that for all *Body stressing* claims in 2002-03 (with 1 week or more of absence), over half (54%) of all cases affected the *trunk* (including upper and lower back, chest, abdomen) of which the majority affected the *back- upper or lower* (86%). From another viewpoint, 85% of all cases involving the *back - upper or lower* were caused by *body stressing*. The *trunk* was also the bodily location most affected by *muscular stress while lifting, carrying, or putting down objects* (68 % of all cases coded against this sub-group), *muscular stress while handling objects other than lifting, carrying or putting down* (47 %) and *muscular stress with no objects being handled* (also 48 % of cases for this sub-group).

In 2003, as in earlier years, the bodily location most affected after the *trunk*, was the *upper limbs* (29.6% of all *Body stressing* cases). This bodily location constituted a large percentage (67 %) of all body stressing cases due to *repetitive movement, low muscle loading*, followed by *muscular stress while handling objects other than lifting, carrying* (36 %), *muscular stress while lifting, carrying, or putting down objects* (23 %), and lastly *muscular stress with no objects being handled* (10 %).

Table 8. Body stressing cases by bodily location and mechanism of injury, 2003

Mechanism	Head	Neck	Trunk	Upper Limbs	Lower Limbs	Multiple locations	Systemic locations	Non Physical	Unspecif ied	Total
41		630	17750	6000	950	940		10	10	26290
42	10	610	8340	6390	1480	760			10	17620
43		310	2980	610	2050	210	10		0	6170
44		290	680	3270	240	390		0		4880
Total	10	1840	29750	16270	4710	2300	20	10	20	54950

41 = Muscular Stress while lifting, carrying, or putting down objects

42 = Muscular stress while handling objects other than lifting, carrying or putting down

43 = Muscular stress with no objects being handled

44 = Repetitive movements, low muscle loading

4.2.7. Body Stressing by type of agency classification

The agency of injury or disease can play an important role in the type of injury sustained. *Non-powered hand tools, appliances and equipment* accounted for over a third of all *Body stressing* cases and nearly half of all cases from *Muscular stress while lifting, carrying, or putting down objects* and one third of cases from *Muscular stress while handling objects other than lifting, carrying or putting down* whereas over 60% of cases coded for *Muscular stress with no objects being handled* involved *other and unspecified agencies*. *Repetitive movement, low muscle loading* cases were more likely to be linked to *Powered equipment, tools and appliances* and *other and unspecified agencies* than the other agencies.

4.2.8. Duration of Absence and Cost of Body Stressing Claims

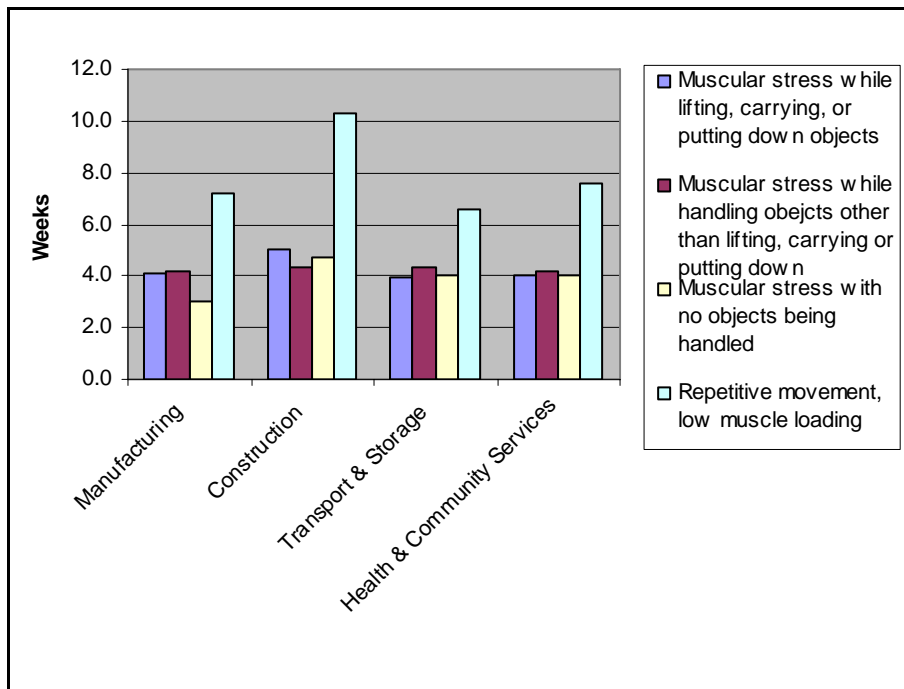
While duration of absence from work and cost of claims should be interpreted with caution¹⁰, it nevertheless gives an indication of the severity of the problem.

Body stressing cases had longer recorded periods of lost time and higher direct costs than those for all other injury and disease cases. In 2001-2, the Australian median time lost was 3.4 weeks for all cases combined, compared to 3.8 weeks for *body stressing* cases (figure 6).

Figure 7 graphically represents the median time lost (weeks) per claim by *body stressing* sub-groups and priority industries, 2001-02. The number and incidence rate for each priority industry for *repetitive movement and low muscle loading* are lower than those for other reported mechanisms of injury (as seen in section 4.2.2), it is associated with the considerably more time off work than other mechanisms. Median time lost due to this mechanism is the highest for the *construction* industry (10.3 weeks).

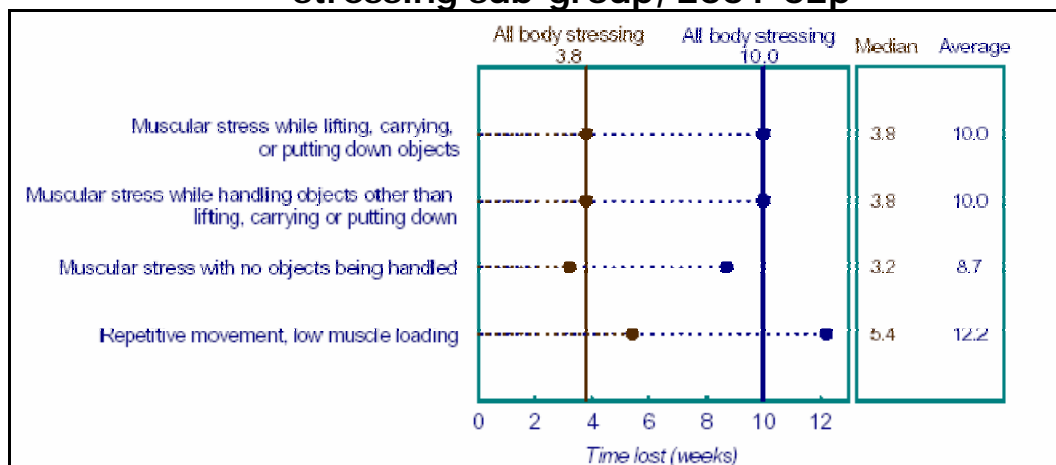
¹⁰ For more serious cases, duration of the period of absence from work may not be known for some time after the database close-off date, and differences in the scope of data collections in some jurisdictions, associated with the effect of employer insurance excess on threshold provisions, may impact on the number of short duration claims reported.

Figure 7. Median time lost (weeks) per claim by body stressing sub-groups and priority industries, 2001-02.



Similar to the trend observed in the four priority industries, for all new body stressing cases in 2001-02, those involving *repetitive movement, low muscle loading* had the highest median and average time lost of 5.4 weeks and 12.2 weeks respectively while cases involving *muscular stress with no objects being handled* had the lowest median and average time lost of 3.2 weeks and 8.7 weeks respectively (Figure 8).

Figure 8. Median and average time lost per new case by body stressing sub-group, 2001-02p



The median direct cost of all body stressing claims is \$4,500/case. As expected, *repetitive movement, low muscle loading* recorded the highest median and average costs in 2001-02 at \$7,200 and \$11,700 respectively as a direct consequence of the higher median and average time lost for this sub-group. The median cost for the other

sub-groups were much lower (\$4,300) but the costs were still higher than the Australian average.

It is estimated that the compensation costs associated with musculoskeletal disorders in Australia were over \$1,570 million in 2001-2. However, the cost of claims (as has the overall number of claims) has decreased from \$1,819 million in 1998 to \$1,571 million in 2000. While cost statistics beyond 2000 are not completed as cases are still active early indications are that this trend is continuing.

Of note is that these costs and data relate only to the more severe incidents, and therefore account only for a portion of the total number of WMSDs. The number of body stressing cases is the highest in the *construction* and *health and community service* sectors; however, the severity of the cases, suggested by the median time lost, is slightly higher in construction.

5. APPROACHES TO PREVENTION OF WRMSDs

In this section, general principles of injury prevention are reviewed in terms of their relative effectiveness and applicability to WMSDs.

Some public health researchers have identified three overlapping levels of injury prevention activities, starting with preventative or 'primary' interventions, through 'secondary' interventions, to 'tertiary' interventions (Halperin 1996; Last 1988). Primary interventions are those designed to eliminate or reduce exposure to hazards and associated risk levels within a healthy workplace population. Secondary interventions are those that promote early detection of MSDs, at a stage when symptoms are mild and more easily treatable and reversible. Tertiary interventions address clinically diagnosed musculoskeletal conditions, and so fall within the area of rehabilitation and return to work. In the present context, primary interventions are of the greatest importance.

5.1 Primary Prevention Approaches

A basic tenet of OHS, enshrined in the relevant Australian and Territory standards, codes of practice and guidance materials, is that primary prevention is the cornerstone of good OHS practice. It is recommended that this is most effectively achieved through the identification of hazards, assessment of the risks and specification of possible control solutions using a hierarchy of risk control interventions. Further, risk control is most effectively achieved during the planning, design and purchasing stages. The most cost-effective and therefore preferred order of control is from Elimination as the first option through to Personal Protective Equipment (PPE) as the last option. The more general principle underlying this hierarchy is that it is more effective to eliminate hazards at source, or at least to reduce their potential for causing injury, than it is to rely on human

behaviour to safely 'work around' hazards. This general principle is well established also in other spheres. For example, it is recognised amongst road safety researchers and system administrators that reductions in injuries on our roads are much more effectively achieved by designing safer road systems and safer vehicles, than by educating or training road users to comply more fully with road laws, or having them wear protective helmets.

Consistent with this principle, strategies to prevent WMSDs can be categorised as shown in Table 7, broken down in relation to the different types of hazard that were identified in Section 3 above.

Table 7. A hierarchy of potential hazard and risk control interventions, categorised in terms of different sources of hazard.

HIERARCHY OF INTERVENTIONS			
Lower priority interventions should be implemented only <i>after</i> implementing all possible interventions in higher priority categories			
	HIGHEST PRIORITY: eliminate or reduce the severity of hazards	MEDIUM PRIORITY: avoid or minimise people's exposure to hazards	LOWEST PRIORITY: maximise people's capacity to withstand exposure to hazards
Hazards arising from individuals' performance of specific tasks	<p>(Re)design work tasks and associated processes, workstations, equipment or tools to eliminate or minimise activities presenting physical hazards (e.g. eliminate or reduce work entailing short cycle times and highly repetitive action patterns; completely automate 'manual handling' processes; install lifting hoists; change workstation layout; purchase or develop tools and equipment that are better fitted to user needs).</p> <p>(Re)design products to reduce weights to be lifted (e.g. package in 5 kg rather than 20kg bags)</p> <p>Redesign work tasks and equipment to avoid excessive rates of information processing, and the consequent potential for hazardous stress levels (e.g. ensure that production targets or line speeds take adequate account of variations in the perceptual or cognitive difficulty of work tasks).</p> <p>(Re)design work tasks and equipment to maximise user satisfaction and minimise their potential to provoke negative emotion, and the consequent potential for hazardous stress levels (e.g. ensure that automated alarm systems on control panels are designed to provide optimal support without being unduly intrusive and annoying)</p>	<p>Ensure that existing hazards are 'guarded' as appropriate, to isolate them and maintain separations from people who might be harmed.</p>	<p>Ensure wearing of appropriate personal protective equipment</p> <p>Train workers in 'manual handling' techniques to reduce their risk of injury When they <i>must</i> perform hazardous lifting tasks (e.g. emergency service workers in some situations).</p>

HIERARCHY OF INTERVENTIONS Lower priority interventions should be implemented only <i>after</i> implementing all possible interventions in higher priority categories			
	HIGHEST PRIORITY: eliminate or reduce the severity of hazards	MEDIUM PRIORITY: avoid or minimise people's exposure to hazards	LOWEST PRIORITY: maximise people's capacity to withstand exposure to hazards
Hazards arising from work organisation or job design	Design and implement staffing policies to ensure that sufficient numbers of people are available at all times, to avoid excessive workloads, or excessively long working hours, to avoid the development of excessive levels of fatigue or stress (both of which are associated with higher levels of WMSDs) Ensure that work processes and procedures, job designs and management systems: <ul style="list-style-type: none"> • do not require people to work excessively fast • do not result in highly repetitious or psychologically monotonous jobs • provide workers with adequate control and autonomy in relation to the work they are required to perform (e.g. when people are not able to vary their work rate because it is determined by production line speeds or by the rate at which machines operate) • provide adequate opportunities for people to utilise and further develop their skills. 	Reorganise work processes and/or redesign jobs to reduce the total amount of significant lifting required of any individual during a work shift; for example, distribute exposure to hazard more evenly across the workforce via practices such as 'job rotation'.	Ensure that total working hours, rest break regimes, and the design of shift systems provide adequate time and opportunity for people to recover from fatigue – both physical and psychological.

HIERARCHY OF INTERVENTIONS
 Lower priority interventions should be implemented only *after* implementing all possible interventions in higher priority categories

	HIGHEST PRIORITY: eliminate or reduce the severity of hazards	MEDIUM PRIORITY: avoid or minimise people's exposure to hazards	LOWEST PRIORITY: maximise people's capacity to withstand exposure to hazards
Hazards arising from the workplace environment	<p>Modify the physical environment, where possible, to avoid extreme cold or heat.</p> <p>Ensure that lighting levels enable people to perform all work tasks without having to adopt physically stressful postures to see some essential details</p> <p>Ensure that lighting levels are adequate for people to move safely around any potential slip/trip hazards that cannot be eliminated.</p> <p>Promote a workplace culture in which:</p> <ul style="list-style-type: none"> • there are adequate opportunities for people to 'have a say' in decisions affecting their work; • there is adequate recognition or reward for people's work-related effort, commitment and achievements; • there is a high level of social cohesion and good relationships between coworkers • levels of support from their supervisors and managers are perceived as adequate • safety is perceived at all levels as a very high priority.¹¹ 	Reorganise work processes and/or redesign jobs to reduce the total amount of exposure to any physical environment hazards that cannot be eliminated of any individual, during single work shifts, and in total.	Ensure that people wear appropriate personal protective equipment to provide protection against any physical environment hazards that cannot be eliminated.

¹¹ These interventions are effective means of minimising stress levels and associated increased risk of WMSDs, and maximising safe behaviours at all levels.

HIERARCHY OF INTERVENTIONS		
Lower priority interventions should be implemented only <i>after</i> implementing all possible interventions in higher priority categories		
	MEDIUM PRIORITY: avoid or minimise people's exposure to hazards	LOWEST PRIORITY: maximise people's capacity to withstand exposure to hazards
Hazards arising from personal factors specific to the workplace	<p>At a personal level, interventions at <i>all</i> priority levels are dependent on :</p> <p>(a) people's optimal knowledge and understanding of WMSD hazards and associated control principles and potential interventions, as outlined above, and</p> <p>(b) people's high motivation to act appropriately to achieve maximum possible risk reductions.</p> <p>Clearly, the precise meaning of the above two requirements will vary considerably between people in different jobs.</p> <p>Managers are arguably the most important category of people, since their knowledge and motivation must underpin the development, implementation and management of strategies in all of the other cells of this table – <i>particularly and most importantly</i> – interventions in the highest priority column above.</p> <p>In addition, they are also responsible for ensuring that (a) personnel selection and placement procedures maximise the 'match' between each individual's personal capacities and their job demands, and (b) everyone is assisted, by appropriate training and other forms of support, to achieve the necessary skills and strategies to cope optimally with their job demands, and (c) everyone is motivated, by the application of effective management strategies, to place a high value on safety and health at work.</p> <p>System designers and other technical experts are very important also, since their work can have major impacts on the technical quality of many of the above types of interventions.</p> <p>Finally, everyone in the workplace has the general responsibility to apply their knowledge and skills to maximise safety and health.</p>	

To minimise the risk of people developing WMSDs, hazards must first be identified and the associated levels of risk must then be assessed (formally or otherwise). On this basis, practical control solutions

must be identified and implemented, followed by re- assessment to determine whether risk has been acceptably reduced. Where elimination of the risk is not possible, the line between acceptably “safe” and unacceptably “unsafe” levels of risk may be difficult to determine. This task is made more complex by the many and diverse hazards and related risk factors that may contribute – singly and/or interactively – to the development of WMSDs, as summarised in Table 7 above. Because of this complexity, the effective control of WMSDs is a much more conceptually difficult process than, for example, the control of hazardous noise. In the latter case, noise regulations can include reasonably clear, regulatory statements that define conditions when the level of risk is “reasonable” or otherwise. The absence of such clarity in the case of WMSDs has presented a difficult barrier to the effective implementation of existing ‘manual handling’ regulations, which according to Addisson and Burgess (2002) must rely as much on common sense and economic forces as on the formal risk management system.

Given these challenges, it is particularly important that managers and supervisors, as well as workers themselves, have appropriate training in processes of WMSD hazard identification, risk assessment and control measures relevant to their own situation. Effective prevention of WMSDs requires all parties to be aware of the risk, be committed to action and have the appropriate resources. In the first instance, failure to perceive a risk exists as a barrier to prevention. Yeung *et al.* (2002) described how low-level effort exertion in manual handling was under-estimated by employees.

Among managers and business owners, level of awareness and knowledge about manual handling regulations and their application varies widely. A South Australian telephone survey (O’Keefe and Furness, 2001) found that while general awareness was very high for medium to large workplaces (96.5% for the Regulations; 90% for the Code), this dropped in small workplaces to 57% (Regulations) and 44% (Code). Further, while 44% of medium to large businesses had taken preventative actions as a result of applying the Manual Handling Code, only 4% of small businesses had reached this point.

Integral to prevention is the provision of information that is easily accessible, practical and relevant. As reflected in the work of the NOHSC National OHS Skills Plan, there is increasing emphasis on providing these skills as part of vocational training. However, a key requirement for any training program addressing WMSDs is that it should focus on those intervention strategies that are known to be the most effective. ‘Manual handling’ training has been a traditional management strategy intended to prevent WMSDs, but unfortunately, the content of such training has largely focused on interventions in the lowest priority column of Table 7, such as the use of PPE, ‘safe’ lifting techniques and more generally, hazard avoidance strategies at a personal behaviour level. While there is clear support for personal equipment such as vibration attenuation gloves [NIOSH

1989] and knee pads for carpet layers (Bhattacharya *et al.* 1985), there appears to be no such evidence supporting the effectiveness of wrist braces in preventing injuries in health workers. Even at best, the effectiveness of all PPE is dependant upon their design, fit and use patterns.

As argued in that table, there is a stronger case (based on the hierarchy of control) for training everyone – but particularly managers and supervisors – in the skills necessary to support hazard elimination or reduction, followed by methods of reducing exposure levels. Further, there is a need for training to address methods of controlling hazards other than the most easily observable, physical hazards relating to specific tasks and the physical workplace environment. Training that encompasses interventions addressing the other types of WMSD hazards shown in Table 7 is required.

It must also be recognised that conventional 'training', no matter how effective in enhancing people's knowledge and skills, is not a reliable means of influencing people's attitudes and behaviours. Especially where training occurs in isolation from interventions which will eliminate or reduce the risk exposure, there is little evidence that interventions predominantly based on technique training (e.g. 'back schools' and 'manual handling' training) have any long term impact on working practices or injury rates of non injured workers (Hignett 2003; Silverstein and Clark 2004). On the other hand, there is strong evidence that using a participatory approach to develop hazard management interventions, involving representatives from all levels within the organisation on a working group, increases their effectiveness (e.g. Blewett and Shaw 1995).

The central role of managers in all of the above is highlighted in Table 7, where it can be seen that their role is particularly important in facilitating interventions at the highest priority level.

Unfortunately, little effort appears to have been devoted to the development and implementation of training programs for managers related to WMSD prevention (or to OHS more generally, for that matter). For example, one component of such a program should address the benefits of developing a positive safety culture, and the strategies by which this can be achieved (Geller 1996; Hely 2001). Safety culture refers to a workplace environment where the pervading attitude is that safety is important; where relationships between workers and management are positive and cooperative and there is a proactive approach to solving OHS problems, with emphasis on the highest priority interventions. In order to develop and maintain a positive safety culture in an institution, it is necessary to integrate safety with quality and productivity management. According to Roughton and Mercurio (2002) and others, the following are essential to fostering a positive safety culture:

- priority given to high standards of safety performance
- risk planning to address OHS must be part of normal business practice

- visible senior management commitment to safety
- active employee involvement and safety training at all levels;
- clear statement of responsibility and accountability; and
- programs that are performance-based rather than compliance-oriented; and
- activities must be measured and communicated consistently.

Building good OHS management systems into the normal business practices could be an effective form of WMSD prevention.

The more active involvement of managers in WMSD prevention, would be promoted by wider awareness of the potentially positive cost-benefit ratio (for health, safety and productivity) for businesses that invest in the kind of high priority interventions identified in Table 7 – that is, interventions entailing the design of work processes and tasks, tools, jobs and workplaces in accord with best ergonomics practice (Oxenburgh *et al.* 2004; Straker *et al.* 2004; Dul *et al.* 2004). In an extensive study of peer-reviewed articles, conference proceedings and case studies of interventions to prevent WMSDs, Karsh *et al.* (2001) found positive outcomes for 90% of studies where the intervention involved tool or technology change to reduce risk exposure.

The above approach to WMSD prevention would be supported by implementation of Safe Design strategies, which is one of the five national priorities articulated in the National OHS Strategy 2002-2012. According to this priority, the design of work systems, tools and equipment and workplace environments more generally is a critical phase in system development, where it is possible to design out potential OHS problems, effectively preventing them from entering the workplace. Responsibility to eliminate hazards or control risk rests at their source. This principle applies to all hazards that might impact on the health and safety of workers. Responsibility falls on a wide range of parties, including those outside the workplace such as designers, manufacturers, constructors or suppliers. Clearly, more needs to be done to educate, train, and motivate these various groups.

When all possible has been done to eliminate or reduce the severity of a hazard and its associated risks, interventions that reduce people's *exposure* to hazards is the next most effective type of strategy. As shown in Table 7, strategies vary according to the type of WMSD hazard. Thus, exposure to hazards stemming from the physically demanding nature of a particular task might be reduced by increasing the variety of different tasks that comprise a job – ensuring that the variety is not in name only, but actually entails different types of task *activities* (e.g. sitting instead of standing; walking around instead of sitting at a computer). Designing work to allow longer or more frequent breaks is another way to reduce exposure. Based on a systematic review of WMSD intervention studies in peer-reviewed journals published in English between 1990-2002, Silverstein and Clark (2004, p.150) found that "exercise

appears to be effective in mitigating some of the consequences” of exposure to WMSD hazards, although attempts to modify individual risk factors was not found to be useful. They concluded that multifactorial interventions are the most effective means of preventing WMSDs – an approach that is consistent with the framework presented above and summarised in Table 7.

5.2. Secondary Interventions

Unfortunately, risks often only come to people’s attention when symptoms of physical discomfort have been reported providing the impetus for secondary interventions. Secondary prevention interventions are those which occur in response to the identification of acute problems (for example through workplace wellbeing surveys or submission of workers’ compensation claims). These aim to reduce the worker’s exposure to risk factors and reduce symptom severity. Secondary ‘care’ is usually early non-specific exercise and education programs to help recovery from asymptomatic or mild symptoms such as stretch programs, work hardening or exercise programs.

Ensuring work processes and procedures are in place to facilitate early recognition and reporting of discomfort or symptoms and implementation of remedial action is a key strategy in effective MSDs prevention (Arnetz *et al.* 2003). Organisations that regularly undertake health surveillance activity or analyse near miss, or workers compensation data are able to more effectively target prevention activities to those groups in most need.

It is recognised that MSDs will be less effectively managed when the signs and symptoms of MSDs are not recognised, ignored and not reported or accepted as “just part of the job” (Punnett and Wegman 2004). As both occupational and psychosocial factors appear to be associated with progression from acute to chronic pain, the National Health and Medical Research Council (NHMRC) advises that the interventions to reduce exposure to both factors should be addressed early. Many authors have reported that early intervention will consider the physical, environmental and psychosocial risk factors and help prevent MSDs conditions becoming chronic (Gatchel 2004).

The US Department of Labor (DOL) developed a workplace WMD prevention standard which includes specific training for workers, supervisors and managers in prevention principles including health promotion such as good body mechanics, engineering controls, and early recognition of the signs and symptoms of WMDs;

- Changes in work practices and management policies to minimize high-hazard situations;
- Appropriate medical management to identify and treat WMDs; and
- Appropriate health and hazard surveillance.

There is a wide literature on systematic analysis of jobs to evaluate musculoskeletal risk and their impact in the development of work

related injury and disease (Armstrong 2000). The number and variety of risk assessment tools for practitioners and managers has grown considerably in the last 15 years (Stanton et al. 2004). A number of barriers remain in applying this knowledge in the earliest point of intervention (NOHSC 2003).

To achieve a sustainable improvement of working conditions, however, it is not sufficient to act at the workplace level only. There is a need to identify the 'causes of causes' leading to occupational health problems and intervention aiming at their control is needed at the systems level. It has been generally agreed that intervention programmes, benchmarking practices and self-steered actions as the forms of future preventive programmes at the company level is very valuable.

5.3. Tertiary Interventions

These interventions are designed to facilitate functional recovery and rapid return to work for those who have already developed work-related conditions. Tertiary care (such as pain management) is usually physician-directed interdisciplinary where individualised and intensive treatment is designed for those patients whose condition has become chronic. In comparison, tertiary prevention attempts to avoid high costs associated with permanent disability, for example, by facilitating return-to-work by providing rehabilitation, by substantially modifying work demands, and if required, providing vocational retraining (Gatchel 2004).

Facilitating early resolution of symptoms is important. While clinical approaches to the treatment of MSDs symptoms (and the success of these) vary, a review of these is outside the scope of this report.

Under the *Safety, Rehabilitation and Compensation Act, 1988*, there is a requirement to provide rehabilitation to recovery and return-to-work. To be effective, all OHS jurisdictions and many researchers recognise that return-to-work programs need to ensure that:

- level of service is well matched with the injury severity and disability risk factors;
- timely communication between the doctor, worker, rehabilitation provider, employer representative, and claims staff especially where there are indications that the disability could be serious within weeks of injury;
- timely consultation or referral to an appropriate specialist if problems occur, such as, difficulty making a diagnosis, slow medical progress, or difficulty with return to work efforts;
- treatment plans that includes a return to work plan that is communicated clearly to the worker, employer, and claims staff; and
- early ergonomic assessments to ensure modification of duties (consistent with the worker's functional capacity)and

improvements in work routine or workstation to facilitate safe, stable return to work (Loisel 1994; Silverstein and Clark 2004; Krause *et al.* 1998; Brooker 1998)

While many of the most important multifactorial MSD risk factors have been recognised, the U.K. Health and Safety Executive (2003) has identified that it is important for further research to be undertaken to improve the understanding of “the pathomechanisms and epidemiology” of WMSDs, including: “studies of the natural history of MSDs with a particular focus on the development of acute versus cumulative/chronic cases”.

6. AUSTRALIAN PREVENTION ACTIVITY

All OHS jurisdictions are currently undertaking activities ultimately designed to prevent the occurrence of or severity of respiratory disorders. Readers are directed to the following organisations' website for information on past and current initiatives.

- **NSW WorkCover Authority**
<http://www.workcover.nsw.gov.au/default.htm>
- **Victorian WorkCover Authority**
<http://www.workcover.vic.gov.au/dir090/vwa/home.nsf>
- **WorkSafe Western Australia**
<http://www.safetyline.wa.gov.au/>
- **South Australian WorkCover Authority**
<http://www.workcover.com/>
- **Workplace Services South Australia**
<http://www.eric.sa.gov.au/home.jsp>
- **Queensland Division of Workplace Health and Safety**
<http://www.whs.qld.gov.au/>
- **Workplace Standards Tasmania**
<http://www.wst.tas.gov.au/node/WST.htm>
- **Northern Territory WorkSafe**
<http://www.nt.gov.au/deet/worksafe/>
- **ACT WorkCover** <http://www.workcover.act.gov.au/>
- **Comcare** <http://www.comcare.gov.au/>

Information on relevant legislation, regulations, standards, codes of practice and guidance notes may be accessed at the NOHSC website www.nohsc.gov.au.

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APPENDIX A: POSSIBLE PATHWAYS BETWEEN MSDS AND STRESS

Four possible pathways have been hypothesized by Aptel and Cnockaert, (2002, pages 53-54) to suggest how stress might be associated with increased MSD risk; these are graphically outlined in the Figure 1 below.

1. Activation of the central nervous system: A well documented effect of stress is activation of the reticular formation in the brainstem, associated with generalised physiological 'arousal' that, amongst other consequences, results in higher muscle 'tone'. This increases the "biomechanical load" within muscles and tendons and may thereby contribute to an increased risk of MSDs.
2. Activation of the catecholaminergic pathway: Another effect is activation of the autonomic nervous system and stimulation of the adrenal gland with consequent increased levels of catecholamines including adrenaline and noradrenaline. One effect of this is arteriolar vasoconstriction which can impede microcirculation within the muscle bed, tendons and ligaments, hampering nutrient delivery and waste product removal, which in turn results in poorer healing of the microlesions that routinely develop and self-heal during physical activity. As a result, muscular discomfort and pain appear more likely, especially if biomechanical loads are high.
3. Activation of the adrenal cortex: Another consequence of adrenal gland stimulation is an increase in levels of corticosteroids. These hormones can disrupt the body's mineral balance resulting in oedema which further impedes microcirculation and produces local compression of soft tissue structures, which is especially acute if the work requires working in extreme ranges of motion. As a result, an increased risk of syndromes such as 'carpal tunnel' would be expected.
4. Activation of cytokine secretion: Another dimension of the stress response entails changes to immune system functioning, which include increased levels of circulating pre-inflammatory cytokines, with a likely resultant increased risk of MSDs.

Schleifer *et al.* (2002) suggested a further pathway which was that stress ('emotional tension') might also lead to 'over breathing' and consequent disruption in the acid-base equilibrium, triggering a chain of systemic physiological reactions including increased muscle tension, muscle spasm, amplified response to catecholamines, and muscle ischemia and hypoxia – all of which have potentially adverse implications for musculoskeletal health.

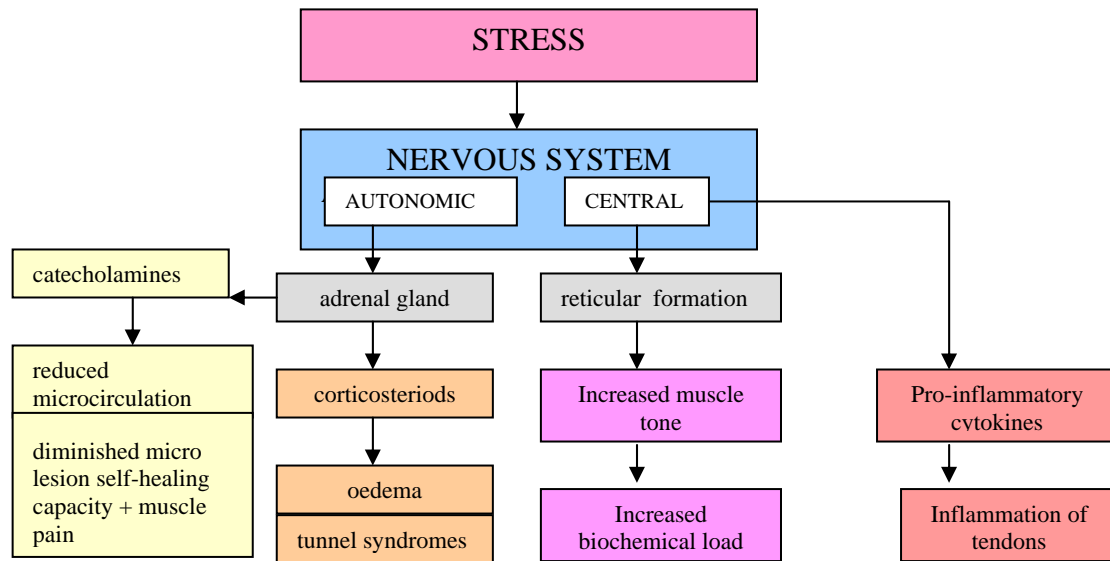


Figure 1 Suggested relationships between some physiological components of the stress response and MSD symptoms (from Macdonald, 2004, after Aptel and Cnockaert, 2002)

Apart from their possible contribution to the development of cumulative MSDs, organizational climate and work context may influence how people perceive, interpret and respond to somatic symptoms (Sauter & Swanson, 1996). Punitive work experiences and related dissatisfaction may alter people's willingness to tolerate physical discomfort (Andersson *et al.* 1983; Ahlberg-Hultén *et al.* 1995; Grimshaw, 2000; Keyserling, 2000; Leino & Hänninen, 1995).

It has also been suggested that people who are bored by their work are more likely to have the spare attentional resources and motivation to attend to and report symptoms of physical discomfort that they might have ignored had they been more actively and/or happily occupied (Schleifer, Ley & Spalding, 2002). Devereux, Vlachonikolis and Buckle (2002, p.275) found that workers "exposed to physical and psychosocial risk factors at work, experienced the biological effects of background exposure, high physical exposure, high psychological exposures, and the interaction effects of these two factors". People exposed to both physical and psychosocial risk factors may be more likely to report symptoms than those who are exposed to high levels of one but not of the other. They also found that "exposure to psychosocial workplace factors may increase risk of symptoms of musculoskeletal disorder... even when the physical demands were relatively low" (Devereux, Vlachonikolis and Buckle (2002, p.276). This suggests that effective prevention needs to address both physical and psychosocial risk factors.

