Biomechanical Hazards

Core Body of Knowledge for the Generalist OHS Professional

Safety Institute of Australia Ltd

Australian OHS Education Accreditation Board

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Disclaimer

The OHS Body of Knowledge for Generalist
OHS Professionals has been developed under the
auspices of the **Health and Safety Professionals Alliance**

The Technical Panel established by the Health and Safety Professionals Alliance (HaSPA) was responsible for developing the conceptual framework of the OHS Body of Knowledge and for selecting contributing authors and peer-reviewers. The Technical Panel comprised representatives from:

The Safety Institute of Australia supported the development of the OHS Body of Knowledge and will be providing ongoing support for the dissemination of the OHS Body of Knowledge and for the maintenance and further development of the Body of Knowledge through the Australian OHS Education Accreditation Board which is auspiced by the Safety Institute of Australia.

Synopsis of the OHS Body of Knowledge

Background

A defined body of knowledge is required as a basis for professional certification and for accreditation of education programs giving entry to a profession. The lack of such a body of knowledge for OHS professionals was identified in reviews of OHS legislation and OHS education in Australia. After a 2009 scoping study, WorkSafe Victoria provided funding to support a national project to develop and implement a core body of knowledge for generalist OHS professionals in Australia.

Development

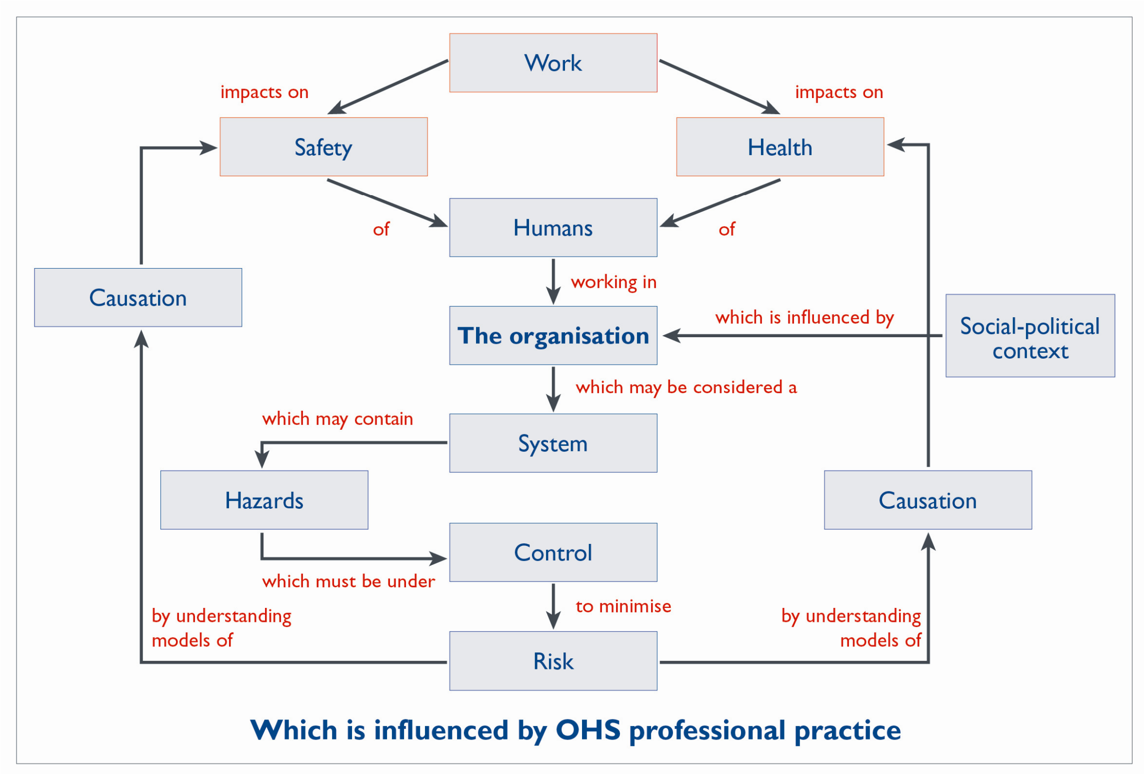
The process of developing and structuring the main content of this document was managed by a Technical Panel with representation from Victorian universities that teach OHS and from the Safety Institute of Australia, which is the main professional body for generalist OHS professionals in Australia. The Panel developed an initial conceptual framework which was then amended in accord with feedback received from OHS tertiary-level educators throughout Australia and the wider OHS profession. Specialist authors were invited to contribute chapters, which were then subjected to peer review and editing. It is anticipated that the resultant OHS Body of Knowledge will in future be regularly amended and updated as people use it and as the evidence base expands.

Conceptual structure

The OHS Body of Knowledge takes a ‘conceptual’ approach. As concepts are abstract, the OHS professional needs to organise the concepts into a framework in order to solve a problem. The overall framework used to structure the OHS Body of Knowledge is that:

> **Work** impacts on the **safety** and **health** of humans who work in **organisations**. Organisations are influenced by the **socio-political context**. Organisations may be considered a **system** which may contain **hazards** which must be under control to minimise **risk**. This can be achieved by understanding **models causation** for safety and for health which will result in improvement in the safety and health of people at work. The OHS professional applies **professional practice** to influence the organisation to being about this improvement.

This can be represented as:



Audience

The OHS Body of Knowledge provides a basis for accreditation of OHS professional education programs and certification of individual OHS professionals. It provides guidance for OHS educators in course development, and for OHS professionals and professional bodies in developing continuing professional development activities. Also, OHS regulators, employers and recruiters may find it useful for benchmarking OHS professional practice.

Application

Importantly, the OHS Body of Knowledge is neither a textbook nor a curriculum; rather it describes the key concepts, core theories and related evidence that should be shared by Australian generalist OHS professionals. This knowledge will be gained through a combination of education and experience.

Accessing and using the OHS Body of Knowledge for generalist OHS professionals

The OHS Body of Knowledge is published electronically. Each chapter can be downloaded separately. However users are advised to read the Introduction, which provides background to the information in individual chapters. They should also note the copyright requirements and the disclaimer before using or acting on the information.

Biomechanical Hazards

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Abstract

Musculoskeletal disorders (MSDs) as a result of manual tasks are responsible for nearly half of all workers' compensation claims in Australia. While the causation of MSDs is multi-factorial, biomechanical hazards creating body-stressing forces and movements are the major cause of such injuries. Assessing the risk of MSDs and developing effective control measures requires an understanding of how forces and movements damage human anatomical structures and the factors impacting on the risk of injury. The generalist Occupational Health and Safety (OHS) professional has a key role in identifying and assessing the risk of biomechanical hazards; however, specialist ergonomic advice may be required for analysis of risk factors and identification of risk control priorities. A framework is provided for designing and implementing controls through a 'participatory ergonomics' approach.

Keywords

biomechanics, injury, musculoskeletal disorder, MSD, ergonomist, ergonomics

Note from the Body of Knowledge Technical Panel:
Much discussion occurred as to whether this chapter should be titled 'biomechanical hazards' or 'musculoskeletal disorders (MSDs).' However, as MSDs are an outcome with multi-factorial causation and the OHS Body of Knowledge has taken a hazard approach, the consensus was that 'biomechanical hazards' appropriately reflected the content. Many incidents of work-related injury, disease and ill health have multi-factorial causation and this is recognised in the chapters on causation. It is expected that the generalist OHS professional will incorporate knowledge from many components of the OHS Body of Knowledge to create the conceptual framework that informs their professional practice.

Contents

1 Introduction

In considering 'biomechanical hazards' it is important to recognise that biomechanics is relevant to more than 'manual handling.' As defined by Frankel and Nordin (as cited in Chaffin & Andersson, 1999, p. 1), "Biomechanics uses laws of physics and engineering concepts to describe motion undergone by the various body segments and the forces acting on these body parts during normal daily activities." These movements and forces may enable workers to safely perform jobs or, where they over-stress the body, may cause a musculoskeletal disorder (MSD), which is defined in the draft *Code of Practice: Hazardous Manual Tasks* (Safe Work Australia, 2010a, p. 5) as:

> …an injury to, or a disease of, the musculoskeletal system, whether occurring suddenly or over a prolonged period of time. It does not include an injury (such as fractures and dislocations) caused by crushing, entrapment or cutting resulting from the mechanical operation of plant. MSD may include conditions such as:
> - sprains and strains of muscles, ligaments and tendons
> - back injuries, including damage to the muscles, tendons, ligaments, spinal discs, nerves, joints and bones
> - joint and bone injuries or degeneration, including injuries to the shoulder, elbow, wrist, hip, knee, ankle, hands and feet
> - nerve injuries or compression (e.g. carpal tunnel syndrome)
> - muscular and vascular disorders as a result of hand-arm vibration
> - soft tissue hernias, and
> - chronic pain.

Thus biomechanical hazards may be single or repetitive movements and forces imposing stress on the body with a potential to cause or contribute to injury or disease affecting the musculoskeletal or neurological systems. To identify these hazards and develop effective control measures, it is important to understand the principles of biomechanics as well as relevant physics,[1] engineering and behavioural science[2] concepts.

This chapter examines the extent of the problem of biomechanical hazards. It outlines the ways in which various body parts may be damaged by forces and movements, and the factors that affect risk of biomechanical hazards. It concludes by providing a 'participative ergonomics' framework for developing and implementing controls for biomechanical hazards.[3]

2 Historical context

Although Leonardo Da Vinci (1452–1519) described the biomechanical operation of muscles and bones and, in the 1700s, the physician Ramazzini identified "certain violent and irregular motions and unnatural postures ...by which...the natural structure of the living machine is so impaired that serious diseases gradually develop" (as cited in Chaffin &

[1] See *OHS BoK* Foundation Science.
[2] See *OHS BoK* Human Basic Principles of Psychology.
[3] Sections of this chapter have been previously published as Burgess-Limerick (2003; 2008).

Andersson, 1999, p. 3), it was not until the 1900s that concern developed for minimising biomechanically induced workplace injury. This historical neglect of biomechanical injury management has been attributed to manual labour being relatively cheap and easily replaced, and a dearth of information about prevention available to those making decisions in the workplace (Chaffin & Andersson, 1999).

Until relatively recently, the predominant foci for preventing injuries associated with manual-handling tasks have been on the setting of legislated or suggested weight limits, and altering handling technique. This was based on the assumption that weight and body posture were the prime sources of risk. Contemporary understanding of the complexity of injury mechanisms and evidence from intervention evaluation research have revealed this approach to be flawed. The focus on 'manual handling' (lifting, lowering, pushing and pulling) has broadened to encompass 'manual tasks,' defined as tasks "requiring the person to use force to lift, lower, push, pull, carry or otherwise move, hold or restrain any person, animal or thing" (Safe Work Australia, 2010a, p. 5). Current approaches to biomechanical injury prevention consider MSDs as being the result of multi-factorial causation, including biomechanical loading and psychosocial factors.[4]

3 Extent of the problem

Musculoskeletal injuries resulting from biomechanical loading are a ubiquitous OHS issue. In 2006–07,[5] there were 55750 workers' compensation claims (42% of all claims) for 'body stressing.' The majority of these were associated with handling objects (Table 1); of these, 62% were sprains/strains, 2% were fractures/dislocations and 26% were categorised as "diseases of the musculoskeletal system and connective tissue." The majority (73%) of claims for body stressing involved at least two weeks' absence from work. Manufacturing, Health and community services, and Retail trade accounted for 46% of all body stressing claims (Table 2) (Safe Work Australia, 2006–07).

Table 1: Mechanisms cited for workers' compensation claims for body stressing, 2006–07 (Safe Work Australia, 2006–07)

Mechanism of body stressing claims	% of body stressing claims
Muscular stress while lifting, carrying or putting down objects	44.6%
Muscular stress while handling objects other than lifting, carrying, or putting down	36.2%
Muscular stress with no objects being handled	12.2%

[4] See *OHS BoK* Models of Causation: Health Determinants
[5] This was the most up-to-date complete data available at the time of writing.

Repetitive movement low muscle loading	6.9%

Table 2: Body stressing claims by industry 2006-07 (Safe Work Australia, 2006-07)

	Body stressing	
	No. of claims	**% of claims**
Agriculture, Forestry and Fishing	1310	2.4
Mining	873	1.6
Manufacturing	11365	20.4
Electricity, Gas and Water Supply	320	0.6
Construction	4855	8.7
Wholesale Trade	2970	5.3
Retail Trade	6130	11.0
Accommodation, Cafes and Restaurants	2165	3.9
Transport and Storage	4660	8.4
Communication Services	545	1.0
Finance and Insurance	495	0.9
Property and Business Services	3935	7.1
Government Administration and Defence	2310	4.1
Education	2170	3.9
Health and Community Services	8530	15.3
Cultural and Recreational Services	1040	1.9
Personal and Other Services	1945	3.5
Not Stated	140	0.3
Total*	55758	100.3

*The sum of the claims for each column may not equal the total listed as the number of claims for each category has been rounded to the nearest 5 to maintain confidentiality.

4 Understanding biomechanical hazards

Biomechanical injuries occur when the forces on a body tissue (e.g. muscle, tendon, ligament, bone) are greater than the tissue can withstand. These injuries can occur suddenly as a consequence of a single exposure to a high force; they can also arise gradually, as a consequence of repeated or long-duration exposure to lower levels of force. Even low levels of force can cause small amounts of damage to body tissues. This damage is normally repaired before injury occurs; however, if the rate of damage is greater than the rate at which repair can occur, a musculoskeletal disorder (MSD) may result. Also, MSDs can result from a combination of these mechanisms; for example, a tissue that has been weakened by cumulative damage may be vulnerable to sudden injury by lower forces.

4.1 Role of biomechanical hazards in causation of MSDs

The general problem with assessing musculoskeletal injury risk is that the loads on anatomical structures and the individual biomechanical-loading tolerances of structures are difficult to estimate. Biomechanical models are used to estimate loads on anatomical structures and mechanical testing of cadaveric specimens is used to estimate capacities. Epidemiological data is then used to infer the links by assessing the relationship between task characteristics and subsequent injuries.

Considerable attention has been paid to the epidemiological evidence for associations between various possible risk factors (Bernard, 1997; NRC & IM, 2001). Evidence exists for a relationship between MSDs and prolonged or repeated exposure to forceful exertions, or awkward or static postures.

Tissues at risk of damage include bone, muscle, tendon, ligament, articular cartilage and other connective tissues, nerves and blood vessels. The mechanisms of injury to specific tissues are varied; however, injuries associated with manual tasks may be generally characterised as either acute or cumulative (Kumar, 1999). Acute injuries are associated with a relatively short exposure to loads that exceed the tissue tolerance. Cumulative injuries, as the term suggests, occur as a consequence of relatively long-term exposure to loads. In the latter case, the general mechanism of injury is believed to be an accumulation of micro-damage exceeding the tissue's capacity for repair. Injuries may also occur as a combination of both general mechanisms where a history of cumulative loading leads to reduced tissue tolerance, which is then exceeded by short-term exposure to a relatively high-intensity load (McGill, 1997). Psychosocial factors such as stress, conflict with peers or supervisors, time pressure, cognitive overload and boredom are known to interact with physical risk factors (e.g. Devereux, Vlachonikolis & Buckle, 2002)[6] as is whole-body vibration.[7]

4.1.1 Biomechanical damage to bone

Although fracture of bone can occur as a consequence of a single application of high load, an accumulation of micro-damage in excess of the tissue's capacity to repair that leads to stress fracture is more common in occupational situations. Damage to bone associated with manual tasks most commonly occurs as fractures in vertebral endplates as a consequence of prolonged exposure to repetitive forceful exertions and awkward postures (Adams & Dolan, 1995).

4.1.2 Biomechanical damage to muscle

The ways that muscles contract are relevant to the mechanisms of potential damage. If a muscle is shortening while generating tension, the contraction is referred to as "concentric". If the length of the muscle remains constant while tension is generated within the muscle the contraction is referred to as "isometric". If the muscle lengthens while generating tension the contraction is referred to as "eccentric"

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[6] See *OHS BoK* Models of Causation: Health Determinants.
[7] *See OHS BoK* Physical Hazards: Noise and Vibration.

Acute injury to muscle occurs as a consequence of loading that exceeds the tolerance of the tissue; this is particularly likely during eccentric contractions, e.g. when working with gravity such as lowering a load or walking down stairs (Edwards, 1988).

Cumulative injury occurs as a consequence of prolonged exposure to isometric muscle activation, which occurs when tension develops within muscle fibres while the muscle as a whole is not changing. Isometric muscle contractions often occur when part of the body is stabilised as, for example, the shoulder is when working overhead. Although the mechanism by which these contractions occur is not completely understood, it probably involves disruption to microcirculation in the preferentially recruited Type 1 muscle fibres (Sjogaard & Jensen, 1999). Also, injury to muscle may occur as a consequence of prolonged exposure to repeated similar movements (Kilbom, 1994). Muscle-fibre strength is highly dependent on fibre length, which varies with joint posture and, consequently, extremes of joint posture may place muscle fibres at increased risk.

The risk factors associated with injury to muscle are prolonged or repetitive exposure to high exertion, and static or awkward postures.

4.1.3 Biomechanical damage to other connective tissues

Tendons and ligaments are susceptible to acute injury through exposure to high load. Compared to muscles, tendons and ligaments have less capacity for repair due to their relatively poor blood supply. Acute injury to ligaments is likely when large forces are exerted when a joint is at end range. Cartilage is even slower to repair, and is susceptible to repetitive impact loads. Cumulative damage to tendons appears to occur most frequently in situations where tendons are loaded simultaneously in both tension (due to muscular contraction) and transverse reaction forces due to passing over adjacent structures. Generally, these reaction forces are higher as joint postures approach end range. Risk factors associated with tendon, ligament and cartilage injury are forceful exertions and, particularly, prolonged exposure to repetitive forceful exertions in awkward postures.

4.1.4 Biomechanical damage to nerves

Pressure applied to nerves inhibits function and causes dose-dependent microscopic changes. While acute effects reverse rapidly, prolonged exposure causes irreversible effects, although the critical thresholds are unknown (Wells & Keir, 1999). Nerve compression typically occurs where nerves pass through other structures, such as the carpal tunnel. In such situations, pressure is increased as joint posture approaches end range, and with loading.

4.1.5 Biomechanical damage to blood vessels

Prolonged exposure to forceful exertions can lead to arterial occlusion caused by clot formation. This is typically observed in the hand where a task involves repetitive striking or twisting an object. A more common vascular injury is permanent change to peripheral circulatory function that occurs as a consequence of prolonged exposure to peripheral vibration (Raynaud's syndrome).

4.2 Assessing the risk of biomechanical hazards

The ultimate aim of manual-task risk management is to ensure that all tasks performed in workplaces require dynamic and varied movements of all body regions with low-to-moderate levels of force, comfortable and varied postures, no exposure to whole-body or peripheral vibration, and that breaks are taken at appropriate intervals to allow adequate recovery. Injury risk is elevated by deviations from this optimal situation, and injuries are most likely to occur when there is significant exposure to multiple risk factors.

Assessing and evaluating the risk of injury associated with biomechanical hazards is complicated by the number of aspects of the task that contribute to the risks, and by the interactions between different risk factors. Also, the risk-assessment process is complicated by the variety of body parts that can be injured and the ways in which injury can occur. As well as the forces involved, the risk of injury to a body part is dependent on the movements and postures involved, the duration of the exposure, and whether there is exposure to vibration or other environmental or psychosocial risk factors.

4.2.1 Risk factors

The first step in assessing the risk of injury associated with the biomechanical aspects of a particular hazardous manual task is to determine the body regions of interest. This may be self-evident, in that the task has been identified as causing injuries or discomfort to a particular body part or parts. Alternatively, the risk assessment should consider the risk of injury to each of the following regions independently: lower limbs, back, neck/shoulder, elbow/wrist/hand. Physical factors impacting on the risk of injury from biomechanical hazards – exertion, movement and repetition, body posture, exposure and vibration – are discussed below. Psychosocial factors also impact on the risk of MSD.[8]

Exertion

An important factor in determining the likelihood of injury to a specific body part is how much force is involved. Historically, the mass of objects being handled has been the focus of risk assessment; however, the force involved in a task also depends on several other

[8] See *OHS BoK* Models of Causation: Health Determinants

factors. For example, in lifting and lowering tasks, the force required by the back muscles depends as much on the distance of the load from the body as it does on the mass of the load. Similarly, if the task involves pushing or pulling a load, the force involved will depend on the frictional properties of the load and the surface as well as the mass of the load. While other manual tasks may not involve the manipulation of any load, high forces can still be required.

If the force exerted by a body part is close to the maximum the person is capable of, then the risk of sudden injury is high and urgent action is indicated. Even if the forces involved are not close to maximum, the task may pose a high risk of injury if the body part is exposed to other risk factors. High-speed movements (e.g. hammering, throwing) are an indication of elevated risk, mostly because high speed implies high acceleration, which in turn implies high force, especially if the speed is achieved in a short time. Such ‘jerky’ movements are a sure indication of high exertion at the body parts involved. This also includes rapid changes in the direction of movement. The strength of muscles is in part dependent on the speed at which they shorten; high-speed movements reduce the strength of the muscles producing the movement. Another high-force situation occurs when impact forces are applied by the hand to strike an object or surface; in this case, there is a high force applied to the hand by the object or surface being struck.

The magnitude of the force relative to the capabilities of the body part is an important factor in biomechanical-hazard risk; for example, the small muscles of the hand and forearm may be injured by relatively small forces, especially if the task involves extremes of the range of movement at a joint. This implies that the capability of the individual performing the work must be taken into consideration when assessing the injury risk. This is also true of the assessment of posture, in that people of different sizes may well adopt very different postures to perform the same task.

Movement and repetition

The optimal design of work provides tasks involving slow-to-moderately paced movements and varied patterns of movement. Little or no movement at a body part elevates the risk of discomfort and injury because the flow of blood through muscles to provide energy and remove waste depends on movement. Tasks involving static postures quickly lead to discomfort, especially if combined with exposure to other risk factors.

If the task involves repeated performance of identical patterns of movement, and especially if the cycle time of the repeated movement is short, then the same tissues are being loaded in the same way with little opportunity for recovery. Such repetitive tasks are likely to pose a high risk of cumulative injury if combined with moderate-to-high forces (or speeds), awkward postures and/or long durations.

Body posture

Posture influences the likelihood of injury from biomechanical hazards several ways. If joints are exposed to postures involving extremes of the range of movement, the tissues around the joint are stretched and the risk of injury is increased. Ligaments, in particular, are stretched in extreme postures. If the exposure to extreme postures is prolonged, the ligaments do not immediately return to their resting length afterwards. Also, tissue compression may occur as a consequence of extreme postures; for example, extreme postures at the wrist increase the pressure on the nerve that passes through the carpal tunnel.

The strength of muscles is influenced by the posture of the joints over which they cross. Muscles are weaker if they are shortened; this effect will be greatest when the joints approach the extreme of the range of movement. Some non-extreme joint postures are known to be associated with increased risk of discomfort and injury. These include trunk rotation, lateral trunk flexion or trunk extension; neck extension, lateral flexion or rotation; and wrist extension or ulnar deviation.

Exposure

If a task is performed continuously without a break for a long time, the tissues involved do not have opportunity for recovery, and cumulative injury risk increases. This is especially likely if the task involves a combination of moderate force or repetitive movement, and awkward postures. Changing tasks can provide recovery if the second task involves different body parts and movement patterns. The appropriate task duration also depends on environmental factors.

Vibration

There are two types of exposure to vibration in manual tasks: peripheral vibration (typically associated with power tools) and whole-body vibration (typically associated with vehicles). In both cases, the vibration exposure impacts directly and indirectly on the risk of injury. Exposure of the upper limbs, and particularly the hands, to high-frequency vibration associated with power tools is a direct cause of damage to nerves and blood vessels. Short-terms effects are temporary loss of sensation and control, and blanching of the fingers – hence ‘Vibration White Finger Syndrome.’ These effects may become irreversible with long-term exposure. Also, use of vibrating power tools can be an indirect cause of injury to the upper limbs because the vibration increases the force required by the upper limbs to perform the task. The degree of risk increases with higher-amplitude vibration tools (e.g. hammer drills or jack hammers). Long-term exposure to whole-body vibration is strongly associated with back injury. As well as a direct effect on the back, exposure to whole-body vibration has an indirect influence on injury risk by causing fatigue of the back muscles. Again, the risk is greater when the amplitude of vibration is high (e.g. heavy vehicles and/or rough terrain).

4.2.2 Risk assessment tools

Codes of practice (see Safe Work Australia, 2010a) and other references (e.g. OHSCO, 2007) provide hazard identification checklists and other tools of relevance for generalist OHS professionals. Also, a semi-quantitative method of assessing and evaluating manual-task injury risk suitable for workplace use is provided in Burgess-Limerick (2008).

The complexity of biomechanical hazards and the interrelationship of risk factors mean that an ergonomist's assistance is sometimes valuable. The value an ergonomist brings is not in the risk assessment and evaluation per se (although an ergonomist might be called upon to provide training in manual task risk management), but rather in assisting workplace staff to systematically consider and evaluate the risk factors and potential control measures where solutions are not immediately obvious.

5 Legislation and standards

Regulation of biomechanical hazards has been included in the draft model *Work Health and Safety Regulations* (Safe Work Australia, 2010b) under the section on hazardous manual tasks (WHSR s 4.2.1). As with other hazardous tasks, the legislation requires persons conducting a business or undertaking (PCBU), so far as is practicable, to identify all manual tasks that may involve hazardous manual tasks and, where it is not practicable to eliminate that task, to minimise the risk of MSD by: changing design or layout of the workplace; changing systems of work; changing the object being handled; providing mechanical aids; changing the environment; or a combination of these strategies. Where the risk is not minimised by these actions then information, training and instruction must be provided. The PCBU must ensure the risk control measures are reviewed as required including before any hazardous manual tasks is carried out, before any change is made to the system of work or the object being handled or when an MSD is reported.
A draft code of practice (Safe Work Australia, 2010a) provides advice on compliance with these requirements.

6 Controlling biomechanical hazards

Control of biomechanical hazards causing body stressing should be a workplace priority becuase such hazards and the MSDs they may cause have a major affect on Australian workers and workplaces (section 3). The most effective control is to eliminate the task; where this is not practical, a combination of other controls must be applied. Control options are outlined below.

6.1 Elimination

Having identified the existence of a biomechanical hazard, the next step is to determine whether any, or all, of the manual tasks responsible for the hazard can be eliminated. This will be the most effective way of reducing injuries. Some manual tasks can be eliminated by adjusting the flow of materials, reducing double handling or changing to bulk-handling systems. Outsourcing hazardous manual tasks may be an appropriate way of eliminating hazards if the organisation undertaking the task has specialised equipment that reduces the risk to acceptable levels. Some non-productive tasks such as cleaning up waste may be able to be eliminated or reduced by examining the source of the waste.

6.2 Designing controls: A participative approach

If it is determined that a biomechanical hazard cannot be eliminated, the next step is to design controls to reduce the risks. This step is most effectively undertaken in consultation with the people who perform the work. Apart from the fact that these people know most about the tasks, the probability of success of the changes is enhanced if the people concerned have a sense of ownership of the changes. Also, it is important to ensure that all people affected by proposed design changes are consulted; for example, maintenance as well as operational staff may need to be involved.

Such ‘participative ergonomics’ approaches in which people are involved in “planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcome” (Wilson & Haines, 1997) have been demonstrated to be effective in reducing musculoskeletal injury risks (Cole et al., 2005; Liang et al., 2005; Rivilis et al., 2006; Silverstein & Clark, 2004; Straker et al., 2004). Several authors (Burgess-Limerick, et al., 2007; Haims & Carayon, 1998; Van Eerd et al., 2008) have addressed the implementation of such programs. The following options for control can be developed and implemented within such a framework.

6.2.1 Work areas – height, space, reach distances, work flow, adjustability

The design of work areas has a large impact on the risk associated with biomechanical hazards. For example, limited space, limited clearances and restricted access to work are common causes of awkward postures. Work should be located at an appropriate height and close to the body. Providing adjustable workstations may be an option to accommodate workers of different sizes. Workplaces should be designed to increase postural variability during work.

6.2.2 Loads – size, shape, weight, stability, location, height

Loads delivered to, handled within or produced by a workplace are common sources of biomechanical hazards. Implementing mechanised bulk-handling systems is an effective design control. Reducing the size and weight of loads is another option, but requires training and ongoing supervision to ensure multiple loads are not handled simultaneously to increase speed. Ensuring loads are easily gripped is important. Hot or cold loads should be insulated to allow them to be comfortably held close to the body. Where loads are manually handled, they should be stored at waist height rather than on the floor or above shoulder height.

6.2.3 Tools – size, weight, handles, grips, trigger, vibration

Poorly designed hand tools are a common source of awkward postures, high exertion (particularly of small muscles of the hand and arm) and peripheral vibration. Hand tools should be designed such that joint postures remain close to neutral during use, and should be as light as possible. Heavy tools may be counter-balanced to reduce exertion. While power tools reduce exertion, the vibration associated with them introduces a new risk; tools should be chosen to minimise the amplitude of the vibration as far as possible.

6.2.4 Mechanical aids – hoists, overhead cranes, vacuum lifters, trolleys, conveyers, turntables, monorails, adjustable height pallets, forklifts, pallet movers

A large range of mechanical aids is available to reduce the risk of biomechanical hazards, and these can be effective controls. However, care is required to ensure than the use of the aid does not slow down the performance of work. If it does, the probability that the control will be effective is reduced because administrative controls and ongoing supervision will be required to ensure compliance. The design of the mechanical aids requires careful consideration. For example, trolley wheels should be as large as possible to reduce rolling friction and vertical handles should be provided to allow the trolley to be gripped at different heights by different-sized people. Introducing mechanical equipment such as forklifts also introduces new risks, which require control. Where mechanical aids are introduced to control biomechanical hazards it is important to ensure that they are maintained in working order and available when, and where, required.

6.2.5 Administrative controls

Administrative controls – relevant to maintenance, workload, job rotation and task variety, team lifting, training and personal protective equipment (PPE) – rely on human behaviour and supervision, and are more effective when used in combination with other controls.

Maintenance

Maintenance of tools, equipment and mechanical aids is crucial, but requires development of a maintenance schedule and supervision to ensure compliance. Maintenance includes good housekeeping.

Workload

Reducing shift duration or the pace of work can contribute to effective biomechanical-hazard risk control. It may be possible to change the distribution of work across the day or week to avoid high peak workloads. Ensuring appropriate staff levels are maintained is important. Also, provision of adequate rest breaks can reduce injury risk.

Job rotation and task variety

It may be possible to reduce risks by rotating staff between different tasks to increase task variety. This requires that the tasks are sufficiently different to ensure that different body parts are loaded in different ways. Alternatively, multiple tasks might be combined to increase task variety.

Team lifting

Team lifting may be effective in reducing risk where the load is bulky, but relatively light. If team lifting is employed as a control, training and supervision are required to ensure the task is only undertaken when appropriate staff is available.

Training

Training is an important administrative control regardless of the design controls employed; training in appropriate work performance and equipment use should always be provided. Implementing an effective manual-task risk-management program requires that staff are able to identify hazardous manual tasks, and are aware of the biomechanical aspects that increase the risk of injury. In the context of lifting, this might legitimately extend to principles such as ‘keep the load close’ and ‘avoid twisting;’ however, the evidence is clear that training in ‘correct’ load-handling techniques is not effective in reducing injuries associated with biomechanical hazards (Daltroy et al, 1997; Haslam, 2007; Verbeek et al., 2011).

Personal protective equipment

Some forms of PPE, such as kneepads, protective aprons and gloves, may be effective in reducing the risk of injury. However, there is no evidence to support the use of ‘back belts’ or ‘abdominal belts’ and these devices should not be employed (Jellema et al., 2001).

6.3 Monitor and review

Managing risk associated with biomechanical hazards and manual tasks is an iterative ‘continuous improvement’ process. Following implementation of any control measures it is important to check that the controls are working as anticipated and that new risks have not been introduced.

6.4 Record keeping

It is important to keep records of the steps taken in the risk-management process. This will ensure that the existence of an effective risk-management process can be demonstrated, should that be necessary. More importantly, it provides a method of tracking the improvements made and maintaining the corporate memory of the reasons changes were necessary.

7 Implications for practice

Professional practice is about more than implementing codes of practice. To reduce workplace risks associated with hazardous manual handling, the generalist OHS professional should have knowledge of basic biomechanics and the causation of MSDs. Furthermore, the generalist OHS professional should be able to identify when specialist ergonomic input is required, and be able to assist in the implementation of a ‘participatory ergonomics’ program. The role of the generalist OHS professional in such programs will vary according to the complexity of the issues involved. The generalist OHS professional should recognise when the specialist input of an ergonomist is required, the nature of their input; and the advice they may provide. The generalist OHS professional may liaise with a professional ergonomist to provide assistance in setting up a program, providing the tools and frameworks, and training for personnel within an organisation. A formal procedure for implementing a participative framework is documented in Burgess-Limerick (2008).

8 Summary

Despite the prevalence of biomechanical injuries in workplaces, little attention was paid to preventing such injuries until the 1900s. Until relatively recently control activities focused on limiting weight or providing training in certain handling techniques that did little to prevent the injuries; awareness of the multi-causality and interrelation of risk factors in MSDs dates from the 1980s.

This chapter has provided an overview of biomechanical hazards, with a focus on their role in causation of biomechanical injuries and manifestation of MSDs. Measures to control risks associated with biomechanical hazards were presented. Ideally, biomechanical hazards should be eliminated; however, if elimination is not practical, a combination of controls should be developed and implemented through a participative ergonomics process. Administrative controls alone are an insufficient means of addressing biomechanical hazards.

With some knowledge of basic biomechanics and the mechanism of injury causation the generalist OHS professional can play a key role in assisting workplace staff in identifying, assessing, evaluating and controlling the risks associated with manual tasks. The involvement of an ergonomist may be helpful to develop the structures and training required to implement a participative ergonomics process at a workplace, and to assist with the development and evaluation of control measures in complex situations.

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