ERGONOMICS

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A. Hazard Identification and Control Review

Detailed information on the legislated requirements for hazard assessment is included in the chapter on legislation. Detailed information on the process for identifying and controlling hazards and sample hazard assessment forms are included in the chapter on health and safety management systems. A brief overview is provided here to reinforce the importance of the basic principles of hazard identification, assessment and control.

What is a Hazard?

A **hazard** is any situation, condition or thing that may be dangerous to the safety or health of workers.

(OHS Code Part 1)

Identifying Hazards

The first step in preventing incidents, injuries or illness in the workplace is identification of all the hazards within the workplace that could cause injury or illness. In Alberta, the employer is responsible for conducting an overall hazard assessment in the workplace (Alberta OHS Code, Part 2); however, all workers should be able to recognize and identify hazards in the workplace on an ongoing basis. As work conditions change, so may the hazards, and it is essential that workers be alert and aware of their surroundings at all times.

Controlling Hazards

The hierarchy of controls applies to all types of hazards and is outlined below.

Whenever possible, hazards should be **eliminated**. If this is not possible, they must be controlled. **Control** means reducing the hazard to levels that do not present a risk to worker health. Controls, in order of preference, include:

- Engineering Controls
- Administrative Controls
- Personal Protective Equipment (PPE) (Used only when other levels of control are not possible or if additional protection is required to ensure the health and safety of workers.)

B. Legislation

The OHS Code, Part 14, is where employers will assess ergonomics hazards related to **lifting and handling loads**. There is also a requirement for employers to investigate whenever workers report symptoms of a musculoskeletal injury that they believe to be work related.

Summary of Sections of the Code Related to Lifting and Handling Loads

Section 208 requires employers to provide, where reasonably practicable, appropriate equipment for lifting, lowering, pushing, pulling, carrying, handling or transporting heavy or awkward loads. The intent of this section is to reduce or eliminate the manual handling of materials and, therefore, the possibility of injury.

Section 209 requires that, when it is not reasonably practicable to provide such equipment, loads be adapted to facilitate handling or that manual handling be otherwise minimized.

Section 210 requires employers to implement hazard assessments of manual materials handling activities.

Section 211 requires employers to investigate and take corrective measures (if indicated) whenever workers report symptoms of musculoskeletal injuries they believe to be work related.

C-Overview.ppt
Slides 1–2

C. Ergonomics Overview

Ergonomics is about fit: the fit between people, the things they do, the objects they use and the environments they work, travel and play in. When we talk about fit, we do not just mean physical fit, we are concerned with psychological and other aspects too. That is why ergonomics is often called human factors. The focus of this chapter is on the physical aspects of ergonomics.

Poor ergonomic conditions at work, home, school or play can negatively affect our health and safety and enjoyment of what we do. Ergonomists contribute to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people.

- Ergonomics literally means laws of work.
- Ergonomics is made up of two Greek words: "ergos" meaning "work" and "nomos" meaning "laws."
- These laws are simple:
  - We need a fit between people and what they do.
  - If good fit is achieved, the stresses on people are reduced. They are more comfortable, they can do things more quickly and easily, they make fewer mistakes and get injured less frequently.
- The process of designing for a better match between people and tasks is a continuous process – the goal is for a good fit between various and changing capabilities and any new tasks undertaken.

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See Handout 1 – What Is Ergonomics and Why Is it Important.

D. Work

D-Work.ppt
Slide 1

What Is Work?

Work can be thought of simply as activity – either mental or physical. Although it may not seem like it sometimes, the body works constantly, even when asleep! You carry out mental work whenever you use your brain to do something; e.g., read, watch television, solve a problem. You carry out physical work whenever you use your body to do something, such as walk, sit or lift.

(From the website: www.ergonomics4schools.com/lzone/work.htm)

Static and Dynamic Work

There are two types of muscle activity that apply to all work we do: static and dynamic.

- *Static* – this is where a muscle remains contracted for a period of time but there is no movement. Examples of this include:
  - holding a picture against the wall
  - standing in one place operating a foot pedal
  - pushing a heavy load

Holding a static or fixed posture can be very tiring as muscles do not have an opportunity to relax. The greater the force exerted, the more rapid the onset of muscle fatigue. Static muscle work cannot be maintained for long periods of time.

Any fixed posture will bring on symptoms; e.g., gripping something tightly for long periods like writer's cramp when writing essays or exams.

- *Dynamic* – this is where there is a regular contraction and relaxation of a muscle that results in movement. Examples include:
  - pulling open a drawer
  - walking up stairs

Dynamic work is less tiring and more efficient than static work.

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Handout 2 – Static and Dynamic Work provides two activities for students to help them think about static and dynamic work. The activities are also described below.

Activity 1

Hold a small book in each hand. Put one arm straight out in front of you and keep it in that position. This arm is doing static work. With your other arm, keep your elbow at your side and move your forearm up and down repeatedly. This arm is doing dynamic work. Which arm gets tired first? It is probably the one holding the book in front of you – the one apparently doing nothing!

D-Work.ppt
Slide 2

Activity 2

Try to identify some examples of jobs or sports that involve static and dynamic work.

E. Physical Capabilities

E-Capabilities.ppt
Slide 1

In order to work most effectively, we have to look at people and their capabilities. There has been research into what people can do – both physically and mentally – for many centuries. Because of research done using different groups of workers, we know what capabilities to measure. The capabilities of people to undertake activities include:

- ability to apply force; e.g., how much we can lift, push, pull, grab or press
- how well we are able to see things in our field of vision and how quickly we adapt to different levels of light
- ability to hear sounds in all ranges
- body dimensions, including how tall we are and how much we weigh will affect how well we fit in our home and work environments, and our ability to interact with things around us
- movement; i.e., how well and how far we are able to move our bodies and parts of our bodies; e.g., arm reach, stride length
- mental capacity; i.e., our ability to think, concentrate, remember and analyze situations
- physical endurance; i.e., how many times we can continue an activity or task before our body or muscles fatigue

These capabilities are subject to change as we get older, if our general health or fitness changes, or if we are tired, weak or sick. They are also different from one individual to the next.

What Physical Capabilities Are Important for Physical Work?

Everyone does some sort of physical work during their daily activities. The three important physical capabilities are:

- ability to apply force; i.e., how much we can lift, push, pull, hold, grab or press
- ability to move; i.e., how well and how far we are able to move our bodies and parts of our bodies
- ability to continue an activity for periods of time; i.e., physical endurance

All three capabilities involve using the muscles of our body. We might notice that when we try to use some muscles and parts of the body to apply force or move we get better results than using other parts.

Even though our physical capabilities include being able to apply force, move and perform activities for periods of time – we need to think about using the best designed parts of our body for the activities we need to do.

F. Anthropometry – Why Size Matters

Whatever we do, we work in an environment that sometimes limits how we interact with it. Take a car for example. The steering wheel is placed in a certain spot, the mirror in another and the seats and seatbelt in another. Think about the mini cars. Would basketball players choose to buy one? Would they be comfortable or cramped? This is an example of another important area in ergonomics, called anthropometry.

Anthropometry is that part of ergonomics that deals with body size and physical abilities, such as strength.

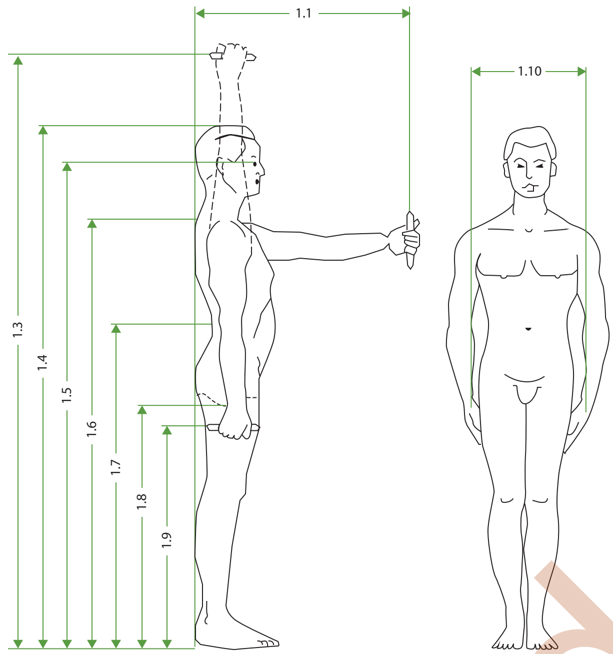
Because people come in all shapes and sizes, the products they use have to be designed to suit their physical characteristics. This applies to something as simple as the shape and softness of the grip on a pen, to the sizing of a backpack or the design of a car.

Anthropometric Tables

Fortunately for many designers, tables of body measurements have already been created. By actually measuring the body dimensions of thousands of people, both male and female, of different age groups and nationalities, scientists and ergonomists have created anthropometric tables.

Figure 1 shows various measured body dimensions. Dimension 1.7, for example, is a measure of elbow height above the floor. The "f" and "m" for the same dimension indicate female and male data. The percentile column provides the range of elbow heights for both females and males at three specific sizes of individuals. The final column provides examples of where elbow height is important; e.g., in setting the height of desks and counter tops. Figure 2 shows another anthropometric table with different data.

F-Anthropometry.ppt
Slide 1



Dimension Number and Name		Percentile				Examples
			5th	50th	95th	
1.4	Stature/body height	F	1510	1619	1725	Doorways
		M	1629	1733	1841	
1.5	Eye height	F	1402	1502	1596	Arrangement of scales, visual tasks
		M	1509	1613	1721	
1.6	Shoulder height	F	1234	1339	1436	Standing room, ramps
		M	1349	1445	1542	
1.7	Elbow height	F	957	1030	1100	Desks, sales counters, bars
		M	1021	1096	1179	
1.8	Functional downward reach	F	664	738	803	Trunks, bags, roller-cases
		M	728	767	828	
1.1	Functional forward reach	F	616	690	762	Controls, key panel
		M	662	722	787	
1.10	Shoulder breadth	F	323	355	388	Width of prison bars
		M	367	398	428	

Figure 1—Anthropometric Table – British Adults Aged 16 to 60 Years Old

F-Anthropometry.ppt
Slides 2–4

No.	Dimension	5th percentile	50th percentile	95th percentile
758	sitting height	889	942	995
330	eye height, sitting	762	819	869
529	knee height, sitting	526	567	609
678	popliteal (back of knee) height	406	444	481
751	shoulder-elbow height	337	366	394
194	buttock-knee length	568	613	658
420	hand length	179	193	206
411	hand breadth	82	89	96
416	hand circumference	203	218	234

Figure 2—Anthropometric Table – 40 Year Old U.S. Males

Now that we know what these tables look like, which one should we use? Since body measurements and physical abilities are different for males and females, for persons of different ages and persons of different nationalities, designers need to know for whom they are designing the product. In the case of office chairs, few are designed for children so designers of office chairs consider the body dimensions of adults of working age. In contrast, a toy or playground area designed for small children has to consider children's body measurements rather than the measurements of adults.

With so many tables of data available, the next question to answer is which body measurements – or which parts of the body – are important to the product's design. If we were designing a set of adjustable crutches, we would be looking at the height of the armpit above the floor, the length of the arm, the width of the hand and the grip size of the hand. We would not be interested in the length of the user's legs, although his or her weight would influence the necessary strength of the crutches.

Nobody Is Average

Although you might be of average height for your age, nobody is average in all body dimensions. You may have a longer than average hand length or your legs might be longer or shorter than the average. Figure 3 shows the extent to which leg length and trunk length can be different for three people of the same height.

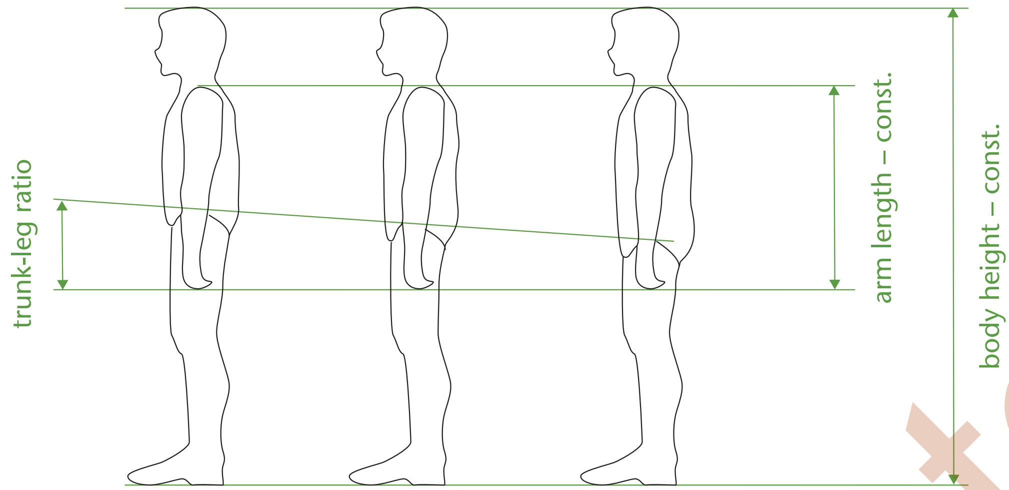


Figure 3—Different proportions of trunk and leg length for three people of the same height

This activity shows the extent to which students' height and hand length measurements vary when compared to the average for identically aged youth in Britain. The data for the British youth is shown in Figure 4 and on F–Anthropometry Slide 5.

Activity 3

To show you the extent to which you are not average, try measuring yourself. Shown in Figure 4 are the average heights and hand lengths of British youth aged 11 through 18. Measure your standing height (without shoes) and measure the length of your hand from the wrist to the tip of your middle finger. Compare your results to the values shown in the figure. Try to compare your personal results with other results in your class. All measurements are in millimetres.

	Height (mm)		Hand Length (mm)	
Age	**Girls**	**Boys**	**Girls**	**Boys**
11	1440	1430	155	155
12	1500	1490	165	165
13	1550	1550	175	190
14	1590	1630	175	190
15	1610	1690	180	195
16	1620	1730	180	195
17	1620	1750	180	200
18	1620	1760	180	200

Figure 4—Average height and hand length data for British youth

F-Anthropometry.ppt
Slide 5

F-Anthropometry.ppt
Slide 6

The Bell Curve

People differ widely in size and shape, even on simple measures, such as height and hand length. Imagine what would happen if you designed a product based on your measurements alone. It would only be suitable for people the same size and shape as you and, as a result, your product might be a total flop.

If you look at the heights of a group of adults, most seem to be about the same height. A few may be much taller and a few may be much shorter. If we graph the heights (or most other body dimensions) of a very large group of adults, the results take on the shape of a bell curve (see Figure 5).

The peak in the middle represents the average or mean height of the group. The mean is given a special name in anthropometry – the 50th percentile. Because the curve is symmetrical, 50% of the group is taller than the mean and 50% is shorter than the mean.

At the far edges of the curve are those people who are very tall or very short. To the far left of the average is the 5th percentile – meaning that 5% of people are shorter than this height. To the far right is the 95th percentile, meaning that only 5% of people are taller than this height. What you have between the 5th and 95th percentiles are the heights of 90% of the population.

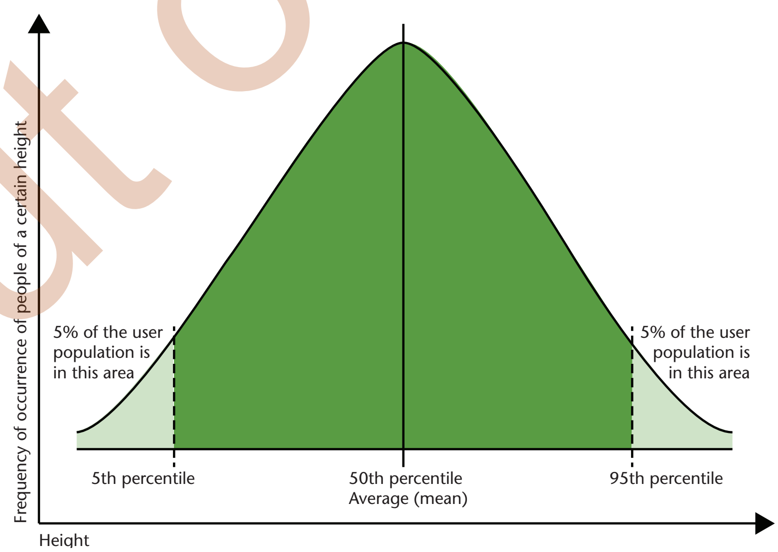


Figure 5—Typical bell curve for height

Activity 4: Setting Limits

Now that the concept of the 5th and 95th percentiles has been introduced, students should check their understanding. The handout for this activity is included in Handout 3.

Here are the instructions for the students:

Complete the table to indicate which body characteristic and percentile determines the design limit of the listed examples.

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Below is the completed version of the table.

	Design for the… • tallest male, shortest female? • shortest female reach, longest male reach? • weakest person, strongest person? • largest male, smallest female?	**5th or 95th percentile?**
Height of doorway	Design for the tallest male, all others will be able to get in without bumping their head	95th
Height of shelf above floor	Design for the female with the shortest reach, all other individuals will reach it easily	5th
Force required to open lid of container	Design for the weakest person, all others will have the strength to open it	5th
Width of opening into storage cupboard	Design for the largest male, all others will be able to get through (consider heavy winter clothing if it applies)	95th

The 90% Solution

Since it is usually not practical to design products that fit all people, good designers disregard extremes of body size – the 5% of people at either end of the bell curve. Many designers manage to meet the needs of 90% of people by allowing the equipment or product to be adjusted. For example, seating and work surfaces may adjust up, down or sideways or be designed to tilt.

F-Anthropometry.ppt
Slide 7

In some situations, a designer may need to use the 5th or 95th percentile because of the type of product. For example, a work space must provide enough headroom, legroom and elbow room to allow a person to work safely. Handles and openings for hands must be large enough to allow for large hands to get in and out easily. Designing clearances for the largest person – at the top end of the 90% range – means that there will always be enough clearance for smaller persons as well.

The location of controls or the height of shelving depends on the distance a person can reach. Designing reach distances for the smallest person – at the bottom end of the 90% range – means that controls and shelving are always within the reach of larger persons.

F-Anthropometry.ppt
Slide 8

So Why Do Designers Get it Wrong?

Failing to consider the size and shape of the person using the product is the main reason. The thinking goes that if the product suits the designer, based on his or her size and shape, it must be good enough for everyone else. This is incorrect.

The second line of thinking is that if the product is good enough for the average person, it must be good enough for everyone else. This is also incorrect. Designers should be using readily available body size information and avoiding the average. Designing a screw-off bottle cap means you need to design it so that the weakest 5% of people can open it. A bottle designed for the strength of the average person means that 50% of people cannot remove the lid.

Finally, there is an assumption that everyone's needs cannot be met and that good design is too expensive. Again, this is incorrect. Meeting the needs of 90% of the population is not that difficult. A good design will pay for itself by keeping users happy and safe.

In some cases, particularly where safety is concerned, the designer may have to consider people from the 1st to the 99th percentiles. This would ensure that the product meets the needs of 98% of the population rather than the usual 90%.

G. What Is Studied in the Workplace?

Now that we have some background in how the muscles function and how our size and shape (i.e., anthropometry) influence how we work, we can talk about the right balance of our physical capabilities against activity demands. Most study of this balancing has been in the sports area (by exercise physiologists) and in the workplace (by ergonomists and other professionals). Occupations like fire fighters have been studied extensively here in Alberta.

All work can be broken down into tasks. Ergonomists look at each task (called job task analysis) to determine how the job is done and what stresses it may put on the body. Some physical hazards for the muscles, ligaments, joints and nerves include:

- maintaining awkward body **posture**; e.g., having to keep the neck twisted to look backwards when using a forklift for extended periods of time
- applying **force** to lift, pull, push, carry or drag; e.g., drilling holes, shovelling snow, moving a shopping cart full of groceries in the supermarket
- doing the same movements **repeatedly**; e.g., removing boxes from a moving conveyor, clicking the mouse over extended periods of time, practising a tennis swing
- working with **vibrating** equipment; e.g., operating a chainsaw
- working in very hot or cold places
- time (duration)
  - how long each task must be performed
  - length of the working day

Introducing new technology constantly changes these job demands. For instance, with increasing use of computer technology in all jobs, more and more people work in a sitting position for long periods of time.

Awkward Posture

Posture is the position of the body while performing work activities. Awkward posture is associated with an increased risk for injury. It is generally considered that the more a joint moves away from the neutral (natural) position – especially without any support – the greater the risk of injury.

www Problem Postures

Specific postures or positions in different parts of the body have been associated with injury. For example:

Wrist

- flexion/extension; i.e., bending up and down
- ulnar/radial deviation; i.e., side bending

Shoulder

- abduction/flexion; i.e., upper arm positioned out to the side or above shoulder level
- hands at or above shoulder height

Neck (cervical spine)

- rotation or turning the neck too far; e.g., looking behind you when reversing the car out of a parking spot
- flexion/extension; e.g., bending the neck forward and backwards
- side bending; e.g., trying to hold the telephone receiver on the shoulder

Low back

- bending at the waist, twisting

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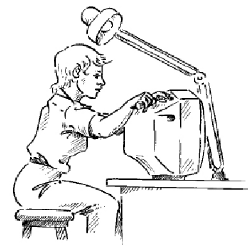
Activity 5

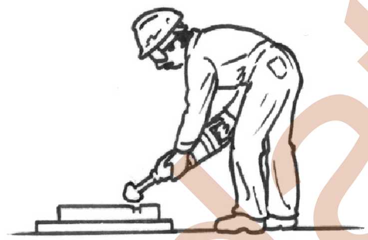
Using Handout 4, have students identify the awkward postures in each drawing. Answers are provided on the next page.

Neck is rotated and flexed.
Wrists are extended.



Shoulders are abducted and flexed.
Wrists are ulnar deviated.

Hands are above shoulder.
Wrists are ulnar deviated.



Back is fully flexed.

Back is twisted.

Wrist is ulnar deviated.

G-WhatStudied.ppt
Slides 1–3

Force

Force is the amount of muscular effort required to perform a task. Generally, the greater the force, the greater the degree of risk.

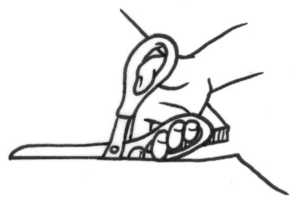


Figure 6—Cutting a heavy fabric requires significant effort from the muscles in the forearm, wrist and hand.

Repetition

Repetition is the number of a similar exertions performed during a given period. A warehouse worker may lift three boxes per minute from the floor to a countertop. A process line worker may move 40 or 50 boxes per hour from the conveyor belt and an assembly worker may make 20 units per hour. Repetitive motion has been associated with injury and worker discomfort.

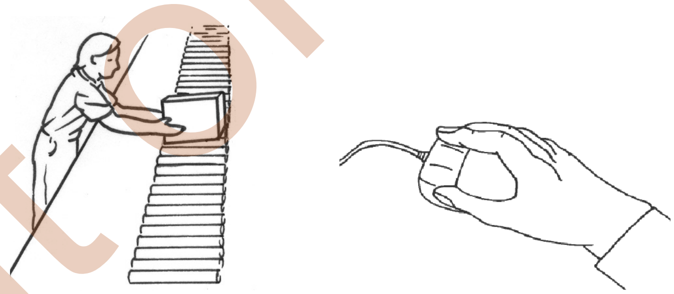


Figure 7—If certain muscles are required for the same task over and over again, there is a risk of injury.

Vibration

Powered hand-held tools, such as a chain saw or grinder, can cause hand-arm vibration.

People who sit or stand on a vibrating floor or seat have their entire body affected.

Risk of vibration-related injury depends on:

- strength of the vibration
- frequency of the vibration
- how long the person is exposed, usually measured in years
- part(s) of the body affected

H. Body Mechanics and Injury Prevention

H-BodyMechanics.ppt
Slides 1–2

One of the most important ways to reduce the risks of work-related injuries is to improve body mechanics. Body mechanics refers to how the body is used. It is about using some of the principles previously discussed – like using the largest muscles to do the heaviest work.

Principles of ergonomics and body mechanics have been used to develop guidelines and programs to help lower the risk of workplace injuries. There are numerous types of injuries that can happen on the job, including acute injuries, such as falls or crush injuries. However, the most common workplace injuries are musculoskeletal injuries that result from exposure to the risk factors described on the last few pages. When these risk factors happen in combination, the higher the potential for injury.

What Are Musculoskeletal Injuries and How Do They Happen?

Musculoskeletal injuries, or MSIs, go by many different names, including:

- repetitive strain injuries (RSIs)
- repetitive motion injuries (RMIs)
- cumulative trauma disorders (CTDs)

Specific types of MSIs include:

- carpal tunnel syndrome (CTSs); i.e., injury to the wrist
- bursitis, injury causing inflammation to the bursa – a part of the joints
- tendonitis or inflammation in the tendons; e.g., tennis elbow
- trigger finger; i.e., injury usually to forefinger from operating triggers on tools
- hand/arm vibration syndrome (HAVS)

Whatever the term used, the effect is the same; bones, joints, ligaments, tendons, muscles and other soft tissues are being injured. Many MSIs have names that describe the cause of the injury; e.g., tennis elbow is an MSI that can result from the repetitive swinging of a tennis racquet or from other repetitive arm movements similar to those used by tennis players. Carpet layer's knee, letter carrier's shoulder and pizza cutter's wrist are other examples. MSIs also have medical names, such as carpal tunnel syndrome, thoracic outlet syndrome and tendonitis.

No matter what you call them, MSIs can involve inflammation, swelling and pain in the affected area. They can range from a minor nuisance to severe disability. In the occupational or workplace setting, there are a number of symptoms that workers may experience that tell them there is something wrong.

Injuries Progress in Stages

- The first indication of a muscular strain on the body is aching, stiffness and tiredness. Think of how your legs feel if you do too much physical activity; e.g., like running up lots of stairs.
- As we continue doing the same things, the ache progresses into pain, tenderness or soreness, loss of sleep, difficulty applying force (e.g., gripping) and problems in moving hands, back or shoulders.
- As the pain becomes an injury, we may not be able to do the work or even everyday activities.

Stages of Injury

Most people affected by MSIs do not realize that if they do nothing to correct their problem they may be headed for increasing and potentially devastating disability.

There are three stages of injury:

Stage 1

- Discomfort may persist for weeks or months but is reversible.
- Most workers experience pain and weakness during work activities but improve on days away from work.
- Interference with work tasks is minimal.

Stage 2

- Discomfort may persist for months.
- Symptoms begin more quickly and last longer.
- Physical signs may be present and sleep may be disturbed.
- Work tasks may be difficult to perform.

Stage 3

- Discomfort may persist for months or years.
- Symptoms are always present, even at rest.
- Activities of daily living are disrupted and sleep is disturbed.
- The person is unable to perform light duties at work.
- The likelihood of recovery is poor.

When you experience aches and pains from performing tasks, you should see your doctor immediately, tell your supervisor (under Section 211 of the OHS Code) and work with your supervisor to figure out what is causing the injury and how to correct the hazard.

Reality Check

The risk factors for MSI can occur in many different types of jobs. Some of the more common examples are:

supermarket cashiers – stand and repetitively lift and scan groceries. Sometimes, they have to twist and overreach to do the job; e.g., when placing grocery bags into shopping carts.

tree planters – repetitively bend and apply force to dig earth and plant trees in the ground. They have to carry their trees in a pouch and this can be heavy. They are often paid according to the number of trees they plant so they are encouraged to work very quickly, which further increases the repetition and force used.

assembly line operators – do repetitive work, sometimes in awkward body positions and controlled by the speed of the assembly line.

computer operators – do highly repetitive motion with hands while holding arms, shoulders and the rest of the body in a static position. If the workstation is not adjusted properly, the chance of awkward postures increases.

Think of some other occupations where MSI risk factors might occur.

Relating ergonomic injuries to everyday life can be a powerful reminder of why we need to identify situations that may cause us injury and make changes to protect ourselves. An example to consider relating to students: If you have an injury in your lower back from constant poor posture when studying or slouching over the computer screen, you may find that you are not able to swing the golf club or baseball bat without some pain. Sore hands and wrists from excess mouse use or gaming may mean that you have a hard time brushing your hair. Preventing these injuries in the first place is important!

H-BodyMechanics.ppt
Slide 3

I-MaterialsHandling.ppt
Slides 1–2

I. Manual Materials Handling

Activities

The lifting and handling of loads is often called manual materials handling (MMH) because materials or loads are moved by hand; i.e., manually. This is often physically demanding work. Manual materials handling involves the following activities:

- lifting
- lowering
- pushing
- pulling
- carrying
- maneuvering

MMH is not limited to boxes filled with things. Think of the type of loads that have to be handled at hospitals, long-term care facilities, veterinary clinics, pet stores and zoos. Trying to lift and carry an elderly person, a nervous dog, or a 4 m long boa constrictor has its own special problems. These loads may move unpredictably, lack appropriate lifting handles and resist being lifted and handled.

The first question a person needs to ask when facing a manual materials handling problem is **How am I going to do this?** While using your own strength is often the most obvious answer, it may not be the best or safest way to go. Before throwing all your muscle into the task, think about what equipment is available to help you do it more safely and faster.

Equipment, such as hand trucks, cranes, hoists, scissor lifts, conveyors, powered mobile equipment and lift trucks, overhead handling and lifting equipment and vacuum lift devices all provide a mechanical advantage during the handling task. Equipment as simple as wheeled platforms for garbage containers can help reduce the potential for a worker injury.

Adapting Loads

In some situations, it may not be possible to use or have access to mechanical handling equipment, but it may be possible to change the load or the handling task. Here are some ways that a person could adapt the load to make it easier to lift, lower, push, pull, carry, handle or transport, without injury:

- Reduce the weight of the load by dividing it into two or more lighter loads.
- Reduce the capacity of the container so that it cannot hold as much.
- Provide handholds.
- Reduce the distance the load must be held away from the body by reducing the size of the packaging. The further the load is away from the body, the more effort is required to hold and handle it.

A different way to adapt the load is to make it impossible to carry; i.e., make it heavier instead of lighter. For example, order product in 200 kg sacks, rather than 20 kg bags. The heavier sacks will require use of mechanical equipment.

I-MaterialsHandling.ppt
Slide 3

Activity 6

Handout 5 asks students to discuss the pros and cons of different ways to adapt a load; e.g., boxes of shoes. Some answers are provided below; students might identify others.

Page 39

Option	Advantages	Disadvantages
Move one box at a time	• light and easy to lift	• make a lot of trips
Move four boxes at a time	• fewer trips	• awkward to carry four loose boxes
Place 10 boxes in a larger box	• fewer trips	• box is a little awkward and hard to hold onto
Place 20 boxes at a time on a cart and push the cart to the storeroom	• fewer trips • easier to push cart than carry boxes • easy to load/unload cart because it is at a good height	• may have uneven floor surface to go over • may have to go find the cart • stacking the boxes too high could obstruct view

I-MaterialsHandling.ppt
Slides 4 –7

Load that Cannot Be Adapted

If the load cannot be adapted, try to minimize the manual handling required to move and handle the load. Examples of how to do this include:

- Team lift the object with two or more workers.
- Improve the layout of the work process to minimize the need to move materials.
- Reorganize the work method(s) to eliminate or reduce repeated handling of the same object.
- Rotate workers between jobs that require manual handling and those with little (or no) manual handling.
- Use mobile storage racks to avoid unnecessary loading and unloading.

Real World Solutions

The following examples describe a particular materials handling problem, a solution and its benefits. These come from the real world. The teacher can use them to demonstrate ideas for safer and better manual handling.

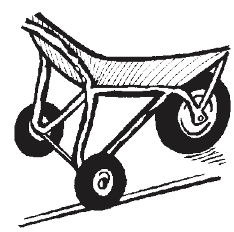
LIFTING HUNDREDS OF PLANT POTS

THE PROBLEM
Workers at garden centres may need to handle hundreds of small plant pots in a day – reaching, lifting, carrying and lowering them.

A SOLUTION
A light, length-adjustable pot lifter can handle several pots at once. The lifter could be adapted for use with other objects.

BENEFIT
By greatly reducing repetitive bending and lifting, the worker avoids overusing the back and arms.

WHEELBARROW CONVERTED TO DUMP CART



THE PROBLEM
Wheelbarrows need to be raised up by the handles to ride on their single wheel.

A SOLUTION
Convert the wheelbarrow to a push cart by adding two wheels at the back. Various conversion kits are available commercially.

BENEFITS
Workers avoid unnecessary lifting, and when necessary the wheelbarrow can still be used on its single front wheel.

(Source: OHS Magazine, Sept 2005)

No Equipment, Single Person Manual Handling

After trying everything else, you may still end up without any handling equipment and have to move and handle a load. At this point, you have to know that material handling injuries happen when lifting and handling tasks involve:

- too much weight
- objects that are located too low to the floor (i.e., below the knees) or too high above the floor; i.e., above the shoulders
- objects that are too far away from the body
- twisting or bending
- repeating the movement too often
- handling objects without handles or a way to grasp them properly
- handling objects that are too large to grasp easily

I-MaterialsHandling.ppt
Slides 8–9

Lifting Zones

The optimal load handling height for heavy materials is between your shoulders and knees. Loads should be held as close to the body as possible. Figure 8 shows this by indicating the preferred zone for lifting and handling materials, with fair zones above and below it corresponding to the vertical area between shoulders and knees. It is important to note that the worst zones are above the shoulders, below the knees and anything more than forearm length from the body. You should avoid bending low or lifting high when lifting and handling loads to reduce the risk of injury.

Simon Says Lift!

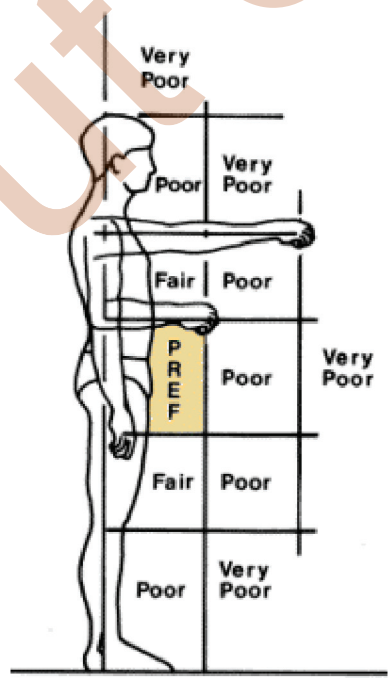


Figure 8—Best and worst zones for manual materials handling

I-MaterialsHandling.ppt
Slide 10

Freestyle Lifting Technique

Are you still being told that the only way to lift an object is to place it between your knees and then lift with your legs, not your back? The person who gave that advice never had to lift a bundle of 3 m long pipes or a washer and dryer.

This advice does not reflect the real world of over-sized pipes, appliances and boxes. It also assumes that many people have sufficient leg strength to perform the lift and many simply do not. With up to 80% of all adults expected to experience back pain during their lifetime, learning to lift, lower and move objects safely is very important.

For many years, workers were taught to keep their backs straight and lift with your legs. Despite years of workers being told to lift this way, back injuries have not decreased, leading researchers to question this method of lifting. In practice, most people use a semi-squat posture, with both the back and knees slightly bent.

People make up their own minds as to the most efficient way of lifting loads in terms of energy and time. This so-called **freestyle technique** is fine, as long as you follow these basic principles:

- **Keep the natural curve in your lower back.** When standing straight, the lower back naturally curves to create a slight hollow. Always try to maintain this curve when lifting, lowering or moving objects. The spine and back are their most stable in this position.
- **Contract your abdominal muscles.** Contract the abdominal muscles during lifting, lowering or moving activities. This improves spine stability. Sometimes described as bracing, contracting the abdominal muscles even slightly (as little as four to five percent) improves spine stability and reduces the likelihood of injury.
- **Avoid twisting.** Twisting the back can make it less stable, increasing the likelihood of injury. Bracing helps reduce any tendency to twist.
- **Hold it close.** Keep the load as close to your belly button as possible. Hugging the load in tight to the body reduces the strain on back muscles and trunk. If necessary, protective clothing, such as leather aprons, should be used so that sharp, dirty, hot or cold objects can be held as close to the body as possible.

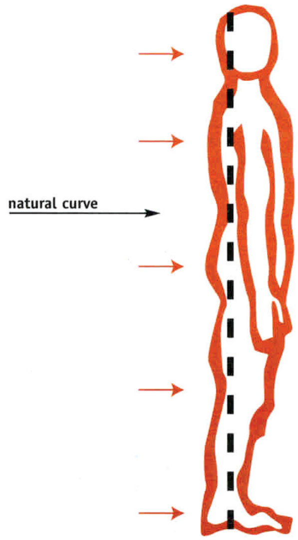


Figure 9—The curve of your back

How Much Can I Lift?

A question often asked by workers is, What is the maximum weight that I should be lifting at work? The answer comes in two parts. First, there is no weight of load, however small, that guarantees complete safety from injury.

And second, it is difficult and often inappropriate to state a single maximum weight of load. So many factors influence the weight that can be handled safely that a single answer cannot cover all possible situations. The factors that need to be considered include:

- the starting height of the lift
- the finishing height of the lift
- the frequency of lifting; e.g., twice per hour, twice per minute
- the duration of lifting activities; e.g., for one hour, entire shift
- how much twisting of the body takes place
- whether the lift is performed with one hand or two hands
- the distance that the object is away from the body
- the size, shape and texture of the object
- the presence of appropriately placed handholds on the object
- whether or not the lift must be performed in a space that restricts or prevents worker movement
- whether the object has a changing centre of gravity; e.g., water in an aquarium, a half filled box of bolts
- whether the object is alive, like a person or animal

I-MaterialsHandling.ppt
Slides 11–13

In addition, there are personal factors that will impact your risk of a lifting related injury:

- gender – typically males are stronger than females, so lifting a 20 kg object will put less strain on the average male
- age – most people lose muscle as they age, starting as early as their 30's
- general health/fitness – generally, someone with a stronger set of core muscles is less prone to a lifting related injury
- previous injury – someone with a previous back injury is at a higher risk of future injuries

I-MaterialsHandling
Slides 14–15

What about Back Belts?

So far, we have looked at mechanical devices to help with lifting (i.e., engineering controls) and procedures, such as two-person lifts or splitting up a load; i.e., administrative controls. Is there any personal protective equipment that can be used when lifting?

You may have seen workers at a local hardware store or garden centre wearing back belts. They often look like a weightlifter's belt and are called back or lumbar supports. Typically, a back belt is a wide elastic band (with or without suspenders) wrapped around the waist and lower back and worn on the outside of work clothes.

Although purchased in the belief they prevent back injury, scientific evidence supporting claims of injury prevention is scarce. Many health and safety organizations such, as Alberta Occupational Health and Safety, recommend that back belts not be used to prevent back injuries among workers who have never been injured.

One concern about back belts is that their long-term use may make workers dependent on them, weakening muscles of the lower back and abdomen. Problems may also arise from a worker's false sense of security when wearing the belt. Believing they are protected, workers may lift more weight more often, exposing themselves to greater risk of injury.

It is important to know, however, that back belts may be appropriate in the treatment of certain back injuries. In these cases, a back belt should be offered to an injured worker but only on the advice of a medical professional.

Push or Pull?

The cart is loaded and must be moved. Assuming that you have the option of pushing or pulling it, what should you do?

All else being equal, loads should be pushed rather than pulled. The reasons for this include:

- Body weight moves the load. Most people can develop higher push forces than pull forces as they lean their body weight into the load.
- Watch where you are going. Pulling while walking backwards means that the person is unable to see where he or she is going.
- Avoid banging your feet. The feet can be run over and the ankles struck painfully when pulling carts or trolleys.
- Avoid shoulder and back injury. Pulling a load while facing the direction of travel means that the arm is stretched behind the body, placing the shoulder and back in an awkward position. This increases the likelihood of injury to the shoulder and arm.

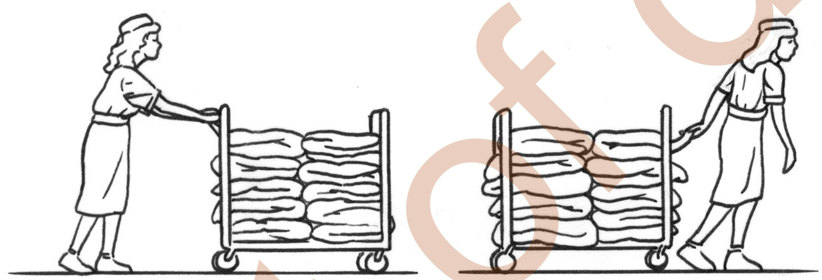


Figure 10—Pushing is preferred to pulling with an arm extended backwards

If there is a choice of carts or trolleys for pushing, try to get one with handles at the right pushing height for you. For pushing, the handle should be at a height between your elbow and hip. You can also use carts and equipment with continuous vertical handles (Figure 11) that allow workers to place their hands at an appropriate height. (For pulling, the handle should be at a height between the hip and knee.)

If pushing on the load itself will not cause it to shift or slide off the cart, workers can push on the load, instead of the handle; e.g., a refrigerator on a wheeled dolly. Pulling a load almost always requires a handle.

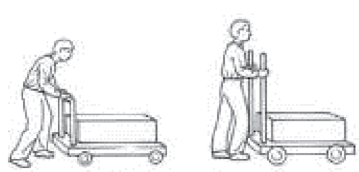


Figure 11—Pushing a load with handles too low – advantage of continuous vertical handles

I-MaterialsHandling.ppt
Slide 16

J. Applying Ergonomics at Home: Class Activity/ Question Time

Ergonomics is an integral part of our everyday lives. Remind students of examples they experience every day:

- Watching TV while sitting on the floor and looking up at the screen. After a half-hour show, your neck may begin to ache – that is because the posture is putting strain on your neck.
- Video games! One game turns into two and so on and so on. All the while you are hitting the small keys on a keypad, using a joystick, eyes glued to the screen. It does not take long before you are rubbing your eyes, shaking out your hands and feeling a little stiff from sitting. Again, the posture and what you are doing is beyond the normal comfort range for human capabilities. Children are now being diagnosed with MSIs to their hands/thumbs.
- How about making a snack in the kitchen? How would it feel if the counter height were six inches lower? How about a foot lower? Would making a sandwich be more difficult if you had to stoop down to do it? Kitchen counters are built to a standard height to make them less stressful for adults of average height. (Of course, if you are significantly taller or shorter than average they still will not suit you.)

J-Applying.ppt
Slide 1

Activity: Work Surface Height

- What is wrong here?
- Make two suggestions to correct the situation.

Possible Options:

- Raise the counter height and provide a step for shorter workers.
- Make the counter adjustable to suit the needs of different users.

What is Ergonomics and Why Is It Important?

Ergonomics is important in everyday life. Think of yourself watching TV and then think of your posture. How are you positioned? Are you comfortable? Will you be comfortable after you get up or will you be stiff? In learning about ergonomics, you will have the opportunity to understand why it is important, how it affects our lives and what you can do to prevent injuries before they occur.

Ergonomics is about fit – the fit between people, the things they do, the objects they use and the environments in which they work, travel and play.

Things to Consider…

When you are performing a task, you need to consider two things:

- What are **you** capable of doing? Think of your classmates and the sports they excel in. For different classmates, it could be weightlifting, running or gymnastics. Then, think about the differences in capabilities that your classmates possess that allow them to perform the different activities. You need to recognize your own capabilities and limitations before beginning a particular task.
- The other important consideration is the **activity**. Compare the tasks of mowing the lawn versus shovelling snow. Both these activities require you to work for a period of time but one involves pushing and the other involves lifting. Both tasks put stresses on your body but in different ways. Therefore, you have to make sure the task is within your capabilities and you can use your body effectively to reduce the chances of injury.

Static and Dynamic Work, Activity 1 and 2

Activity 1

Hold a small book in each hand. Put one arm straight out in front of you and keep it in that position. This arm is doing static work. With your other arm, keep your elbow at your side and move your forearm up and down repeatedly. This arm is doing dynamic work. Which arm gets tired first? It is probably the one holding the book in front of you – the arm apparently doing nothing!

Activity 2

Try to identify jobs and sports that show static and dynamic work. Examples might include rowing, cycling, typing or reading.

Types of Work	Examples
Dynamic – whole body (Muscles in upper and lower body regularly contract and relax.)	
Static – whole body (Muscles remain contracted, with no movement.)	
Static/Dynamic (Some muscles remain contracted while others are active.)	

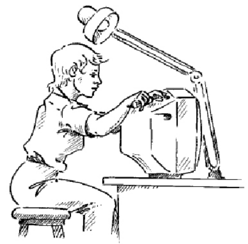
Activity 4: Setting Limits

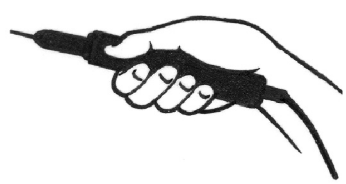
Complete the table to indicate which body characteristic and percentile determines the design limit of the listed examples.

	Design for the… • tallest male, shortest female? • shortest female reach, longest male reach? • weakest person, strongest person? • largest male, smallest female?	5th or 95th percentile?
Height of doorway		
Height of shelf above floor		
Force required to open lid of container		
Width of opening into storage cupboard		

Activity 5: Spot the Awkward Posture

Identify the awkward postures in each sketch. Discuss the reasons for your choices.





Activity 6: Little Boxes

Discuss the following scenario and brainstorm ideas to complete the chart.

You are working in a shoe store. A new shipment of 100 boxes of shoes arrives and your supervisor asks you to move them from the loading dock to the storeroom. There are several ways to do this. Think about each one listed in the chart below and list the advantages and disadvantages of each option.

Option	Advantages	Disadvantages
Move one box at a time		
Move four boxes at a time		
Place 10 boxes in a larger box		
Place 20 boxes at a time on a cart and push the cart to the storeroom		

ERGONOMICS

Ergo-what?

Ergonomics is about fit – the fit between people, the things they do, the objects they use and the environments in which they work, travel and play.

- Physically fit: can I reach all the controls in the airplane cockpit?
- Psychologically fit: can I interpret the information from the cockpit display, make the right decision and execute the action properly?

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C-Overview.ppt Slide 1

ERGONOMICS

Ergonomics

- literally means "laws of work"
- ergonomics strives for a good fit between the person and what he or she does
  - stresses on person reduced
  - person is more comfortable
  - person can do things more quickly/easily
  - person makes fewer mistakes
  - person is less likely to be injured

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C-Overview.ppt Slide 2

ERGONOMICS

What is Work?

- activity – either mental or physical
  - read, do homework, practise guitar, play computer games
  - play sports, go for a walk, wash floors

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D-Work.ppt Slide 1

ERGONOMICS

Jobs and Sports that Show Static and Dynamic Work

Types of Work	Examples
Dynamic – whole body (Muscles in upper and lower body regularly contract and relax.)	rowing, playing golf, hockey
Static – whole body (Muscles remain contracted, with no movement.)	sentry on guard
Static/Dynamic (Some muscles remain contracted while others are active.)	cycling, working at computer

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D-Work.ppt Slide 2

ERGONOMICS

Physical Capabilities

- ability to apply force – how much a person can lift, push, pull, grab or press
- vision
- hearing
- body dimensions, including height and weight
- range of motion; i.e., reach and flexibility
- mental capacity; i.e., our ability to think, concentrate, remember and analyze
- physical endurance; i.e., how long a person can continue an activity

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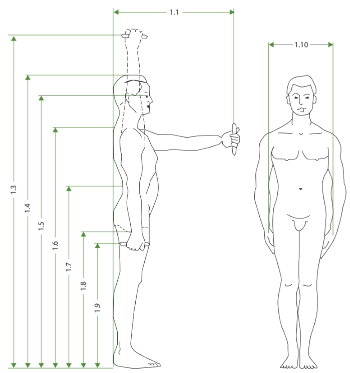
E-Capabilities.ppt Slide 1

ERGONOMICS

Anthropometric table – UK adults (16 to 60 years old)



Dimension Number & Name			Percentile			Examples
			5th	50th	95th	
1.4	Stature/body height	F	1510	1619	1725	Doorways
		M	1629	1733	1841	
1.5	Eye height	F	1402	1502	1596	Arrangement of scales, visual tasks
		M	1509	1613	1721	
1.6	Shoulder height	F	1234	1339	1436	Standing room, ramps
		M	1349	1445	1542	
1.7	Elbow height	F	957	1030	1100	Desks, sales counters, bars
		M	1021	1096	1179	
1.8	Functional	F	664	738	803	Trunks, bags, roller-cases
	downward reach	M	728	767	828	
1.1	Functional	F	616	690	762	Controls, key panel
	forward reach	M	662	722	787	
1.10	Shoulder breadth	F	323	355	388	Width of prison bars
		M	367	398	428	

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F-Anthropometry.ppt Slide 1

ERGONOMICS

Anthropometric Table – body size of 40 year old U.S. males

No.	Dimension	5th percentile	50th percentile	95th percentile
758	sitting height	889	942	995
330	eye height, sitting	762	819	869
529	knee height, sitting	526	567	609
678	popliteal height	406	444	481
751	shoulder-elbow length	337	366	394
194	buttock-knee length	568	613	658
420	hand length	179	193	206
411	hand breadth	82	89	96
416	hand circumference	203	218	234

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F-Anthropometry.ppt Slide 2

ERGONOMICS

Anthropometric Data

- Body measurements and physical abilities are different for:
  - males and females
  - persons of different ages
  - persons of different nationalities
- Designers need to know for whom they are designing the product.
- Designers need to know which measurements are important in the design.

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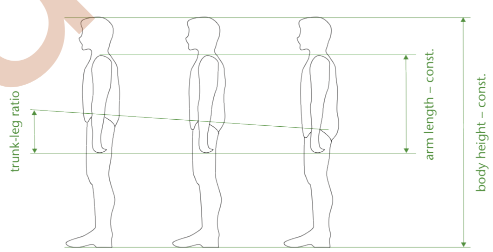
F-Anthropometry.ppt Slide 3

ERGONOMICS

Nobody Is Average

- No one is average in all body dimensions.
- Everyone is different, even if we look more or less the same.



Different proportions of trunk and leg length for three people of the same height

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F-Anthropometry.ppt Slide 4

ERGONOMICS

How Do You Compare?

	Height		Hand Length	
Age	Girls	Boys	Girls	Boys
11	1440	1430	155	155
12	1500	1490	165	165
13	1550	1550	175	190
14	1590	1630	175	190
15	1610	1690	180	195
16	1620	1730	180	195
17	1620	1750	180	200
18	1620	1760	180	200

Average height and hand length data for British youth

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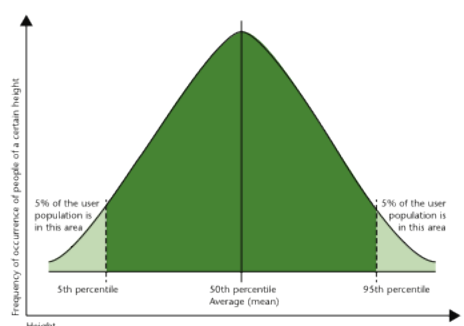
F-Anthropometry.ppt Slide 5

ERGONOMICS

Bell Curve (for height)

- 50th percentile: 1/2 population is taller than this; 1/2 is shorter
- 95th percentile: 5% of the population is taller than this
- 5th percentile: 5% of the population is shorter than this
- 90% of the population fall between the 5th and 95th percentile



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F-Anthropometry.ppt Slide 6

ERGONOMICS

Product Design Basics and Anthropometric Data

- usually not practical to design products that fit all people
- normally disregard extremes of body size – the 5% of people at either end of the bell curve
- needs of 90% of the target population are usually met by making the equipment or product adjustable

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F-Anthropometry.ppt Slide 7

ERGONOMICS

Why Do Designers Get it Wrong?

- They design for someone physically like them and do not know about (or ignore) anthropometric data.
- They design for the average person, making the product unusable for a large proportion of the population.

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F-Anthropometry.ppt Slide 8

ERGONOMICS

Force

- Force is the amount of muscular effort required to perform a task; generally, the greater the force, the greater the degree of risk.
- It is important to compare the force required to the muscle group doing the work – your pinky finger is not as strong as your bicep.

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G-WhatStudied.ppt Slide 1

ERGONOMICS

Repetition

Repetition is the number of similar exertions performed during a given period.

- A production operator might have to move one box of widgets every minute during an eight-hour shift.
- A data entry clerk might have to type 70 key strokes per minute for an eight-hour shift.

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G-WhatStudied.ppt Slide 2

ERGONOMICS

Vibration

There are two types of vibration:

- hand-arm – from hand-held power tools
- whole body – from sitting or standing on a vibrating surface; e.g., a car with poor shocks

Risk/severity of vibration-related injury depends on:

- strength of the vibration
- frequency of the vibration
- how long the person is exposed, usually measured in years
- part(s) of the body affected

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G-WhatStudied.ppt Slide 3

ERGONOMICS

Musculoskeletal Injuries (MISs)

Include injuries to the bone, muscle, tendon, ligament or other soft tissues.

Also called:

- repetitive strain injuries (RSIs)
- repetitive motion injuries (RMIs)
- cumulative trauma disorders (CTDs)

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H-BodyMechanics.ppt Slide 1

ERGONOMICS

Common types of MSIs include:

- carpal tunnel syndrome – affects the wrist and hand
- bursitis – causes inflammation of the bursa sac (a part of the joints)
- tendonitis – causes inflammation of the tendons
- trigger finger – causes injury to finger from operating trigger activated tools
- hand/arm vibration syndrome (HAVS) – causes injury from operating power tools

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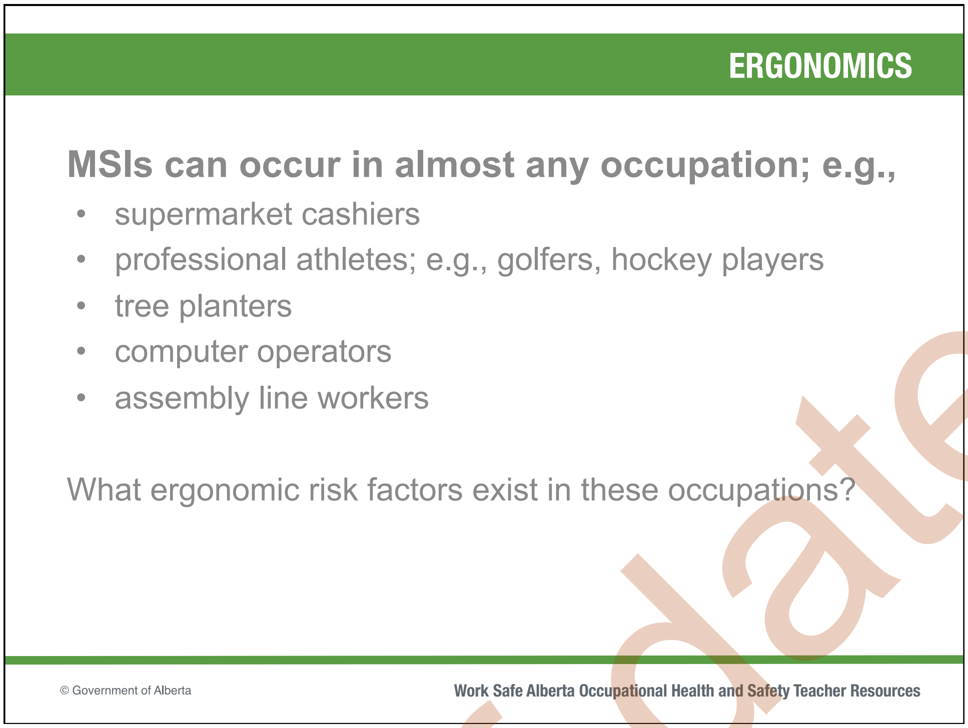
H-BodyMechanics.ppt Slide 2



H-BodyMechanics.ppt Slide 3

ERGONOMICS

Manual Materials Handling (MMH)

Involves the:

- lifting
- lowering
- pushing
- pulling
- carrying
- maneuvering

of loads.

Loads can include:

- small boxes
- washing machine
- a dog or boa constrictor
- obese patient

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I-MaterialsHandling.ppt Slide 1

ERGONOMICS

Examples of Manual Handling Equipment:

- hand trolley
- drum lifter
- rotating pallet holder
- magnetic lifting head on overhead crane
- variable height scissor lift
- drum truck

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I-MaterialsHandling.ppt Slide 2

ERGONOMICS

Adapting Heavy or Awkward Loads

- Reduce the weight of the load by dividing it.
- Reduce the capacity of the container so that it cannot hold as much.
- Provide handholds.
- Change the packaging so the load can be carried closer to the body.
- Increase the weight of the load so that lifting aids **must** be used.

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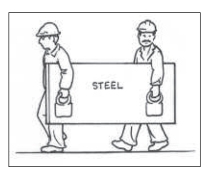
I-MaterialsHandling.ppt Slide 3

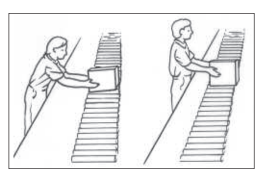
ERGONOMICS

Other Options:

- team lift



- improve the layout of the work process



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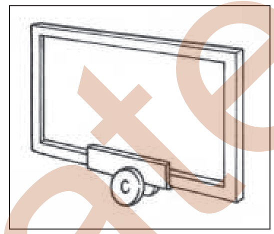
I-MaterialsHandling.ppt Slide 4

ERGONOMICS

Other Options:

- Reorganize the work to reduce repeated handling.
- Rotate workers through jobs with light or no manual handling to give them a rest.
- Keep loads on mobile storage racks to avoid unnecessary loading and unloading.



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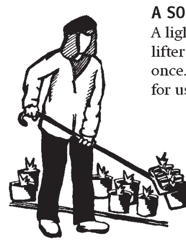
I-MaterialsHandling.ppt Slide 5

ERGONOMICS

Real World Solutions

LIFTING HUNDREDS OF PLANT POTS

THE PROBLEM
Workers at garden centres may need to handle hundreds of small plant pots in a day – reaching, lifting, carrying and lowering them.



A SOLUTION
A light, length-adjustable pot lifter can handle several pots at once. The lifter could be adapted for use with other objects.

BENEFIT
By greatly reducing repetitive bending and lifting, the worker avoids overusing the back and arms.

Source: OHS Magazine – Sept 2005

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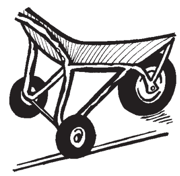
I-MaterialsHandling.ppt Slide 6

ERGONOMICS

Real World Solutions

WHEELBARROW CONVERTED TO DUMP CART



THE PROBLEM
Wheelbarrows need to be raised up by the handles to ride on their single wheel.

A SOLUTION
Convert the wheelbarrow to a push cart by adding two wheels at the back. Various conversion kits are available commercially.

BENEFITS
Workers avoid unnecessary lifting, and when necessary the wheelbarrow can still be used on its single front wheel.

Source: OHS Magazine – Sept 2005

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ERGONOMICS

MMH Injuries

Happen when lifting and handling tasks involve:

- too much weight
- objects that are located too low to the floor (i.e., below the knees) or too high above the floor (i.e., above the shoulders)
- objects that are too far away from the body
- twisting or bending
- repeating the movement too often
- handling objects without handles or a way to grasp them properly
- handling objects that are too large to grasp easily

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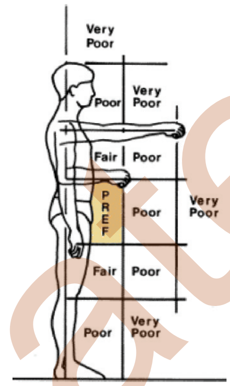
ERGONOMICS

Lifting Zones

- Optimal load handling height is between shoulders and knees.
- The worst zones are:
  - above the shoulders
  - below the knees
  - more than a forearm's length from the body



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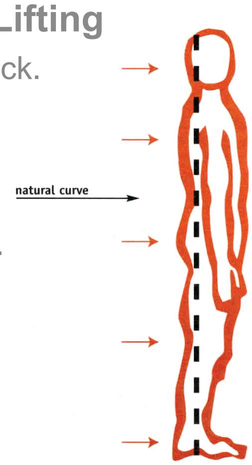
ERGONOMICS

Four Key Points to Follow when Lifting

- Keep the natural curve in the lower back.
- Contract the abdominal muscles.
- Avoid twisting; it makes the back less stable.
- Hold the load close to the belly button.



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ERGONOMICS

How Much Can I Lift?

It depends on the work and environment; e.g.,

- starting height of the lift
- finishing height of the lift
- frequency; e.g., twice per hour, twice per minute
- duration; e.g., 2 hours, entire shift
- how much twisting takes place
- restrictions to worker movement, such as small space

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ERGONOMICS

How Much Can I Lift?

It depends on the object; e.g.,

- whether the lift is performed with one hand or two hands
- the distance that the object is away from the body
- the size, shape and texture of the object
- whether it has handholds
- whether it has a changing centre of gravity; e.g., an aquarium full of water
- whether the object is alive and moving

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ERGONOMICS

How Much Can I Lift?

It depends on the individual; e.g.,

- age
- gender
- general health/fitness/condition
- previous back injury

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ERGONOMICS

Review of Controls for MMH

- Engineering Controls
  - hoists
  - cranes
  - carts
- Administrative Controls
  - 2 person lift
  - split the load

What about personal protective equipment?

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ERGONOMICS

Back Belts

- look like a weightlifter's belt
- worn to prevent back injury but scientific evidence is scarce
- recommended that back belts **not** be used to prevent back injuries among workers who have never been injured
- issues
  - Long-term use may make workers dependent on them by weakening back muscles.
  - Worker's false sense of security when wearing the belt might encourage him or her to lift too much.

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I-MaterialsHandling.ppt Slide 15

ERGONOMICS

Push It or Pull It?

All else being equal, loads should be **pushed**:

- body weight moves the load – lean into it
- can see where you are going
- avoid banging heels with the cart
- avoid shoulder and back injury – pulling increases the likelihood of injury to the shoulder/arm

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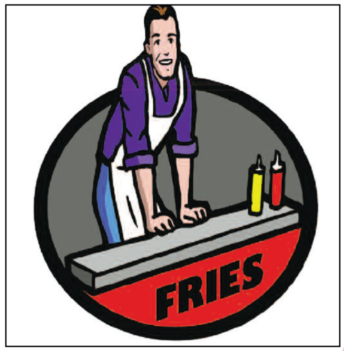
ERGONOMICS

What is Wrong Here?



Make two suggestions to correct the situation.

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J-Applying.ppt Slide 1

TEACHER'S NOTES

SA-ProductDesign.ppt
Slides 1–3

A. Product Design

Ergonomic Products – Do Not Get Sandbagged

The brochure for the mop handle, baby stroller or digital camera says that the product has been ergonomically designed. What does that really mean? Just because a product claims to be ergonomic does not mean it actually is.

Manufacturers are always trying to improve products. They may add padding to a handle, calling it "viscoelastic energy-damping shape-forming ergo-gel," or add a new curve to a product's shape, calling it a "fatigue-preventing neutral-balancing ergo-arc." The manufacturer says the product is ergonomic but it takes more than a bunch of fancy words for a product to be truly ergonomic.

To really be an ergonomic product, the designer has to at least consider:

- who the target group is; i.e., who will use the product
- the body size and physical abilities (i.e., anthropometry) of the target group so that the product is appropriate for the group
- how the product will be used
- where the product will be used; i.e., does it fit into the work space

Consider a pair of ergonomic scissors. They may be designed in small, medium and large sizes to suit different sized users but they may still require too much effort to be used comfortably if user grip strength has not been considered. Scaling a product up or down in size may not be enough.

Designing Based on Body Size and Physical Ability

In an earlier section about anthropometry, we stated that some designers fail to consider the size and shape of the person who will be using the product. The designer may only consider their own size and shape or the sizes and shapes of a small group of their friends. The result is a product that may be great for that group of people but is a complete mismatch for anyone else. Would a car designed for people 175 cm in height be suitable for someone 210 cm tall? Probably not.

This means that designers should be using readily available body size and physical ability information. They should avoid designing for the average since nobody is average in all body dimensions. A product intended for children or people with reduced dexterity, such as elderly people with arthritis, will need larger, chunkier controls, buttons or handles than required for a teenager. In general, a good design will take into account the needs of 90% of the target group.

SA-ProductDesign.ppt
Slides 4–5

Spotting Ergonomic Design

How do you know if the product really is ergonomic or has ergonomic features? Look for a product that reduces a user's exposure to ergonomic risk factors, such as:

- **Forceful exertions** – does the design allow the worker to accomplish some action with less force? e.g., some can openers require much less force to open a can than others.
- **Awkward body positions or postures** – does the design eliminate the need to put the worker into an awkward position to do something simple? e.g., finding the USB port on the back of a computer, changing a light bulb on the car's dashboard.
- **Repetitive motions** – does the product reduce the number of times the worker has to repeat the same motion? e.g., automating a task, such as having to key in prices at a supermarket checkout (A laser scanner and UPC codes have largely eliminated this task).
- **Vibration** – is the product designed to minimize vibration? e.g., a vibration-damping handle, a different type of drive motor that reduces vibration.

If the product has features that try to do something about these risk factors, it was probably designed with ergonomics in mind.

Page 71

Handout 6 provides some examples of process or product design modifications that reduce one or more of these ergonomic risk factors.

Case Study 1 – Push to Start

I am at a self-serve gas station. I just walked over and handed the attendant a twenty and told him I wanted to fill it. I go back to the pump, put the nozzle in the tank and squeeze the control. Nothing happens. I look at the gas pump for a lever to flip. No lever. I look at the gas pump for instructions or a button or something. I do not see a button. I systematically scan the gas pump, left to right, top to bottom. Nothing.

I go back to the attendant. He says, "Push the button." I say, "I don't see a button." He shows me.

It was right in front of me! Why didn't I see it? Part of the problem may have been that I was looking for a "real" button to start the pump – a three dimensional button – and the actual button was flat. The bigger problem was probably that there were so many stickers and decals on the gas pump that finding the start button was like finding a needle in a haystack.

Design Suggestion

Here are some things that would have made it easier to see the "push to start" button:

- make it larger
- use colours that contrast with the background
- remove some of the nearby stickers and decals
- make it more centrally located on the gas pump
- use a real 3-D button

(Source: Darnell, M. J. "Bad Human Factors Designs," www.baddesigns.com/pushto.html.)

Case Study 2 – Where's the Flusher?

I recently went on vacation to Europe. In a restroom in Holland, I had difficulty figuring out how to flush the toilet! Luckily, there was a big yellow homemade sign with an arrow pointing to a flusher button on the floor. I appreciated the sign and figured that I had probably not been the only visitor who had encountered difficulty finding the flusher.

This design reduces germ transmission since you do not have to touch the flusher with your hand. However, it is not easy to see the button on the floor and it is not obvious that the button is for flushing the toilet.

Design Suggestion

To improve this design, the flushing mechanism could be made more visible so that a sign would not be necessary. People are generally inclined to associate a control (e.g., the flusher) with the object it controls (e.g., the toilet), so they look first at the object for the control.

One solution might be a foot pedal that is attached to the toilet itself, provided that the foot pedal is visible to the user. In the case of the current design with the flusher button on the floor, the flusher button could be made the same colour as the toilet to show that the two are associated.

(Source: Darnell, M. J. "Bad Human Factors Designs," www.baddesigns.com/floorbutn.html.)

B. Vibration

Many workers are exposed to vibration daily while using vibrating equipment or machinery. Workers operating hand-held equipment, such as a chain saw or grinder, are exposed to hand-arm vibration. Workers sitting or standing on a vibrating floor or seat are exposed to whole body vibration because the vibration affects almost their entire body. The risk of injury from exposure to either type of vibration depends on:

- the strength of the vibration
- the frequency of the vibration
- how long the person is exposed, usually measured in years
- the part(s) of the body affected

Hand-arm Vibration

Hand-arm vibration is vibration transmitted into a person's hands and arms when hand-held powered equipment is used. It results in a disease known as hand-arm vibration syndrome (HAVS), also known as vibration-induced white finger (VWF), dead-finger or raynaud's syndrome.

Hand-arm vibration damages blood vessels in the hands and fingers, reducing the flow of blood and harming the skin, nerves and muscles. Affected fingers turn white or blanch, especially when exposed to cold (see Figure 1). Symptoms of HAVS include:

- tingling fingers
- numbness
- loss of strength in the hands; e.g., a person may be unable to pick up or hold heavy objects
- clumsiness with the hands
- fingertips that turn white or blue
- cold and painful hands

SB-Vibration.ppt
Slide 1

The chances of getting HAVS increase with exposure to vibration, particularly when combined with risk factors, such as cold exposure and smoking. Both of these reduce the flow of blood to the hands.

Figure 1—Example of vibration-induced white finger

Major sources of vibration among hand tools are grinders, sanders, drills, impact wrenches, jackhammers, riveting and chipping hammers and chain saws. Unfortunately, there is no protective equipment that workers can wear to prevent exposure to vibration. Gloves are available with vibration-damping material built into the palms and fingers but they have not been proven effective. If the gloves fit well and do not cause the worker to tighten his or her grip, it may not hurt to try them.

Regular work gloves and warm clothing are important in cold weather to keep hands warm and dry, since operating a vibrating tool with cold hands increases the risk of injury.

Activity

The teacher may wish to discuss the following case study with the class.

SB-Vibration.ppt
Slides 2–4

Case Study – The Vibrating Computer Controller

What:

- a 15-year old boy complains that his hands have been sore for the past two years
- his hands turn white and swell when exposed to the cold

What he was doing:

- he was using computer games for up to seven hours a day
- he especially liked the driving games, using a vibrating game controller (rumble board) Bottom line?
- The boy's doctor treated him as having a case of hand-arm vibration syndrome.
- The boy was playing the game for up to seven hours per day – way too much time and far more than the manufacturer recommends.

Reducing Exposure to Hand-arm Vibration

The best way to avoid injury is to work with nonvibrating tools, whenever possible. If a vibrating tool must be used, use one that has effective anti-vibration features built in. Some new designs can reduce tool vibration by more than 50 percent.

To reduce exposure to hand-arm vibration:

- Limit the amount of time (hours per day and days per week) vibrating tools are used.
- Take a 10-minute break for every hour spent working with a vibrating tool.
- Alternate work with vibrating and nonvibrating tools.
- Let the tool do the work. Use as light a grip as possible to keep the tool under control. A tight grip restricts blood flow in the hands and fingers and allows more vibration to pass from the tool to the body.
- Maintain tools properly. Tools that are worn, blunt or misaligned vibrate more.

SB-Vibration.ppt
Slides 5–8

Whole Body Vibration

Whole body vibration is vibration transmitted into a person's body, most often through the legs when standing and through the buttocks and back when sitting. Whole body vibration can cause fatigue, insomnia, headaches and shakiness during or shortly after exposure. The symptoms are similar to those that many people experience after a long car or boat trip.

After daily exposure over a number of years, whole body vibration can affect the entire body and result in a number of health disorders, including damage to the spinal column, its discs and the digestive system.

A rough road surface causes an up and down movement of the truck and the driver's seat, exposing the driver to whole body vibration.

Heavy Equipment Operators Get Injured more Often

Research shows that back injuries occur more often and are more severe among individuals who experience whole body vibration as compared to individuals who are not exposed to whole body vibration. Operators of off-road vehicles are likely to have the most hazardous exposures, although this depends on how long they work and the quality of the vehicle's suspension system, shock absorbers, seats and tires.

Methods of controlling whole body vibration in vehicles may include:

- air-ride suspended seats
- suspended cabs
- maintaining vehicle suspension systems
- inflating tires to their proper pressure
- seats with armrests, lumbar support, adjustable seat back and adjustable seat pan

Another approach is to decrease the amount of vibration a driver is exposed to by:

- reducing the speed of travel
- having workers take rest breaks
- rotating workers to other jobs that do not cause whole body vibration

C. Hand Tools

SC-HandTools.ppt
Slides 1–5

Poorly designed hand tools – too heavy, poorly balanced, with a grip that is too large, the wrong shape or slippery – can lead to injuries of the hand, wrist, forearm, shoulder and neck.

Hammers or pliers with bent handles keep the wrist and forearm straight to reduce injury and increase power. Pliers and cutting tools with spring-assisted jaws require less finger and hand effort to open the jaws. Power tools with foam or rubberized grips help reduce the transfer of vibration to the hands and arms.

Grip

A well-balanced tool, with a properly designed grip or handle, instantly feels comfortable in the hand. If a tool is poorly designed, does not fit the user or is not right for the job, it may have to be held more firmly and at an awkward angle. A properly designed grip helps to reduce fatigue and pain. Consider whether the job requires a tool with a pistol grip or an in-line grip. When significant power or torque needs to be delivered, select tools that allow for a power grip; i.e., the hand makes a fist with four fingers on one side and the thumb on the other, similar to holding the pistol grip of a power drill.

Tools that can be used in either hand allow workers to alternate hands and the tool can be used properly by the 10 percent or more of workers who are left-handed.

Handle Size

The right-sized handle is one that allows the hand to go more than halfway around the handle without the thumb and fingers meeting. The recommended grip diameter, in most cases, falls between 50 and 60 mm. To provide good control of the tool and prevent pain and pressure hot spots in the palm of the hand, handles should be at least 120 mm long. A precision grip (i.e., when the tool is pinched between the tips of the thumb and fingers) is primarily used for work that requires control rather than a lot of force. Handles for precision tools should be 8 to 13 mm in diameter and at least 100 mm long.

SC-HandTools.ppt
Slides 6–8

Grip Surfaces

The grip surfaces of hand tools should be smooth, nonconductive and slightly compressible to dampen vibration and better distribute hand pressure. Avoid tools that have grooves for fingers – for most people, the grooves are either too big or too widely or closely spaced. The resulting pressure ridges across the hand can damage nerves or create hot spots of pain. Grooves along the length of the handle are intended to prevent slipping but can also cut into the hand and create pressure ridges, particularly if the tool is in continuous use. If a grooved handle is the only choice available, ensure the grooves are many, narrow and shallow. If it is available, try a grip shape that is noncylindrical. Triangular grips measuring approximately 110 mm around, at their widest part, can be quite comfortable and help to increase power.

Weight

Weight is often a problem with power tools as well as with tools, such as axes, hammers and saws. To reduce hand, arm and shoulder fatigue, the hand tool should not weigh more than 2.3 kg. If the centre of gravity of a heavy tool is far from the wrist, this maximum weight should be reduced. Studies have shown that tools weighing 0.9 to 1.75 kg feel right for most workers. For precision work where the small muscles of the hand support the tool, it should weigh far less. Lighter is better. Heavy tools can be made easier to use by suspending or counter- weighting them.

Triggers

Many power tools have a trigger that is operated either by the thumb or one or more fingers. To avoid hand and forearm fatigue, look for tools that can be activated by either hand. Also, the trigger should have a mechanism that holds or locks it in place while the tool is being used. Triggers should be at least 25 mm long for single-finger activation and 50 mm long for two-finger activation. Use four-finger activation only with suspended tools.

Conclusion

There is no definition for an ergonomic tool. Look for hand tools that have features, such as the ones described. If the tool fits, it is the right one for the worker and the job, whether or not it is called ergonomic.

Examples of process or product design modifications to reduce ergonomic risk factors, such as force, posture, repetition and vibration.

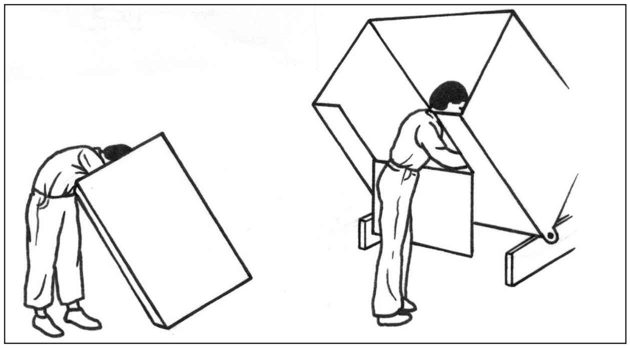

Figure 1—Raising and tilting the bin can eliminate an awkward posture

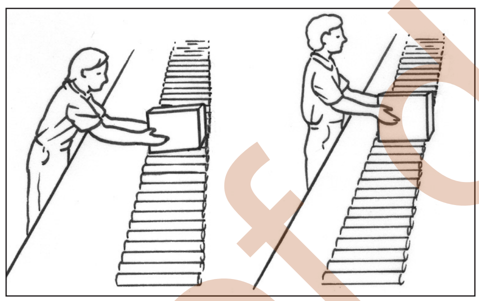

Figure 2—Placing the conveyor closer to the worker reduces excessive reaching and an extended body position

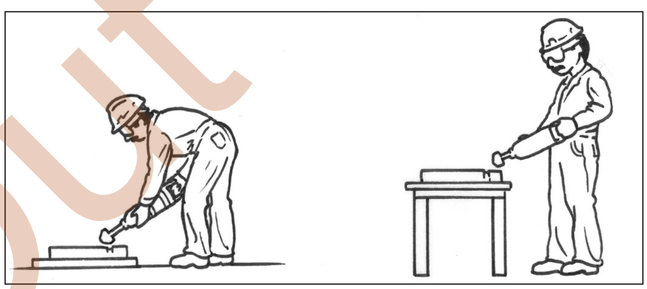

Figure 3—A raised work platform can eliminate awkward posture

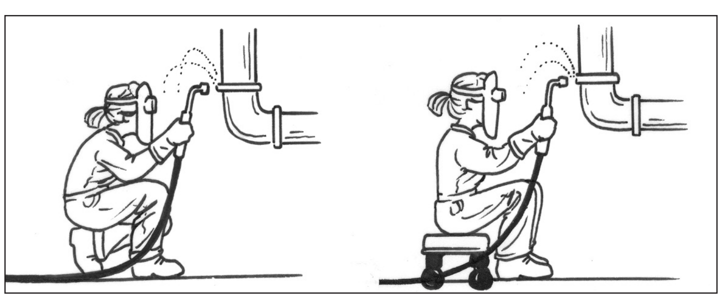

Figure 4—A wheeled footstool can make awkward work comfortable

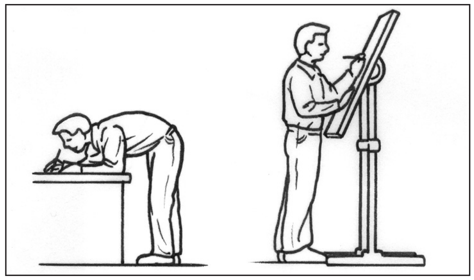

Figure 5—A tall, tilting table eliminates an awkward work position

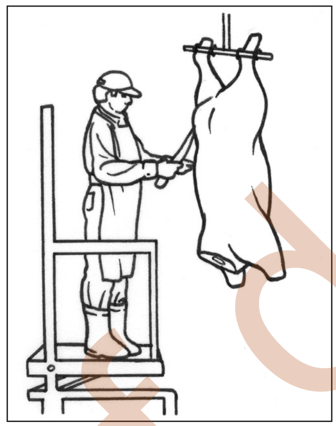

Figure 6—An elevated work platform reduces awkward overhead reaches

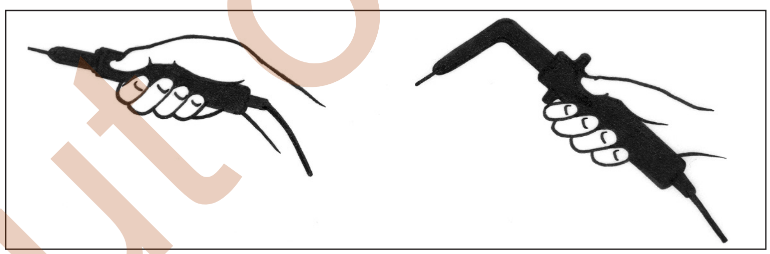

Figure 7—A bent tool eliminates an awkward wrist position and provides good grip

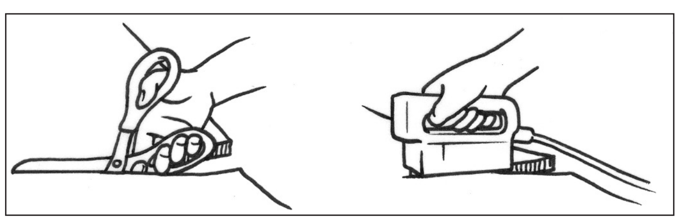

Figure 8—Electric scissors can eliminate the high hand forces required to cut thick material

ERGONOMICS

Ergo-hype:

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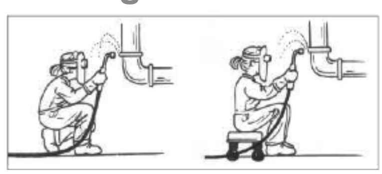
SA-ProductDesign.ppt Slide 1

ERGONOMICS

Ergonomic Products or Solving a Problem?

A raised work platform eliminates awkward posture but does that make it an ergonomic table?

No



A wheeled footstool can make awkward work comfortable. Does that make it an ergonomic footstool?

No

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SA-ProductDesign.ppt Slide 2

ERGONOMICS

Designers Have to Consider:

- who the target group is; i.e., who will use the product
- the body size and physical abilities (i.e., anthropometry) of the target group
- how the product will be used
- where the product will be used

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SA-ProductDesign.ppt Slide 3

ERGONOMICS

Spotting Ergonomic Design

- **Forceful exertions** – does the design allow the worker to accomplish the action with less force?
- **Awkward body positions or postures** – does the design eliminate the need to put the worker into crazy positions?
- **Repetitive motions** – does the product reduce the number of times the worker has to repeat the same motion?
- **Vibration** – is the product designed to minimize vibration?

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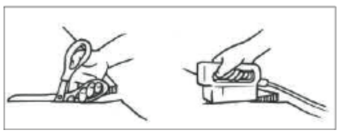
SA-ProductDesign.ppt Slide 4

ERGONOMICS

Ergonomics Applied to Product Design

A bent tool eliminates an awkward wrist position and provides good grip.



Electric scissors can eliminate the high hand forces and repetitive movements required to cut thick material.

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SA-ProductDesign.ppt Slide 5

ERGONOMICS

Hand-arm Vibration

- vibration transmitted into a person's hands and arms when hand-held powered equipment is used
- results in a disease known as hand-arm vibration syndrome, also known as:
  - vibration-induced white finger (VWF)
  - dead-finger
  - raynaud's syndrome

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SB-Vibration.ppt Slide 1

ERGONOMICS

Signs and Symptoms of Hand-arm Vibration Syndrome

- Blood vessels in the hands and fingers are damaged.
- Flow of blood is reduced.
- Skin, nerves and muscles are damaged.
- Affected fingers turn white or blanch, especially when exposed to cold.

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SB-Vibration.ppt Slide 2

ERGONOMICS

Case Study

- 15 year old male complained of sore hands for two years
  - hands turn white, swell when cold
- history
  - uses computer game for up to seven hours per day
  - plays driving games with a vibrating game controller
- diagnosis
  - overuse of vibrating equipment, resulting in hand-arm vibration syndrome

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SB-Vibration.ppt Slide 3

ERGONOMICS

Reducing Exposure to Hand-arm Vibration:

- Use nonvibrating tools, whenever possible.
- Use tools that have effective anti-vibration features built in.
- Limit the amount of time vibrating tools are used.
- Take a 10-minute break for every hour spent working with a vibrating tool.
- Alternate work with vibrating and nonvibrating tools.
- Let the tool do the work.
- Maintain tools properly.

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SB-Vibration.ppt Slide 4

ERGONOMICS

Whole Body Vibration

- vibration transmitted into a person's body through the legs, when standing, or through the back and buttocks, when sitting
- can cause fatigue, insomnia, headaches and shakiness during or shortly after exposure
  - symptoms are similar to those that many people experience after a long car or boat trip
- chronic exposure can cause:
  - damage to spinal column
  - digestive tract problems

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SB-Vibration.ppt Slide 5

ERGONOMICS

Why do so many heavy equipment operators have back problems?

- They may sit in awkward body positions in poorly designed cabs that do not fit them well.
- They may need to twist their body backwards or to the side when operating the equipment.
- Drivers may sit work in this equipment for up to 14 hours per day.
- They are constantly being bounced up and down, forwards and backwards, front to back and side to side.

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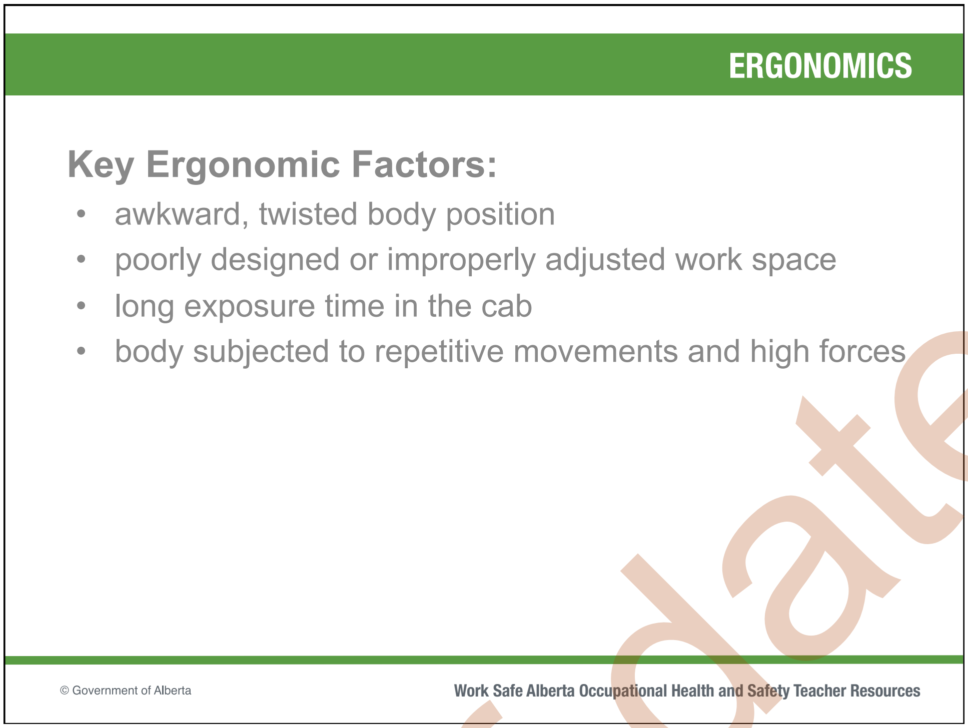
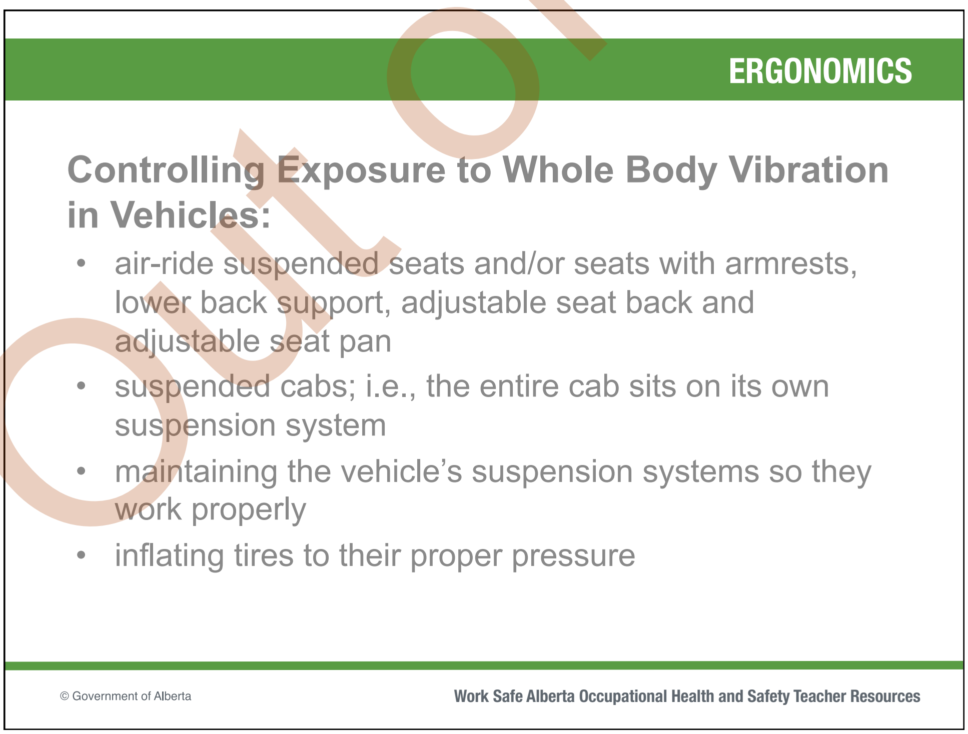
SB-Vibration.ppt Slide 6



SB-Vibration.ppt Slide 7



SB-Vibration.ppt Slide 8

ERGONOMICS

Poorly Designed Hand Tools:

- too heavy
- poorly balanced
- too large or too small a grip
- wrong shape
- slippery

They can injure the hands, wrists, forearms, shoulders and neck.

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ERGONOMICS

Better Designed Hand Tools

- pliers with spring-assisted jaws to reduce the forces needed to open the jaws
- ice climbing tool with curve for better hand and arm positioning while climbing
- bent/curved handled tools to keep the wrist in a neutral position
- properly sized grips to reduce the force required to hold onto the tool

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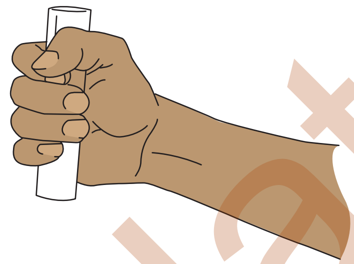
ERGONOMICS

Power Grip

- used when significant power or torque needs to be delivered
- the hand makes a fist with four fingers on one side and the thumb on the other
- similar to holding the pistol grip of a power drill



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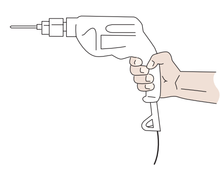
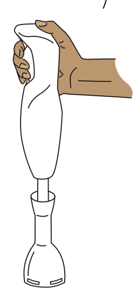
ERGONOMICS

Grip Styles

- pistol grip helps keep the wrist neutral when working on vertical surfaces; e.g., a wall



- in-line grip helps keep the wrist neutral when working on horizontal surfaces



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ERGONOMICS

Precision Grip

- used for work that requires control rather than a lot of force
- occurs when the tool is pinched between the tips of the thumb and fingers

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ERGONOMICS

More about Grip

- The right-sized handle is the one that allows the hand to go more than halfway around the handle without the thumb and fingers meeting.
- Surface should be smooth, nonconductive and slightly compressible to dampen vibration and better distribute hand pressure.
- Avoid tools that have grooves for fingers – for most people, the grooves are either too big or too widely or closely spaced.

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ERGONOMICS

Tool Weight

- To reduce hand, arm and shoulder fatigue, hand tools should not weigh more than 2.3 kg (5 pounds).
- If the centre of gravity is far from the wrist, this maximum weight should be reduced.
- Tools that weigh 0.9 to 1.75 kg (2–3 pounds) feel right for most workers.
- For precision work where the small muscles of the hand support the tool, it should weigh far less.

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ERGONOMICS

Trigger Activation

- Many power tools have a trigger operated either by the thumb or one or more fingers.
- To avoid hand and forearm fatigue, look for tools that can be activated by either hand.
- The trigger should have a mechanism that holds or locks it in place while the tool is being used.

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