# Practical Ergonomics

Application of ergonomics principles in the workplace.

Barbara McPhee

A Project funded by the
Coal Services Health and Safety Trust

Human Factors at Work

PRACTICAL ERGONOMICS

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# Practical Ergonomics

## Application of ergonomics principles in the workplace

A Handbook by
Barbara McPhee

With contributions from
Rebecca Mitchell, Christine Aickin,
Cliff Carrasco and Jim Knowles

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# Aim

There are many hundreds of textbooks and thousands of papers written on ergonomics and human factors in design. Most contain detailed information that is useful to the specialist or the professional when solving ergonomics problems. However, their technical nature may confuse the non-ergonomist and they may require specialist interpretation.

Ergonomics is often straightforward as much of it is commonsense. At the same time, its application may not be obvious or easy because it involves people and people are complicated. The difficulties in applying ergonomics lie in the differences between people and how these can be accommodated. The combination of sex, age, experience, education, fitness and health, inherent abilities and social values makes every person unique. Everybody can draw on his or her own experience, knowledge and skills to say what is reasonable to expect a person to do but we know that this works only part of the time.

Many jobs contain unnecessary and potentially damaging design faults and organisational obstacles that compound the intrinsic difficulties of the tasks. Normal job demands may then become hurdles increasing errors and reducing productivity and efficiency. These hurdles can also lead to risks to workers' health and safety. For many people it is often difficult to know where the reasonable cut-off point is between completing tasks and maintaining a safe and healthy work environment.

Unfortunately there are very few books available that cater for the needs of workers and their supervisors who have no formal education in ergonomics principles and application. Those that do exist tend to concentrate on the problems of office and industrial work and there are significant gaps when trying to identify and solve problems outside those areas. Nevertheless workers and their supervisors in all occupations in Australia are now actively involved in solving ergonomics problems at work. Usually these are primarily related to occupational health and safety issues but increasingly they also relate to productivity, efficiency, and job satisfaction.

Recognising and solving ergonomics problems requires some knowledge and teamwork. This handbook aims to provide some basic information on ergonomics principles and how workers and supervisors may apply these, particularly for the prevention of health and safety problems at work.

This Handbook is designed as a 'map' of ergonomics: its scope and application in the workplace rather than a complete summary of all issues. It provides introductory material in the form of general principles and guidance that might be of use to people working in heavy industry such as mining, construction, agriculture, forestry and the utilities. For the most part it steers away from recipe solutions and concentrates on the process of ergonomics problem solving. It does not attempt to repeat what is adequately covered in other publications. Key Principles for sections are included.

The reading list (Further Reading) is intended to provide access to further, more detailed or specialised information on different topics. However, it is suggested that when seeking solutions for groups of people, particularly at the beginning of the process, a professional ergonomist can assist in the interpretation of technical material.

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# Contents

## Reference symbols

KEY PRINCIPLES

• Look for these coloured boxes throughout the book for important key principles.

# Introduction

## What is ergonomics?

The word 'ergonomics' is derived from an Ancient Greek word meaning 'rules or study of work'. It is also referred to as 'human factors (in design)'. Ergonomics is concerned with appropriate design for people – the design of systems, processes, equipment and environments so that tasks and activities required of them are within their limitations but also make the best use of their capabilities. Therefore the focus of the design is on the person or a group of people.

Ergonomics is a science; it is a rigorous, user-centred approach to research and design. It is also a philosophy and a way of thinking. It is applied widely in areas such as aviation and other transport systems, sport, education, public facilities, the home, recreational equipment and facilities and in the workplace generally. In fact, the whole community benefits from ergonomics design.

## Scope of ergonomics

Ergonomists and designers take into account a wide range of human factors and consider biological, physical and psychological characteristics as well as the needs of people – how they see, hear, understand, make decisions and take action. They also consider individual differences including those that occur due to age, fitness/health, or disability and how these may alter people's responses and behaviours.

### Human characteristics considered in ergonomics

| | | |
|---|---|---|
| Anatomy | Anthropometry | Dimensions of the body (static and dynamic) |
| | Biomechanics | Application of forces by gravity and muscles |
| Physiology | Work physiology | Expenditure of energy |
| | Environmental physiology | Effects on humans of the physical environment |
| Psychology | Skill psychology | Information processing and decision making |
| | Occupational psychology | Training, motivation, individual differences, stress |

*From: Singleton WT (1972) Introduction to Ergonomics, WHO, Geneva*

As there are many factors to be considered in ergonomics, a range of people are involved in its research and application. Specialist ergonomists usually have university qualifications in ergonomics and related fields and can come from a range of disciplines such as physiology, psychology, engineering, physiotherapy, occupational therapy, medicine, industrial design, architecture, occupational health and safety (OHS), industrial relations and management.

The word 'optimum' is often used in ergonomics and refers to the balancing of the needs of people with real-life limitations such as availability of solutions, their feasibility and costs. Successful solutions depend on solving the real rather than the apparent problem(s). This in turn requires careful observation and analysis.

In reality ergonomics problems and solutions may not transfer exactly from one country, region or industry to another – they have a social context. Although the basic human characteristics are the same they take on local differences for a range of reasons – geographical, social, economic or historical. It can be described as 'the way we do things around here' and relates to the culture of a country, region, industry and/or company. Therefore problems must be identified and addressed locally because each set of circumstances is different. Importing solutions without reference to local issues and resources may fail.

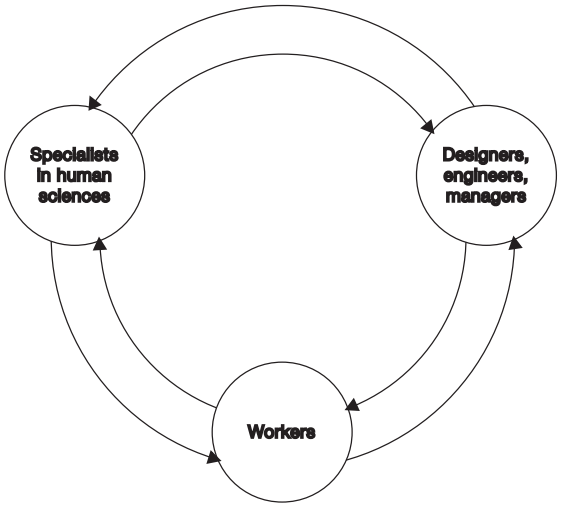



*Figure 1.1: The relationship between different contributors to ergonomics*

In terms of cost benefits the costs of solutions and the time needed to identify and quantify the problems need to be considered against the cost of making mistakes or having injuries. Unfortunately reduction of work-related disorders is often hard to prove statistically and there is likely to be a long delay before information is available to justify changes. Sometimes it is easier to justify the cost of ergonomics changes because they will make the job faster, easier and probably safer. Therefore the benefits of changes need to be assessed in different ways in the short and long term.

## Ergonomics in Occupational Health and Safety

At work ergonomics is applied to the design of the workplace and tasks and to work organisation. It is often referred to as occupational ergonomics within the OHS community. As such it aims to promote health, efficiency and wellbeing in employees by designing for safe, satisfying and productive work.

Positive performance factors such as worker comfort, well being, efficiency and productivity are all considered in determining how to achieve an acceptable result. In this respect ergonomics is different from many other areas of OHS hazard management, where the primary aim is to reduce risks of injury or disease. Good ergonomics in the workplace should improve productivity and morale and decrease injuries, sick leave, staff turnover and absenteeism.

### Elements in occupational ergonomics

When analysing work and how it can be improved from an ergonomics point of view there are five elements that need to be addressed:

1. **The worker –** the human element of the workplace. Employees have a range of characteristics that need to be considered including physical and mental capacities; experience and skills; education and training; age; sex; personality; health; residual disabilities. An individual's personal needs and aspirations are also considered.
2. **Job/task design –** what the employee is required to do and what they actually do. It includes job content; work demands; restrictions and time requirements such as deadlines; individual's control over workload including decision latitude; working with other employees; and responsibilities of the job.
3. **Work environment –** the buildings, work areas and spaces; lighting, noise, the thermal environment.
4. **Equipment design –** the hardware of the workplace. It is the part of ergonomics that everybody recognises and includes electronic and mobile equipment, protective clothing, furniture and tools.
5. **Work organisation –** the broader context of the organisation and the work and how this affects individuals. It includes patterns of work; peaks and troughs in workload, shiftwork; consultation; inefficiencies or organisational difficulties; rest and work breaks; teamwork; how the work is organised and why; the workplace culture; as well as the broader economic and social influences.

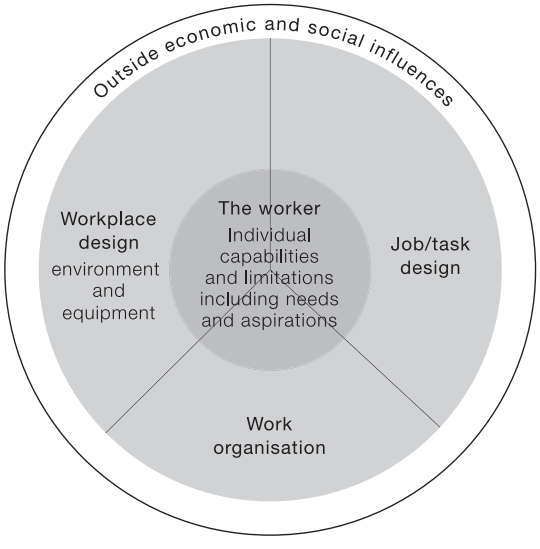



*Figure 1.2: The relationship between different elements of ergonomics*

To design better jobs we need to know about the work and how it will be done. We also need to know about the people who will do the work and their capabilities and limitations. Not only do we need to consider physical and mental aspects but we also need to take into account individual aspirations and needs –

the social component. As work changes over time reviews and modifications are constantly required if systems and people are to work harmoniously and efficiently. No matter how well the workplace is designed it can be undermined by poor job design and work organisation.

## Seeing the whole picture

As most people realise disorders arising from work can have a number of causes and they are not always obvious. Organisations are complex and people are too. For instance we now know that physical disorders may not arise purely from physical stresses. Psychological and social factors can contribute to the development of symptoms in some individuals at particular times. In order to understand these issues we need to examine the work and its organisation more broadly and understand how various work factors may interact with each other and how personal factors might change the impact of work factors.

In occupational ergonomics, the physical design aspects of work or the 'hardware' may be only part of the problem and therefore part of the solution. In some cases it may be a small part. Other factors influence the development of a problem including work organisation and task design, job content, work demands and control over workload, support and training. Usually these aspects require ergonomics to be integrated into the broader work systems.

Therefore to determine if an optimum solution has been achieved the people who will perform the work (the 'who'), the nature of the tasks (the 'what') and the context in which they are done (the 'where', 'when' and the 'how') need to be considered.

# Human capacities and limitations

## The sense organs

Humans make physical contact with their environment through their senses. Information is conveyed to the brain through sense organs such as the eyes, ears and nose.

The stimulus has to be strong enough for the senses to detect before a person can be aware of any stimulation from the environment. The 'absolute threshold' marks the difference between being aware and not being aware of a stimulus and this may vary at different times and under different conditions.

A second threshold, termed the 'difference threshold', refers to detectable differences between two stimuli that can be observed by an individual.

People's senses adapt to various stimuli in different situations. If the stimulus is constant and familiar the sense organs can become insensitive to it.

### Eyes

The eye operates like a camera catching (through the pupil) and refracting light (lens) and converting it to a picture (retina to the optic nerve).

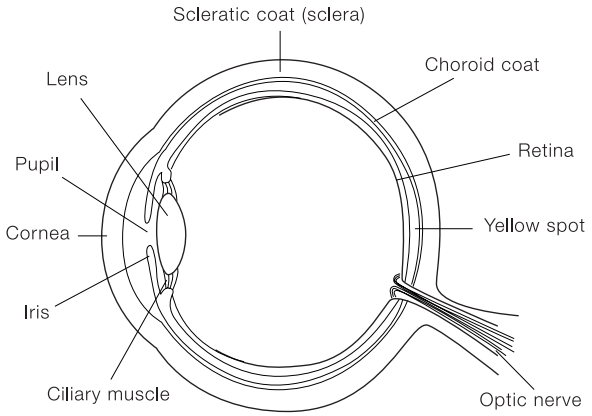



*Figure 2.1: Anatomy of the human eye.*

Eyes are susceptible to hazards such as flying particles and irritating dusts, chemical or radiation damage and, in cases of inadequate lighting, eyestrain. Protection for the eyes can be achieved either with physical barriers that protect against foreign objects eg safety glasses or by improving workplace and task design so that the eyes do not have to work too hard – reducing glare and reflections, optimising workplace lighting and viewing object qualities such as contrast, colour, size and shape. This includes the design of displays and printed material. (See also Illumination and lighting; Displayed and Oral Information).

A small percentage of the population is colour-blind. These people are usually men with varying degrees of red/green blindness. This can be critical for certain occupations and when viewing visual displays involving these colours.

### Ears

The ear and auditory system are more complicated than most people realise. It consists of the external ear, middle ear (separated from the external ear by the ear drum), inner ear and the central auditory pathways. Sound travels to the ear in waves. These are transmitted via the auricle (visible part) and external auditory canal through the eardrum to small bones in the middle ear that vibrate. From there the vibrations are transmitted to the inner ear and to the sensory cells of the cochlear that respond to particular frequencies or pitches. The cells transform the sound waves to nerve impulses that are transmitted to the brain. The cells and hairs can be damaged when exposed to loud noise.

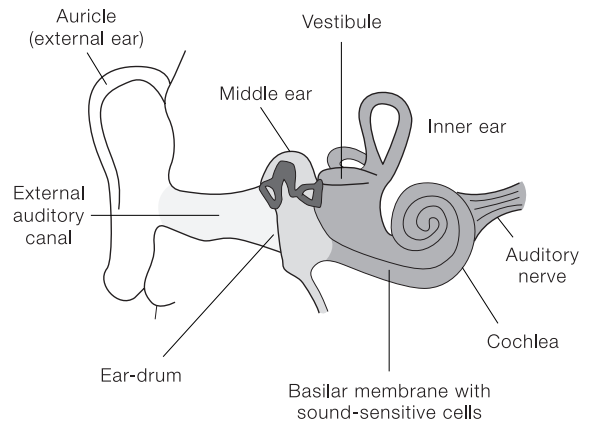



*Figure 2.2: Anatomy of the human ear.*

Different kinds of noise affect hearing in different ways: the higher the pitch the worse the effects; the clearer the tone the greater the hazard; the higher the intensity the greater the damage. The greater the length of exposure to damaging noise on a daily basis the greater is the risk of hearing loss. (See also Noise).

The ears also contain the semicircular canals that are necessary for balance and body orientation.

## Skin

The skin is the largest (1.4-2 square metres) visible part of an individual and is also the body's largest organ. It protects tissues underneath from physical and chemical damage as well as protecting the body from drying out and abrupt changes in temperature.

The skin contains:

- **sweat glands –** help maintain an even body temperature;
- **fine blood vessels –** assist in temperature control, nutrition and waste removal;
- **nerve endings –** act as sensory receptors for heat, cold, pain, pressure and touch;
- **sebaceous glands –** secrete substances to keep the skin supple and protect it from harmful bacteria.

Exposure of the skin to some substances and physical agents, such as the sun, may cause skin irritation, non-allergic contact eczema and burning. Protection of the skin is achieved best through elimination of or isolation from the substances and agents, and less effectively with PPE.

## Nose

The nose both transmits sensations of smell and filters and alters the temperature of the air that an individual inhales. An individual's sense of smell adapts quickly to some smells. However, some of these may tell a worker that there is a problem.

Workers may need respiratory protection in environments where unpleasant or noxious smells cannot be eliminated. Dangerous, unnecessary and/or unpleasant smells will need to be controlled where the sense of smell is needed as an early detection monitor.

## Taste

Taste buds are on the tongue and respond to the sensations of sweetness, salt, bitterness and sour tastes.

# Posture and movement

Kinesiology is the science of human movement as it relates to the structure of the musculoskeletal system. It describes motions of the body segments and identifies the muscle actions responsible for those.

Posture provides the basis for movement and refers to the angular relationships of the body parts and the distribution of their masses. These elements influence the stability of postures, the loads on the muscles and joints, and how long different body positions can be maintained before fatigue sets in.

The interaction of human movement and posture is called biomechanics and this deals with the levers and arches of the skeleton, and the forces applied to them by the muscles and gravity.

Movement and posture is fundamental to human existence. People have evolved through the activity and postures imposed by their living conditions and their need to feed, clothe and look after themselves. As a result, human physical performance is optimum when postures and movements are dynamic and varied. (See also Problems Arising from Poor Task Design; Rest and Work Breaks).

In general the human body moves and works most efficiently when joints are in the neutral (mid) range and the muscles are around mid length pulling at right angles to the bone. However, movement of joints through their full range each day is necessary to keep the body supple and the joints and muscles working efficiently.

*Figure 2.3: Mid position for the shoulder elbow and hand.*

## Balance and movement control

Balance is the ability to maintain equilibrium in different positions. This changes with the size of the base of support such as the feet, the buttocks in sitting or the whole body in lying and the height of the centre of gravity. Balance is maintained in standing and sitting by continually making minor corrections of position. In general we maintain stable postures by static balancing and unstable postures by dynamic balancing such as in walking.

As the position of a person's limbs changes sensors in the muscles, tendons and joints relay this information to the brain. This allows a person to know where different parts of their body are in space even when they cannot see them.

Both the muscle and joint sensors as well as those located in the ear (semicircular canals) are essential for balance and co-ordinated movement.

## Muscle work

Muscle exerts its effects by contraction, which is the development of tension in a muscle. However when the muscle 'contracts' it does not always shorten. Contraction may be static (no movement) or active (movement). These states are further categorised as:

**1. Isometric (static) –** the muscle builds up tension but the length remains unchanged. Static muscle work is the most energy efficient but is also the most tiring. Compression of blood vessels and nerves stops nutrients and wastes from muscle activity from being dispersed eg when attempting to lift an immovable object or when an object is held stationary.

**2. Concentric (active) –** muscle fibres contract to shorten the muscle eg the biceps muscle bends the elbow and overcomes the resistance of the weight of the arm, the source of the resistance being inertia and the force of gravity.

**3. Eccentric (active) –** allows for controlled lengthening of the muscle(s) against gravity.

Static muscle work is common in postural muscles of the neck, shoulders, back and buttocks. These stabilise the trunk allowing for more accurate and efficient movement of the limbs. The positioning of the body for optimum movement occurs naturally where the environment allows.

Both types of active muscle work use more energy but are less tiring than static muscle work.

## Levers in the body

A muscle seldom acts alone; most muscle action involves the complex integration of muscle activity to produce whole movements. Most movements employ lever action, the bones acting as levers and the muscles applying force about a fulcrum (joints).

Three types of lever action are employed:

**1. First order lever –** mechanical advantage is determined by the length of the lever on either side of the fulcrum eg the see-saw and nodding of the head.

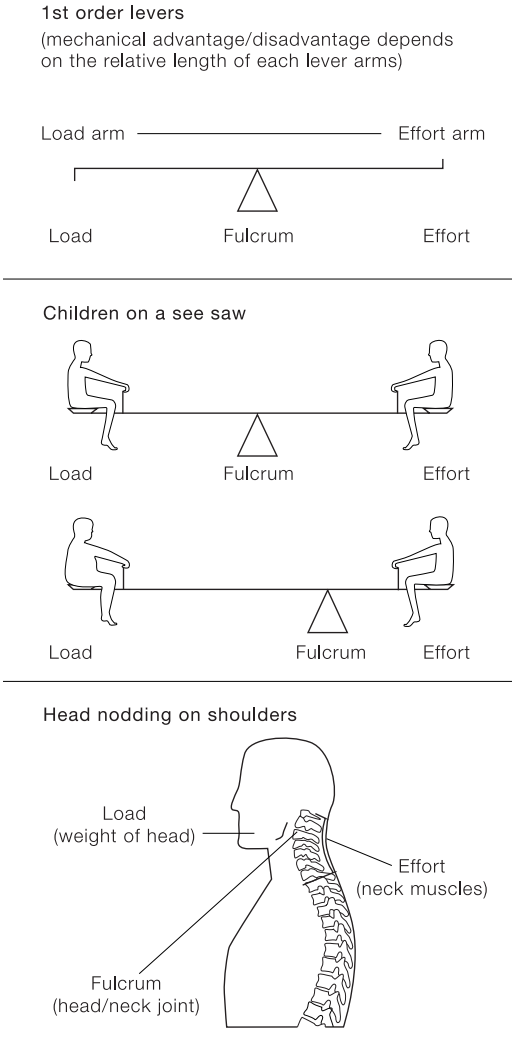



*Figure 2.4: First Order Levers*

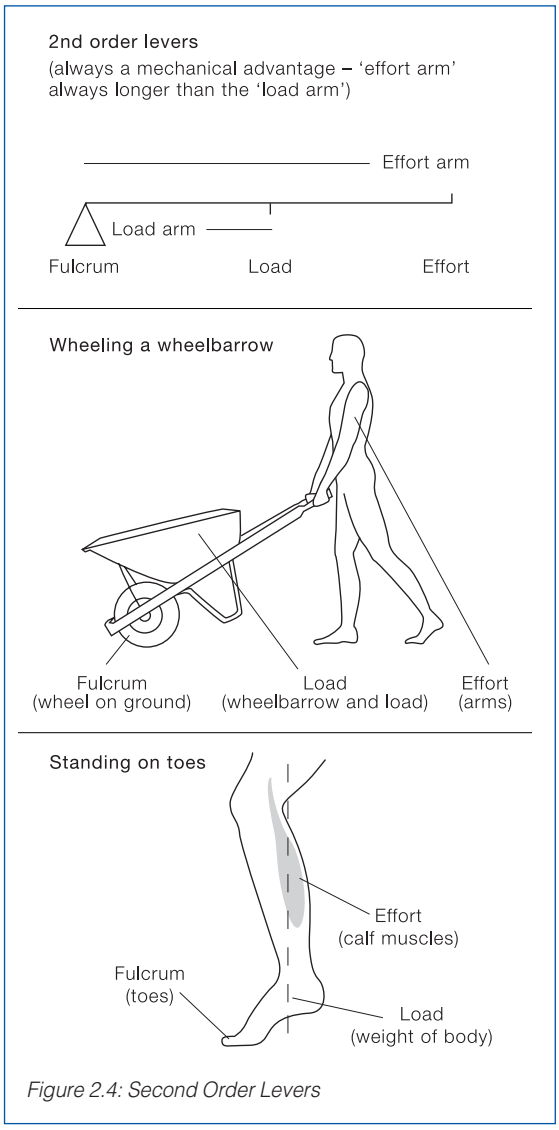



*Figure 2.4: Second Order Levers*

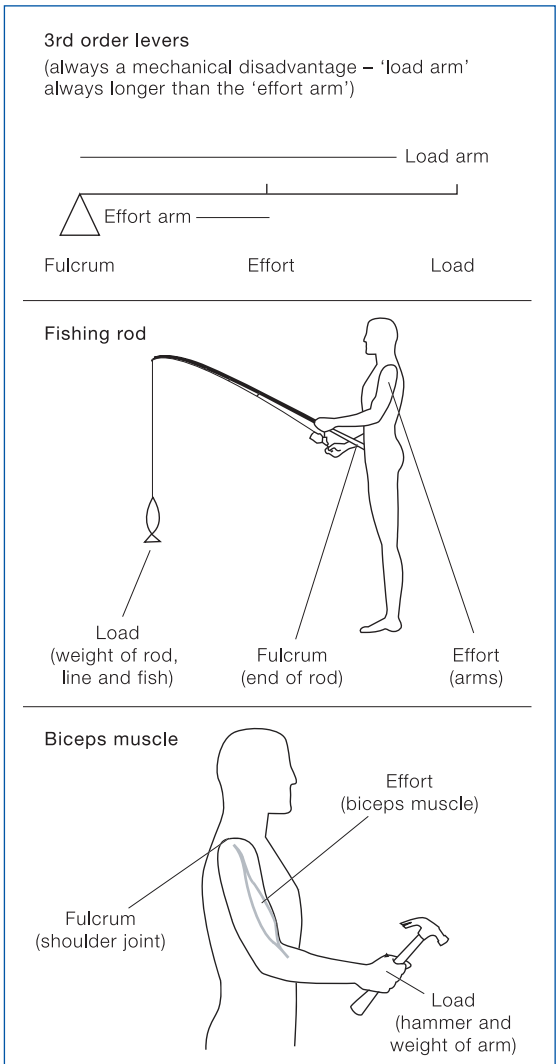



*Figure 2.4: Third Order Levers*

**2. Second order lever –** a relatively small force (the calf muscles pulling on heel) acting through a large distance lifts a large weight through a short distance. This always imparts a mechanical advantage eg a wheelbarrow or in tip toeing.

**3. Third order lever –** a relatively large force (in this case the muscles of the upper arm) acting through a short distance lifts a smaller weight through a large distance. This always leads to a mechanical disadvantage eg pulling up a fishing rod the lower end of which is supported against the body or in lifting an object by bending the elbow.

Most levers in the body are third order and as a result the body is very inefficient at generating force. The human body usually works at a large mechanical disadvantage and considerable energy is required to achieve modest output.

However, third order levers give humans some special advantages. These are speed, range and precision of movement.

As a rule of thumb in ergonomics work should never be designed so that it requires strength and precision at the same time. This can place intolerable stresses on muscles and joints especially if it is required for repeated or extended periods during the working day.

## The upper limb

The upper limb comprises the hand, wrist, forearm, upper arm and shoulder. The hand is comprised of 19 bones with a further eight in the wrist. It is highly flexible but also delicate and has evolved to manipulate and feel small items with a great degree of sensitivity and skill. It does not have intrinsic strength or mechanical power as the muscles of the hand are very small and are adapted to fine movements and precision. Some mechanical power can be achieved through the larger forearm muscles acting on the fingers and through body leverage. Therefore the hand can perform two different types of grasp – the pinch or precision grip and the palmar or power grasps. (See Figures 2.5 and 2.6)

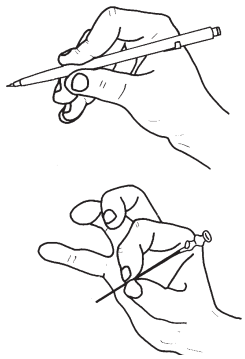


*Figure 2.5: Pinch or precision grip*

Both require the forearm and particularly the hand to be stabilised. This is achieved by forearm, upper arm, shoulder and trunk muscles which for the most part are working statically. The manipulative ability of the hand is improved by the full range mobility of the shoulder joint, the hinge action of the elbow and by the rotation of the forearm at the elbow and wrist.

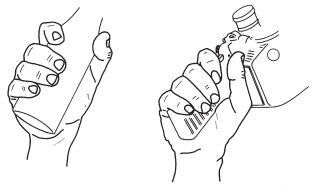


*Figure 2.6: Power grasp*

### Strain injuries in the upper limb

The hand is a delicate and highly complex machine at the end of a very flexible lever on a mobile body but its ability to perform depends to some extent on the rest of the body. Its optimum position (neutral position) is called the position of function. (See Figure 2.8). Where the shoulder or the trunk cannot be positioned for optimum movement of the hand all three areas may suffer strain. This possibility must be considered in relation to the physical layout of work or the demands of the task.

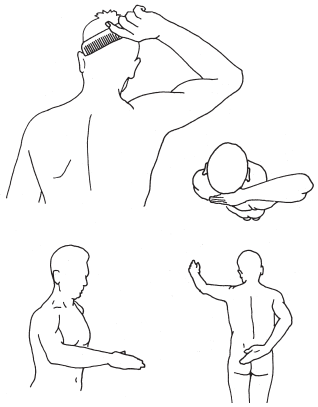


*Figure 2.7: Shoulder flexibility.*

Similarly where joints are in their outer or inner positions repeatedly or long periods, all structures – capsules (connective tissue around a joint), ligaments (strengthening tissue in a capsule), tendons (join muscles to bones) and muscles – may be stressed. For most people such positions are held for short periods and are desirable intermittently. They are not difficult or damaging unless maintained for long periods or repeated many times. Sitting reading or sewing with the neck bent is an extreme posture and may lead to considerable discomfort if continued over any length of time.

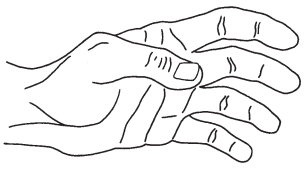


*Figure 2.8: Position of function.*

Work that requires the human body to adopt fixed postures and to repeat movements has become common over the last two to three hundred years. In such jobs the body must work in a way that it was never evolved to do. Repeated movements, be they light or forceful, and fixed work postures, such as at a computer terminal, a work bench or conveyor line put mechanical stress on the body. This cumulative loading on muscles, their capsules and ligaments sooner or later results in fatigue and perhaps strain, and eventually disorders such as Occupational Overuse Syndrome (OOS). (See also Problems Arising from Poor Design)

## The spine

The spine is made up of a series of bones called vertebrae. Discs and a series of muscles, fine ligaments and capsules hold the 24 moveable vertebrae together. The discs act as shock absorbers and allow the spine a great range of movement and postures, which are controlled and activated by the muscles. Ligaments and capsules protect the smaller joints in the spine. There are four fixed vertebrae in the lower end of the tailbone known as the coccyx. (See Figure 2.9)

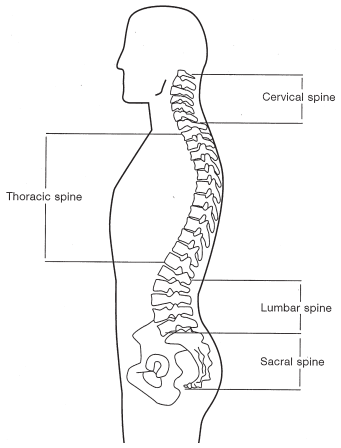



*Figure 2.9: The human spine*

### How strong is the spine?

The spine is often considered a 'weak link' in humans because it is frequently subject to injury. The exact reverse is true. The spine is the axis of human movement and must meet two competing mechanical requirements: rigidity and plasticity. The muscles and ligaments act like the stays on a ship's mast to achieve this. The spine sits on the pelvis and extends to the head and neck. The shoulders are set transversely and act like a mainyard to stabilise the upper spine and this is linked in turn by muscles and ligaments to the pelvis. (See Figure 2.10). These multiple components superimposed on one another and interlinked with muscles and ligaments allow for movement and stability. It is therefore a remarkably adaptable and flexible structure.

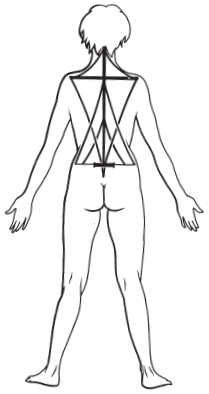


*Figure 2.10: Supporting structures of the spine*

Flexibility and adaptability come at a price and that is strength. The spine is not well designed for the heavy loads and the repeated abuses it suffers in modern life. It needs to remain reasonably flexible and strong to function correctly.

Overweight, lack of physical fitness and overuse lead to injuries and these are common in leisure and work. Most injuries, especially in the early stages, are simply muscle strains and small tears of the ligaments or other supporting soft tissues. However, over time more serious injuries can develop and may result in damage to the vertebrae and, more commonly, the intervertebral discs. Therefore back injuries are nearly always cumulative in nature and arise after months or years of excessive loads on the structures of the back.

**KEY PRINCIPLES**

- Human physical performance is optimum when postures and movements are dynamic and varied.
- In general the human body moves and works most efficiently when joints are in the neutral (mid) range and the muscles are around mid length.
- If joints are held in more extreme positions over extended periods strain can occur.
- Static muscle work tends to be more tiring than active muscle work even though the latter uses more energy. Most stabilising postures involve static muscle work.
- Most levers in the body are third order and therefore the body is most inefficient at generating force. However, third order levers give humans some special advantages. These are speed, range and precision of movement.
- Work should not require strength and precision at the same time.
- The upper limb (arm and shoulder) is capable of highly skilled and precise movements but is not strong and is subject to strain injuries. The shoulder is particularly flexible but can be unstable in certain positions.
- The spine can meet two competing physical requirements – rigidity and plasticity but this comes at a cost, which is strength. It is therefore subject to injury when it is strained.

## Body size

Anthropometry refers to the dimensions of the human body and how these are measured. It covers the size of people; their height and circumference; their weight and percentage body fat; the length and range of movement of their limbs, head and trunk; and their muscle strength.

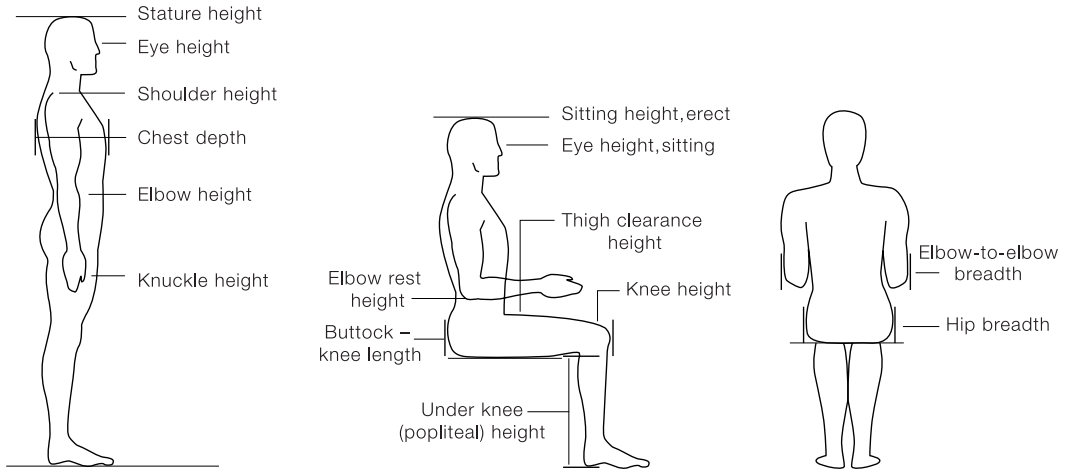



*Figure 2.11: Static body measurements*

Measurements of large numbers of people are needed in any given population to determine ranges, averages and percentiles. Children of different ages, male and female adults and older people all may be included in the population sample depending on how the data may be used.

Measurements are made in two different ways – referred to as static and dynamic anthropometry. The most common measurements are made with the body in rigid standardised positions and this is static anthropometry. Dimensions are linear and are made relative to the body surface eg standing height, length of leg, head circumference. Measurements are standardised using the same methods and postures on different individuals but they allow comparisons between individuals and between population groups. They provide information on the size differences of individuals but they are not functional measurements.

Dynamic or functional anthropometry, in which dimensions are measured with the body in various working positions, is more complex and difficult to perform but it has important applications in the workplace. Measurements are three-dimensional and describe such things as space envelopes in driving cabs, arcs and ranges of movements for the optimum use of controls, and safety clearances.

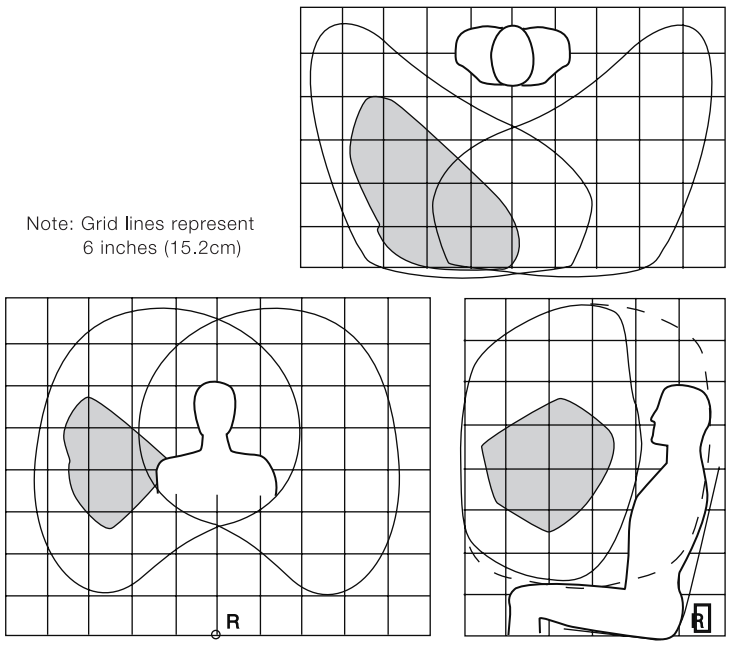



*Figure 2.12: Space envelope – hand movements and hand grasps depicted in three-dimensional space showing the optimum for different manipulations*

## Using anthropometric information

In workplace and equipment design, ranges of dimensions are often specified to allow for the short and the tall, the fat and the thin and those who may be differently proportioned to the average. Ranges can include extremes at either end such the 5th percentile in height represents people who are in the shortest 5%, while the 95th percentile represents the tallest 5%.

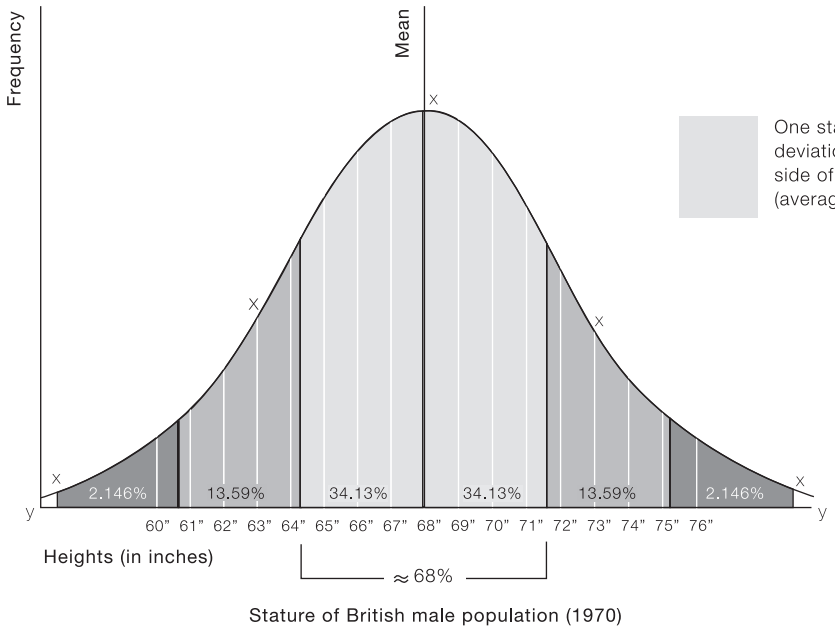



*Figure 2.13: Curve of normal distribution showing range of height for British men. One Standard Deviation from the mean (average) represents nearly 68% of men with a range of about 7 inches (180mm).*

Often a design needs to suit the majority of the population as far as possible while not accommodating everyone in the extremes of range eg seats in a bus or an aeroplane suit 90% of the population adequately but may be very uncomfortable for very short or tall or obese people. In these cases static dimensions are used as a guide e.g. average (mean) height of the travelling population.

In most dimensions the middle 68% of the population can be accommodated relatively easily with little or no adjustment required. Ninety-five percent of the population can be accommodated with some flexibility in design or by using adjustments eg desks and chairs. It may be very uncomfortable to achieve a fit for very tall/short or big/small people above 97.5 percentile or below 2.5 percentile.

If it is possible to use equipment lower/higher/wider/narrower than the optimum, variation is limited to one direction – it has a one-way tolerance eg the height of a door for a tall person, the height of shelf for a small person.

Some design is concerned with static dimensions such as body height (stature), leg length or shoulder width. For instance, thigh length governs the optimum depth of a seat for a particular person while lower leg length dictates the height of the seat.

Where dimensions may not be critical, one dimension, usually stature, may be used as an approximation of other dimensions such as leg length and shoulder width. Using commercially available data tables other static dimensions can be derived. However, this method must be used with care as there are many exceptions to the rule and all the data that are readily available in this form are from the USA or Europe.

## Factors that effect body size

The following factors effect body size:

- **age –** there is an increase in dimensions from birth to age 20 in males and to age 17 in females with a decline after 60 years.
- **sex –** men generally are physically larger except in hip breadth and thigh circumference than women. Men's arms and legs are longer than women's absolutely and relatively in standing and sitting.
- **ethnicity –** statistical variations occur in size, proportions and body builds between people of Asian, Caucasian and African racial backgrounds as well as within each of these groups eg between nationality groups such as Scandinavian and Mediterranean people.
- **fitness and health –** the presence or absence of disease, nutrition and physical fitness can significantly effect height and size.
- **occupations –** workers in active jobs may tend to be physically larger than those in sedentary work. This may be due a self-selection process but is also related to age, diet, health and activity. However sedentary workers tend to have more body fat due to inactivity.
- **posture and body position –** differences in measurements occur between rigid and slumped postures, and dynamic and static measurements. The rigid, static measurements may provide a starting point for design but the dynamic or more functional postures are more likely to reflect the true situation.

**KEY PRINCIPLES**

- Consider differences in users' body size in the design of furniture, equipment and tools. Allow for different sized users by incorporating adjustments or other methods where the fit between the equipment and user is critical.
- When in doubt measure the standing height of your working population to determine roughly the range of sizes that you may need to consider.
- The middle two-thirds of the population can be accommodated relatively easily. However, designing for the other third (one sixth either side) may need more attention and time.
- Body size changes with age and different levels of fitness and health.
- Decide beforehand if you need to accommodate people in the extremes of body size range and make special provision for these people in the design of the workplace.
- Use static and dynamic body dimensions appropriately.
- Use the appropriate anthropometric tables for specific populations.
- Commercially available anthropometric tables are useful as a guide when designing work, workplaces and equipment but they should be interpreted with care.

***Further reading:*** *• Book 2: Kroemer & Grandjean • Book 3: Sanders & McCormick • Book 4: Stevenson • Book 18: Pheasant*

# Physical strength and work capacity

## Strength

### Differences between men and women

While some women are stronger than some men on average men are one third to one half stronger than women. This is due to body size, muscle mass (40 – 45% of body weight in men and 25 – 25% in women), the distribution and percentage of fat, and muscle bulk in the shoulders, abdomen, hips and legs.

### Differences between younger and older workers

Muscle strength peaks are reached in men at about 20 years old and in women a few years earlier. Maximal oxygen uptake, heart rate, stroke volume, lung ventilation and muscle strength decrease significantly with age. In both sexes maximal aerobic power reaches a peak at the age of 18-20 years followed by a gradual decline. At the age of 65 the mean value of aerobic power is about 70% of what it is for a 25year-old. The mean value of aerobic power for a 65-year-old man is roughly the same as a 25-year-old woman.

The strength of a 65-year-old individual is, on average, 75-80% of that attained at the age of 20-30 years when medical conditions are not a limiting factor. The rate of decline in muscle strength with age is in both sexes greater in the leg and trunk muscles than in the strength of the arm muscles. The decline in muscle strength with age is due to a decline in muscle mass.

## Work capacity

The capacity of an individual to undertake physical work can be measured directly by examining the individual's maximal oxygen uptake or indirectly by measuring heart rate. Heart rate is a reliable measure of workload and is easily measured in the workplace.

To maintain a work level all day for a fit, young and healthy person, 25-30% of the maximal aerobic power (oxygen uptake) is usually acceptable. Maximal aerobic power varies markedly between individuals and the important thing is that individuals are measured against their own basic cardio-vascular capacity. However for all people the heavier the work rate the shorter the work periods should be.

Maximal heart rate can be roughly estimated as 220 minus the individual's age. For instance for a 40 year old person the maximum heart rate could be expected to be about 180 beats per minute. In most people a heart rate of about 120-130 beats per minute corresponds to a workload of 50 per cent of the individual's maximal oxygen uptake. These figures would need to be modified for older, less fit or dehydrated workers.

An average heart rate of 110 beats/min for moderate levels of work is generally acceptable physiological limits for an 8-hr working day for a 20 to 30 year old person. Exceeding these limits, even slightly for some people, may lead to fatigue (tiredness) and general lack of coordination, which may result in errors and injuries.

Environmental factors such as temperature, humidity, air velocity, (see also Work in Hot and Cold Environments) noise, vibration and dust need to be considered carefully as these may effect the performance of individuals doing strenuous work. They may decrease the person's alertness, concentration or physical capacity for work thereby increasing the risks of errors and injuries.

## Endurance and efficiency of muscles

Efficiency of muscular contraction is desirable at work. It may be promoted by:

- eliminating unnecessary movements;
- using muscles according to their correct function;
- making use of body weight and momentum and of gravity;
- maintaining balance;
- varying movements;
- varying position and posture;
- employing postures allowing maximum torque;
- using accessory supports for counterthrust or stability;
- training and practice.

Endurance of a given muscular performance varies with the nature and intensity of exertion, the size and structure of the muscles involved, and practice in the task. Static effort can be endured for much shorter periods than exertion involving movement. Endurance fails sooner when either rate of work or load is increased, or when degree of contraction of muscles approaches maximum levels. Postural muscles have greater endurance than faster moving muscles, which are designed more for speed of contraction; most muscles have variable amounts of red or pale fibres depending on their main function, movement or support of posture.

Practice increases power and endurance, due largely to better coordination and elimination of unnecessary contraction: the same end is achieved with less effort. Training enhances the speed, strength and stamina of muscle contraction. However, motivation is also of great importance in any activity requiring endurance of muscular effort.

In prolonged static or repetitive muscular exertion, the maintenance of constant speed and load requires a progressive increase in muscle activity ie more contraction for the same output, both in the muscle group mainly involved and in recruitment of other muscles. Movements become larger and longer, one running into another, and involuntary contractions of other muscles occur. Eventually, the manner of achieving the task may change and there may be a reversion to earlier established habits. These changes are related to the onset of muscular fatigue.

## Physical fatigue

If particular movements are carried out continuously it is reasonable to expect all the muscles to tire, both those executing the movement and those stabilising or enhancing the movement. Stabilising (static muscle work) is more fatiguing than muscle contractions that cause movement (active muscle work). As fatigue can lead to strain the effect of unchanging postures and static muscle work can be equally as damaging as highly repetitive movements. Muscles may tire and become sore to touch and move. Points of weakness such as the muscle/tendon/bone junction at the knee, shoulder or elbow or the tendons over the ankle or the wrist suffer damage and lead to pain.

Dynamic physical work can also lead to problems if it is excessive for the particular individual. Movements in the outer range of the muscle or the joint, heavy lifting, pushing, or pulling (forces that are too high), movements that are prolonged (duration of activity) or repetitive can lead to strain and fatigue and eventually injury. In this respect younger and older, trained and untrained individuals, as well as men and women can vary widely in their capacities. Health and nutrition, previous injuries, lifestyles and natural abilities also play a part in contributing to a person's capabilities to undertake a specific task. (See also Problems Arising from Poor Task Design)

**KEY PRINCIPLES**

- Incorporate frequent short breaks in the work rather than a single long one.
- Limit duration of continuous muscular effort.
- Vary tasks, postures and movements as much as possible.
- Limit energy expenditure in a task to a reasonable level.
- Ensure appropriate frequency and length of rest breaks in all work but especially in heavy tasks, repetitive work and hot work.
  - Avoid:
    - ~ work in fixed or awkward postures
    - ~ sudden or jerky movements
    - ~ sudden peak forces
    - ~ prolonged repeated work with the same muscle groups
    - ~ working with the joints in the extremes of their range movements for more than a few minutes at a time
    - ~ prolonged periods of continuous muscular effort.

***Further reading:*** • *Book 20: Rodahl*

## Information processing and decision-making

Humans process incoming information and make appropriate decisions regarding this information in any work environment. When an individual receives a stimulus it progresses to a short-term sensory store. From there stimuli are moved to a perception stage where the incoming information is matched with prior knowledge or experience of a similar situation. A decision is then made regarding the appropriate action to be taken in a situation. A response may be selected immediately or additional information may be required for further processing.

Further processing will involve working memory and long-term memory. Working memory holds a limited amount of both verbal and spatial information, while long-term memory holds information that a person has retained during their lifetime and this information may be retrieved in order to aid in the decision-making process.

The level of attention of the individual varies with each stage of information processing and with the level of arousal of the individual. Difficulties regarding decision-making can occur at any stage of the model.

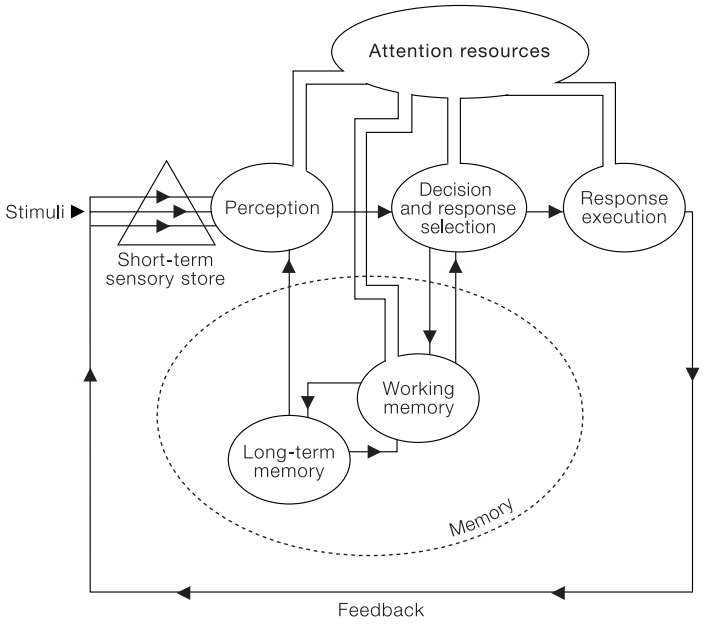



*Figure 2.14: Wickens' model of human information processing.*

If numerous events occur at the same time an individual might have trouble processing a lot of information at once and critical information may be missed, or the correct information might not be able to be retrieved from long term memory (forgetting) or incorrect information may be retrieved. (See also Human Error).

## Controlled and automatic processing

People can attend to multiple sources of information from their surrounding environment at the same time. As an example, it is possible for an experienced driver to drive a vehicle safely and listen to the radio. Individuals can process two types of information simultaneously. This is called parallel or dual processing and can be divided into two main types:

- **controlled processing –** requires intentional effort;
- **automatic processing –** occurs without an individual's conscious awareness when a particular event or procedure is well known and is repeated often eg a person's ability to ride a bicycle usually improves with practice and the movements become automatic.

## Individual variation

Individual factors such as the level of fatigue, boredom/ arousal, stress and skill level and environmental conditions such as the physical environment, job/ task design and organisational features can influence a person's information processing and decision making ability.

Both personal and environmental factors need to be addressed to ensure an optimal environment for decision-making. For example, people can be rotated through different monotonous tasks to decrease boredom. If necessary, specific tasks or jobs should be re-designed. (See also Task Design)

KEY PRINCIPLES

- Incorporate appropriate rest breaks and variation of tasks.
- Limit the difficulty level of tasks.
- Ensure the worker's skills and ability matches work demands.
- Ensure the work environment is optimal for the tasks to be completed.
- Avoid:
  - ~ Environmental hazards, such as poor lighting, glare, excessive noise or temperature
  - ~ Prolonged work on monotonous tasks
  - ~ Confusing or complex displays of information.

## Human error

A human error has been defined an inappropriate or undesirable human decision or behaviour that reduces, or has the potential for reducing effectiveness, safety, or system performance.

Several systems have been developed in order to classify the types of errors that people can make. Two frequently used methods are based on information processing or on actions. Rasmussen distinguished between three levels of human performance:

1. Skill based performance;
2. Rule based performance;
3. Knowledge based performance.

Reason adopted this approach and extended it. He maintained that each type of performance produced different types of errors, with different causes and solutions.

## Information processing errors

**Skill based performance –** Failures in the execution of the planned action – either performing an action that was not part of the original plan (slip) or missing out a part of a sequence of the original plan (lapse). The cause is inappropriate checks on performance (attentional failures). These are operational errors made by the individual; they are almost subconscious actions and make up the majority of errors.

**Rule based performance –** Failures are in the selection of the correct plan of action – either applying a rule that was not appropriate in this situation, or applying a 'bad' rule. These are tactical errors; they are informal and common and arise from inadequate rules governing performance.

**Knowledge based performance –** Failure in active problem solving arising from normal decision making biases; poor 'knowledge' or an incomplete mental model of a situation. These errors in decision-making are strategic, formal, planned and rarer.

Each type of performance produces different types of errors with different causes and solutions. For instance, knowledge-based errors can be occurring for months at a high decision making level of the organisation. These can lead to catastrophic outcomes. On the other hand a skill -based error may happen quickly and affect just one person.

A fourth level is referred to as a violation. This is where a person knows that they are performing an incorrect (inappropriate) action, but chooses to do so anyway and his/her actions are carried out as intended. There are a number of 'causes' of violations. The motivation to act according to the rules is not present; positive consequences of breaking the rule outweigh negative consequences; there was no choice but to break the rule (conflicting rules); or there was a personal 'need' to break the rule (perception of societal norm, sensation seeking).

## Actions-based errors

Using this system individuals can make two types of errors – an error of omission, where part of a task or the entire task is omitted and an error of commission, where a task is performed, but performed incorrectly.

There are several types of commission errors:

- **improper selection –** involves making the incorrect selection eg hitting the start button instead of hitting the stop button on a piece of machinery;
- **sequential errors –** occurs when actions are performed in the wrong order, eg a forklift operator raises the tines, selects a container from a stack and transfers it to another location without lowering the tines. The container falls;
- **timing errors –** occur when actions are performed at the wrong time eg while operating a pressing machine the operator takes too long to remove his hand from the press and his hand is crushed;
- **qualitative errors –** involve actions where the poor quality of the information constitutes an error eg the wrong date is put on a permit-to-work and an electrician is electrocuted because he commences work on the incorrect day when the electrical supply is still connected.

## What causes errors?

An individual may be susceptible to making an error due to the influence of numerous organisational and individual factors.

Organisational factors include:

- inadequate or inappropriate work layout;
- poor physical environment eg noise, heat, humidity, poor lighting or visual distractions;
- inadequate design of equipment including poor ergonomics;
- poor supervision.

Individual factors include:

- inadequate training;
- inexperience on a task;
- poor knowledge of a task;
- inadequate skill level;
- low motivation;
- attitude and emotional state;
- perceptual disabilities;
- stress levels;
- poor physical condition;
- social factors.

## Avoiding errors

There are three basic ways to decrease human errors:

1. Improve the training received by an individual on a particular task so errors are minimised;
2. Reduce the likelihood of a human error;

   ~ improve the work design and work layout – make improvements that will accommodate human limitations and reduce error provocative situations;

   ~ ensure early detection of errors and early remedial action eg installing safeguards and early feedback devices that will alert the individual that an error has occurred and ensure that remedial action is well practiced;
3. Reduce the impact of a human error by ensuring that the impact is minimised when things do go wrong.

KEY PRINCIPLES

- All humans make errors.
- Understanding human error is important when designing work so that the frequency of errors is reduced and/or the consequences of making errors is minimised.
- Two frequently used methods of classifying the types of errors that people can make are based on information processing or on actions.
- Training and design are two approaches to decreasing the impact of human error at work.
- Employ early detection systems to ensure errors are identified early so remedial action can be taken.

## Motivation

Motivation in the workplace refers to as an individual's intention or willingness to perform a task to achieve a goal or reward that will satisfy them. Each individual experiences differing amounts and types of motivation and considers different rewards or incentives as being attractive.

Some individuals are intrinsically motivated ie performing and completing a task and the resulting feeling of accomplishment is its own reward. Others are extrinsically motivated and prefer their rewards to come from external sources in the form of bonuses, promotions and/or praise.

### Improvement strategies

Devising goals to be met by employees and rewarding them for meeting these goals are one way in which employers can motivate employees. In order for motivational strategies to succeed in the workplace employers must recognise that each employee will have different individual needs and goals. Thus types of organisational rewards that motivate one employee to perform well may not necessarily motivate all employees eg monetary, or time off in-lieu. Employees must be included in the decision-making process regarding goal setting and have the ability to provide comment on the types of rewards that are proposed by management.

The organisation needs to ensure that:

- goals to be achieved contain an element of challenge for the employee;
- goals are attainable;
- feedback mechanisms are in place so that employees are provided with information regarding their performance;
- any organisational rewards offered are linked to objective employee performance achievements and that these rewards are individualised;
- group goals do not have unwanted outcomes such as peer pressure that leads to overloading of slower or physically weaker workers.

### Incentives

An incentive is an anticipation of reward. Some organisations use incentive-based schemes to enhance motivational levels among staff while others try to motivate by building incentives into an individual's job eg performance-related pay systems and rewards of 'free-time' away from work.

However these incentives will often increase the risks taken by the individual and ultimately produce poorer performances. Quality of work can also suffer if the emphasis is placed on speed and quantity.

### Incentive payment schemes

Bonus schemes, piece rates, premium systems, payment by results, and measured day work are terms given to methods of production involving incentive payment schemes. These are designed to encourage and reward higher individual and group performance and/or productivity in a range of occupations.

While it is acknowledged that many incentive schemes operate in order to maintain production at a viable and predictable level, they have disadvantages, which, given the different circumstances of their

application, may have considerable hidden costs. Many of these are in the area of occupational health and safety and include cumulative disorders (OOS and low back pain), mental stress and accidents.

While these schemes are a means of sustaining productivity, they should not operate where the sole criterion for their operation is speed of production. Within any group of employees, a variation in working rates will occur due to factors such as natural skills, arousal and fatigue. Incentive payments should not be used to encourage employees to work beyond their personal limits.

Appropriate methods of reward that do not compromise safety and health need to be determined in consultation with all key stakeholders.

## Low morale

When individuals are de-motivated, low morale may develop. Indicators of low morale include:

- increased absenteeism;
- higher than usual turnover of employees;
- a decrease in individual performances and productivity;
- higher than expected accident or incident rates.

Low morale in an organisation can be addressed by:

- encouraging individuals to become interested in their work. This may include having a variety of tasks and responsibilities, building up knowledge about the purpose of the task, and experiencing task completion;
- improving job satisfaction by being given some degree of autonomy and responsibility for the outcomes of work;
- being given feedback on the results of work activities.

**KEY PRINCIPLES**

- Different people are motivated in different ways.
- Workers should be consulted regarding any improvement strategies.
- Improvement strategies should not compromise health and safety.
- Quality of work can suffer if undue emphasis is placed on speed and quantity.
- Vary tasks and responsibilities, increase autonomy and provide feedback to counter low morale.

## Occupational stress

Individuals can experience stress when demands exceed an individual's ability to cope. These demands can be personal or work-related or both. Stress can have negative effects on an individual's work performance, health and wellbeing. It can occur in the workplace when individuals experience:

- a lack of control over workloads or overly demanding workloads and schedules;
- a lack of social support in the workplace, either through supervisors or peers;
- a lack of clear direction from supervisors or management;
- a lack of information regarding the individual's role in the organisation;
- a lack of career opportunities or job security;
- conflict with other individuals within or external to the organisation;
- physical work environment problems with extremes in temperature, noise, vibration or exposure to hazardous substances;
- violence or aggression from fellow employees or clients or as the result of events such as armed hold-ups.

## The signs of stress

Individuals who are experiencing stress may have psychological symptoms such as increased feelings of anxiety, depression, aggression or confusion. They may have physical symptoms such increased blood pressure, heart rate and muscle tension and headaches. They may also be prone to habits such as smoking or drinking alcohol, show signs of irritability, perform poorly at work and have a high rate of absenteeism.

## Overcoming occupational stress

Identifying the real causes of stress amongst individuals may take time and may need mediation skills to resolve. In some cases discussions and a general willingness to listen will be all that is required. In general solutions to the problem of occupational stress can involve both alterations to the work environment itself and/or attempts to improve an individual's ability to manage stressful situations. Stress management training can be beneficial and may include development of coping techniques to deal with stress such as muscle relaxation, meditation and time management skills.

Organisations should try to identify why individuals may be feeling stressed. They should then structure an appropriate response that will address the stressor or stressors – stress related problems could have several causes. All interventions should be developed in consultation with the individual involved, trialled and then evaluated. (See also Task Design; Ergonomics Risk Management; Employee Participation in Problems Solving)

KEY PRINCIPLES

- Stress can have a negative effect on work performance, health and wellbeing.
- Symptoms of stress may be both psychological and physical.
- Interventions to decrease stress may involve changing the work environment or work organisation and/or improving a worker's ability to manage stressors.

***Further reading:*** *• Other material 8.11: Devereux • NOHSC 1.20: Stress & Burnout at Work • Other material: 8.6: Stress*

# Fatigue

Fatigue, (weariness from effort) has no characteristic pattern and occurs in various forms depending on the part of the body exerted. It may manifest itself in one or more of three ways – as a subjective sensation of weariness and discomfort, as objective physiological change, or as a decrement in performance. The onset of the manifestations may occur in any order.

Fatigue is a normal feature of most work, yet it cannot be easily measured. It can be assessed roughly in terms of impairment or decreased performance, although one can occur without the other. The detrimental effect on work of continued work while an individual is fatigued includes effects such as diminished quality and quantity of output.

Transient fatigue is normal in day-to-day activity and is removed by appropriate rest. Cumulative fatigue builds up from period to period of activity, and is not relieved by apparently reasonable rest. It indicates that the activity is beyond current capacity and a person may feel general lethargy or that they are 'going stale'.

Tired people need increasingly more effort to achieve the same output and they may accept lower standards of performance. However, with high external or internal motivation a tired person may continue to perform as before but will require proportionally longer and longer periods of rest in order to recover.

Although awareness of fatigue may be sudden, a time of onset and the point at which performance starts to deteriorate is hard to determine for most people doing routine tasks.

## Physical fatigue

The nature and effects of repeated muscle activity may not be obvious to the untrained observer. It will be obvious to the person undertaking the activity and may be discerned by the skilled observer. Effects can be measured but this can be difficult in a work situation.

Heavy physical or repetitive work can cause general physical and/or local muscle fatigue. These are usually indicated by a decreased ability and desire to undertake the work with increasing energy required to maintain the level of output. Errors and accidents can increase with physical fatigue so appropriate rest breaks should be taken. (See also Physical Strength and Work Capacity; Rest and Work Breaks)

## Mental fatigue

Mental fatigue can be described as the experience of deterioration in perception usually as a result of prior mental effort or physical activity. Mental fatigue is complex and cannot be measured easily by a single indicator.

Mental fatigue can occur:

- after complicated tasks requiring extensive mental effort;
- when monotonous tasks are performed over long periods of time;
- when individuals are getting inadequate sleep.

A number of factors can also influence an individual's feelings of fatigue including:

- **personal factors –** age, gender, health/ physical fitness, sleep patterns, training, task experience, job satisfaction;
- **organisational factors –** organisational culture, morale, motivational schemes, shift schedules, task demands, operating procedures;
- **environmental conditions –** temperature, noise, vibration, light;
- **design of equipment –** hand tools, the relationship between displays and controls, machinery and workstation design.

## The signs of fatigue

Individuals who are fatigued will feel tired and lethargic, experience reduced alertness and vigilance, an unwillingness to work and generally experience a decline in both mental and physical performance. Evidence of this decline will include poor decision-making ability, which may include increased risk taking to make savings in the effort required to perform a task. There also is an increased risk of a tired person making errors. (See also Human Error; Shiftwork and Extended Hours).

## Reducing fatigue

For ways to minimise effects of fatigue and boredom see also Task Design.

KEY PRINCIPLES

- Fatigue is a normal part of most work.
- Tired people need to lift their levels of effort to perform the same amount of work. They are more likely to be slower and make more errors.
- Personal, organisational, and environmental factors, and design of equipment can influence feelings of fatigue.
- Rest breaks are necessary to delay the onset of fatigue and allow people to recover from mental and/or physical effort.

***Further reading:*** *• Book 20: Rodahl*

## Older workers

Older workers tend to be more consistent, careful and conscientious. They have no more work absences than other workers, they have fewer accidents and are less inclined leave their jobs. They usually have extensive work and life experience which can be used to advantage in most jobs.

However, increasing age brings some limitations including some reduced physical and mental capacity. The main limitations include:

- vision and hearing acuity which decrease with increasing age;
- decreased ability to concentrate for long periods on difficult tasks especially in noisy or difficult work environments;
- lowered ability to focus and divide attention and to suppress irrelevant information;
- slower rates of information processing, recalling from memory, speech processing and language production;
- cumulative musculoskeletal wear and tear (sprains and strains) and decreasing physiological capacities leading to a decreased work ability (this appears to be greater in those who have worked in physically demanding jobs);
- other health problems such as cardiovascular disease, diabetes and digestive disorders.

The design of tasks and work organisation need to take these factors into account. Strategies to accommodate older workers might include:

~ the reduction of physically heavy work as age increases;

~ the use of corrective spectacles especially where the tasks are computer based;

~ allowing time to learn new tasks and understand new technology;

~ designing training programs to assist older workers adapt to new methods and systems. The programs should be based on what older workers already know, 'learn by doing' methods. Using older trainers may help overcome difficulties.

Generally older workers have considerable knowledge and experience to contribute that is important in decision-making. They are usually keen to give information and offer suggestions and opinions and they respond well to consultative and participatory processes. These factors need to be considered systematically during job reviews and in long-term planning.

## Shiftwork

Evidence concerning the influence of age on the shift working population is not conclusive but it is generally accepted that the ability to tolerate shiftwork declines after 45 years. (See also Shiftwork and Extended Hours).

## Accidents

A review of the literature regarding occupational accidents showed that:

1. Older workers do not have more accidents at work than younger workers;
2. In an Australian study, the greatest number of traumatic work-related deaths occurred in the age range 20–54 years (about three-quarters); a smaller number of deaths occurred in individuals aged less than 20 years (6%) and those over 65 years (5%);
3. Older workers generally require longer periods of recuperation from injury due to age-associated physiological changes;
4. Factors that can influence recovery time from injury include the type of workplace hazard exposure, socio-economic factors and possible changes in reporting of minor workplace accidents (older workers may tend not to report minor injuries);
5. Older workers may be at risk of particular types of accidents, specifically sprains and strains of joints such as the shoulder, knee, ankle or back. However, information on exposure to work hazards, taking age into account, is not available.

**KEY PRINCIPLES**

- A lifetime's acquisition of knowledge, knowledge of procedures and expert skills often compensate for physiological and physical limitations in older workers.
- Older workers may not work as quickly as younger workers in stressful working conditions such as those induced by noise and sleep deprivation particularly if they are taking medication.
- Design of tasks and organisation of work can be structured to accommodate any limitations older workers may have.
- Older workers need and appreciate consultation and specific and careful training in new tasks especially those related to computer-based systems.

***Further reading:*** *• Book 27: Langford and McDonagh • Book 28: Kumashiro*

## People in systems

Systems are the structures that underlie complex situations. A system can be considered to be a set of interrelated and interdependent parts arranged so that it appears to be a unified whole. Organisations are systems and they are made up of sub-systems acting together to meet the objectives of the organisation. Organisations themselves are sub-systems within society. The design and management of organisations has a very powerful effect on the safety and health of people at work.

The size and complexity of an organisation is often baffling and intimidating for individuals within it. Understanding what constitutes a system, how it works and how and why decisions are made can help individuals become more active in the process of change and development.

### Systems ergonomics

Solving ergonomics problems involves improvements at various levels within a system. Local ergonomics solutions (microergonomics) often cannot be properly implemented because of wider issues. To be effective today's systems require people to be involved in implementing changes including ergonomics solutions if they are to be really effective. This is also required by some occupational health and safety (OHS) legislation.

Systems ergonomics is also referred to as organisational design and management (ODAM) or macro ergonomics. It tries to examine the whole picture. It attempts to look at problems and issues in the perspective of the overall system so that it achieves effective and lasting change.

### Managing change

In the developed world change is a feature of most workplaces. As a result 'change management' is a term commonly used to denote a special approach to the way changes are handled in an organisation. Change is difficult to manage because normal human responses are subject to personal and emotional influences as well as rational, logical ones. No matter how good the technology, how wide the debate, how clear the arguments, individuals will not always agree with the experts about the benefits of change – whatever form they take. Responses will vary depending on the age, sex, education level of the person and a range of other personal and social factors. What works well in one location for one group may not work in another. These issues need to be recognised as a barrier to change and managed. Therefore designers and decision-makers must take care not to impose change without adequate consultation or to transfer technology and systems from one workplace to another without a proper analysis of local requirements and limitations.

It is unreasonable and counter-productive to be too prescriptive in an approach to solutions for recognised and foreseeable problems. This tends to blunt imagination and discourage local, more appropriate solutions over the long-term. If general principles of good task and workplace design are understood and applied, and peoples' local needs are given adequate consideration when planning the system, the basic mismatches and obvious problems can be avoided. More specialist ergonomics input becomes necessary as the complexities of the systems increase and as the need to contain costs and to reduce errors and wastage becomes more critical. System reviews are essential to ensure that changes are working and to rectify outstanding problems.

Essential elements to successful change management are:

- Change must be justified;
- Careful and iterative planning moving from generalised goals to more specific and concrete objectives;
- Commitment to the change by the most senior managers;
- Involvement of and participation by stakeholders (individuals or groups who will be affected by the change);
- Knowledge and communication including adequate feedback;
- Incentives for individuals to change;
- Support by managers and fellow workers.

KEY PRINCIPLES

- Ergonomics problems need to be addressed within the context of the wider work system.
- Successful change requires vision, careful planning and firm and on-going commitment by senior and middle managers, workers and other stakeholders. Without this the change process will be less successful or may fail totally.
- Commitment can be gained through the active involvement and participation of stakeholders. Imposing changes without this can be counterproductive.
- Local problems need local solutions. These may or may not be solutions that have been applied elsewhere. Imported solutions need evaluation with respect to their suitability for a particular workplace.

***Further reading:*** *• Book 23: Kuorinka & Forcier • AS 5.19: AS/NZS 4804:2001• AS 5.20: AS/NZS 4801:2001*

## Ergonomics risk management

The application of the risk management approach for all types of risks is becoming increasingly important to reduce the probability that corporate objectives will be jeopardised by unforeseen events. The focus is one of positive and directed due diligence rather than negative compliance and for many organisations this is a significant change in direction.

Risk management involves hazard identification, risk assessment and control and the monitoring and evaluation of controls (solutions). Analysis of risk is at the heart of the risk management process. This is determined from the range of potential consequences and the likelihood (exposure and probability) of their occurrence. It can be as detailed and technically precise as is required by the process or equipment being assessed. However, for the most part, simple methods can achieve reasonable outcomes and the reduction of risks to an acceptable level for day-to-day ergonomics hazards. (See also Risk Management Techniques).

Changes to OHS laws in most Australian jurisdictions over the last few years require workers and supervisors to manage their own health and safety risks. Ignoring risks or imposing unsatisfactory solutions to problems is not morally or legally defensible. Problems should be identified and solved through a process of consultation and risk management. Both the process and the outcome are important.

OHS legislation in New South Wales now requires that risk management be practiced by all organisations and for all risks – from major to minor. This implies that workers and managers must be informed about ergonomics and be able to apply ergonomics principles on a daily basis.

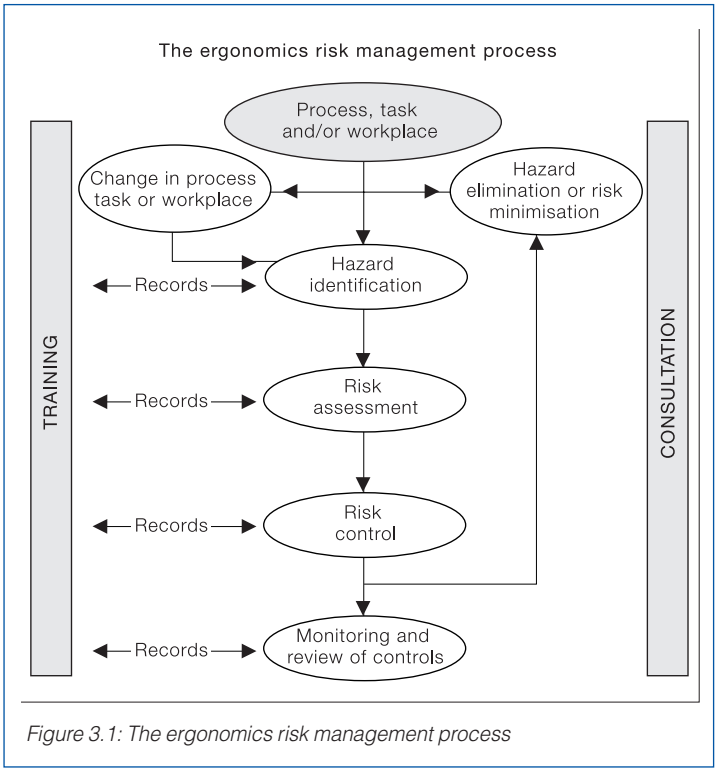



*Figure 3.1: The ergonomics risk management process*

***Further reading:*** *• AS 5.17: AS/NZS 4360:2004 • AS 5.18: HB 436:2004 • AS 5.21: HB 205:2004 • Industry material 6.2: MDG 1010 • NSW WCA 2.1: Risk Management at Work*

## Adapting risk management to ergonomics

Risk management techniques, commonly used in business and safety management systems, can be adapted easily to ergonomics. They have the added advantage that systems safety personnel understand the process and can integrate it into a company's OHS program.

A risk management strategy in ergonomics involves identifying ergonomics hazards in the workplace, assessing them to decide how important each one is and then controlling them by the best means possible ie finding an 'optimum' solution. It also involves monitoring to ensure that the process continues and is successful.

### Ergonomics hazard identification

The first step in controlling a risk is to identify that a hazard exists either in your industry as a whole or at your workplace and which jobs might be affected. Which jobs or tasks are associated with difficulties, complaints, incidents or injuries? Where are those jobs?

In determining which tasks or activities may be hazardous and need to be assessed the following sources of information could be used:

- **statistics and injury records –** eg first aid records, records of accidents and near misses, workers compensation records and reports by supervisors/team leaders and employees. However, injury records from years past may provide a list of past problems and may not be a true indication of the hazards that currently exist;
- **consultation with employees –** eg formal supervisor/safety representative reporting, meetings, informal discussions, questionnaires;
- **direct observation of the workers, tasks and the workplace –** eg area inspections, walk through surveys, audits.

Teams of people do this process best. They may be from the areas being assessed or from different areas. The workplace should be surveyed systematically to ensure that no hazard is missed. Ergonomics hazard identification can be carried out on jobs/tasks, locations/areas, roles/duties or processes.

### Ergonomics risk assessment

Risk assessment is necessary after possible sources of injury, loss or other problems have been identified. If all risks cannot be dealt with immediately it is important to deal with the most hazardous first. To do this it is necessary to determine the possible severity of the hazard and the likelihood of a problem occurring.

Risk assessment should highlight:

- **frequency of the risk –** is the risk common? how many people might be exposed to it? how many people might be effected if exposed?;
- **severity of the risk –** nature of the injuries and losses associated with the risk, cost of work and individual factors which might contribute to the risk --the nature of the task, the load, the work environment, work organisation, training, individual capability;

The risk assessment will indicate the areas requiring risk control measures and it should be carried out in consultation with those who do the job. The following is an example of a commonly used risk ranking method (WRAC) that can be modified for use in ergonomics.

Risk assessment is particularly important whenever:

- a work process and/or practice causes problems especially an injury; or
- a work process and/or practice is introduced or modified.

***Probability:***

**A** Common **B** Has happened **C** Could happen
**D** Not likely **E** Practically impossible

***Maximum reasonable consequence***

| | *Descriptor* | *People* | *Equipment/costs* | *Production delays* |
|---|---|---|---|---|
| 1 | Catastrophic | Fatality | Major > $500k | > 2 days |
| 2 | Major | Serious Injury/ Illness | $250 k – $500k | 1 to 2 days |
| 3 | Moderate | Lost Time Injury or Illness (LTI) | $50 k – $250 k | 6 to 24 hours |
| 4 | Minor | Injury/illness requiring medical treatment | $5 k – $50 k | 1 to 6 hours |
| 5 | Insignificant | First aid or less | Minor < $5 k | < 1 hour |

***Risk Ranking Matrix***

The identified risks are then ranked according to their likelihood of occurrence and consequence according to the Risk Matrix:

| | | *Probability* | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| *Consequence* | 1 | 1 | 2 | 4 | 7 | 11 |
| | 2 | 3 | 5 | 8 | 12 | 16 |
| | 3 | 6 | 9 | 13 | 17 | 20 |
| | 4 | 10 | 14 | 18 | 21 | 23 |
| | 5 | 15 | 19 | 22 | 24 | 25 |

*Figure 3.2: An example of a risk ranking method. A Risk Ranking of 1 to 6 indicates High Risk; 7 to 15 indicates Moderate Risk; and 16 to 25 indicates Low Risk.*

## Controlling ergonomics risks

In practice, finding solutions to some problems using control measures is often hard to achieve. Usually a problem is not solved with one solution because a range of control measures is required. Sometimes these are systems changes that can seem insignificant and unimpressive and certainly not as glamorous as the one-off solutions that are so often portrayed in solutions handbooks. However, achieving a solution should be the focus.

Sources of information on solutions can be found from:

- the workers who do the job including supervisors and managers;
- manufacturers and suppliers of equipment;
- specialists in particular areas of engineering, ergonomics, health and safety;
- other workplaces that perform the same or similar functions.

It is also important that appropriate controls are matched to the level of risk. This is referred to in safety as the hierarchy of controls and is required by law through OHS legislation in some states in Australia. The first three in the hierarchy are known as hard barriers; the last two are soft barriers. They are:

- **elimination –** ie elimination of the hazards;
- **substitution**;
- **engineering controls –** eg reduction through design;
- **administrative controls –** eg provision of policies and procedures, appropriate training, work breaks, job rotation and/or warning signs, training.
- **personal protective equipment (PPE)**.

Hard barriers are usually much more effective in reducing real risk and are required where the risks are high and there is the likelihood of a serious injury or fatality.

Soft barriers are generally less effective, as they rely on people's adherence to procedures or rules and are subject to error or violation. Compliance with rules and procedures is a major problem in any workplace and each individual must be highly motivated if they are to work effectively.

Training (awareness raising, procedures, skills) is a soft barrier but necessary at every stage to complement a well designed workplace and efficient systems. It is particularly important for the successful implementation of change. Sometimes training may be used as a substitute for hard controls, where there is the need for an immediate, temporary solution or where no other method of control is available. However it needs to be done very well in such circumstances. This training must always include information on why ergonomics is important and the general principles of risk reduction.

Education and training can modify peoples' perception of risk and sometimes their behaviour but there is much less evidence of success in training people to use a safe method. Therefore, while training is essential for all workers, used on its own, it is likely to be unsuccessful in reducing risks of injury. (See also Training, Experience and Skill Development)

## Evaluating controls

When monitoring hazards it is important to regularly repeat the hazard identification and risk assessment process to ensure that the solutions are working and, where necessary, make appropriate changes. Improvement must be continually monitored and ongoing.

The solution(s) needs to be evaluated in terms of:

- effectiveness/impact on the problem;
- availability including long-term implications;
- cost benefit and or cost effectiveness.

A risk assessment should always include a review to evaluate the impact of the process and the implementation of the solutions. Unfortunately this rarely occurs. There is a great reluctance to revisit problems unless there is an obvious failure or lack of progress.

Sometimes people are so committed to their solutions they are reluctant to admit that they do not work. Others move on to the next problem and assume that the proposed solutions have been implemented and are working. This may not be the case. Some solutions may work well, while others may not have been implemented appropriately and others may have made no impact at all on the problem. There might be little indication of continuing or new problems as a result of the intervention until such a review is undertaken. An honest and timely examination of how well the intervention or solution has worked is important but it is not easy to achieve.

**KEY PRINCIPLES**

- The process of risk management (hazard identification, risk assessment and control) can be readily applied to ergonomics.
- It is essential that hazard identification and risk assessment be carefully carried out to ensure that the right problems are being solved.
- Finding solutions to ergonomics problems is often a process of combining a range of small and unimpressive changes to reduce risks. Seldom is there a spectacular one-off solution to routine problems.
- All solutions and interventions need to be evaluated for their effectiveness but this process is often ignored or forgotten.

## Employee participation in problem solving

Employee participation in different forms can contribute substantially to the success of different work systems and workplaces. However, successful participation in decision-making and consultation takes time and skill, and there must be time in the planning process to allow for it. It must also start early as sometimes decisions are made at the outset that cannot be reversed by the people who ultimately have to make the system work.

Participative processes are an excellent way of involving workers and training them in the practical aspects or ergonomics application.

The participative approach may take longer and it may be more difficult but it is more likely to lead to the desired outcomes in the short- and long-term. Employee participation in the planning or redesign of their work and/or workplaces does not cost more than the cost of getting it wrong.

The following principles for participatory management have been proposed:

- There are many ways of achieving participatory management;
- Participatory management programs should start gradually and work towards higher-involvement management;
- Participatory management is easier to initiate in new operations, as there is inertia in existing organisational structures and procedures that must be overcome. This diverts resources;
- Pilot or experimental projects in participatory management often are too isolated to succeed. It is better to start with a broader base of involvement;
- Once an organisation moves towards greater involvement of the workforce it may be difficult and counter productive to unwind this process;
- Leadership and vision are critical to success. Everyone must share the vision of successful participation;
- Shared values such as self-worth, democracy, equality and fairness are important to success;
- Success breeds success. Start with small things that will succeed and work towards more complex issues;
- Things rarely go to plan so plan for the unexpected;
- Plan for the long-term as organisational change that lasts takes time.

## Participatory ergonomics

Participative techniques have been used successfully by designers and in safety management systems for many years. They are now proving to be an interesting and productive method for systematically identifying workplace ergonomics problems and developing solutions.

The concept of participatory ergonomics has been promoted for about 20 years and refers to the co-operative interchange between expert and non-expert to find satisfactory solutions to a range of problems especially where there needs to be trade-offs and compromises. It arose from the need to involve workers, who did not have an expert working knowledge of ergonomics, in the process of change. It has proven useful in disseminating ergonomics information and helping organisations find real ergonomics solutions in the workplace. It is another application of macro ergonomics.

In the design of work the depth of employee experience should be used to plan, implement and refine the system and employees should be encouraged to become actively involved in the process of change and improvement. This information can then be harnessed by managers and designers to achieve more workable solutions for identified problems and, more importantly, to prevent problems occurring in new systems of work.

Participative ergonomics can provide:

- names, labels and models for ideas, principles and practices that workers are already using;
- ownership of ideas and responsibility for identifying the most appropriate solution that enhances the likelihood of implementing ergonomics successfully;

- a framework and model for further change – if workers are involved in the process of identifying the problems and solutions they will be able to use the same framework to solve future problems.

## Participatory risk assessments

Participatory ergonomics takes many forms. One that is useful is the participative risk assessment workshop. This forum allows a focus group to devote uninterrupted time to a problem using a systematic approach with a view to identifying solutions to the problem. In particular it allows ergonomics issues to be aired with respect to the wider work system and therefore provides a perspective that may not be possible using other methods. It also gives the company a documented starting point for change.

Participatory risk assessments can be carried out on tasks, locations, roles or processes but using sub tasks (sometimes referred to as job steps), tasks or activities is the most common approach. They involve as many key stakeholders as is feasible because a crucial factor in their effectiveness is the availability of relevant knowledge and expertise of a cross-section of people who are familiar with a particular work situation. Outcomes are dependent on the team being representative and providing a balanced view at a level of expertise appropriate to the nature of the subject under review. The ergonomist as the facilitator is independent within the team but can also provide background information on ergonomics. This is different to most facilitators' functions. In some cases further expertise may be required to advise and/or supplement the core team.

The availability of relevant information and expertise is an essential factor in the effectiveness of the participative process. Technical knowledge is usually required at both the assessment level and for the development of suitable solutions (controls). Therefore the composition of the assessment group is critical to solving the problem. People who are not fully acquainted with the process and its limitations in assessing different types of risks need to take care and seek guidance from experienced personnel.

In addition this process can be used for training, disseminating information and successfully achieving change in complex areas such as ergonomics. It can also provide the opportunity for full and constructive consultation with all stakeholders, something that is difficult and time-consuming to achieve with other processes.

It is important to be realistic about identifying and selecting solutions and what may be achievable. The participative approach allows these issues to be aired and worked through by the group thereby gaining support for the process. Group members also can gain an appreciation of how continual small improvements can substantially reduce risks of illness and injury as well as improving the job.

## Communication at work

Human communication is the two-way exchange of ideas and information between people and is one of the most important elements in the effective working of our society and our workplaces. Poor communications due to lack of language or reading skills, unresolved differences between individuals or an inability or unwillingness to seek and receive feedback are at the heart of many serious OHS issues at work. The use of jargon or technical language that needs to be learned may also be a barrier to communication for new or young workers. (See also Measuring the Benefits of Ergonomics)

Effective communication in the workplace it is one of the hardest things to achieve and maintain in practice. Women innately communicate differently to men and while this is recognised often different styles of communication are not accommodated especially in highly technical areas. Many training programs and textbooks are devoted to improving written, spoken and organisational communication.

There is an increasing focus on communication of danger and risk in the workplace. Effective signage and other written communication are important but these may not be as effective as they need to be if people are not literate in English. Symbols and pictorials may help but some training in recognising these may be required. (See also Displayed and Oral Information)

Written information on OHS and ergonomics may need to be conveyed to workers and it may be difficult to determine how much is read and understood. Training and worker participation in risk management are two ways in which misunderstandings or miscalculations about dangers, hazards and risks can be identified and overcome. This process must be ongoing.

**KEY PRINCIPLES**

- Participatory management is difficult but can fundamentally change an organisation for the better if undertaken with care and commitment.
- Participation by employees in problem solving at work can encourage ownership of changes and understanding of the process of change.
- Participatory techniques are an excellent method for training workers in the theory and application of ergonomics.
- Participatory workshops must have a suitable mix of skills and knowledge about different aspects of the work under review. This includes ergonomics and OHS expertise where necessary.
- Effective workplace communication is essential in all areas of OHS and ergonomics.

***Further reading:*** *• Book 23: Kuorinka & Forcier • Book 26: Noro & Imada • Book 27: Langford & McDonagh*

# Task design

The aim of job or task design is to provide interesting, worthwhile work that in turn improves productivity and efficiency though reduced injuries and ill health, absenteeism, employee turnover and social stress.

Job or task demands that exceed the individual's physical or mental capacity to meet them may result in errors, fatigue, stress and injuries. For instance manual handling research over the last 30 years indicates that heavier weights, repetition and force beyond an individual's capacity, and awkward or constrained postures lead to higher than expected rates of errors, discomfort, injuries and other disorders. Mental overload or underload can lead to errors and other inefficiencies. (See also Human Error; Physical Strength and Work Capacity; Rest and Work Breaks)

When trying to solve occupational health and safety (OHS) or productivity problems, task design and how the work is organised may be as important as hardware solutions such as better-designed furniture or job aids. There are a number of methods that can be used to improve the design of work including broadening and varying tasks, increasing responsibilities, allowing control over work and encouraging social contacts. Problems with computer work may be overcome by a more efficient arrangement of work and more appropriate software design as well as improved information displays and better designed furniture. Manual handling problems may be solved by either rearranging the job or eliminating the handling rather than installing a manual handling aid.

## Fragmentation of work

Over the last few hundred years there has been a tendency to reduce the complexity and to increase the repetitiveness of some types of work. This is referred to as the fragmentation of work or Taylorism. It describes production methods devised by Frederick W Taylor who was an early methods study expert. Complex jobs are broken down into simpler components each of which requires relatively little training and which an individual worker repeats. This approach was considered more efficient by some and was adopted in the earlier part of the 20th century by large manufacturers for production lines eg Henry Ford. This has spilled over into jobs in white-collar industries such as banking, insurance, and finance and increasingly into industries such as mining.

However, while there were perceived benefits to this approach a downside became more evident as the protection of workers' health and safety was given greater emphasis. Physical health problems particularly emerged as efforts to increase efficiency further were unsuccessful. People have physical and mental limits at work. These limits vary enormously between individuals and workers' health and safety can be compromised where these limits are not understood and taken into account when work is designed.

## Task variation

In contrast to the perceived benefits for production many OHS recommendations advise strongly against the fragmentation of work and are in favour of task variation or multi-skilling. This is desirable for the prevention of many occupationally related disorders because it reduces constant exposures a range of both physical and psychological hazards.

Task variation can be achieved in three ways: through job enlargement, job rotation or the use of self-directed work teams:

**1. Job enlargement (enrichment) –** increasing and varying the job content either by adding tasks or adding complexity to tasks. Broadening and enriching jobs in this way allows people to move through a succession of different jobs, each of which make different demands on the persons abilities. This encourages employees to reach their potential over time. It is a much more acceptable alternative for providing variety, but requires careful planning and longer training periods.

**2. Job or task rotation –** moving workers from one component task to another to bring variety to work although the job remains unchanged. It is a ready way of spreading the load of stressful jobs among a large group of employees, but it does have drawbacks. It is effective only where jobs are different enough to provide physical and mental variety. Many employees do not like rotating for a number of reasons, even when it is in their best interests to do so. It can be disruptive and time-consuming and workers may need to do tasks they do not like and are not good at. Also, job

rotation can mask the real causes of the problems and may only extend the period before problems eventually arise. Employees have to learn more skills and thus require more training and supervision.

**3. Self-directed work teams –** more worker participation than the methods described previously. Workers are organised into groups and the planning and organisation of the work and responsibility for the end product may be delegated to them. Theoretically it gives people more control over the whole process rather than just over parts and encourages a much broader view of the job. This can be rewarding both for the company and the employees but it requires considerable time, training and investment in employees.

## Workload

The individual's performance of a task can vary with the workload required. At extremely low levels of workload boredom may set in resulting in missed signals and a poor performance (See also Human Error). Medium levels of workload are optimal and performance remains high, however further increases in workload may result in overload and a marked decline in performance. (See also Physical Strength and Work Capacity.)

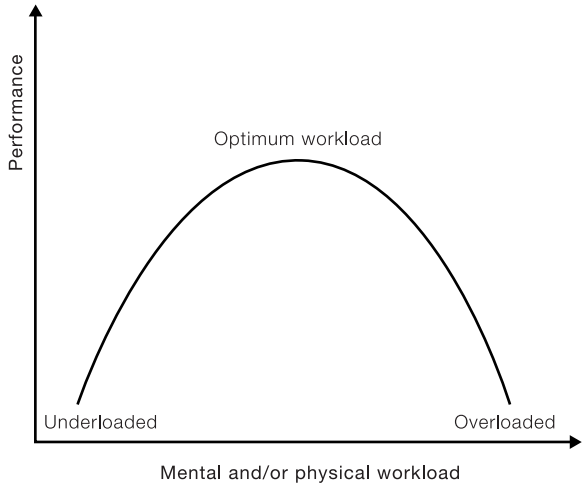


*Figure 4.1: Workload and work performance*

Workload can refer to both physical workload and mental workload. Mental workload is the amount of cognitive processing required by an individual during the performance of a task. (See also Information Processing and Decision-making).

Mental workload is affected by numerous individual and environmental factors that will affect an individual's ability to complete required tasks. These factors include:

- individual – level of fatigue, stress and boredom/ arousal, training, skill level, prior experience, motivation level, perceived difficulty of task and accuracy needed for the task, type of task and time constraints will all affect an individual's ability to perform a task;
- environmental – level of illumination and noise, temperature, design of the workstation and human-machine interface.

## Under-load and overload

When designing tasks to avoid both under-load and overload worker consultation is required as no two people are the same. If individual workers are to achieve greater productivity intensive training and a high level of worker support may be required.

***Further reading:*** • Book 21: Violante, Armstrong & Kilbom • Book 23: Kuorinka & Forcier

## Job satisfaction

Job satisfaction refers to an individual's general attitude or feelings toward their work and work experiences. There can be major differences in job satisfaction between individuals and even between individuals performing the same job. An individual's level of job satisfaction is often interrelated with other aspects of the job, including work conditions. (See also Motivation)

There are three main areas that contribute towards an individual's experience of work satisfaction:

**1. Organisational aspects –** include incentives such as income; possibility of promotions; ability to be involved in decision-making; appropriate supervision; and the match between job expectations and reality;.

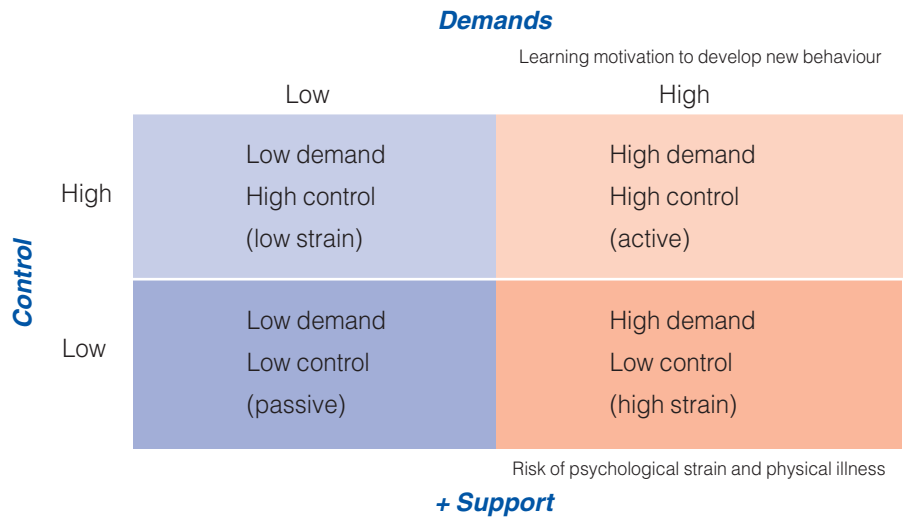
**2. General work aspects –** include workload; appropriate skill and task variety when performing work; significance of task performed to overall work outcome; autonomy or decision latitude in the job; appropriate feedback on work performance; and a suitable physical work environment;

**3. Personal characteristics –** including level of ability to perform work tasks; appropriate levels of experience; stress and coping abilities; general levels of self-esteem; personality; job expectations; and general life satisfaction.

Most people would like to believe that the work they do is of value and that when they work they are productive, efficient and produce high quality work (quality, quantity and time). Very few people achieve this consistently because they work in human designed (and therefore imperfect) systems. However, each person should be able to expect a safe and healthy job, with reasonable conditions of employment and reasonable remuneration or other reward.

## Work demands and job control

Job demands need to be balanced with a degree of control by the worker over how the work will be done. Those employees who have high demands placed on them but who have little job control (decision latitude) are the most likely to be at risk of developing psychological or physical disorders. This is illustrated in the following diagram.




*Adapted from Karasek and Theorell, Healthy Work – Stress, Productivity and the Reconstruction of Working Life. Basic Books, New York, 1990, (page 32)*

*Figure 4.2: 'Karasek' model*

Conversely those who have high demands and a high degree of control over how they meet those demands contribute to high levels of motivation, learning and new behaviours.

## Support

A modifying influence in the demands versus control theory can be support. It is argued that support, or the lack of it, can either reduce or magnify the effects of problems at work.

Supporting people at work by developing their skills, minimising their weaknesses and helping them to cope with life stresses is part of good management. Managers need to understand the strengths and limitations of different types of technology and workplace design and how the limitations of some systems may lead to problems for users. This means full consultation with the people who will be doing the work from the start of the design phase through to the ongoing performance of the system.

People need consistent and adequate support throughout the design and implementation phases of new systems. Workers need to participate fully and provide feedback to designers and managers. Help desk services need to be appropriate and effective for the technology. People, especially older workers, need to learn by doing and to gain confidence with new systems. Managers need to keep a user focus and continually re-appraise and fine tune. Support must be kept going when the system is up and running especially for the crisis times – either at work or in individuals personal lives. (See also Occupational Stress)

KEY PRINCIPLES

- The key characteristics of jobs are task variety, task identity, task significance, autonomy and feedback.
- Redesign repetitive or boring jobs to make them more satisfying.
- Where there are high job demands ensure that there is adequate control (job latitude) by the individual over how the work is completed.
- Aim for task variation and autonomy through job enlargement, and/or autonomous work groups rather than job rotation.
- Consider how changes in technology in the workplace may lead to the need for job re-design.
- Appropriate, timely and ongoing training is an important element in the effective performance of a job or task.
- Employees need education in ergonomics to enable them to participate fully in the development of solutions to ergonomics problems.
- Consider the negative impact of environmental influences and design to minimise these.
- Provide appropriate and on-going support for employees particularly during the implementation of new systems.
- Understand the importance of effective worker consultation and work organisation.

## Problems arising from poor task design

### Sedentary work

Prolonged sedentary work is becoming more the norm in workplaces everywhere and occurs mainly in offices, transport and manufacturing. While sitting all day is preferable to standing a combination of sitting and standing is the most desirable as it provides the necessary postural and physiological variation normal for human beings.

Design of work must allow for these postural variations and should improve levels of alertness and wellbeing. Many work places have introduced task rotation and exercise programs to overcome the possible harmful effects of sedentary work that include back pain, occupational overuse syndrome (OOS), problems for the digestion and circulation in the legs. However, these strategies are less effective than work with inbuilt variation.

KEY PRINCIPLES

- Build variety into tasks wherever possible.
- Allow for freedom of postures and movements in tasks where workers are seated for more than an hour at a time.
- Encourage seated workers to exercise and undertake activities other than sitting during breaks.
- Encourage regular, frequent breaks from the seated workstation.

### Computer work

More and more jobs involve work with computers and input devices such as keyboards and the mouse. Most people find the computer is an invaluable tool when used intermittently throughout the day. Problems arise for some people however when computer work becomes the total job as it may be physically repetitive and undemanding mentally. In some cases computer work requires long hours of absorbing and intensive mental work so that the user is oblivious to time and physical and mental fatigue. Both these types of jobs can lead to physical problems such as OOS, eye fatigue and headaches.

It cannot be predicted accurately who will develop symptoms in high demand/low control jobs but theoretically all who do this sort of work are at risk. Given this, the two most important strategies for preventing problems lie in task design:

1. Keyboard output and skill levels are attainable by all keyboard operators within each job;

2. Deadlines are realistic for everyone and allow adequate breaks.

Some peaks and troughs can be expected but prolonged periods of either high intensity work or underload (more than a day or so) can precipitate problems in some more vulnerable people. If job demands continually outstrip the capacity of all or some groups to meet them, then some urgent reassessing will need to be done.

Computer training needs to match the needs of individuals, and the demands of and skills required by the job and the technology. It must be timed to match the introduction of the equipment and allow people time to learn. Appropriate support for people while they are learning is essential.

Ultimately work groups should be able to reassess their situation regularly to see if changes need to be made. The ability to control work demands at a manageable level for the individual and the group and problem identification and solving by a work group is very important.

***Further reading:*** • NOHSC 1.7: Prevention of OOS in Keyboard Employment • ACTU 7.1: Screen Based Work • Other material 8.3: Display screen equipment • Other material 8.3: Understanding ergonomics • Other material 8.5: Office work • Other material 8.12: Ergonomics

## Repetitive work

Repetitive work may require repeated muscle activity involving the use of the same muscles in a range of apparently different movements or using different muscles in repeated movements that look similar. Sometimes this can lead to injuries. An injury may mean that the same activity is done completely differently after the injury and this is referred to as favouring the injured part , which could lead to further injuries.

Repetitive work processes are often described as monotonous and boring, with individuals performing this type of work often experiencing dissatisfaction. Such occupations may involve responding to intermittent signals eg console operation or require simple, repetitive movements eg factory process work.

Research has found that individuals who perform short repetitive tasks tend to make more errors than employees performing varied tasks, largely because the nature of repetitive work has the effect of decreasing an individual's level of cognitive arousal (see also Information Processing and Decision Making). Different individuals will experience different responses to repetitive work. A few will enjoy the routine nature of repetitive work and find this type of work relaxing, straightforward and free from responsibility. Others will seek greater mental stimulation.

Very simple and repetitive jobs can be automated and performed by machines, although certain repetitive jobs may still require the flexibility of human workers to perform them.

When repetitive work cannot be automated, it is important that job or task rotation or job enlargement be used to diversify the workers' activities, limit physical overuse symptoms and avoid boredom by incorporating more variety into the work.

### Injuries

The term occupational overuse syndrome (OOS) refers to a range of conditions marked by discomfort or persistent pain and/or other dysfunction in muscles, tendons or other soft tissues of the hand, arm or shoulder and sometimes occurs in the foot and ankle. Other terms used to describe these conditions are repetition strain injury (RSI), cumulative trauma disorder (CTD) and work-related musculoskeletal disorders (WMSD). For simplicity they are referred to in this handbook as OOS.

OOS is usually caused or aggravated by work associated with repetitive movements, sustained or constrained postures and/or forceful movements.

Factors such as posture, training, fatigue, a person's size and age, and their muscle strength and fitness also need to be considered. The relationship between workload, its effects on work capacity and on

the development and severity of sprains and strains appear to be modified by factors, such as length of working day, periods worked without breaks, and the percentage of the working day spent doing repetitive activities in fixed postures.

As well personal factors such as personality, mood, the perception of load, work pressures, job satisfaction and non-work related factors might alter the individual's response to early signs of fatigue and discomfort. (See also Fatigue)

Psychosocial factors such as stress at work may contribute to the development of these disorders. Often multiple factors acting together over time lead to symptoms. Two important factors that are often overlooked are excessive time pressures and job demands over which the workers have no control.

It appears that increased risk of strain occurs when individuals:

- have new demands placed on them;
- habitually work beyond their capacity;
- personal, social or environmental factors reduce their tolerance to physical stress.

## Preventive strategies

The following strategies can be used to prevent the development of OOS:

- **task variation or multi-skilling –** highly desirable; achieved through job enlargement which may enable a number of different types of activities to be incorporated into a job description; or less effectively through job rotation;
- **exercise programs –** increasing strength, endurance and increased blood flow. However, results are mixed when only exercise intervention is used to control these disorders. Some programs may slightly increase musculoskeletal discomfort in some workers. Professional advice on exercise programs is advisable;
- **adjusting work rates –** human performance varies between individuals and over time. Therefore work rates should aim to accommodate the physical and psychological capacities of all workers selected for the job including the slowest and least capable. This is particularly important in machine-paced work. Capacities can be increased with training and experience but even the fastest and most capable have off days and this needs to be taken into account;
- **minimising aggravating factors –** mechanical and technical breakdowns and inefficiencies can have a disruptive effect on employees and usually involve periods of extra load to make up production or output. Poor quality control may require reworking for no additional productivity. Therefore adequate machine and equipment adjustment and maintenance is essential in the smooth and efficient operation of any system. Other organisational factors such as overtime, shift work, peak loading, and bonus and other incentive schemes often require higher outputs than the employees can safely manage and should be avoided.

**KEY PRINCIPLES**

- Ensure that working postures are not awkward, prolonged or extreme.
- Ensure that work movements are not excessively repetitive, forceful, fast, jarring or associated with vibration.
- Design tasks that are balanced in content and demands.
- Design work with a variety of movements and postures, sitting and standing, gross and fine movements.
- Consult employees about any problems that they might have with their work and ensure that they are rectified.
- Watch for employees who may be struggling with work and try to support them in solving their problems.
- Allow employees adequate control over their pace of work and the demands that are placed upon them.
- Ensure that all workers are adequately trained for their work especially in work techniques that reduce the risk of strain.

KEY PRINCIPLES

- Do not place excessive demands on employees who have little or no control over their work and the way it is done.
- Ensure that chairs, desks and other furniture and equipment meets the individual employee's particular work requirements.
- Ensure that the work environment eg temperature, airflow, light, noise is designed to optimise work performance.

***Further reading:*** *• NOHSC 1.5: National Code of Practice for the Prevention of OOS • NOHSC 1.7: Prevention of OOS in Keyboard Employment • NOHSC 1.8: Prevention of OOS in the Manufacturing Industry • NOHSC 1.18: Overuse injuries • Victorian WCA 3.4: Code of Practice for Manual Handling • Other material 8.12: Ergonomics • Book 25: Stevenson*

## Manual handling

Manual handling has been defined as:

'any activity requiring the use of force exerted by a person to lift, lower, push, pull, carry, or otherwise move, hold or restrain any animate or inanimate object. Manual handling also describes repetitive actions with or without force, sustained work postures, exposure to whole-body or hand-arm vibration, bending, twisting and reaching'.

Manual handling occurs intermittently in most jobs. In some codes and guides repetitive tasks such as packing, keyboard work and using hand held tools are included in the definition. This avoids a rather artificial separation of heavy and lighter work, which may be confusing and complicate the process of prevention.

Any manual handling activity constitutes a hazard and a potential for injury unless demonstrated otherwise. It may be light or heavy, repetitive or intermittent. Where manual handling is a substantial or significant part of a job it is essential that all risks are identified and minimised. These jobs occur in a range of industries and organisations such as construction, manufacturing, health care, food processing, farming, printing, hospitality and mining.

Some work involves continuous manual handling for most of the day. Warehousing, the removals industry and delivery are examples of such jobs. Great care is needed in these situations to reduce the impact of handling during a work day by correctly pacing work, reducing unnecessary handling and through the use of lifting aids, job and workplace redesign and training.

Generally human handling of materials and people is expensive and inefficient, as well as posing significant risks to health to those who do it. This is especially true where the workload takes people to the limits of their work capacity.

Teaching people specific lifting techniques to overcome lifting problems has mixed success in reducing the risks of injury. Sometimes techniques can be helpful in specific situations but some techniques place extra demands on the muscles and joints eg squat lifting (bent knees and straight back), which is slower and physiologically more demanding. It may also increase the risk of further injury for people with damaged hips, knees or ankles.

### Associated injuries

The majority of problems arising from manual handling are associated with sprains and strains mainly of the back and neck. However, other parts of the body are also affected most notably the shoulders, knees and ankles. Injuries in these areas occur from different aspects of manual handling tasks such as overhead work (neck and shoulders), walking on rough ground or areas with difficult access (knees and ankles). Most manual handling injuries are cumulative, developing over many months or years of overload.

Back disorders are the commonest causes of workers' compensation claims, sick leave and early retirement in the developed world. They are usually painful and no truly effective medical or surgical treatment exists for a large number of cases. They are believed to arise from damage to the spine and surrounding structures brought about by an accumulation of strains placed on the back over time.

These disorders emerge most commonly in middle aged and older people although it is not unusual for symptoms to be reported by teenagers and young adults subjected to high levels of physical stress. In some cases acute injuries, resulting from severe trauma, such as car accidents, precipitate symptoms in young people with little evidence of prior damage. Nevertheless, in most people symptoms and signs develop over many years and the precipitating event is unlikely to be the cause of the disorder – it is simply the last straw.

Different work-related and individual factors are considered to be risk factors for these disorders but there is no clear understanding of their relative contribution. As well there is no general explanation of how back disorders occur, that is, what actually goes wrong in the back which gives rise to symptoms.

## Risk factors

The following work factors are believed to increase the risk of problems when manual handling:

### Weight and load

Load should not be confused with weight. Load is force. The weight of an item may be considerable but with appropriate lifting aids the force required to move it might be minimal. The load experienced by an individual can be influenced not just by the nature of the object to be lifted, but also by task design, organisational and personal factors.

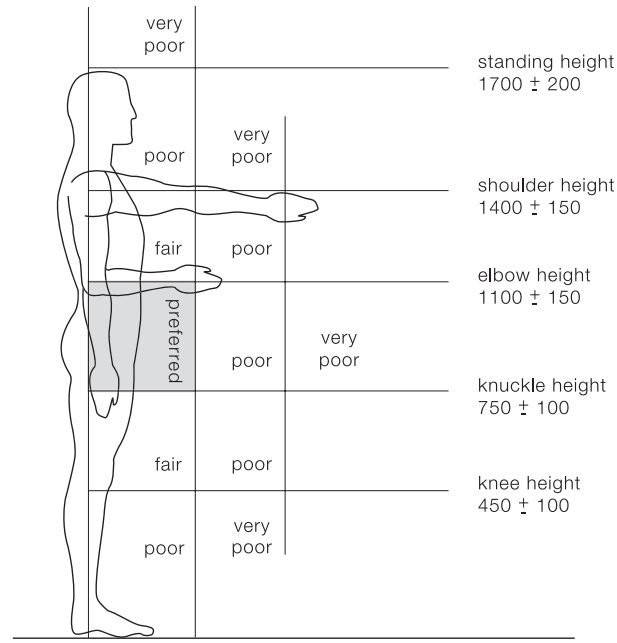



*Figure 4.3: Height ranges for lifting*

In physical work weight is just one aspect of load on the body. In most recent guides and Codes a maximum weight is not specified for this reason. In the National Code of Practice it is mentioned that risk reduction strategies may be required when weights exceed 16 kg for an individual, unaided lift. These must be in place for weights above 55 kg. These limits were set many years ago by international labour groups to limit loads carried by women and children and were embodied in legislation in many countries. When equal employment opportunity legislation was introduced it was these limits that were applied to the whole workforce. They are of little help in reducing manual handling injuries where other factors are not taken into account.

Important aspects other than weight in manual handling include:

- distance of load from the body (moment);
- range through which weight is lifted;
- origin and destination of lifts;
- postures assumed in order to lift (bent, and bent and twisted postures are the ones to which most risk is attached);
- speed of movement;
- characteristics of the load.

For repetitive lifting there is the added factors of:

- frequency of lifts;
- duration of lift, and
- cumulative loading (leading to fatigue).

Handling away from the body, bent twisted postures and speed of movement are now considered to be the factors that create the greatest risks for injury.

### Frequency of lifts

Frequency of lifts between jobs may vary a great deal. The question is: how frequent is 'frequent'? In some regulations in Australia lifting more than twice a minute or a movement sustained for more than 30 seconds at a time is classified as frequent. This is a good guide for practical purposes but each situation needs to be considered in relation to other factors that contribute to load and worker fatigue.

### Matching job demands with worker capabilities

Human beings are not well adapted to heavy physical work, their physical skills lying more in the areas of speed, flexibility, adaptability and range of movement. Therefore there are considerable limitations in designing heavy work for the average person. (See also Body Size; Physical Strength and Work Capacity)

Determining and matching job demands with the capacities of individual workers is particularly important in physically stressful work such as manual handling.

There is a range of task and individual factors that need to be considered in job design where manual handling is involved. These include:

- **physical demands (physiological, biomechanical, anthropometric) –** the workplace and job design features eg work height, reaches, workplace layout, design of loads, how far a load is carried and doubling handling;
- **psychological demands (cognitive and organisational) –** the way the work is done, mental work demands including meeting work targets, control over work, support in the workplace, training and the organisation of work;
- **individual or personal characteristics –** age, physical capabilities (age, sex, stature, ethnicity), fitness for the job including return to work after holidays, health including previous injuries and past exposure to heavy lifting; training for the job skills and experience.

Research carried out over the last 25 years indicates that heavier weights, repetition and force beyond an individual's capacity, and work and workplace design which force workers into awkward or constrained postures lead to problems. In the short term individual workers may cope with demands that exceed their capabilities in one or more of the following ways:

- short cuts in work procedures leading to unsafe practices;
- consistently working at a higher pace than is healthy with an increased risk of chronic or accumulated fatigue and injury especially as they age;
- change of job by those who are unable to meet work demands imposed.

Problems may arise gradually over time in people who adapt in the short-term. They then become evident years after the origins of the disorder have been forgotten. Drawing any kind of cause-effect relationship between the disorders and the initial causes is difficult if not impossible.

## Risk factors and the National Standard

The National Standard and Code of Practice for Manual Handling (1990)* lists the following risk factors to be taken into account in the process of risk assessment and control. These are:

- actions and movements;
- workplace and workstation layout;
- working posture and position;
- duration and frequency of manual handling;
- location of loads and distances moves;
- weights and forces;
- characteristics of loads and equipment;
- work organisation;
- work environment;
- skills and experience;
- age;
- clothing;
- special needs (temporary and permanent) – this is taken to include an individual's health status, fitness for the specific job, training for the job;
- any other factors considered relevant by the employer, the employees or their representative(s) on health and safety issues.

To assess and control risks arising from manual handling it is essential to involve workers in the process of manual handling hazard identification, and risk assessment and control (See also Ergonomics Risk Management)

**KEY PRINCIPLES**

- Any manual handling is costly and inefficient so the workplace should be redesigned to minimise it wherever feasible.
- Correctly estimate individuals' capabilities in terms of handling weights, cumulative loads, and work rates and design for these. Design handling jobs to accommodate the weakest, the smallest and the slowest workers.
- Consider the cumulative effects of weights handled and the different planes of motion.
- Consider the combined effect of task variables (such as height of lift, size of the load) and worker variables (such as age, sex, body weight, anthropometric dimensions).
- Avoid work postures that are awkward, prolonged or outside preferred range.
- Avoid work movements that are repetitive, require excessive strength and endurance, require excessive speed, are jerky, restricted, inefficient or obstructed.
- The time for one basic element of a task to be completed is affected by the preceding and succeeding elements.
- The effect of pacing is exponential so that linear standardising of times gives incorrect estimations of effort.
- Provide well-designed manual handling aids where appropriate.
- Provide specific training in handling techniques where necessary but consider the extra demands that these place on employees eg squat lifting (ie bent knees and straight back), which is slower and physiologically more demanding. Generally this type of training is not particularly successful in reducing risks of injury.
- Optimise environmental variables such as temperature, humidity and air velocity for handling tasks.
- Minimise noise, vibration and dust exposure for people when handling.

***Further reading:*** *• NOHSC 1.2: Code of Practice for Manual Handling (*Note: A new Australian National Code of Practice for the Prevention of Musculoskeletal Disorders from Manual Handling at Work is being prepared. Notice of its publication will be made on the NOHSC website.) • NOHSC 1.15: Managing Back Pain • NOHSC 1.16: Manual Handling • Book 24: McPhee • Victorian WCA 3.4: Code of Practice for Manual Handling • Victorian WCA 3.2: Managing Manual Handling Risks in a Small Organisation • Victorian WCA 3.3: Managing Manual Handling Risks in a Large Organisation • Queensland DWHS 4.2: Advisory Standard: Manual Tasks • Queensland DWHS 4.3: Advisory Standard: Manual Tasks Involving the Handling of People • Other Material 8.4: HSE Manual Handling Assessment Tool • Other Material 8.8: HSE Manual Handling. Guidance on Regulations • Other material 8.10: NIOSH. Work Practices Guide for Manual Lifting • Other material 8.11: Work-related Stress and Musculoskeletal Disorders • Other Material 8.12: Ergonomics*

## Driving vehicles and operating machines

A significant percentage of jobs involve driving or operating vehicles or machines from cabs. In many cases safety and efficiency are critical and both the nature of the work and the design of the cab need to be optimised.

Often driving and operating involves extended work hours and night work. Therefore fatigue, arousal and wakefulness can be problems. Prolonged sitting, awkward postures, poor visibility, vibration and poor cab design can add to the driver's difficulties. (See also Vehicle Cabs; Noise; Vibration; Shiftwork and Extended Hours; Rest and Work Breaks.)

There is a range of additional components in many operators' jobs that can lead to reduced performance or attention to critical functions. For instance in driving buses the safety and welfare of passengers is usually an overriding consideration and can be the source of distractions and interruptions. School buses have the additional demands of children who are prone to unpredictable behaviour either within or outside the bus.

Delivery drivers have a mix of driving, loading and walking as well as dispatch responsibilities but usually have increased time pressures and the stress of heavy traffic. If the loads are heavy, there may be insufficient time for the body to adapt from the seated posture to upright active lifting and injuries can occur.

Dump truck, bulldozer and crane operators can be subject to long hours of sitting, routine (even boring) work and vibration. Ways in which these tasks can be varied need to be implemented.

Design of cabs and the alertness of the driver or operator involve far more complexity than many other workplaces. However, there is considerable information now available to help address task and workplace design issues. (See also Vehicle Cabs)

**KEY PRINCIPLES**

- All tasks undertaken by the driver/operator need to be assessed in terms of job demands and driver capabilities. Fatigue, overload and underload need to be managed to reduce the risk of errors.
- The design of the cab must accommodate driver needs including vision, noise, dust control, seating and task demands.
- Where vehicle operation involves extended work hours and shiftwork there must be adequate provision for rest and work breaks in the work schedule.

## Training, experience and skill development

Few individuals start a job without needing further training or development of skills to perform the job. Continuing technological changes, differences between workplaces, promotional opportunities and multiskilling mean that employees are constantly required to learn new skills and understand different processes and procedures in order to perform optimally at work.

Training can be provided to employees in order to increase their knowledge and skills. It can be on-the-job, in a classroom at the workplace or off-site and can involve individuals learning different types of skills, such as technical (computer software), interpersonal (mentoring or different management techniques) or problem solving.

Adults learn best from their own experience and then move from this into new areas of knowledge and skill. It may be best to train adult learners in practical situations if they are not comfortable in a classroom. Some people like to see, others to hear and others to do. The best training provides a combination of these opportunities.

There is a wide range of skills that users may bring to a job. No two users of the same equipment will operate it in the same way. If it is important that equipment is used in a systematic and standardised way then much more training or relearning will be required.

In complex and highly specific systems much time and money may be needed for training, evaluation of the work system and retraining. Airline pilots are a good example of how training can help people to use complex systems competently. However, pilots are also very carefully selected and well paid. Asking for the same amount of effort and accuracy from workers with little training and paid one quarter of the salary may mean that employers or managers may be disappointed in the workers' performance.

### Acquisition of physical skills

Physically skilled work involves quick and accurate muscular contraction, co-ordination of the different muscle groups involved, precision, concentration and visual control. Usually skilled work involves use of the hand(s) and in particular the fingers.

When a skill is being learned there are two phases: learning the movements and then adapting the body tissues involved. At first movements are done consciously and as training progresses the conscious part gradually reduces and the actions begin to become automatic. As the skill develops the movements change from jerky and unco-ordinated to smooth and flowing. In the first stages of skill acquisition extra muscle work occurs. Less energy is required for a skilled person doing exactly the same job as an unskilled person. As time progresses the body tissues adapt to the work by increasing muscle size or cardiovascular fitness.

Short training sessions, breaking the job up into parts and providing strict controls and good examples can improve skill acquisition. Short training sessions are necessary because a high degree of concentration is required and people tire quickly under these circumstances. Breaking the job into parts allows more difficult or critical parts to get more attention during the training and allows the practice of parts before putting the whole together. It is important that the best technique is developed. This is facilitated if accurate feedback and supervision are provided during the learning process.

## Skill development and individual differences

Differences between individuals should be taken into account when any type of training scheme is developed or offered to employees.

Employees differ in the following areas:

- knowledge they posses before training begins;
- the way that they learn new skills;
- the speed with which they learn new skills;
- confidence in dealing with unfamiliar situations.

Thus the type of training methods employed should be adapted to the learning needs of each individual. The main aim of skill acquisitions is that individuals achieve a satisfactory level of competence.

## Identifying training needs

The first stage of the training process is a review of training needs. This analysis should be performed on three levels:

1. **Organisational –** what training should be performed in the organisation and where is it needed?;
2. **Task/ job (usually called a task or job analysis) –** what skills or abilities are required to perform a specific task or job?;
3. **Personal –** what are the training needs of each individual?

## Types of training

There are several types of training that can be conducted:

- **Knowledge teaching –** the provision of knowledge to employees regarding a specific operation or system. This aids in teaching individuals the reasoning behind safe operating procedures or other safety measures;
- **On-the-job training –** job rotation and the use of mentoring relationships or apprenticeships where new employees learn the skills required to perform their job from more experienced workers;
- **Simulator training –** workers practise their skills on a simulated situation eg aircraft pilots, military personnel and medical staff;
- **Part-task –** workers are taught part of a task that often can require special practice or can be a particular skill that should be developed before comprehensive training is begun eg medical training;
- **Team-based training –** training is provided to groups of individuals who often work in teams. As a member of a team individuals are required to perform their respective jobs successfully and to co-ordinate their efforts to meet team goals;
- **Refresher training –** involves workers re-learning skills and can involve on-the-job drills eg evacuation drills or simulated exercises eg first aid training. Refresher training is essential for workers to sustain skills that are used infrequently but are necessary especially in emergencies;

Whichever training method is used, it should be evaluated. This is can be done in a number of ways but must test the skills and knowledge acquired with regard to what is required by the task.

### Training aids

Training aids are helpful for individuals who have acquired new skills to enhance their performance. They can include:

- reference or procedural manuals;
- checklists;
- charts, notices or labels;
- decision trees or decision charts;
- an in-house expert or outsourced technical support who can provide support when needed.

## Education and training in ergonomics

Education of stakeholders is important for a successful ergonomics program. By definition ergonomics requires that the people doing the work must be involved in the design of that work if solutions are to be successful. As well, if money, time, and expertise are used to produce an ergonomically sound workplace, then employees should understand why it has been so designed and how it can best be used. Training should encompass both of these elements.

Ergonomics training can be formal or it may be incorporated into participative activities such as design reviews, risk assessments, focus groups and quality circles. It may also be learned on-the-job through using checklists and tools developed to identify hazards and solve problems.

KEY PRINCIPLES

- All workers require regular training either to update their skills or to learn new ones.
- Different training methods are used for different types of work and workers as well as for the skills and knowledge required to be learned.
- The application of ergonomics requires worker involvement and training in order for workers to understand why changes are necessary and how best to use them.

***Further reading:*** • *Book 23: Kuorinka & Forcier*