Work Related Musculoskeletal Disorder Prevention Guide for Mining

Training Manual

BRITISH COLUMBIA
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Ministry of Energy, Mines and Petroleum Resources

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Ministry of Energy, Mines and Petroleum Resources

Contents

Objectives

Musculoskeletal Disorder (MSD) Prevention Training Course for Occupational Health and Safety Committee (OHSC) members

Upon completion of the course attendees should be able to:

1. Understand the importance of prevention of MSD in the mining industry.

2. Identify risk factors/causes that are associated with the onset of MSD related to the upper extremities, lower extremities and back.

3. Apply ergonomic principles that can prevent upper limb, lower limb and back discomfort. The principles include:
   - best position and use of the arms, wrists, hands and back
   - job design and work procedures
   - design, selection, and appropriate use of tools
   - design and appropriate use of work area
   - material handling

4. Understand the components of a successful MSD program and be prepared to initiate a plan to implement an on-site program.

The Health, Safety and Reclamation Code for Mines in British Columbia: (1997)

Health and Safety Program
Section 1.6.8.
Amended in 1997 to include the following requirement:

(h) a written preventative training program, acceptable to the Chief Inspector, to educate OHSC members in the recognition, evaluation and prevention of adverse health effects resulting in Musculoskeletal Disorders (MSD) and in reporting related symptoms and injuries.

Section 1

Ergonomics, MSD
and
B.C.'s Mining Industry

Ergonomic Components

Ergonomics is the applied science that is concerned with worker safety—it seeks to fit the job to the worker through the evaluation and design of the work and work environment. Ergonomics proposes to address human performance and well-being in relation to jobs, machines, tools, work environment and work process. While ergonomics is a broad subject, in the context of this course ergonomics will generally focus on the identification and prevention of musculoskeletal disorders.

Ergonomics as a study encompasses many fields including:

- Biology
- Engineering
- Biomechanics
- Physiology
- Psychology
- Kinesiology
- Anthropometry

Why Ergonomics?

The human body can endure considerable discomfort and stress and can perform in many awkward and unnatural positions—for a limited time.

> Musculoskeletal Disorders (MSDs) is defined by the Workers Compensation Board of British Columbia (WCB) as an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including a sprain, strain and inflammation that may be caused or aggravated by work.

The physical capability of our body has limitations such as the amount of force our muscles can exert, or the range of movement that any given joint can produce. When these limits are continually exceeded injury will prevail.

These limits can be pushed over time, for example by:

- Chronically lifting a weight that is too heavy
- Driving on ground that is too rough for long durations
- Not taking enough rest breaks during the day

WCB roughly estimates that musculoskeletal disorders account for 60% of all occupational illness and one third of compensation claims. Between 1988-1992, WCB estimates it paid out over $400 million for over 100 thousand MSD-related claims, with over 4 million days of lost work. Mining, as a specialized heavy industry, will have different safety concerns than other industries. The impact of MSDs specifically on the mining industry must be recognized.

Applications of Ergonomics in Mining

The application of ergonomics in the mining industry hopes to address the issues of musculoskeletal disorders in the workplace. In essence its mandate is to try and tailor the work and the equipment to workers' capabilities; that is, in place of adapting workers to the machine, as was the tradition of the past in many industries, including mining. This tailoring is intended to maximize efficiency while reducing injury. This will be achieved through workplace modification, equipment redesign and worker education and training.

The ultimate goal of this program is to address the issues of increasing disability claims due to musculoskeletal disorders and try to eliminate and/or reduce the risk of MSDs.

The principles of ergonomics recognizes the physical diversity of people in the mining workforce, whether that be in size, height, weight, strength and general ability to withstand the mental, skillful or physical stresses of a particular job. Once we acknowledge these differences we can begin to use ergonomics as a tool to tailor the job to the worker, through workplace design, organization and equipment modification. The end result is to work to maximize productivity while minimizing the risk of injury.

Implementing ergonomic principles does not have to be elaborate or expensive. It can be as simple as adjusting the height of supplies, or adding a forklift to the site or even simple modifications like providing an anti-fatigue mat to cushion the worker's stance. Worker input should be encouraged as they often have good ideas on how the workstation or tools might best be modified. Workers and management need to work together to develop a practical yet safe work environment.

Employer Benefits	
• Healthier employees • Improved labour relations • Increased productivity • Reduced employee absenteeism • Reduced employee turnover • Workstations more suited to a diverse number of people • Decreased re-training costs • Higher quality of production • Fewer injuries	

The Need for Ergonomics

1. Today's workforce is diverse.
   Today's workforce includes minorities, women and people of differing sizes and stature. Safety concerns for all groups represented in the workforce must be addressed.
2. Maintaining good production levels is essential.
   By making a job and/or workstation comfortable and reducing the risk exposure to MSDs, workers will work more efficiently and comfortably. As a result, production levels will increase.
3. WCB MSD claims and costs have been rapidly increasing in the last few years.
   Reducing the number of claims by using preventative measures will see a reduction in claims and associated costs.

Symptoms and Comprehensive Costs of Musculoskeletal Disorders

Musculoskeletal Disorders (MSDs), often called Repetitive Strain Injuries (RSI) or Cumulative Trauma Disorders (CTD), are a group of spinal, muscular and tendinous injuries.

MSDs often occur in the:
- Wrist
- Hand
- Shoulder
- Elbow
- Lower limbs
- Back

They often develop as a result of:
- Repetitive motions of body segments
- Heavy loads and manual materials handling
- Repeated exposure to external trauma
- Maintaining awkward or static postures for long periods of time
- Operating at extreme ranges of motion

The greater the duration and degree of exposure to causative factors, the greater the likelihood of injury. As well, the more risk factors that are present in combination, the greater the chances of developing an MSD.

Symptoms that may be indicative of an MSD:

- Pain
- Decreased range of motion in a joint
- Swelling of a joint
- Numbness and/or tingling sensation in body segment (usually hand)
- Decreased sense of touch
- Inflammation
- Stiffness of joint
- Symptoms worsen over time

Often symptoms appear gradually with the onset of muscle fatigue or pain at work; they begin to disappear at rest.

Costs

- Increase in WCB assessment rates
- Compensation wages for disabling injuries
- Immediate and post-accidental production losses due to injury
- Cost of investigation

Resulting in:

- Loss of equipment
- Loss of production
- Less experienced replacement

Present Regulations

Currently there are no prescriptive regulations regarding ergonomics for the mining industry of B.C.; the Mines Branch's current focus is on MSD education and prevention. The only requirement is to train OHSC in the recognition and prevention of MSDs and the reporting of related injuries.

When developing preventative MSD measures there needs to be a focus on safety, but the practicality of the measures taken and the productivity of the workplace must also be considered.

The Health, Safety and Reclamation Code for Mines in British Columbia: (1997)

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Section 1.6.8.
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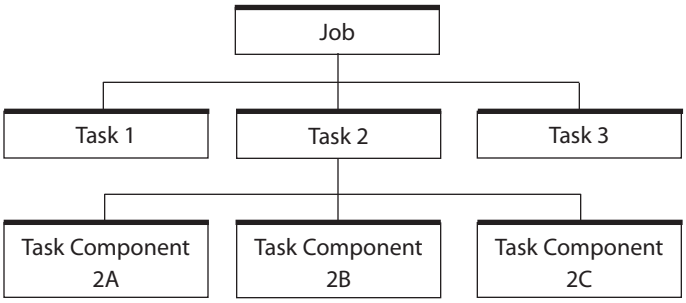
Activity 1

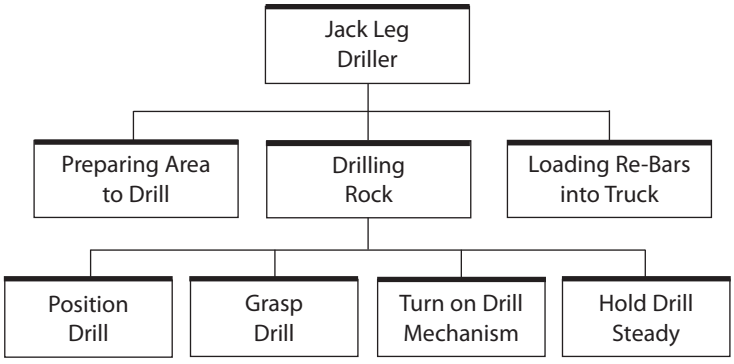
Questions to Consider When Evaluating Risk of MSD

- Is the frequency of repetition in the task high?
- What are total number of movements in a work cycle?
- How long is the work cycle?
- What is the duration of cumulative exposure to risk factors—minutes, days?
- Is there a predisposition to injury?
- Are MSDs more common in inexperienced workers?
- Are off-work habits a factor in relation to exposure?

The goal of these questions is to break down the movements in the task into step-by-step components so the prevalence and degree of risk factors can be assessed. If the focus is on the risk factors they can then be prioritized, which may be the most effective way to determine risk prevention methods. Use of checklists are an effective tool in clarifying risk factors that might be present.



Mining Example



B.C. Mining Industry Statistics

Musculoskeletal Disorders

Back Overexertion Injuries 1993-1997

Taken from WCB of BC Statistics department July 1999

Statistics from 15 mines across B.C. were collected to represent the cost of back overexertion injuries to the mining industry. The statistics were taken from larger B.C. mines. Sand and gravel operations, as well as rock quarry operations, are not represented here. It should be noted in reference to these statistics, that one type of mining cannot be reasonably compared against other types of mining because all of the operating mines are not represented and costs have not been normalized with respect to total man shifts worked. A sample selection of mines were chosen to illustrate the impact of musculoskeletal disorders.

The cost of back overexertion injuries in this five-year period was over $2 million in WCB claims cost. These statistics are representative of claims that have been settled and paid out. The injuries incurred may not have happened in the same year as the pay out, but are reported in the year of claims settlement. The claims cost given represent lost wages and disability pension payments; these costs do not include health care or rehabilitation costs. They also do not account for costs related to lost productivity.

MSD INJURIES of the BACK due to OVEREXERTION 1993-1997

Mine Type	Number of Mines in Sub-group	Number of Claims	Cost of Claims	Days Lost
Industrial Mineral	4	26	$ 57,119	473
Surface Metal	2	19	97,180	507
Underground Coal	1	35	387,889	2,175
Underground Metal	3	30	883,316	2,178
Surface Coal	5	72	681,470	2,300
TOTAL	15	182	$2,106,974	7,633

Musculoskeletal Disorders

Carpal Tunnel Syndrome
Tendonitis
Bursitis
1993-1997

Taken from WCB of BC Statistics department July 1999

Statistics from 8 mines across B.C. were collected to represent the cost of repetitive motion injuries to the mining industry. The statistics were taken from larger B.C. mines. Sand and gravel operations, as well as rock quarry operations are not represented here. It should be noted in reference to these statistics, that one type of mining cannot be reasonably compared against other types of mining because all of the operating mines are not represented and costs have not been normalized with respect to total man shifts worked. A sample selection of mines were chosen to illustrate the impact of musculoskeletal disorders.

The cost of musculoskeletal disorders in this five-year period was almost $1 million in WCB claims cost. These numbers are a representation of claims that have been settled and paid out. The injuries incurred may not have happened the same year as the pay out, but are dated in the year of claims settlement. The claims cost given represent lost wages and disability pension payments; they do not include health care or rehabilitation costs.

CARPAL TUNNEL SYNDROME STATISTICS

Mine Type	Number of Mines in Sub-group	Number of Claims	Cost of Claims	Days Lost
Surface Metal	2	4	$ 44,257	267
Underground Metal	2	1	16,866	139
Underground Coal	1	0	0	0
Surface Coal	3	14	119,833	797
TOTAL	8	19	$180,956	1,203

TENDONITIS STATISTICS

Mine Type	Number of Mines in Sub-group	Number of Claims	Cost of Claims	Days Lost
Surface Metal	2	1	$307,152	237
Underground Metal	2	0	0	0
Underground Coal	1	1	2,374	15
Surface Coal	3	10	48,316	325
TOTAL	8	12	$357,842	577

BURSITIS STATISTICS

Mine Type	Number of Mines in Sub-group	Number of Claims	Cost of Claims	Days Lost
Surface Metal	2	1	$ 1,074	7
Underground Metal	2	1	64,586	17
Underground Coal	1	1	2,374	15
Surface Coal	3	2	113,905	131
TOTAL	8	5	$179,565	155

SUMMARY OF MSD CLAIMS (1993-1997) Statistics from 8-15 B.C. Mines

Type of Injury	Number of Claims	Cost of Claims	Days Lost
Carpal Tunnel Syndrome	19	$ 180,956	1,203
Tendonitis	12	357,842	577
Bursitis	5	179,565	155
TOTAL	36	718,363	1,935
Back Overexertion	182	2,106,974	7,633
TOTAL	218	$2,825,337	9,568

The Mining Industry in B.C. - WCB Musculoskeletal Disorder Claims Statistics

COAL MINING - WCB Stats for Repetitive Motion Injuries (1993-1997)

Type of Injury or Disease	Total Number of Disability Claims Accepted (1993-1997)	Claims Cost Charged (1993-1997)	Days Lost (1993-1997)
Bursitis	3	$1,368,328	258
Tendonitis	16	155,559	851
Carpal Tunnel Syndrome	18	485,810	1,340
TOTAL	37	$1,969,697	2,449

METAL MINING - WCB Stats for Repetitive Motion Injuries (1993-1997)

Type of Injury or Disease	Total Number of Disability Claims Accepted (1993-1997)	Claims Cost Charged (1993-1997)	Days Lost (1993-1997)
Bursitis	5	$131,110	544
Tendonitis	17	657,272	1,141
Carpal Tunnel Syndrome	22	708,300	3,582
TOTAL	44	$1,496,682	5,567

COAL and METAL MINING - WCB Stats for Back Strains due to Overexertion (1993-1997)

Type of Mining	Total Number of Disability Claims Accepted (1993-1997)	Claims Cost Charged (1993-1997)	Days Lost (1993-1997)
Coal Mining	120	$1,763,483	8,363
Metal Mining	137	4,778,530	9,056
TOTAL	257	$6,542,013	17,419

COAL and METAL MINING - WCB Stats for Total Cost of Repetitive Motion and Back Overexertion Injuries (1993-1997)

Coal and Metal Mining	Total Number of Disability Claims Accepted (1993-1997)	Claims Cost Charged (1993-1997)	Days Lost (1993-1997)
TOTAL	338	$10,008,392	25,435

Summary of Statistics

According to these WCB claims figures, musculoskeletal disorders cost the mining industry in B.C. approximately $10 million dollars in claims and 25,500 lost worker days in this five-year period (1993-1997). This averages out to a pay out of $2 million per year, not including health care and rehabilitation costs. Work days lost, based on a 47-week work schedule is equivalent to roughly 110 employees being off for a one-year period. The claims cost given represent lost wages and disability pension payments.

These costs do not include:

- Health care costs
- Rehabilitation costs
- Loss of productivity
- Re-training costs
- Decreased worker morale

In discussions with mine safety representatives, it is estimated the average number of workers are in their early 40s, and many have been with the mine for the past ten to fifteen years. These representatives have mentioned a steady increase in the amount of repetitive motion and back injury claims in the last few years, some suggesting that it was due to the increasing age of the mine workers. This being the case it can be expected that the number and cost of MSD injuries will increase as these mine workers get older and their bodies are less resilient to the stresses of daily living and work. This illustrates the impact of MSDs on the mining industry in B.C. and the need for an MSD prevention program that specifically addresses the worker and the worker's capabilities and limitations.

Under-Reporting of MSD Injuries

The following are some reasons that MSD injuries may not seem prevalent on mine sites across B.C.

Industrial Disease

MSDs such as carpal tunnel syndrome are classified by WCB as industrial diseases and generally happen over time; therefore, they may not appear on the standard injury report at the mine site. These disorders must be diagnosed by a physician, so while a typical MSD injury may be reported to first aid it may just be recorded as back pain or wrist swelling. The first recorded indication of a potential MSD may appear only when a claim is filed with WCB. This may present an issue of under-reporting, as a result it may seem like these MSDs are a rare occurrence and may be overlooked as a significant cause of injury claims in the workplace.

Job Reassignment

When workers report pain typical of an MSD, they may be re-located to easier work until the pain goes away. It is often not officially reported as an MSD, so when pain reoccurs it is difficult to determine from documentation if the injury was due to one incident or from chronic injury.

Psychosocial Issues

There is the possibility that the worker does not want to be seen as unfit or as a complainer so as the first symptoms become apparent, the worker may not report them to the first aid attendant or to their physician. Only when the MSD has become a chronic injury that begins to interfere with their work and personal lives, will they go to doctor and may not even report it to the attendants at the mine.

Incentives

Bonus programs may also lead to creating a work environment that may encourage overuse and overexertion injuries. The financial benefit of working at maximum or near maximum capacity for the duration of a shift may be incentive to ignore signs and symptoms of a potential MSD.

Expected Outcomes and Benefits of an MSD Prevention Program

- i Safety
- i Quality
- i Productivity
- i Job Satisfaction
- i Effective use of Personnel
- m Worker Pain and Suffering
- m Accidents and Injuries
- m Training Time

Notes

Section 2

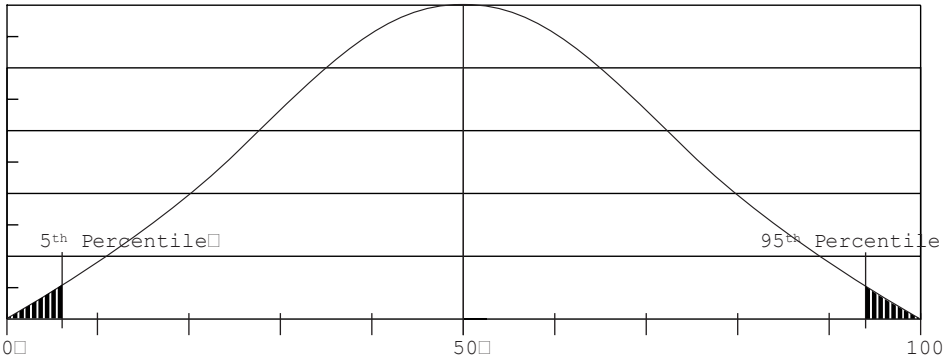
Sciences that Define Human Capabilities and Limitations

Anthropometry

Body shapes and sizes differ from one individual to the next.
The study of these different human dimensions is the study of anthropometry. These include things like height, weight, arm length and leg length. These enable human capabilities such as pushing, pulling, gripping and lifting. There can be significant changes in an individual on a year-to-year basis such as height and joint range of motion, whether it be due to a change in diet, activity level and/or age. Not only can can individuals have very different dimensions than others, but the same person may have very different dimensions at different times of their life.

Anthropometric data consisting of heights, lengths and breadths is used to establish minimum clearances, space accommodations and functional arm, leg and body movements made by a worker during performance of a task.

Anthropometry is an essential tool in designing work and workspaces for a diverse work force. The workplace should be designed so that people of different builds and shapes are able to work with a minimum risk of injury while working at optimal efficiency. These differences must be considered, however, ergonomic changes to fit one person may in fact increase likelihood of injury to someone else. The best approach is to design the work/workstation to accommodate a range of workers. This can be done by creating a workstation and/or equipment that is easily adjustable to the worker. Many workstations are designed for the average person, but it is a fact that the 'average' person does not exist. When designing a workstation it is best to design for the percent of the population between the 5th and 95th percentile, excluding the biggest 5% and the smallest 5%. Adjustable workstations work well to suit the workplace to the varying sizes and shapes of people.



Normal distribution, 5th and 95th percentile highlighted.

For example, if you were to design a door based on the average height and build of the workers, you would likely find that the door would be built to accommodate those between 5'9" and 5'11". But in any population there are likely to be individuals taller than 5'11" and consequently door clearances are designed to comfortably accommodate those over 6 ft tall. This is an example of designing for the 95th percentile.

When using anthropometric data as a design consideration, it is best to look at how long the task is being performed and what type of task is being performed. Specific tools, pieces of equipment and workstations should be considered individually. When using anthropometry as a tool, specific workplace dimensions must be related to the task.

For example, if you are looking at making vehicle seating adjustable, you would probably want to address:

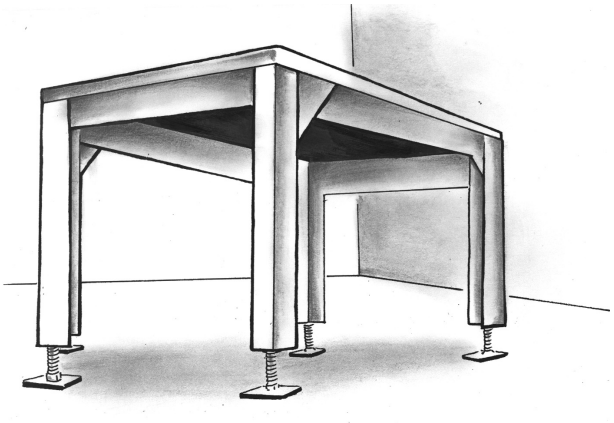
- Seat height
- Horizontal distance from foot to pedals when seated

The goal would be to create a seat that 90% of the worker population could reach. But each vehicle would also have certain individual considerations with respect to seating design (e.g., the considerations for seating in a compact car is very different than that of a haul truck, even though they may have the same driver). When using anthropometry as a tool, these individual workstation considerations need to be addressed.

Other examples where it may be practical to use adjustability:

- Seat height
- Work surface height
- Work surface angle
- Work that requires repetitive reaching (should easily accommodate the smallest arm reaches)

Height adjustable work bench



Activity 2

1. Pick up a binder or textbook.
   While standing, with elbows at right angles, hold book for one minute.

2. Pick up a binder or textbook.
   While standing, with arms straight at right angles with shoulders, hold book for minute.

Questions:

- Was the book easier to hold with elbows bent at right angles, or with shoulder extended at right angles?
- How long do you think you could comfortably hold the book in scenario 1?
- How long do you think you could hold the book comfortably in scenario 2?
- Is this an example of:
  a) Heavy force?
  b) Awkward posture?
  c) Vibration?
  d) Repetition?

Activity 3

- Go around your group and mark down everybody's shoe size.
- Now take the average of those sizes.

Question:

- How well would the 'average' shoe size fit the people in your group?

  Discuss the results.

Physiology

Physiology is the study of the function of the body, its parts and how they work together.

Humans have limitations as to what they are physically able to accomplish through the course of a workday.

These limitations are influenced by:

- Rate of muscle recovery
- Rate and efficiency of oxygen uptake
- Rate of energy expenditure of the body
- The muscular effort the worker expends
- How efficient the muscle is at removing waste products
- How much nourishment the muscle is receiving

Dynamic and Static Muscular Effort

Dynamic work - occurs when there is a cycle of muscle contraction and relaxation, usually using large muscle groups (e.g., walking). When the muscle is allowed to relax between contractions there
is an increased flow of blood throughout the muscle. With each contraction-relaxation cycle, the blood replenishes muscle nutrients and takes away the accumulated waste products in the muscle. Dynamic work is the most favourable type of muscular work from a health perspective. It is easier on the muscle and it is expected to increase muscle efficiency. However, it must be noted that forceful dynamic contractions may lead to repetitive strain injuries in certain work situations.

Dynamic work example: Shoveling ore that falls off the conveyor back onto the conveyor. The muscles in the arms are contracting and relaxing with each cycle of getting ore onto the shovel and ore onto the belt.

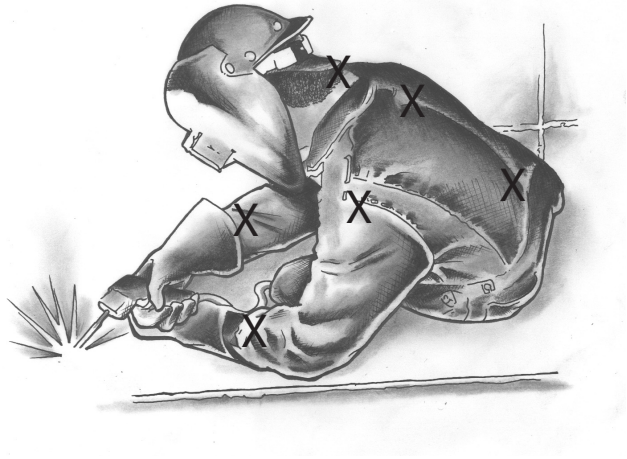
Static work - occurs when a muscle/muscle group is in a contracted state for extended periods of time without relaxation. Static work positions, such as a worker holding an object steady with one hand while working on it with the other, this can be awkward and have detrimental effects on the muscle. When the muscle is left in a static contraction for a long period of time, blood is not flowing properly to the muscle, as a result there are less nutrients for the muscle, and well as an accumulation of waste product in the muscle. In the short term this may lead to pain, tremors, reduced ability to use limbs and fatigue. This will ultimately affect the performance and productivity of the worker, as well as impact negatively on the worker's general health.

Static work example: A worker who power-washes equipment must hold the washing wand with a high force grip and hands held steadily in the same position for long durations. The forearm generally remains contracted for a long period of time with this high force execution. This steady contraction is considered static work. Welders and grinders may also experience this during the course of their work day.

The Xs indicate parts of the body with static loading.

Millwright

Welder



Biomechanics

Biomechanics is defined as the mechanics of human movement and how structural elements of the body, like bones and muscles, work together to produce movements. This concept is particularly important with respect to the back and the vertebral discs in the spine.

Biomechanics and the Back

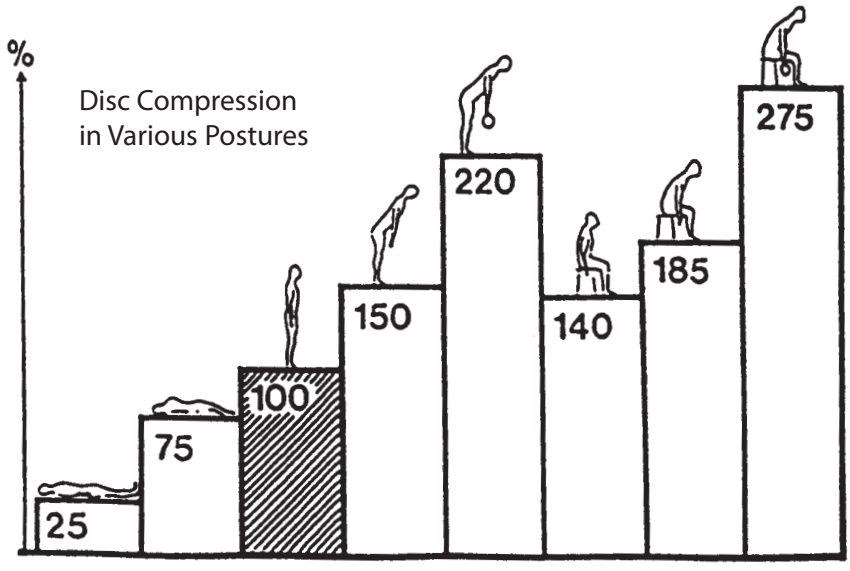
With every movement and posture there are different forces acting on the spinal column. There are certain positions that increase pressure on the discs, for example, standing. There are also positions that put little force on the discs of the back, such as lying down.

Biomechanics is also important when dealing with manual materials handling, and how lifting objects affect the back. For example, lifting with knees bent and the object close to body is better for the back than bending over with straight legs to pick up an object on the ground. These are principles of biomechanics of the body.

Factors that affect compression on vertebral discs:

- Weight of torso and upper body
- Weight of the load being carried
- Position of the body during the lift/carry task

Biomechanics as applied to manual materials handling finds that the heavier the weight lifted, the greater the incidence of chronic low back pain and back injuries. Generally, as the age of the worker increases, the ability to withstand high compressive stresses on the back decreases, resulting in a greater number of back injuries with increasing age.



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Section 3

Musculoskeletal Disorders and Risk Factors Defined

Anatomy Review

Definitions

Ergonomic Risk Factors	Conditions of the job, process or equipment use that contribute to the risk of developing an MSD. Risk factors of the job, equipment and workstation can work together to compound the risk of injury
Musculoskeletal Disorders (MSDs)	MSDs are defined by WCB as an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including a sprain, strain and inflammation that may be caused or aggravated by work. (Section 4.46 WCB - Occupational Health and Safety Regulations.)
Repetition	The amount of repetition any one joint or muscle group can accommodate has limitations in the short- and long-term. When these joint and muscular limitations regarding repetition are exceeded the risk of injury is probable.
Duration	This may be described as sustained exposure to any one type of job or task condition without breaks, for instance, the duration workers have to stand without sitting or taking a break or the amount of time a worker has to use the impact wrench for a given task.
Force	The force needed to execute an action, such as the amount of strength or muscular effort needed to steady a drill or lift a box, or forceful mechanical stresses on the soft tissues, such as using the palm of the hand as a hammer.
Posture	Some postures require more force to execute a required action, depending on the posture of body part. When the joint is in a 'neutral' position it is considered to be in its optimal and most mechanically efficient position.
Awkward Postures	All joints have a comfortable range of motion. When joints are continually pushed to their extreme ranges of motion the amount of stress on the joint and the structures that pass through it increase. This in turn increases the probability that an injury will occur. When joints are in non-neutral positions they are generally considered awkward. For instance, working with a bent wrist would be considered working in an awkward position.
Environmental Factors	These include things such as vibration, mechanical stress and temperature. The amount of vibration that a jack leg drill transmits to the hand-arm segment may increase the likelihood of developing an MSD depending on length and circumstances of exposure to the vibration. Temperature is an especially important consideration with regards to hand-arm vibration.

Contact Stress (External Trauma)	This is defined as the body part pressed against a hard surface, such as a work bench. Pressure on soft tissue will cause it to crush against the bone which can cause bruising and pain. Exposing the body to external trauma (kneeling on a hard surface, or propping up body with elbow) can lead to trauma or stress at the joint, potentially leading to a condition like bursitis.
Vibration	This is defined as mechanical oscillations produced by either regular or irregular periodic movements. Characterized by frequency, amplitude, acceleration and direction.
Whole Body Vibration	The vibration is transmitted through the whole body through the machine-worker interface, such as when a driver in a mobile operations vehicle travels across uneven ground.
Hand/Arm Vibration	The vibration is mainly transmitted to the hand and forearm at the machine-worker interface. An example of this would be somebody holding a vibrating hand tool such as a drill, the vibration is predominantly felt through the hands and arms.
Recovery time	Those parts of the work day where the worker can take a break from a job or task. In this time, the worker's muscles and joints are allowed to recover from the stresses that occur on the body during the course of the work. An example would be a coffee or lunch break, or a point in the day where the worker who has been sitting for most of the work day is able to walk and move around.
Task Cycle	A task cycle is defined as work that has a defined start and end point, such as a mechanic tightening a bolt with a wrench or a shovel operator collecting ore and loading a truck, this is one task cycle.

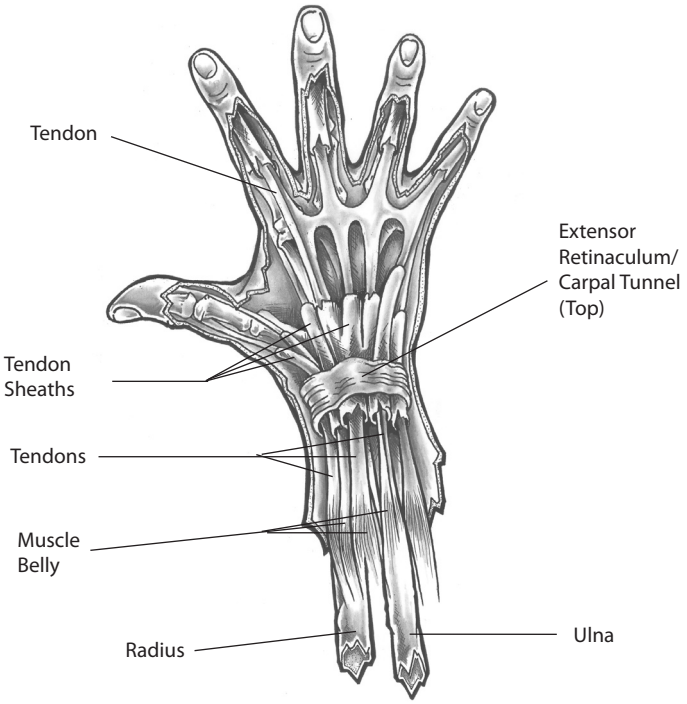
According to the Handbook of Human Factors and Ergonomics, 1997, jobs with a high upper limb repetition rate had a 2.8 greater likelihood of developing carpal tunnel syndrome than a job with a low upper limb repetition rate. Furthermore, it was reported that jobs that require highly repetitive upper limb movements and that require high force increase the likelihood of an MSD by a factor of 29 as compared to a job with low upper limb repetition rate. (Salvendy, pages 1141-2)

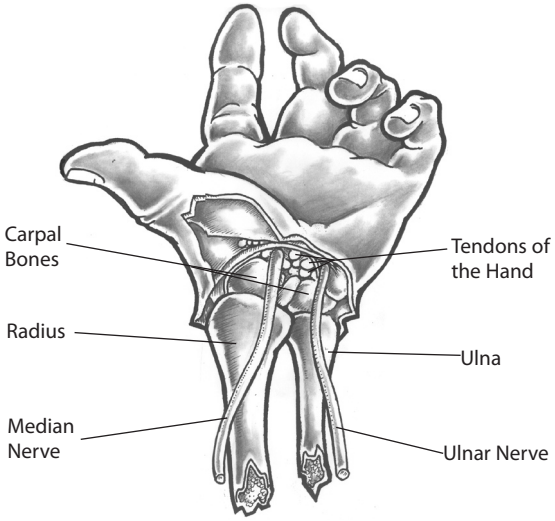
Highly repetitive jobs were identified as those jobs that have a cycle time of less than 30 seconds, or more than 50% of the time doing the same type of work. (Selan, pages II-9, II-10)

Repetitive work that occurs for more than one hour per day is considered to be a potential problem when it comes to MSDs. (Selan, pages II-9,II10)

ANATOMY REVIEW

WRIST





MUSCULOSKELETAL DISORDERS of the HAND and WRIST

Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Carpal Tunnel Syndrome	• The result of compression of the median nerve in the carpal tunnel of the wrist • This tunnel is an opening under the carpal sheath that the median nerve, tendons and blood vessels supplying the hand pass through • High amounts of friction in the tendons causes swelling which will reduce the size of the tunnel and ultimately pinches the median nerve • The size of the tunnel opening is also reduced when wrist is flexed or extended and/or in radial or ulnar deviation	• Back and forth motion of wrist, toward and away from thumb side • Using tools with vibration • Working with wrist in awkward positions • Repetitive hand motions
De Quervain's Syndrome	• A special case of tenosynovitis which occurs in the abductor and extensor tendons of the thumb, where they share a common sheath • Results from forceful gripping and hand twisting	• Using a forceful grip • Wringing hands • Using thumb while thumb is hyperextended for long durations
Ganglion/ Ganglion Cyst	• A condition wherein the tendon sheath swells and is filled with synovial fluid or a cystic tumor at the tendon sheath. The affected area swells and causes a bump under the skin, usually at the back and side of the wrist (dorsal and radial)	• Repetitive motion at the wrist
Sprain	• When fibers of a ligament are torn	• Usually caused by over-stretching • Exposure to repetitive tasks; over time this may increase the likelihood of a sprain
Strain	• When tendon fibers are torn	• When a joint is severely stretched or twisted • Usually in response to a sudden trauma

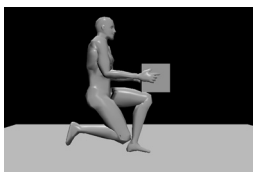
Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Tendonitis	• An inflammation of a tendon. Usually associated with repeated tension, motion, bending and mechanical stress due to impact or vibration. The tendon becomes thick and bumpy, fibers begin to fray and tear apart • Onset is due mainly to repetitive and awkward motions	• Wrenching motion • Awkward wrist postures • Heavy loads on the joint
Tenosynovitis	• Occurs to tendons which are inside a synovial sheath. The sheath swells due to irritation and movement of the tendon with the sheath is hindered and painful. Results from repetitive motion	• Wrenching motion • Awkward wrist postures • Pushing/pressing
Trigger Finger	• A special case of tenosynovitis where the tendon sheath hardens, which causes the tendon to become mainly locked so movements of the finger are forced and jerky	• Operating one finger trigger • Using tools with sharp edges • Pressing motion with tip of finger extended
Hand-Arm Vibration Syndrome White Finger Syndrome (WFS)	• Is a result of insufficient blood flow, with initial symptoms such as blanching of the fingertips. Fingers may feel cold and numb, progressing to a tingling sensation in the hand and loss of tactile sensitivity. • This condition results from vasospasms of the blood vessels in the hand triggered by chronic exposure to vibration. Continued exposure to vibrating tools in a cold environment increases the risk of developing WFS	• Using equipment with a high amount of repetitive impact force or vibrations

Potential Risk Factors for the Hand and Wrist

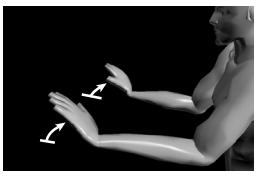
- Awkward positions
- High forces
- Excessive duration
- External trauma
- High frequency
- Exposure to vibration
- Temperature - hot or cold extremes

Positions and Movements of Hand and Wrist

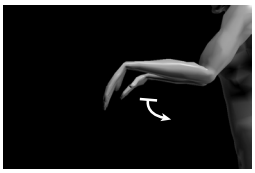
Neutral	the 'neutral' position of the hand and wrist are the most efficient and recommended limb positions
Extension	usually means to straighten the joint to neutral position
Flexion	is to bend the joint, decrease the angle in the joint
Radial Deviation	wrist moves in the direction of the thumb
Ulnar Deviation	wrist moves in the direction away from thumb



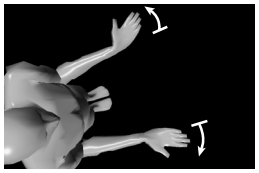
Neutral wrist



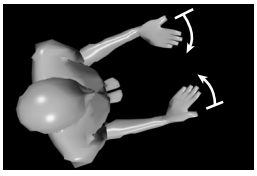
Hands extension



Hands flexion



Radial deviation



Ulnar deviation

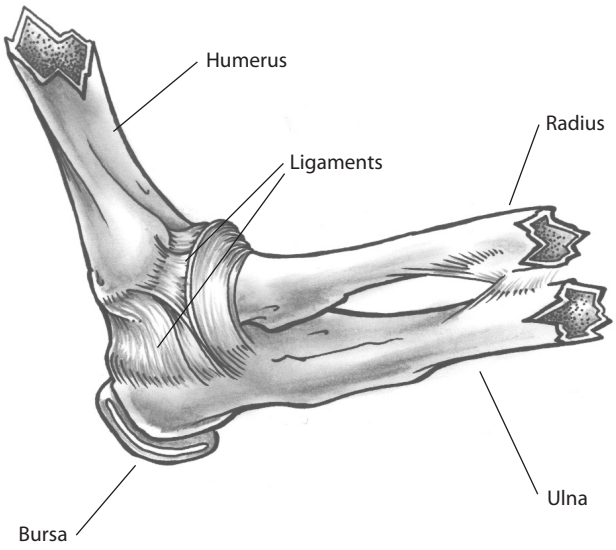
Wrist Positions to be Minimized

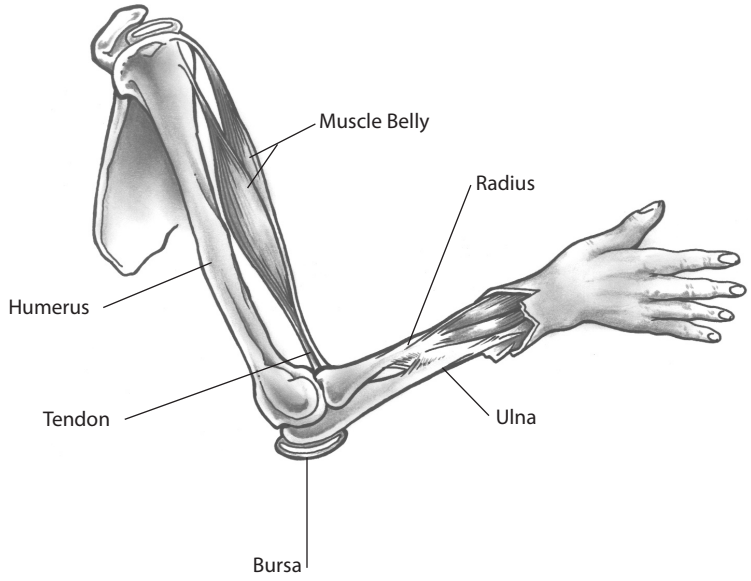
Limit awkward wrist positions.

Work should be done with wrist in neutral position. If this cannot be accommodated for the duration of the work cycle, the use of high repetition and high force should be limited.

ANATOMY REVIEW

ELBOW and ARM





MUSCULOSKELETAL DISORDERS of the ELBOW and ARM

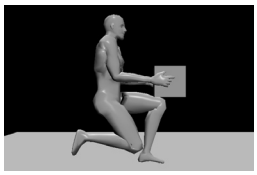
Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Epicondylitis	• Tendons attaching to the epicondyle of the elbow become irritated. This often results from executing jerky throwing motions, repeated rotation of the forearm and forceful wrist exertions • Sometimes referred to as tennis elbow	• Repetitive back and forth motion of the elbows • Hammering motions • Wrenching motions
Bursitis	• An inflammation of the bursa, the fluid filled sac in the knee and shoulder joint. • Due mainly to chronic contact stress on the joint.	• Due to contact stress such as propping elbow up on a hard surface without elbow pads
Tendonitis	• An inflammation of a tendon. Usually associated with repeated tension, motion, bending and mechanical stress due to impact or vibration. The tendon becomes thick and bumpy, fibers begin to fray and tear apart, swelling begins • Onset is due mainly to repetitive and awkward motions	• Wrenching motion • Awkward elbow postures • Heavy loads on the joint
Tenosynovitis	• Occurs to tendons which are inside a synovial sheath. The sheath swells due to irritation and movement of the tendon with the sheath becomes hindered and painful • Results from repetitive motion	• Wrenching motion • Awkward elbow postures • Pushing/pressing

Potential Risk Factors for the Elbow and Arm

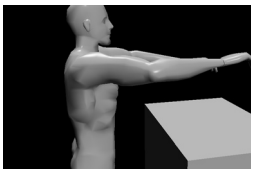
- Awkward positions
- High forces
- Excessive duration
- External trauma
- High frequency
- Exposure to vibration
- Temperature - hot or cold extremes

Positions and Movements of Elbow and Arm

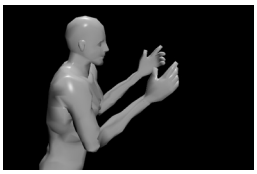
Neutral	the 'neutral' position of the hand, elbow and shoulder are the most efficient and recommended limb positions
Extension	usually means to straighten the joint to neutral position, in the case of the elbow it means to straighten the joint
Flexion	is to bend the joint, decrease the angle in the joint
Pronation	rotation of the forearm toward the inside
Supination	rotation of the forearm toward the outside



Neutral shoulder, neutral elbow



Elbow extension

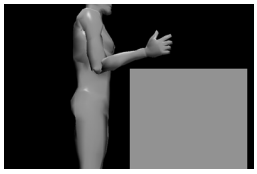


Elbow flexion

Elbow and Arm Positions to be Minimized

Elbow

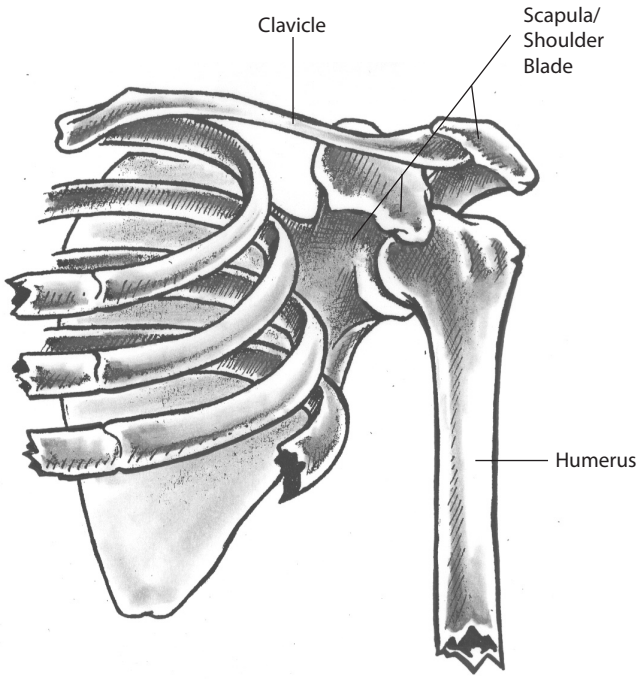
- Limit repetitive rotation, inward or outward, at the elbow
- Limit extreme elbow flexion
- Limit contact stress on the arm

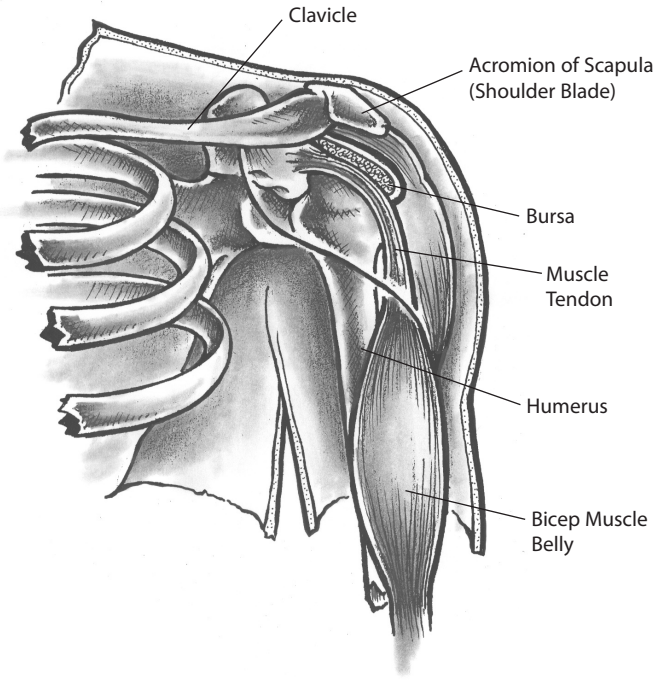


Contact stress forearm

ANATOMY REVIEW

SHOULDER





MUSCULOSKELETAL DISORDERS of the SHOULDER

Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Bursitis	• An inflammation of the bursa, the fluid filled sac in the knee and shoulder joint • Due mainly to chronic contact stress on the joint	• Due to contact stress such as supporting heavy object on shoulder
Tendonitis	• An inflammation of a tendon. Usually associated with repeated tension, motion, bending and mechanical stress due to impact or vibration. The tendon becomes thick and bumpy, fibers begin to fray and tear apart, swelling begins • Onset is due mainly to repetitive and awkward motions	• Wrenching motion with elevated elbow • Awkward shoulder postures • Heavy loads on the joint
Tenosynovitis	• Occurs to tendons which are inside a synovial sheath. The sheath swells due to irritation and movement of the tendon with the sheath is hindered and painful • Results from repetitive motion	• Wrenching motion, with elevated elbow • Awkward shoulder postures • Pushing/pressing • Overhead work • Grinding
Thoracic Outlet Syndrome	• Onset due to compression of nerves and blood vessels between the clavicles and the first and second rib just underneath the armpit. Blood flow to and from the arm may be reduced which may cause the arm to become numb and may limit muscular ability	• Carrying heavy loads. with extended arms

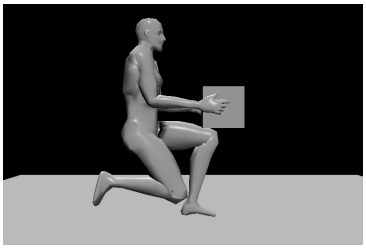
Potential Risk Factors for the Shoulder

- Awkward positions
- High forces
- Excessive duration
- External trauma
- High frequency
- Exposure to vibration
- Temperature - hot or cold extremes

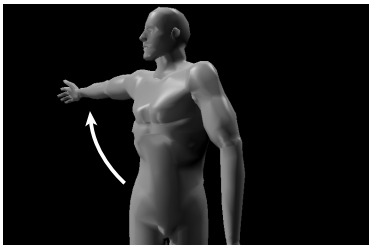
Positions and Movements of the Shoulder

Neutral	the 'neutral' position of the hand, elbow and shoulder are the most efficient and recommended limb positions.
Extension	means to bring arm out, down toward body
Flexion	is to bend the joint, decrease the angle in the joint, bringing arm up away from body
Abduction	bringing arm resting at side, away from body
Adduction	bringing arm out at side, toward the body
Hyperextension	bringing arm resting at side, behind the body

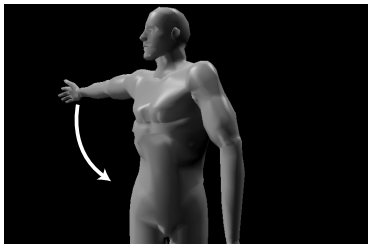
Positions and Movements of the Shoulder



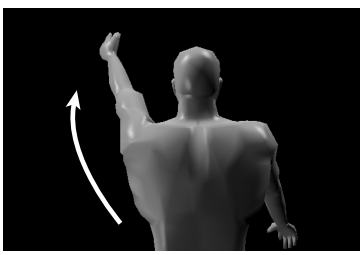
Neutral shoulder



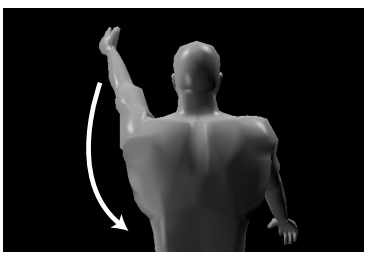
Arm abduction



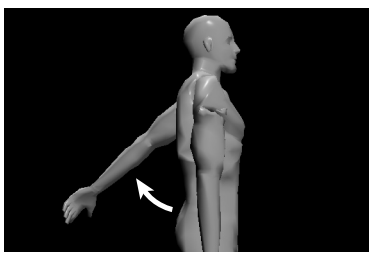
Arm adduction



Arm flexion



Arm extension



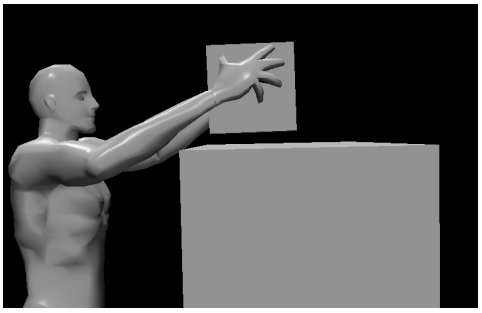
Hyperextension of arm

Shoulder Positions to be Minimized

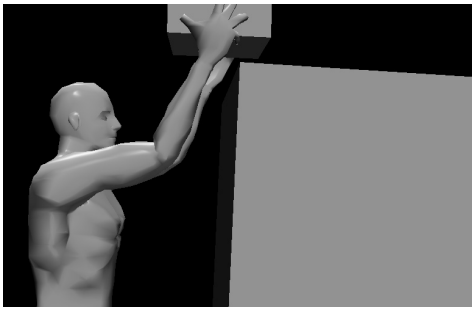
Shoulder/Arm

- Limit reaches above the shoulder
- Limit posterior reaches
- Limit extreme shoulder flexion
- Limit extreme shoulder extension
- Limit extreme shoulder abduction/adduction
- Limit hyperextension of arm
- Lack of rest for muscles, missed breaks

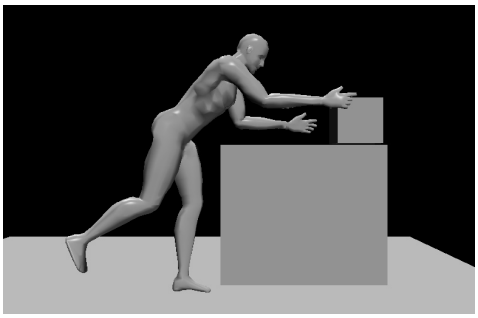
Shoulder Positions to be Minimized



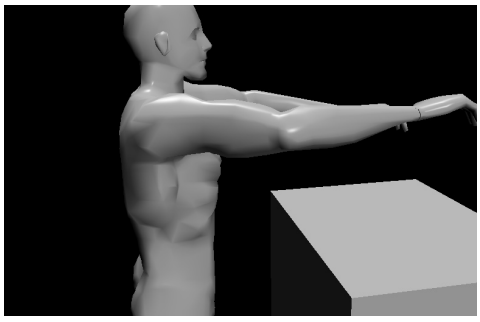
Elevated shoulders



Overhead reaches



Far reaches with obstruction



Working with elevated shoulders

Factors that increase the risk of developing an MSD:

- Continual overtime
- When pace is not controlled by worker, i.e., conveyor belt
- When worker has no control over work and workstation design
- When task is monotonous and/or repetitive
- When worker not appropriately trained at work or use of equipment
- When there is a lack of communication between worker and management
- When there is a poorly organized task sequence

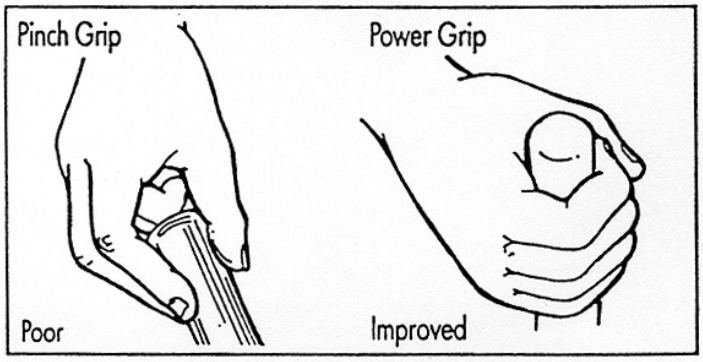
To keep in mind:

Force

- Limit long durations of force applications
- Limit high speed arm movements as it stresses the joints

Static Body Load

- Make job more dynamic with job enlargement
- Encourage rest breaks and exercises
- Job enlargement, give workers more tasks in a work cycle
- Create job rotation where different muscle/muscle groups are used
- Use a power grip versus a pinch grip



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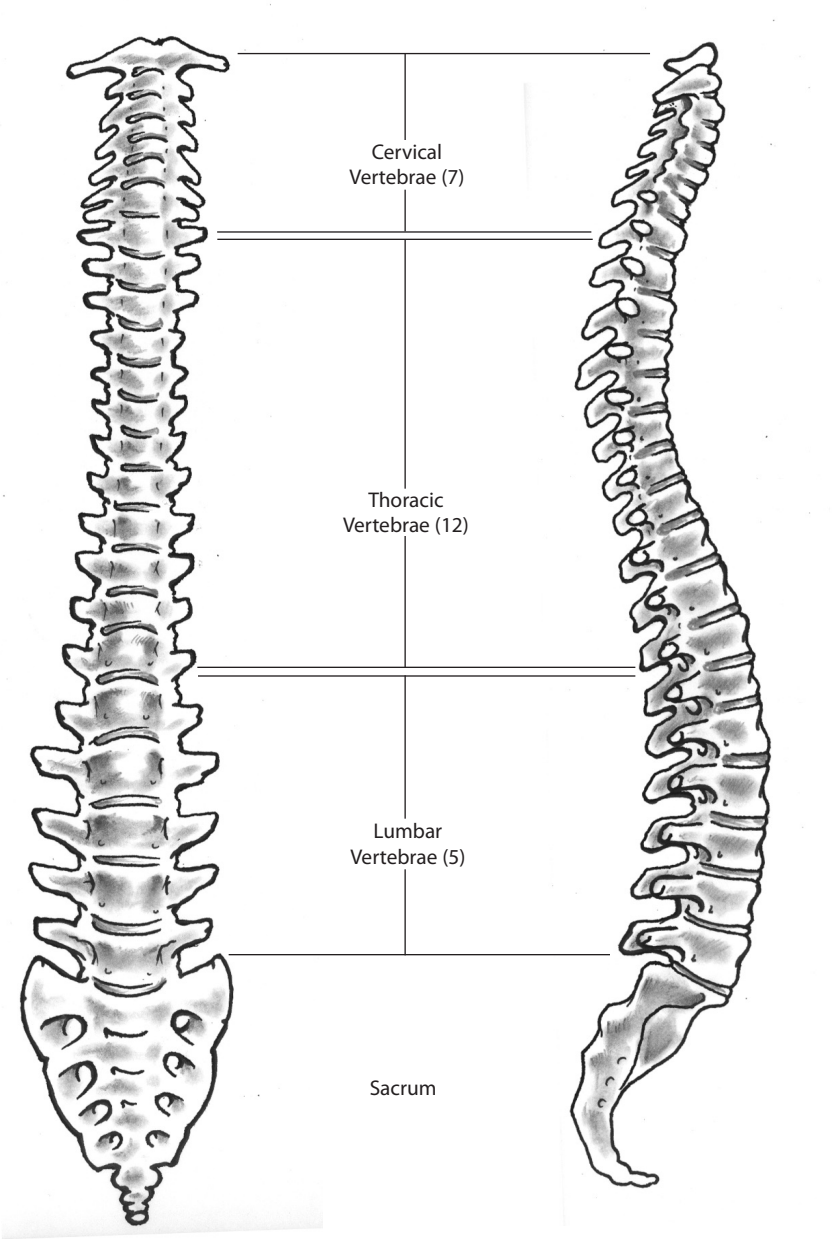
Repetition Rate

- Limit repetitive motions
- Have enough materials at the workstation to get through a significant part of the work cycle to limit continually lifting and reaching to transport materials

ANATOMY REVIEW

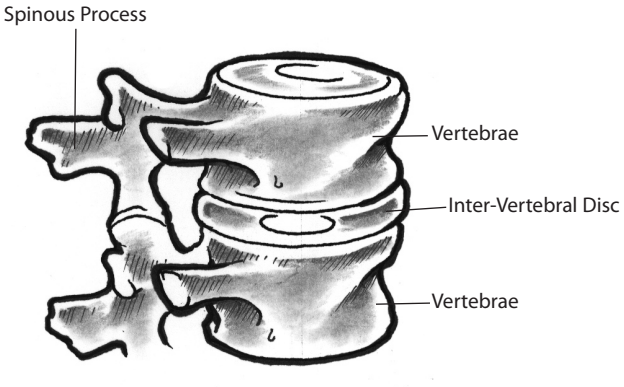
BACK/SPINE



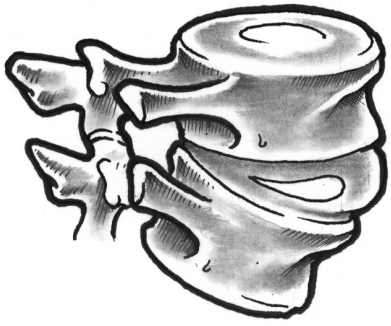
ANATOMY REVIEW

BACK/VERTEBRAL DISCS

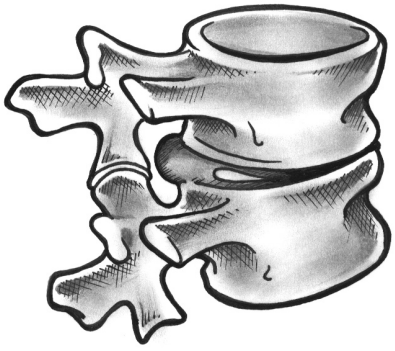
Neutral Back



Back in Extension



Back in Flexion



MUSCULOSKELETAL DISORDERS of the BACK

Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Acute Injury	• One-time event, where the direct cause of injury is readily apparent	• Excessively high force lift
Chronic Injury	• Chronic back injuries occur over time, due to continual stress on the back over long durations. These chronic injuries may appear to be a result of an acute injury, but the initial weakness or injury may have been triggered by chronic exposure to risk factors. As a result, the attack seems acute. A worker may feel back pain that gets slowly worse over the years, then while lifting a certain object may feel as though they have 'thrown their back out', and attribute the injury to that particular lift. However, disc degeneration that occurred over time is more likely the cause of the injury in this case. These types of injuries are more difficult to diagnose as there may be a variety of contributing factors that are not readily apparent. Determining the primary source of back pain takes careful consideration	• Repeated lifting of heavy objects • Repeated lifting of objects while in an awkward posture • Sitting forward for prolonged periods of time • Continually travelling on uneven surface, whether in a vehicle or on foot • Continually walking on hard surfaces, such as concrete
Degenerative Disc Disease	• Over time, the vertebral discs begin to dry, flatten, wear down and may begin to tear or stretch. As a result, nerves and tissue may become pinched, causing pain. This may be accelerated by awkward postures, movements and pre-existing injuries. Workers who are required to spend most of their shift sitting forward may have a higher incidence of low back pain and disc degeneration due to the duration of time in that position. As well, the impact from travelling on uneven ground may stress the discs. This type of degeneration occurs most often in the low back (lumbar) region, the part of the back where most of the weight of the upper body is supported. This type of degeneration occurs gradually over time, aggravated by the different stresses that may be present	• Same as above

Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Herniated Disc	• Degeneration of the disc may lead to tiny rips in the outer wall of the disc which may lead to disc rupture. This is often referred to as a "slipped disc." This happens often in people who spend most of their day with their back bent in awkward postures. This causes more weight on the front part of the disc and eventually the gel-like fluid in the disc get pushed to the back, causing it to 'bulge' from its normal position. When the disc bulges it can put pressure on the nerves passing by, as well as the surrounding tissue. In severe cases this bulge will actually rupture and the gel-like fluid will escape and cause irritation and pain in the affected region of the back	• Repeatedly lifting of heavy objects • Repeated lifting of objects while in an awkward posture • Sitting forward for prolonged periods of time • Continually travelling on uneven surfaces, whether in a vehicle or on foot • Continually walking on hard surfaces, such as concrete
Pinched Nerve	• This occurs when the vertebrae move so close together, due to degeneration of the disc, that they touch the nerve. Symptoms include leg pain in combination with low back pain. The incidence of this condition is quite low	• Same as above
Back Sprains and Strains	• When back ligaments, tendons and muscles are overused they may stretch or tear due to overexertion. These strains and sprains are common occurrences in the back and are generally felt as tightness and soreness in the back muscles	• Same as above

Potential Risk Factors for the Back

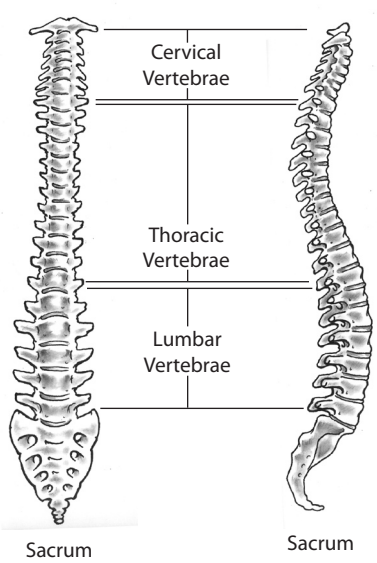
Increased muscle injury, discomfort and fatigue is found to occur in those who:

- Maintain stressful and awkward body positions
- Work in a fixed or static position for long durations of the work cycle
- Do not take enough rest breaks between strenuous tasks to allow the muscles to recover

Positions and Movements of the Back

There are four natural curves in the spinal column:

- Cervical
- Thoracic
- Lumbar
- Sacral



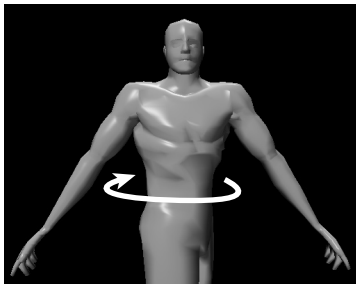
These curvatures help maintain balance, increase supportive strength in the back, and help absorb the shocks encountered in everyday living.

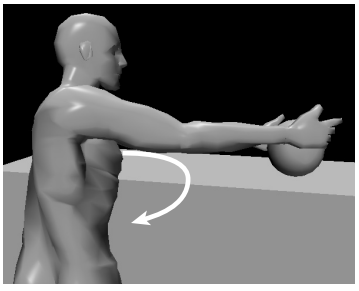
Extreme ranges of motion combined with excessive force or prolonged duration may put significant strain on the lower back, for example:

- Forward bending of the spine
- Twisting of lumbar spine or torso
- Lateral back movements

Manual materials handling risk factors also play a role in the development of MSD risk factors in the back. Please see page 5-15 in this manual for more a more detailed account.

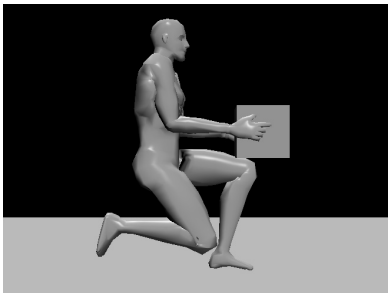
For details on how to address general seating design, please see page 5-22 in this manual.


Twisting of torso

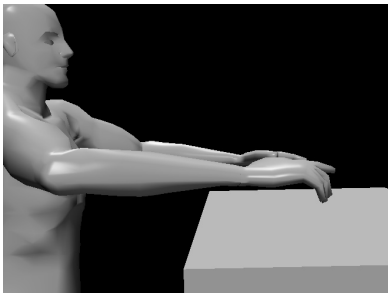

Reaching to the side

Positions and movements of the back

Optimal

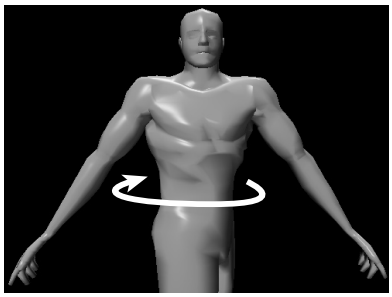


Neutral back

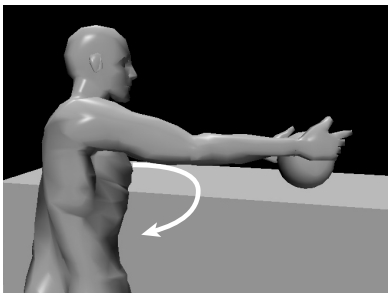


Neutral back

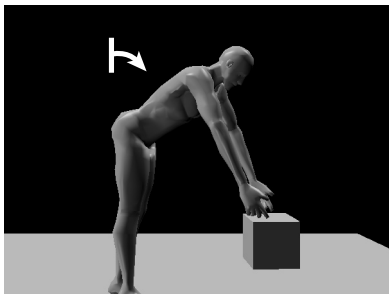
To be minimized



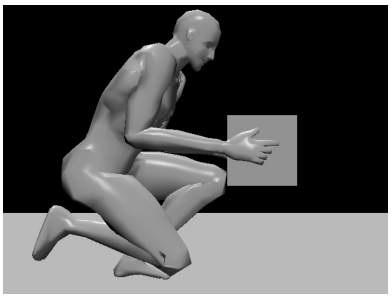
Twisting of the trunk



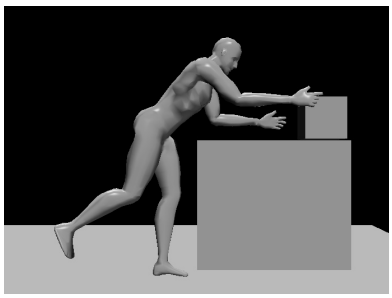
Side reach



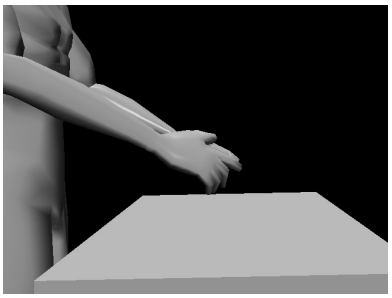
Back flexion



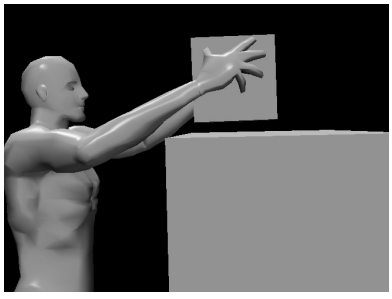
Back flexion



Reach forward causing back flexion

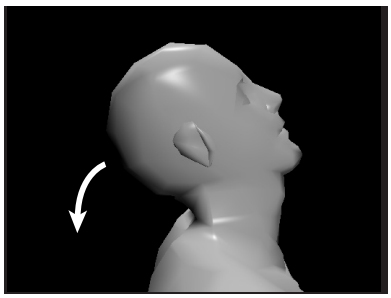


Potential for back flexion

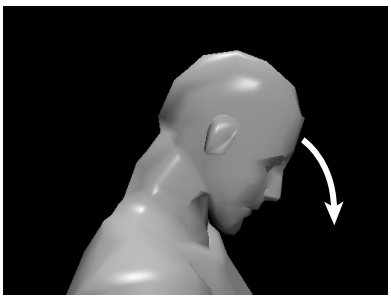


Potential for extension of the back

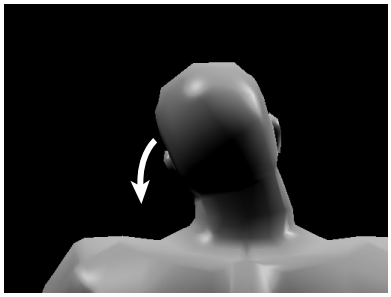
Positions and movements of the neck to be minimized



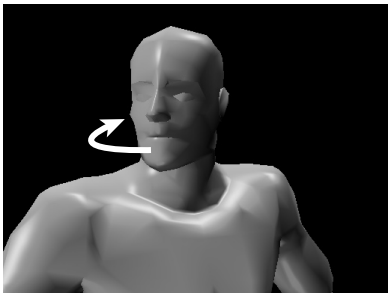
Neck Extension



Neck flexion



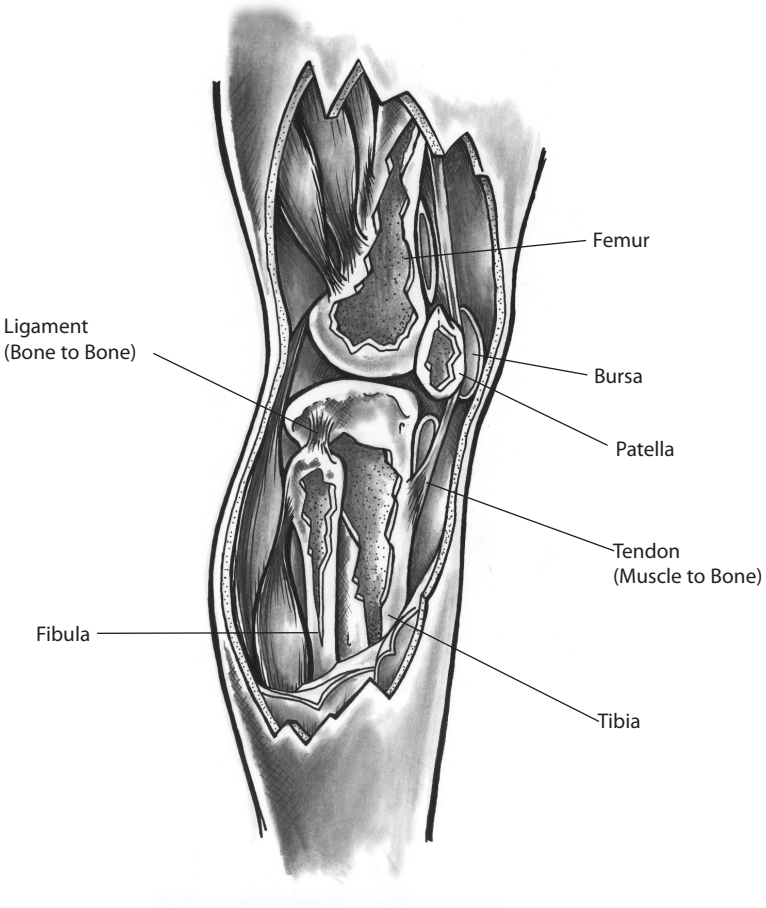
Side tilt



Neck rotation

ANATOMY REVIEW

KNEE and LOWER LIMB



MUSCULOSKELETAL DISORDERS of the KNEE and ANKLE

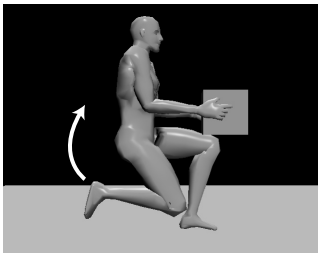
Name of Disorder	Description of Disorder	Typical Motion Associated with Disorder
Bursitis (Carpenters Knee)	• An inflammation of the bursa sac at the knee	• Kneeling on hard surface with no cushioning between knee and surface (no knee pads)
Bone Fracture of the Leg	• A break of a bone in the leg	• Resulting from a large force impacting leg
Contusions of the Knee	• A contact blow to the front of the knee	• Falling forward and landing on knees
Ligament Strains of the Ankle or Knee	• Stretching and/or tearing of the ligaments of knee and ankle joints	• Movement of leg beyond comfortable range of motion
Tendonitis	• An inflammation of a tendon. Usually associated with repeated tension, motion, bending and mechanical stress due to impact or vibration. The tendon becomes thick and bumpy, fibers begin to fray and tear apart. Swelling begins • Onset is due mainly to repetitive and awkward motions	• Repeated pressing of a pedal with foot • Awkward knee and ankle postures • Heavy loads on the joint
Tenosynovitis	• Occurs to tendons inside a synovial sheath swell due to irritation and inflammation. Movement of the tendon with the sheath becomes hindered and painful. Results from repetitive motion	• Repeated pressing of a pedal with foot • Awkward knee and ankle postures • Pushing/pressing with foot
Varicose Veins	• A pooling of blood in the veins of the leg	• Due to chronic standing for long durations

Potential Risk Factors of the Lower Limb

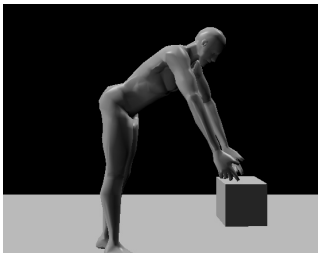
- Awkward positions
- High forces
- Excessive duration
- External trauma
- High frequency
- Exposure to vibration
- Temperature - hot or cold extremes

Positions and Movements of the Lower Limb

Neutral	the 'neutral' position of the knee is at 90 degrees of flexion with respect to the floor
Extension	is when knee moves toward becoming straight with leg
Flexion	is to bend the joint, decreasing the angle in the joint, bending knees toward back of thigh
Dorsiflexion	is to bend the foot 'up' at the ankle
Plantar Flexion	is to bend the foot 'down' at the ankle



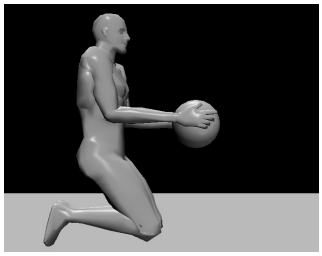
Knee flexion



Knee fully extended

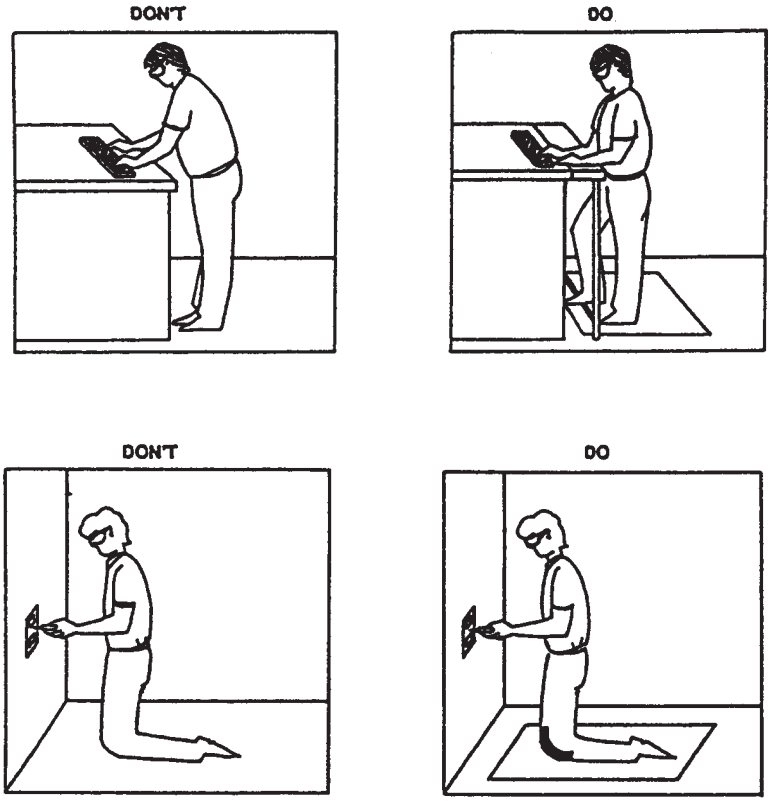
Movements of the Lower Limb that Should be Minimized

- Kneeling on a hard surface without knee pads or padding
- Prolonged repetitive motions of the foot, for example, depressing a foot pedal
- Prolonged standing on a hard surface without appropriate cushioning or footwear
- Static standing for long periods of time



Contact stress on knee

Potential Solutions

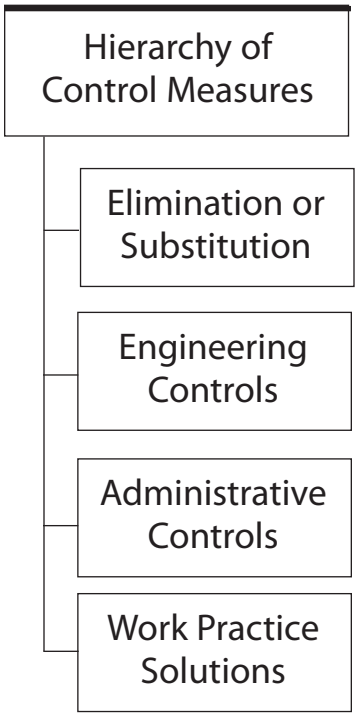


Notes

Section 4

Control Measures and their Applications

Hierarchy of Control Measures



Elimination or Substitution

Substitute or eliminate the equipment or work process that involves a high risk of MSD.

Example: Using a forklift to lift objects in the warehouse, instead of the worker manually lifting it. Replacing the manual work of lifting with operating a forklift is an example of substitution. Substitution in this case eliminates the risks associated with the manual lifting of heavy objects in the warehouse, and effectively reduces the overall risk of developing an MSD in performing that task.

Example: Many mines have eliminated the storage and distribution of hydraulic oil in pails. Hydraulic oil is now delivered to the mine site in large bulk containers. This facilitates the transportation of the oil to a lubrication storage area where the oil can be transferred to mobile equipment via a hose from an automated delivery system. This reduces much of the manual materials handling that was necessary when the pails were widely used.

This entails making physical changes to the workstation or equipment used at

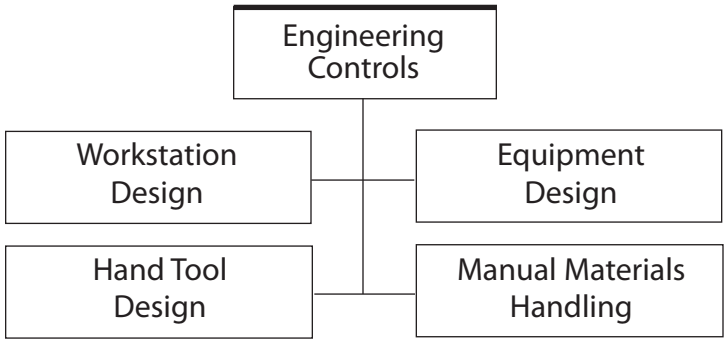
Engineering Controls

that particular job to control exposure to MSD hazards. Engineering controls act on the source of the hazard and control employee exposure to that hazard without relying on the worker to take self-protective action or intervention.

Engineering controls can be applied to:

- Workstations
- Equipment
- Tools
- Materials
- Facilities
- Process

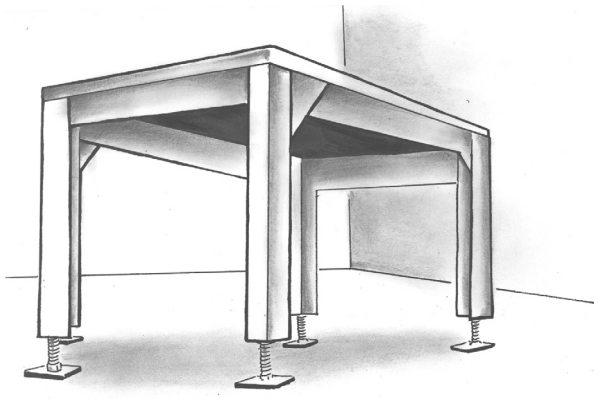
Example: Making a welder's bench adjustable to the height of the worker who is using the bench. In this way, the worker does not need to concentrate on maintaining good posture while working. The worker can adjust the bench before the start of work and raise or lower the bench until the equipment being worked on is at a comfortable height. This should help reduce risk factors associated with MSDs due to awkward postures of the back.



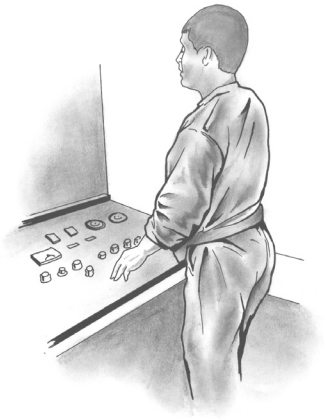
Workstation Design

Make the workstation adjustable or make it to fit the particular worker using it.

Example: Height adjustable work bench



Example: Haul truck dump operator



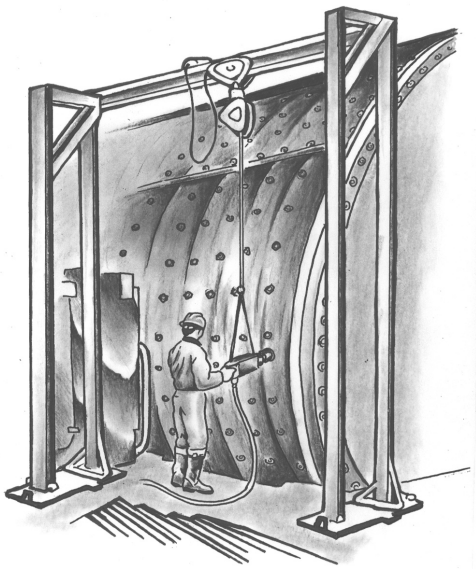
Initial work station
Risk Factor: Awkward Posture

Redesigned Work Station
Reduction of Risk

Equipment Design

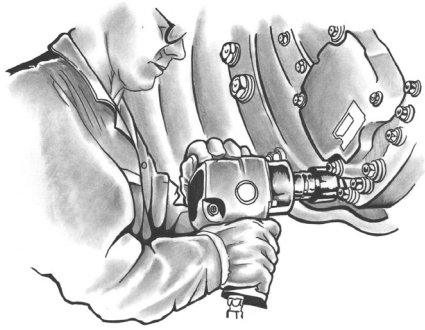
Purchase and develop equipment that fits the worker comfortably, minimizing awkward positions.

Example: Suspended impact wrench

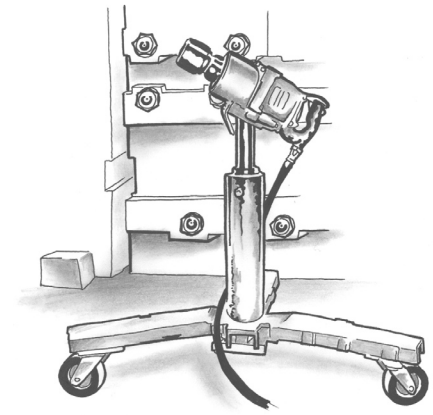


Impact suspended on support beam for liner change

Example: Supported impact wrench



Standard impact wrench



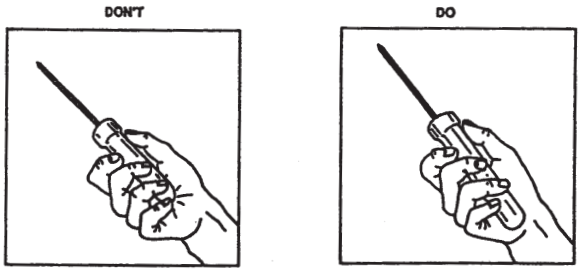
Supported impact wrench

Redesigned impact wrench for Tireman, weight of machine is supported

Hand Tool Design

Hand tools should fit the workers' hands well, try to minimize pinch grip and minimize the need to grip the tool forcefully or awkwardly.

Example: Screwdriver



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Manual Materials Handling Design

When needing to manually work with heavy loads, use mechanical aids and design the workstation to minimize awkward and repetitive lifts.

Example: Mechanical aids used in lifting

Risk Factor: Awkward Posture

Reduction of Risk Factor

Manual Materials Handling
Mine Site Cannery - Use of handling aid in task

Administrative Controls

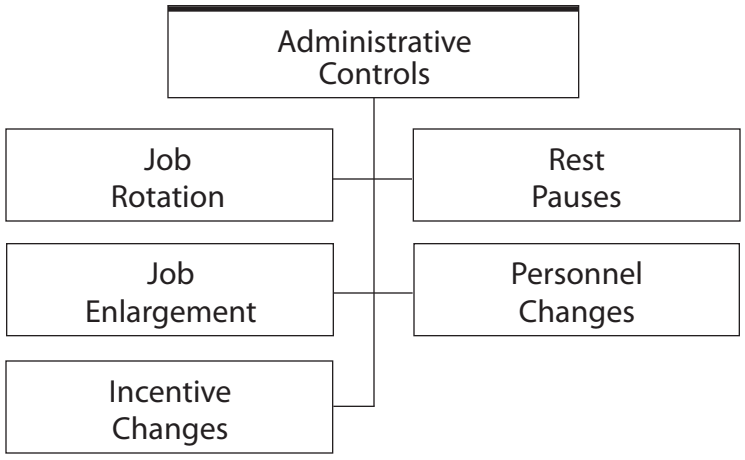
Administrative controls are generally managerial decisions wherein scheduling, financial and/or job arrangement changes are made to reduce duration of risk factor exposure to workers.

These are controls that limit workers' exposure to risk factors. This is done through arrangement of personnel schedules and changing the routine of the job and/or the worker.

Administrative controls can be applied to:

- Job rotation
- Job enlargement
- Work schedule arrangement
- Increasing the number of workers doing the job
- Transferring employees when they have reached their limit of risk
- Ensuring that there is good 'housekeeping' of equipment and facilities

Example: Have workers rotate to different jobs within the work period. This may mean that a welder may spend the first half of his shift working on a haul truck and then trade with his counterpart and work at a welder's bench for the last half of the shift. This gives the worker a chance to take a break from any potentially awkward postures or other significant risk factors that may be present at either workstation.



Job Rotation

This minimizes duration and quantity of exposure to particular MSD risk factors in the workplace. The worker must be rotated to a job using different major muscle groups than the initial job for this process to be effective. When job rotation is in place, the supervisor should ensure that the worker is experienced in the proper techniques of each job and is properly trained in all the jobs that the worker must perform. It must be ensured that the worker is not placed in a job which may either aggravate existing injuries or precipitate new injuries due to inexperience, lack of training or poor selection of the jobs in the rotation.

It must be noted that due to collective bargaining agreements between mine management and unions, crossing over jobs to implement job rotation may contradict clauses of these agreements and therefore may not be appropriate for every mine site.

Job Enlargement

Create more varied tasks within a job cycle, so that the worker has more than just one type of task in a work cycle. The tasks must use different muscle groups.

Example: A miner working on a stope could get materials required to advance to a certain degree, drive a certain amount of footage, then return to the main level to replenish material stores. This would allow the miner to walk around and perhaps use different muscle groups through the course of the work day.

Rest Pauses

Taking frequent rest breaks allows the muscles and joints to recover from the actions of repetitive or awkward work. If frequent breaks are taken, fatigue would likely occur later in the work cycle. It is expected that if frequent rest breaks are taken throughout the work cycle there will be a more even and consistent performance output.

Personnel Changes

Increase the number of workers on site so that the duration of potential sources of MSD risk exposure may be reduced.

Incentive Changes

Structure piece rate bonus systems so that the incentives do not encourage the worker to overexert themselves.

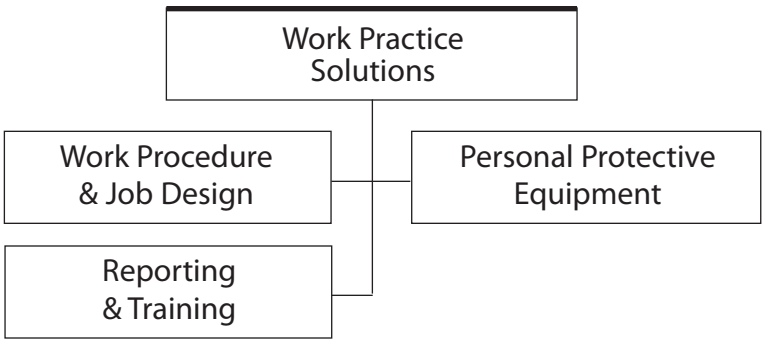
Work Practice Solutions

These are controls that reduce the likelihood of exposure to MSD hazards through the alternation of the manner in which a job or physical work activities are performed.

Work practice solutions can be applied by:

- Ensuring worker is following proper procedure
- Creating a conditioning program for new and reassigned employees
- Providing training in the recognition of MSD hazards and work techniques that decrease exposure to injury
- Ensuring workers are wearing personal protective equipment

Example: Train workers how to properly adjust seats in heavy mobile equipment. By teaching them how to use the adjustment features of a seat, it is more likely they will use them. If the worker feels comfortable adjusting the seat, it may make the work day more comfortable for the worker, as well as reduce the risk of certain MSDs pertaining to the back.



Work Procedure and Job Design

A procedure manual on how the worker should be doing the job efficiently and in the safest manner should be developed and available to the worker at all times. MSD prevention instructions should be included in these procedures. This would be most appropriate for jobs with high accident and MSD rates.

Example: A procedure manual on the appropriate way to lift heavy or awkward objects.

An easy approach to developing a procedure manual is by taking the job and breaking it down into smaller sub-sections. By doing this, not only will it be easier to understand, but it will give the work team a chance to identify the

method of doing the job that has the most potential to reduce injury.

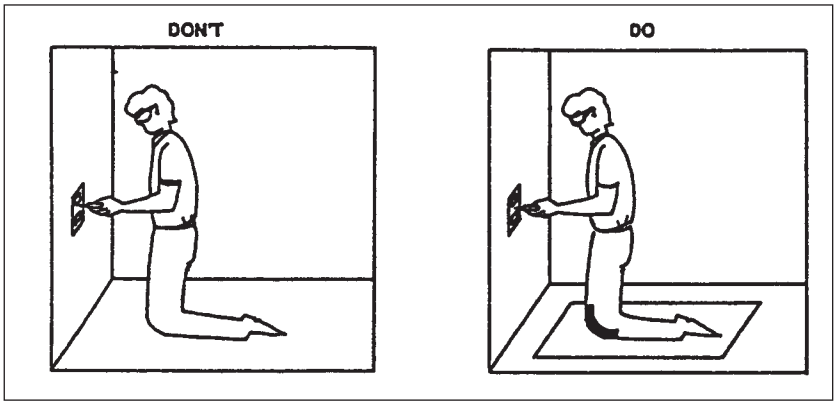
Diagrams, photographs and simple explanations will make it easier to understand. Obtaining worker input is essential in developing such a manual as ultimately they will be the ones using it. Making sure that the worker is able to access and understand the manual is also an important part of this process.

Personal Protective Equipment

The use of personal protective equipment is a control device worn or used while working to protect workers from exposure to MSD hazards. Personal protective equipment includes items such as glasses, gloves and knee pads. Personal protective equipment does nothing to minimize the source of the hazard.

Example: When welders need to kneel on the ground or prop their elbows on an object to weld, ensure they are wearing knee or elbow pads. This will reduce the amount of contact stress at the joint, reducing the risk of certain MSDs.

Back belts and wrist braces are not considered effective personal protective equipment (see page 4 - 13 in this manual).



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Reporting and Training

Worker training should involve job specific training on the risks and preventative measures to be taken with regard to musculoskeletal disorders. This involves educating workers on the causes and symptoms of MSDs. This will also involve teaching workers the best ways to perform the job and the appropriate reporting procedures.

Example: Demonstrating to workers how to keep their wrists and back in neutral positions for as much of the work day as the job will permit. Explain what MSDs are and the potential MSD symptoms in that particular job.

Maintenance activities in the mining industry have a long tradition and there may be some reluctance to move toward new methods of job design. With the introduction of a new type of workstation or tool, the supervisor will need to talk to workers and explain the benefits of the changes with respect to worker comfort and a lowered risk of injury. Proper training in the use of new equipment is very important. Emphasize to workers that although the new workstation or tool may feel different, they should be aware and diligent in using the new product. If this is not made clear, workers may revert to original, more hazardous work protocol out of habit.

This would also be an appropriate time to address the issue of reporting. Workers should know what procedures to take if they feel they have identified symptoms indicative of an MSD, i.e., reporting to the supervisor or first aid. This procedure is individual to each mine.

Wrist Splints and Back Belts

Wrist splints and back belts have often been thought of in industry as personal protective equipment. Many people will use these measures when they feel physically uncomfortable performing tasks on or off the work site. They assume that by keeping the wrist or back steady they are somehow reducing the risk of injury or reducing pain, but these practices may in fact put the worker at greater risk of either aggravating an existing injury or developing a new one. Using wrist splints and back belts may also result in the weakening of supporting muscles used to execute the motion, for example, the back and abdominal muscles used in a lifting task. When these muscles become weakened, the person may be more susceptible to injury once the back belt is off. Furthermore, back belts are notorious for giving the worker a false sense of safety and protection, when back belts have not been proven to provide either. This false sense of security may cause workers to become overconfident and therefore carry out tasks beyond their capabilities, possibly leading to an overexertion injury.

In the case of wrist splints, if there is no modification to the work station, the repetitive nature of the task may still take its toll by acting on the different parts of the body compensating as a result of wearing the wrist splint. Wrist splints and back belts are not injury prevention measures and should only be worn if prescribed by a doctor or a medical professional.

For more information please refer to Appendix: Ergonomics Commentary Vol. 1 and Vol 2.

Notes

Section 5

General Design Guidelines

Workplace Design

The goal of workplace design is to relate the physical characteristics and capabilities of the worker to the design of the equipment being used and the layout of the workplace.

Components of Workplace Design

When examining workplace design, some background is needed:

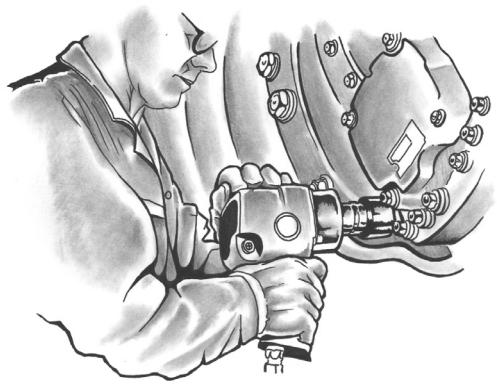
- Detailed observation of the job or task being done
- An understanding of the equipment being used to carry out the task
- The biological characteristics of the worker carrying out the task
  i.e., what potential risk factors does the worker face executing the task or job

Designing the Workplace

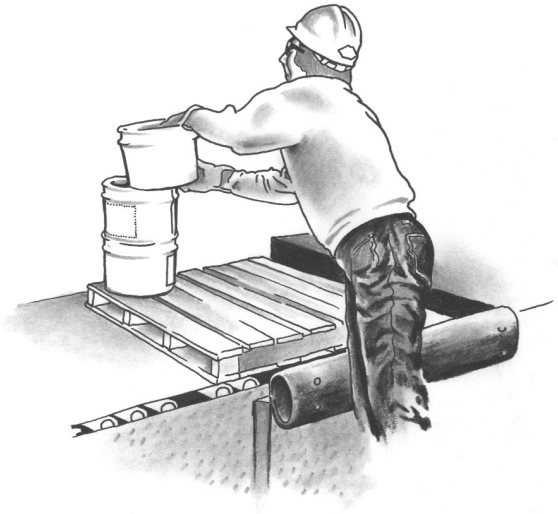
Risk Factors in Workplace Design: Wrist and Hand

Risk Factor	Optimal	Method to Achieve
Awkward Posture	• The height of the workstation should be such that the worker maintains a neutral wrist	• Adjust table to appropriate height for worker • For a multi-user workstation, allow for easy adjustability
Awkward Posture Repetition	• When using a tool for long durations, try to ensure the use of large muscle groups in the operation	• Instead of using a one finger trigger, use a trigger that uses all four digits
Awkward Posture	• Avoid using a pinch grip for prolonged periods	• Use tools with a power grip • Take frequent rest breaks
Awkward Posture	• Maintain neutral posture of the hand and wrist	• Mechanical aids can be used in order to maintain neutral wrist, arm and back
Static Stress Awkward Posture	• Minimize amount the of time spent stabilizing an object with hand	• Use clamps or vices when needing to stabilize object with one arm while working on it with the other
Excessive Force	• Use tool without having to grip strenuously • Low grip force required	• Ensure the object being gripped does not have a smooth, slippery surface. A tool with a compressible surface may reduce chances of slipping

Risk Factors for the Hand and Wrist

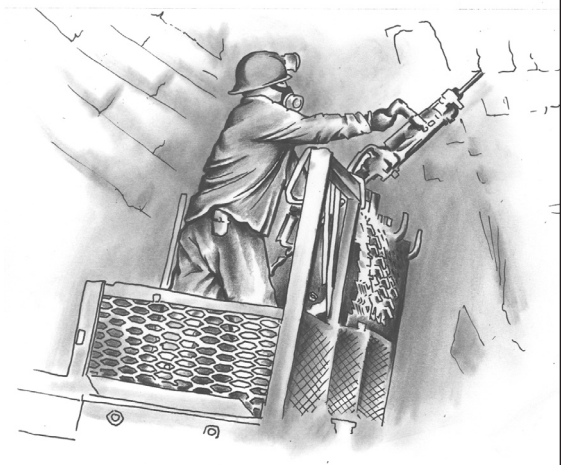


Example: Awkward Posture - Wrist
Vibration - Hand/Arm



Example: Awkward Posture - Wrist
High Forces - Wrist

Example: Awkward Posture - Wrist
Contact Stress - Arm/Wrist
Static Stress - Lower Arm



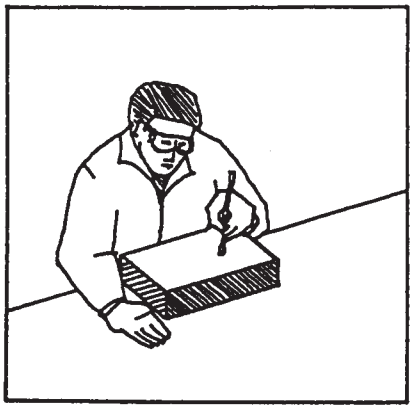
Example: Awkward Posture - Wrist
Vibration - Hand/Arm
High Forces - Hand/Wrist
Static Stress - Hand/Wrist

Methods to Reduce Risk Factors: Wrist and Hand

DON'T

DO

DON'T



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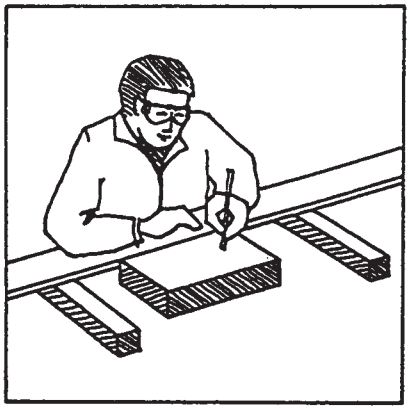

DON'T

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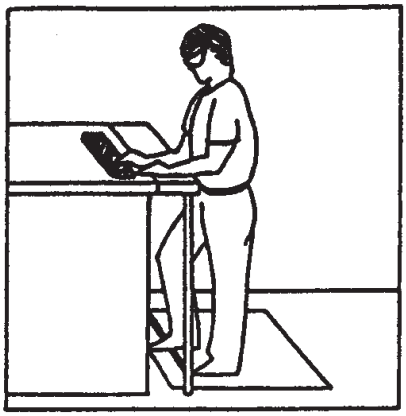
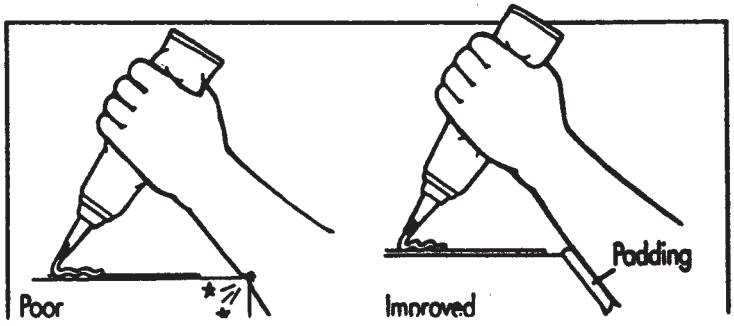
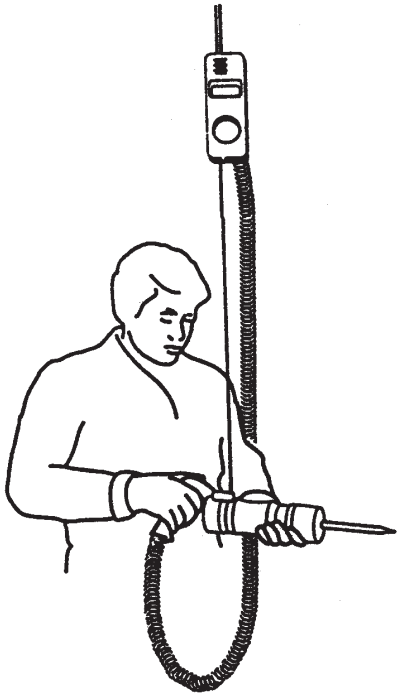
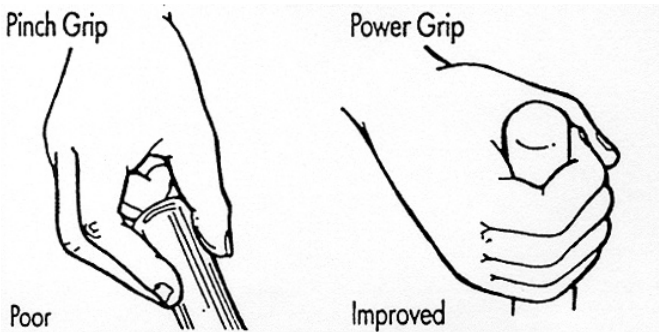


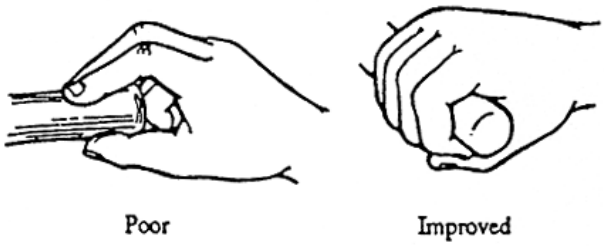
- **Padding**
- **Rounded edge**
- **Redesign**



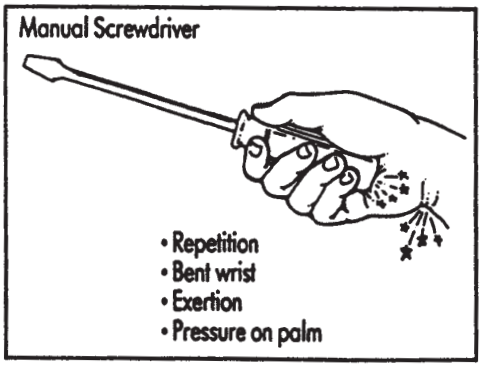


The weight of heavy hand-held tools can be supported by a counterweight.

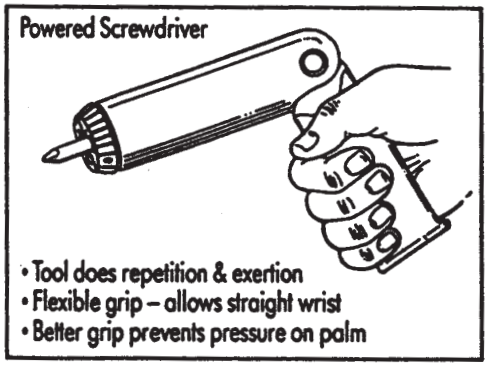




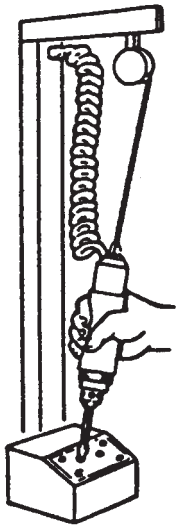
Use a power grip for heavy work, not a pinch grip



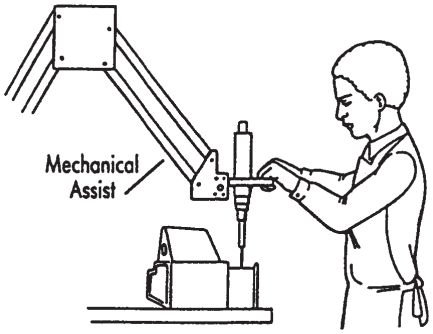
Poor

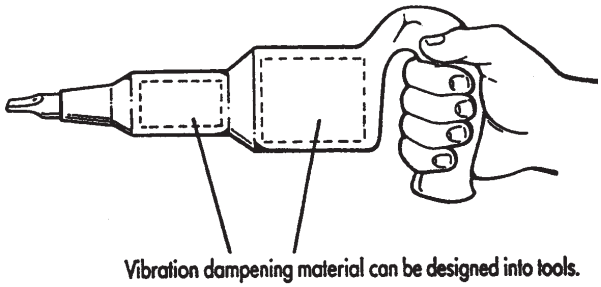


Improved

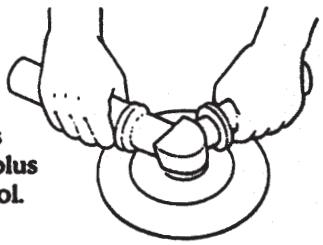


Use tool balancers to support the weight of heavy tools

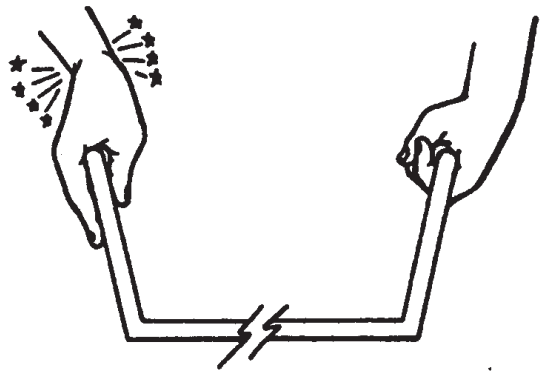




Vibration dampening material can be designed into tools.

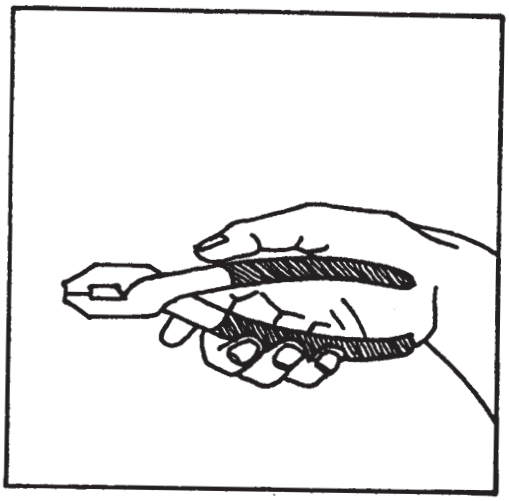


Two-handed tools distribute exertion, plus provide better control.



Poor Improved

DON'T



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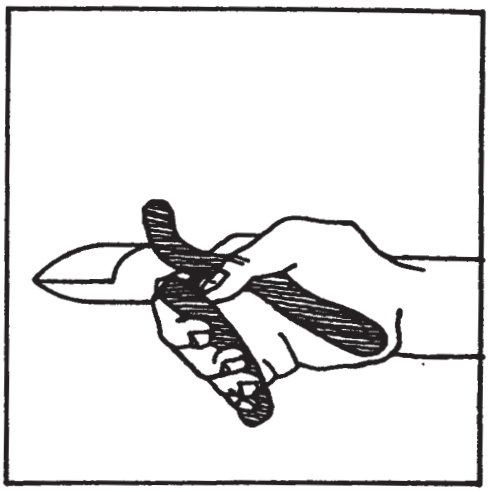

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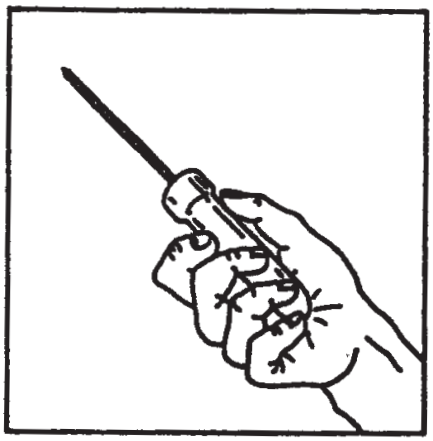

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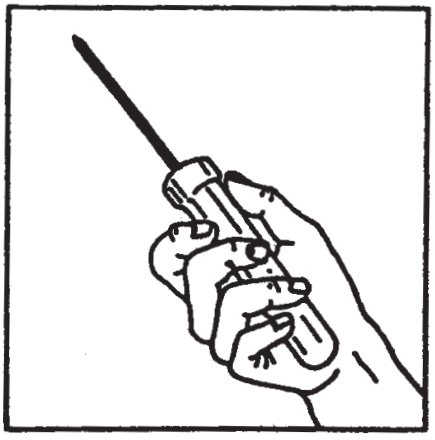

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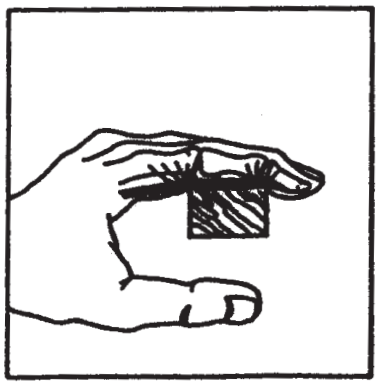

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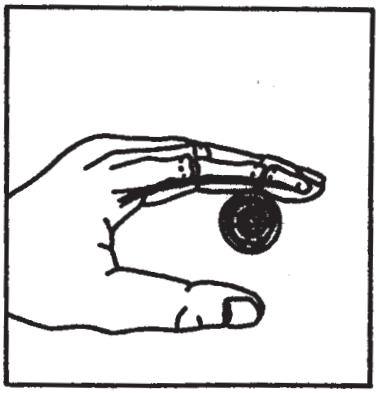

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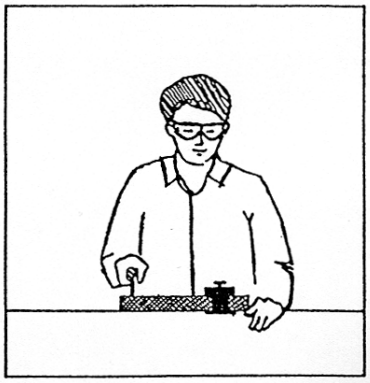

Your thumb and index finger should slightly overlap around a closed grip for maximum strength

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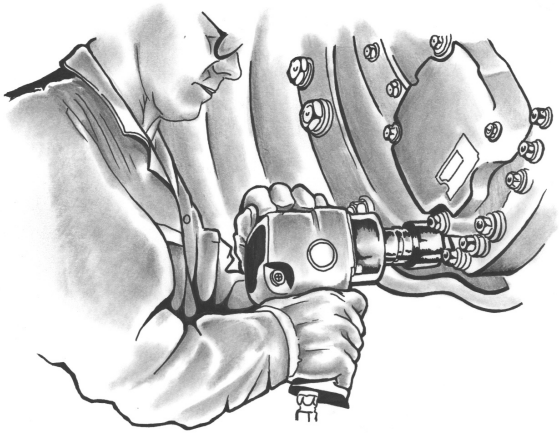
Risk Factors in Workplace Design: Shoulder and Arm

Risk Factor	Optimal	Method to Achieve
Awkward Posture	• Keep work below shoulder height	• Adjust workstation to accommodate worker height • Make workstation adjustable to different users
Awkward Posture	• Work with elbow and shoulder in neutral positions	• Have seating for neutral arm and shoulder positions • Make workstation tools adjustable
Awkward Posture	• Elbows should be maintained at right angles	• Have work close to worker
Awkward Posture	• Limit amount of work done overhead	• Shift work so that it can be done between elbows and shoulders • Add support for arms if they have to be raised for long durations
Awkward Posture	• Upper arms should stay straight at sides	• Limit amount of work that has to be performed overhead, if work must be performed overhead ensure that rest breaks are taken frequently • Rotate and lower work where possible to create a better work position
Awkward Posture	• Limit amount of reaching • Maintain neutral positions of the hand and arm	• Make the controls within easy reach, where shoulder, elbow and wrist are as close to neutral position as possible • Storage bins should be tilted so that items within the bin are within easy reach
Excessive Force	• Limit the amount of contact stress on parts of the body	• If arms must be slightly raised while working, provide an arm rest so that worker is not resting arms against sharp edges

Risk Factors for the Shoulder and Arm

Example: Static Stress - Shoulder/Arm
Vibration - Hand/Arm

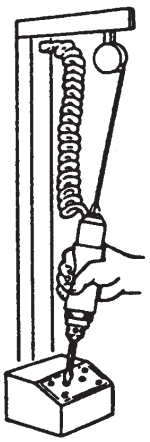
Example: Awkward Posture - Elevated Shoulder



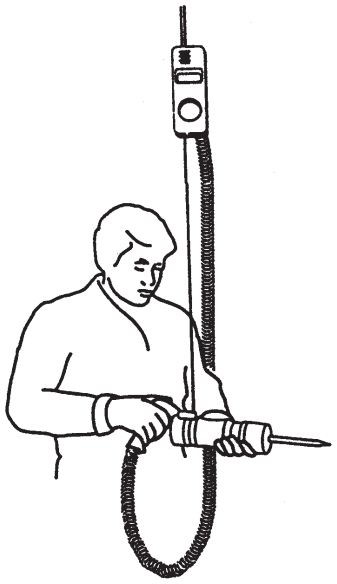
Example: Vibration - Hand/Arm
High Forces - Arm

Example: Contact Stress - Elbow
Static Stress - Arm

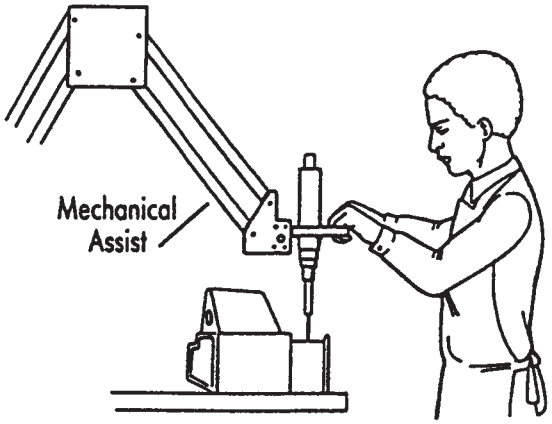
Methods of Minimizing Risk Factors for Shoulder and Arm



Use tool balancers to support the weight of heavy tools



The weight of heavy hand-held tools can be supported by a counterweight.



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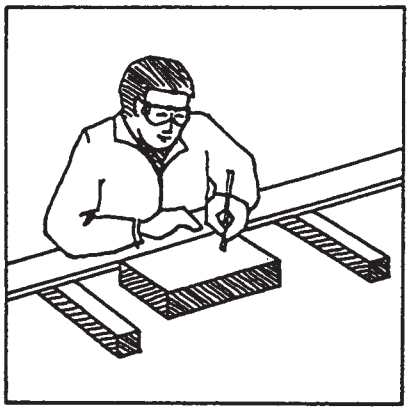

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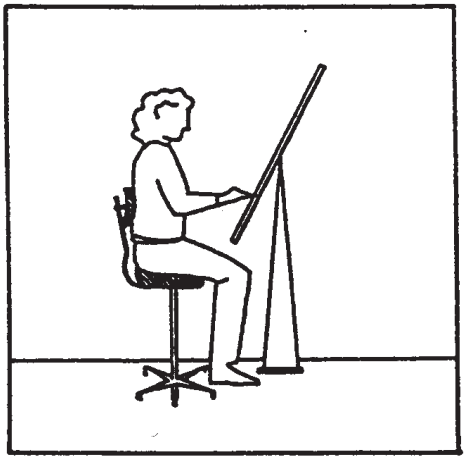

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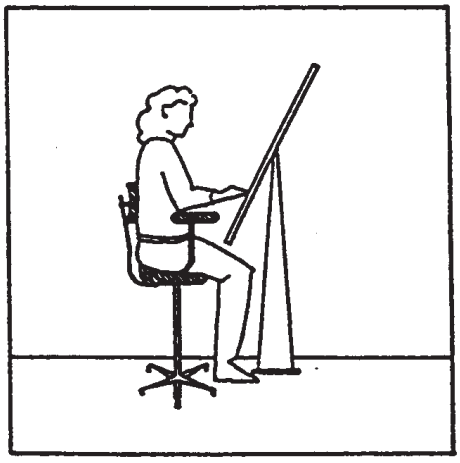

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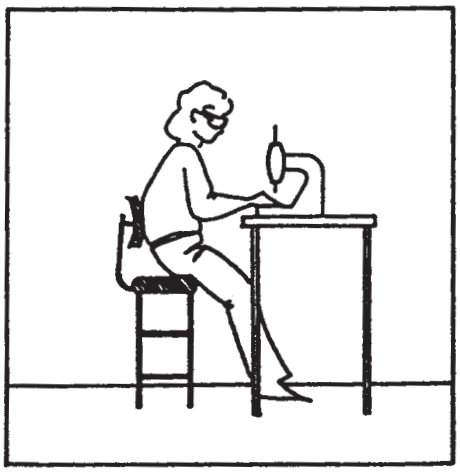

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Risk Factors in Workplace Design: Back

Risk Factor	Optimal	Method to Achieve
Awkward Posture	• Limit amount of work done in flexed forward position • Minimize amount of work time spent with trunk forward in standing, sitting or kneeling position	• Provide the worker with an adjustable platform • Bring work close to the worker • If work is to be done with a bent back, ensure plenty of rest breaks
Awkward Posture	• Limit the amount of reaches from behind and the need for twisting of the torso	• Situate most of the work within forward reach and directly in front of the worker
Awkward Posture	• Try to maintain neutral back posture when working	• If the work is too low to stand, try and find something suitable to sit on that would allow appropriate work height • If the work is too low to sit, elevate the object
Excessive Force	• Reduce the amount of manual materials handling done overhead	• Let gravity help with lifts; rather than oppose gravity, lower the work • Gravity chutes can make placement of final product easier
Excessive Force	• Reduce the amount of manual handling of materials	• Use mechanical aids to help with lifting heavy objects
External Trauma	• Limit the amount of contact stress on the back	• Ensure work seats are adequately cushioned

Risk Factors for the Back

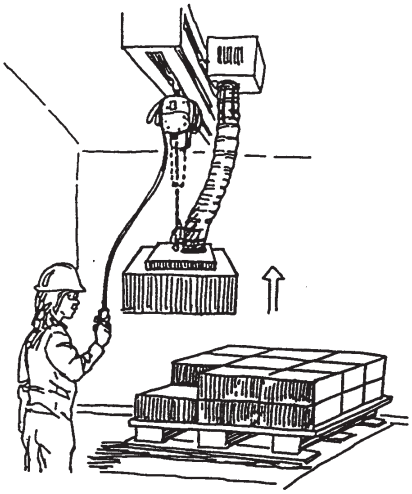
Example: Awkward Posture - Flexed Back

Example: Awkward Posture - Flexed Back
High Forces - Lift

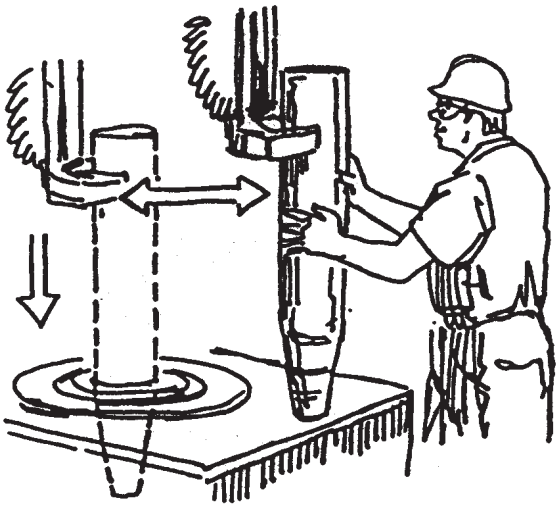
Example: Awkward Posture - Flexed Back
Twisted Trunk

Example: Static Stress on Back
Hand/Arm Vibration
Back Flexion
High Forces

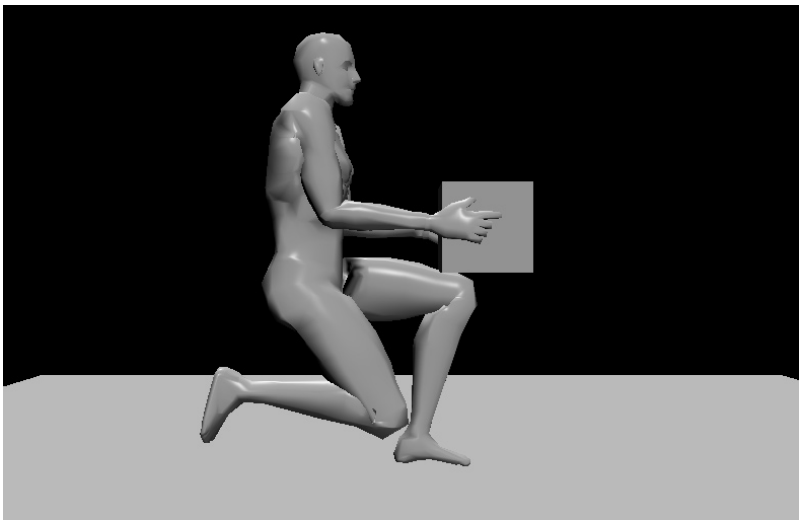
Methods of Minimizing Risk Factors for the Back



Handling aid



Handling aid

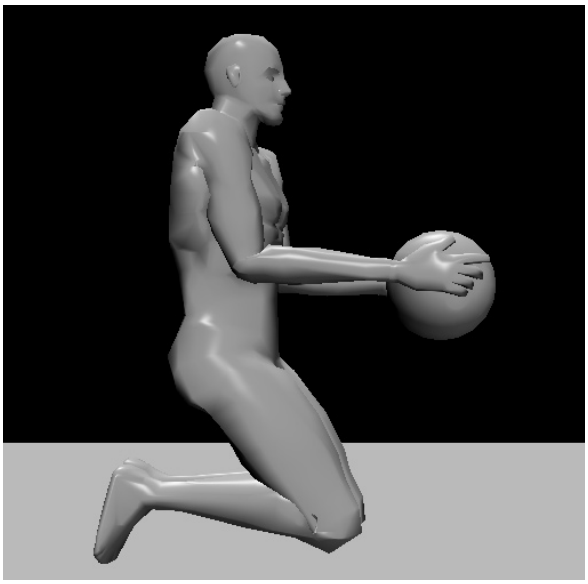


Proper lift techniques

Risk Factors in Workplace Design: Lower Limb

Risk Factor	Optimal	Method to Achieve
Static Stress	• Limit the amount of time the worker must work in the same position	• If worker must stand in same place for long periods of time, install a foot rail or foot rest
Excessive Force	• Decrease the impact of standing or walking on a hard surface like concrete for the duration of the workday	• Install anti-fatigue mats where appropriate • Provide workers with insoles for work boots
External Trauma	• If work needs to be done kneeling on a hard surface, ensure appropriate personal protective equipment	• Provide knee pads or a padded mat if worker is to be kneeling on work surface, even for work done in short durations
External Trauma	• When seated, limit the amount of contact stress the worker is exposed to	• Ensure seats are at the appropriate height, if it is too high it may put pressure behind the knees and on the thighs
External Trauma	• Maintain pathways so that there are no obstructions when walking	• Ensure that pathways are clear of wires and cords to minimize the potential for tripping

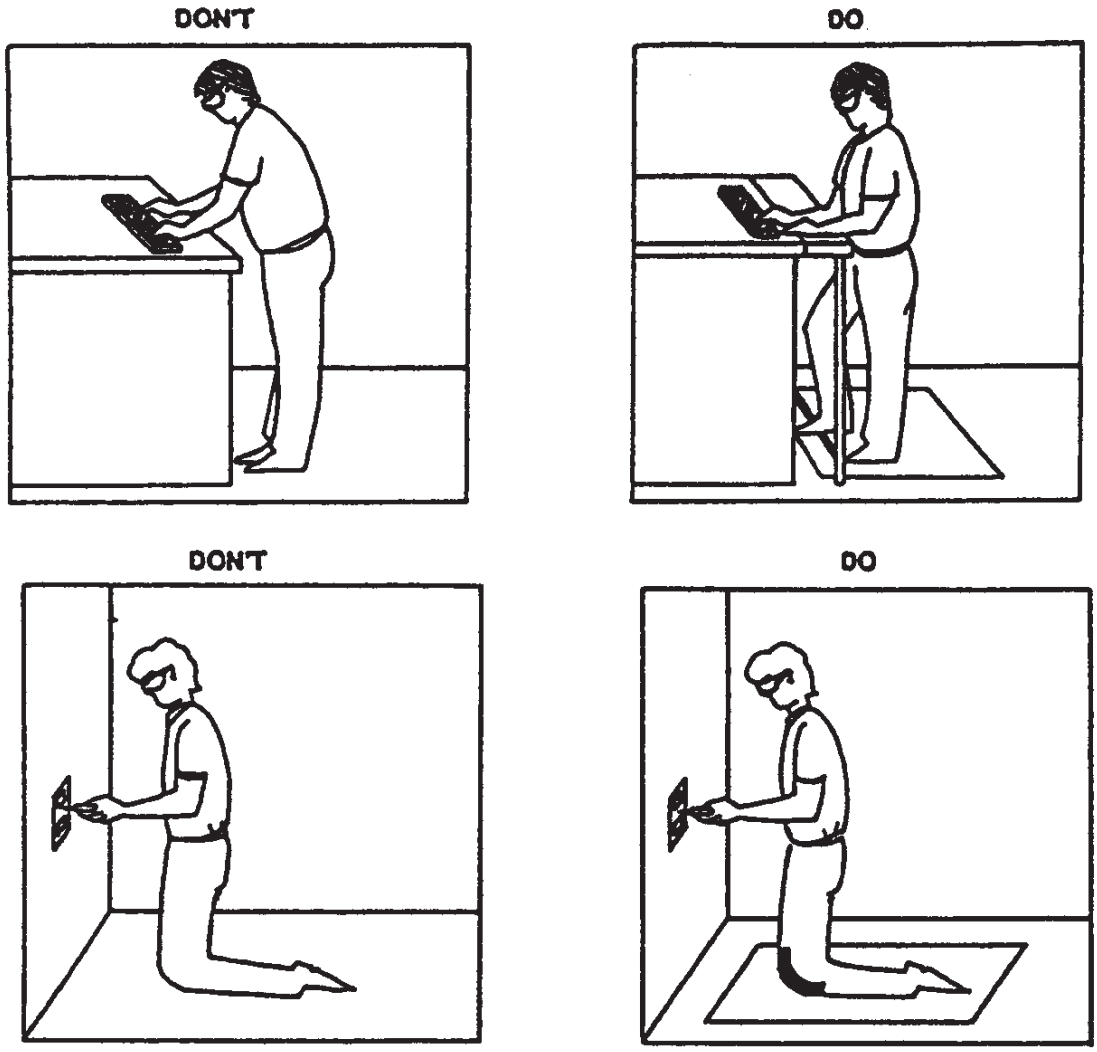
Risk Factors for Lower Limb



Example: Contact Stress on Knee

Example: Contact Stress - Thigh
Static Stress - Leg

Methods of Minimizing Risk Factors for the Lower Limb



Risk Factors in Workplace Design: General

Risk Factor	Optimal	Method to Achieve
Awkward Posture	• Limit the amount of work done in non-neutral positions	• While looking at a task, look for non-neutral or awkward positions; develop a counter measure that will minimize these postures • If awkward postures are necessary then try and limit it to only one risk factor per joint
Static Stress	• Reduce the need to stabilize object with a body part	• When needing to stabilize an object use a vice or a clamp, not a body part
Excessive Forces	• Reduce the amount of pressing, pushing and lifting requiring high manual forces	• For large forces, provide a mechanical aid to reduce the force required • Substitute manual work with machine automation
Repetition	• Limit amount of repetitive work performed by worker during the course of a work cycle or day • While looking at a task note the amount of repetition and how it may be minimized	• Enlarge the job so that the worker has varying tasks to do within each work cycle • Implement job rotation, where the worker may spend part of the work day doing a job that stresses different muscle groups • Encourage workers to take frequent rest breaks in their work cycle
Repetition	• Have a bonus system that is not solely based on piece rate	• Revise bonus system so that it does not encourage worker overexertion
All Risk Factors	• Reduce total amount of risk factors present in the job	• Encourage workers to take frequent mini-breaks • Teach relief stretches and exercises to workers • Consider automating the process

Workstations

If the workstation is well designed workers will be able to do most of their work with their back and limbs in either a neutral or favourably varying position. Operating controls and carrying out other work should not require excessive reaches. Most work, including manual materials handling, should take place between knee level and shoulder height. If work is any higher than the shoulders, then workstation elevation should be used. If the work is any lower, proper lift techniques and/or equipment should be used.

Whether a workstation should be equipped with seating or should be done standing is also an important consideration when it comes to workstation design. Refer to the seating section for more information.

General Workspace Recommendations

Risk Factors	Method to Achieve
Contact Stress Awkward Posture	• Worker should have a comfortable amount of room to work in
Static Stress Awkward Posture	• A sit/stand stool should be considered where applicable
Static Stress Awkward Posture	• A foot rest should be provided while standing, so workers can switch foot position
Excessive Force Static Stress Awkward Posture	• Distribute cushioned foot insoles for workers who spend long durations walking/standing
Excessive Force Static Stress Awkward Posture	• Anti-fatigue floor mats could be placed where workers must stand stationary for long durations
Excessive Force Awkward Posture	• Heavy items that need to be manually lifted should be stored above knee level and below shoulder level
Awkward Posture	• Shelves should be fairly shallow so that workers do not have to reach for items
Excessive Force	• Make sure gloves are well fitted and not thicker than they have to be
Environmental Risk Factors	• For work in cold weather, insulate hand tools or ensure workers are wearing well-fitting gloves
Vibration	• Dampen vibration or reduce direct contact with vibrating machine, using special materials, gloves and mechanical arms
All Risk Factors	• For high risk machines substitute equipment with less risk
All Risk Factors	• Keep equipment well maintained

Work Area Seating Design Sitting, Standing and Sit/Stand Workstations

Must be job and workstation specific.

Sitting

A Sitting Workstation is Recommended When

- Materials needed throughout the work cycle can be easily handled within a seated workspace
- No large lifts or forces required
- No heavy objects are handled
- Precision work is required

Work Done at Seated Work Station

The most effective way to design a seated workstation:

- Design work to be done no more than a relaxed arms length away
- The worker's task should be directly in front of the worker, with minimal twisting of upper body required
- Work area should have enough room and facilities for work to be done in upright position
- Ensure there is adequate illumination of the work area
- Body parts should not be continuously scraping against work surface
- Provide adjustable workstation (including seating) where possible
- Train workers in use of these adjustments
- Provide footrests where practical

Reducing Risk Factors

To reduce the amount of Static Stress:

- Encourage workers to take frequent rest breaks to stretch their joints and muscles
- Make vices available for use in place of using a limb to steady an object
- Allow for variety in the task
- Try and make workstation comfortable

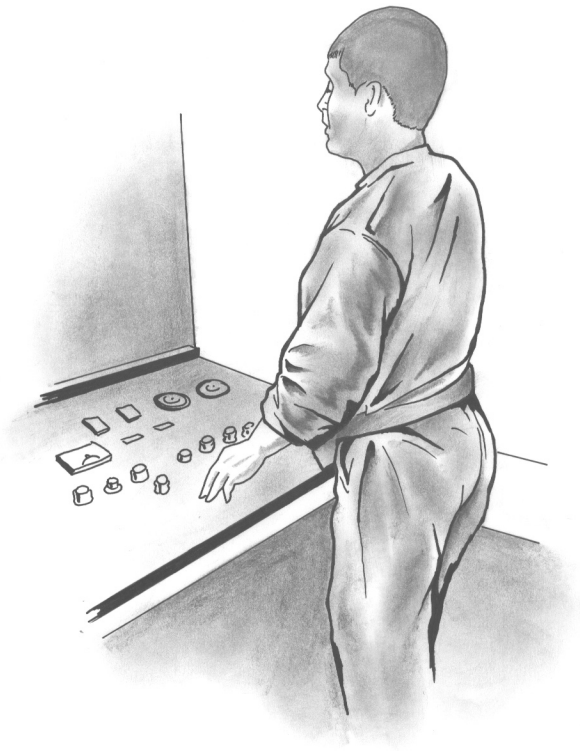
To reduce the amount of External Trauma:

- If workers are sitting or standing, body parts should not be resting on edges of tools or workstations

Initial Workstation Posture: Standing

Workstation Observation:

- Console below waist, must bend trunk to operate
- Primary job is to observe and provide signals to trucks
- Static work
- No large forces required
- No heavy objects handled
- No room for knees when sitting



Redesigned Workstation Posture: Sitting

Workstation Observation:

- Room for knees
- Worker still able to observe trucks
- Console within easy reach

Standing

A Standing Workstation is Recommended When

- Workers have to undertake far reaches
- The work is spread out across more than a comfortable arm's reach when seated
- There is not enough room for the legs when seated
- Working height is fixed such that standing is less awkward
- Workers must continually travel within the work area

Work Done at a Standing Workstation

Recommendations on reducing the risk of MSD by adjusting position of worker:

- When standing, work should be done at elbow height; if elbows are at about 90 degrees of flexion, the back and upper arms will be maintained in more neutral positions
- Ensure that reaches do not extend past a relaxed arm's reach, this will prevent stooping and bending of upper back.

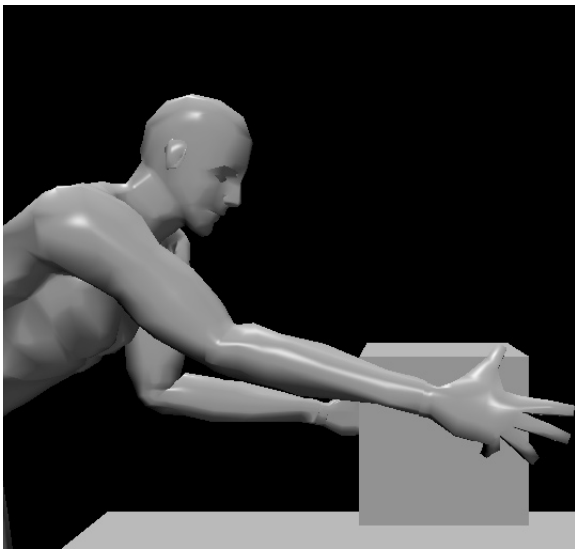
Recommendations on how to reduce Static Stress:

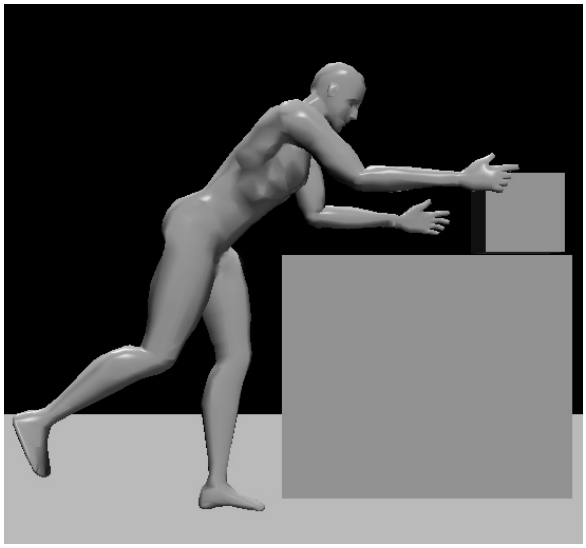
- Have anti-fatigue floor mats and insoles for workers who stand for prolonged periods
- If the work is stationary, provide footrests so workers can change position from time to time
- If work is done standing, encourage workers to take short rest breaks so they can stretch or sit

Recommendations on how to reduce External Trauma:

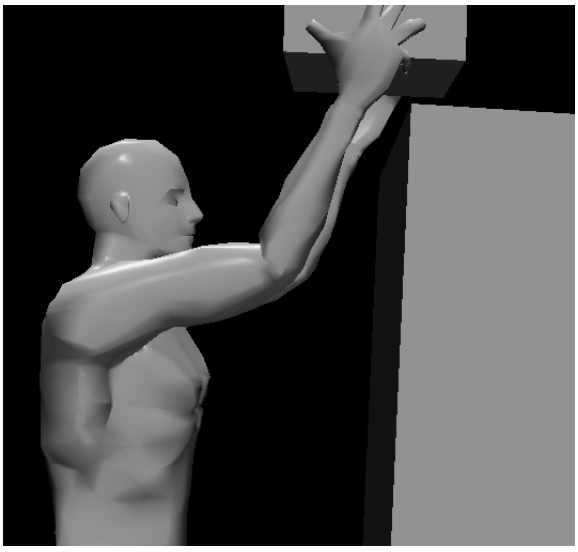
- Reduce or remove the amount of impact knees have against work surfaces
- Remove leg obstructions where possible

Standing Recommended When

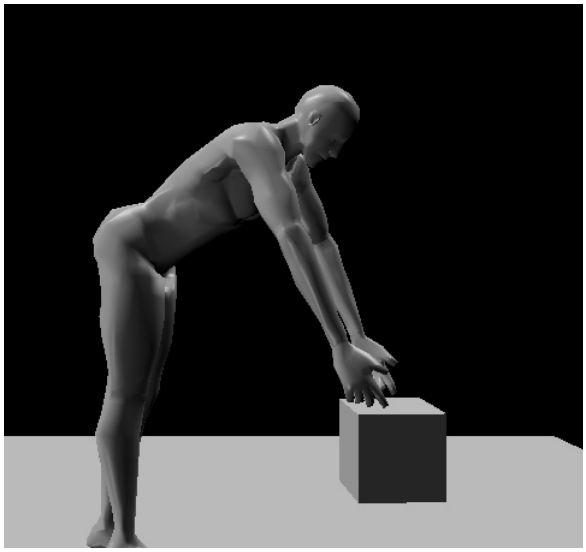




- There is far reaching
- Heavy objects handled
- Awkward/bulky objects handled



- The work is above shoulder height



- The work is below waist level

Sit/Stand

Here the worker may switch off between sitting and standing, or leaning against a sit/stand chair that allows enough support so that the knees and trunk are slightly flexed.

A Sit/Stand Workstation is Recommended When

- Repetitive work with reaches more than one arm's length forward or high reaches
- The task requires the worker to be sitting for some part of the work cycle, but standing for other parts

Work Done at a Sit/Stand Workstation

Benefits of a sit/stand work chair:

- Increases circulation, as it reduces the amount of time spent in a static position
- Because the worker is able to change posture it allows for variation of movement in the task, making it more comfortable for the worker

Ways to reduce awkward positions:

- Training in use of sit/stand stools
- Ensuring the appropriate work surface height

Ways to reduce Static Stress:

- Encourage workers to take frequent short rest breaks to stretch
- Encourage workers to vary the positions of work by alternating from a sitting to a standing position and vice versa

Ways to reduce External Trauma:

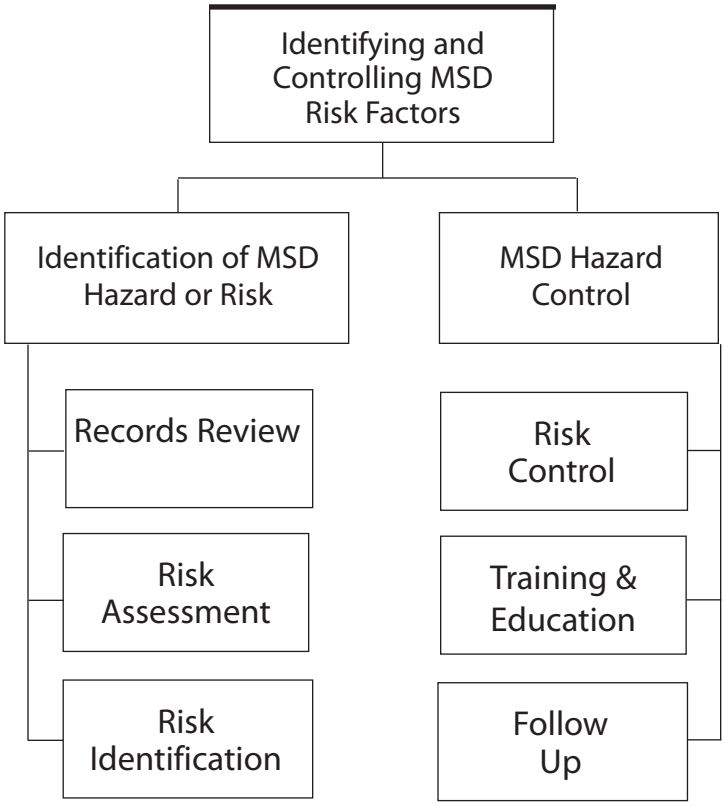
- Ensure the sit/stand stools do not present any sharp edges and are comfortable to the worker

Section 6

Application of MSD Prevention to Mining

Identifying MSD Risk Factors

Worksite Analysis Process



Identification of MSD Hazard or Risk:

Identification Tool	Procedure
Records Review	• WCB claims reports • First Aid reports • Industry WCB injury statistics • Accident reports

Identification Tool	Procedure
Risk Assessment	• Injury statistics • Worker comments - Suggestion boxes - Hazard report forms - Questionnaires - Employee/Supervisor Interviews • Work Site Analysis - Note when workers make modifications to their tools/ workstation - Does the worker frequently take rest breaks? - Does the worker frequently shake out arms or shoulders? - Does the worker wear wrist braces or back belts without physician consultation? - Does the worker change the job procedure in order to make the job more physically comfortable? - Do these adjustments put the worker at higher risk for MSDs? • Regular workplace walk through - Risk identification - Job evaluation • In-depth analysis - Checklists - Physical measurement - Task analysis

Identification Tool	Procedure
Risk Identification	• Extent of exposure to risk factors • Checklists

Control Tool	Procedure
Risk Control	• Implementation of control measures - Implementing ergonomic controls to minimize or reduce the risk of MSDs. This can include: - Designing the work area for reduction of risk factors - Job rotation - Schedule modification - Equipment evaluation and modification

Control Tool	Procedure
Training and Education	• Training - Training on proper work technique that minimize the risk of MSDs • Education - Education on symptoms of MSDs and reporting procedures

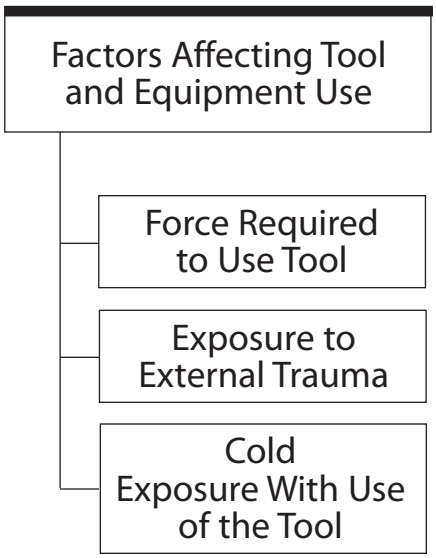
Control Tool	Procedure
Follow Up	• Worker Comfort - Ensure that workers are comfortable using the modified tool/ task and that proposes to reduce the risk of MSDs • Re-evaluate the job when: - There is a change in a component of the workplace - New information about health/work/equipment is available - There is a change in the way task is carried out - New staff arrive, or for returning staff who have been on extended leave

Notes

Section 7

Special Topics in Mining

Addressing Equipment and Tool Concerns



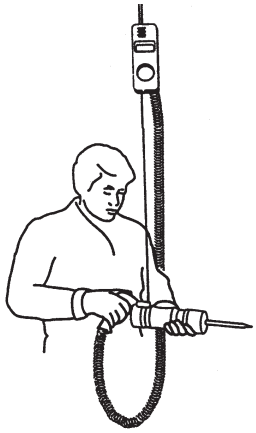
Force

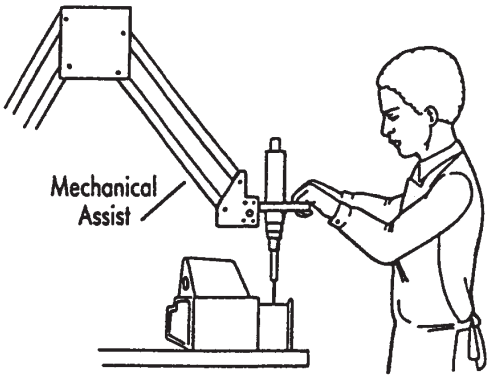
Exerting high amounts of muscular force while carrying out job demands can be a strain on the musculature. This is especially evident when high forces are combined with awkward positions or repetitive motions.

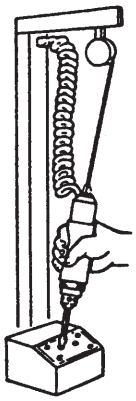
Force	Suggestions on ways of reducing the effects of high force on the muscles: • Keep the load's centre of gravity close to center of the grip • Diameter of tool handle should be such that the thumb and finger just slightly overlap • Use a tool that is as light as possible for the function of the job • Tool weight should be even, i.e. not top heavy • The tool should bend to accommodate awkward positions, not the limbs or body • Ensure that scissor-like tools such as wire strippers have springs

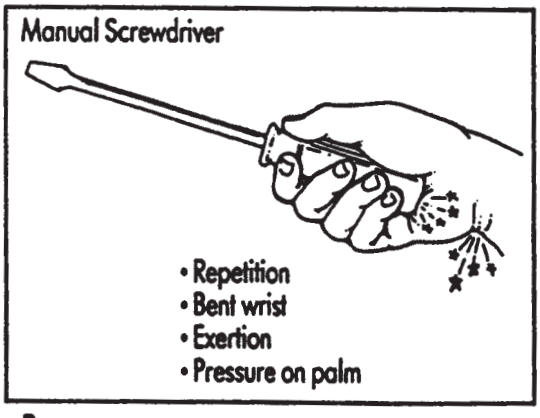
Force	Suggestions on ways of reducing the effects of high force on the body: • Avoid high tension springs in triggers • Avoid triggers that only use one finger to activate tool; four-finger trigger action is best • For precision work, use a two-finger trigger • The fingers should press down on the trigger at the knuckle, not at the ends • Avoid triggers that cause thumb to be hyperextended • If the tool is heavy, use a counterbalanced weight to offset the weight

Methods of reducing effect of high forces on body

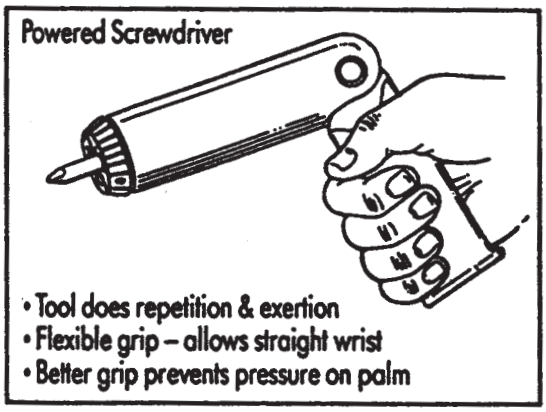








Poor



Improved

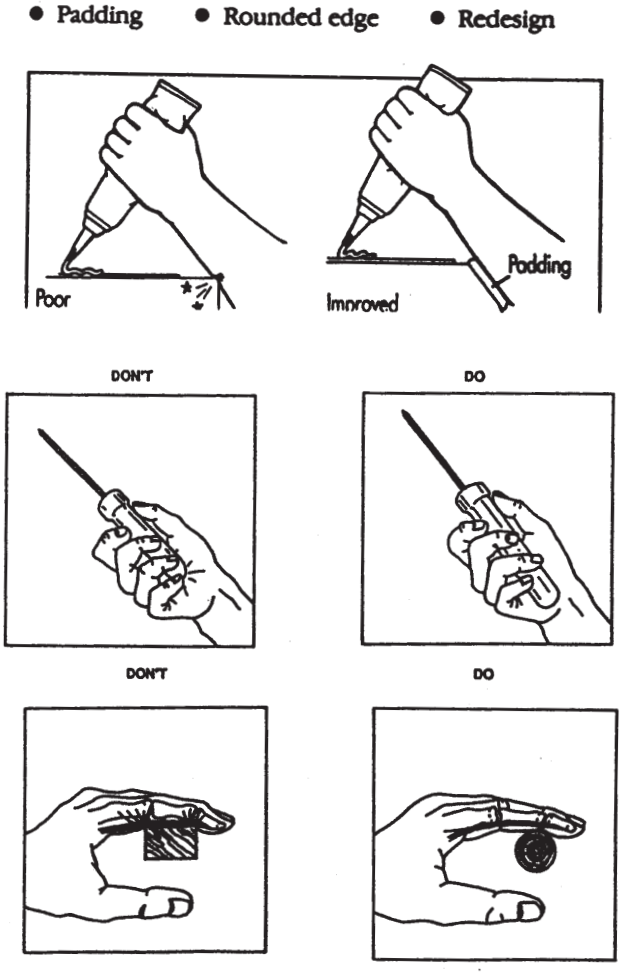
External Trauma

When using tools that may have gripping surfaces with sharp edges, or require force application on a small amount of surface area, there is cumulative stress on that body part.

Example: when a worker is using a screwdriver that is too short for their hand, it may dig into their palm as they are applying the twisting force. Over time this may lead to damage to the blood vessels and tissue of the hands.

External Trauma	Suggestions on ways of reducing effects of external trauma on the body: • Tool handles should be long enough so that they do not press into palm of hand • Use handles that are rounded, avoid handles with sharp edges • Avoid using the hand in place of a tool • Use knee pads when kneeling on hard surfaces • Ensure there is padding on sharp edges of equipment that workers may come into contact with

Suggestion on ways of reducing effect of external trauma on body



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Exposure to Cold

In a cold environment, blood supply in the hands may be constricted, making it harder to grip a particular tool. This in turn causes the worker to use a tighter or more forceful grip.

Exposure to Cold	Suggestions on ways of reducing effects of exposure to cold on the body: • Use gloves if possible when working in a cold environment • Avoid handles that are heat absorbing • Direct cool machine exhaust away from the worker • Use a light grip on equipment

Addressing Vibration Concerns

The effects of chronic exposure to whole body or hand-arm vibration may include resonance damage to the tissue and organs.

What is Vibration?

Vibration is defined as mechanical oscillations produced by either regular or irregular periodic movements of a body, characterized by frequency, amplitude, acceleration and direction.

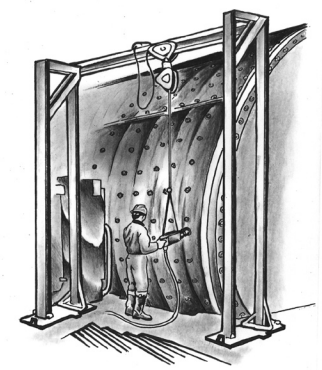
People coming into direct contact with vibrating equipment or machinery may experience high levels of vibration passing through their limbs and body. This stresses the soft tissue, especially in a cold environment, and may lead to an MSD over time.

Whole Body Vibration - The vibration is transmitted through the whole body through the machine-worker interface. An example is a driver in a mobile operations vehicle travelling across uneven ground.

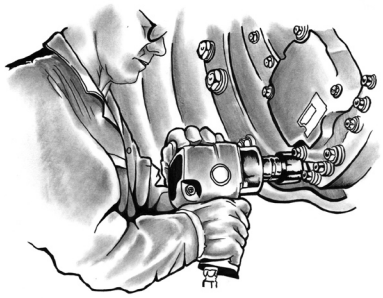
Hand/Arm Vibration - The vibration is mainly transmitted to the hand and forearm at the machine-worker interface. An example of this would be somebody holding a vibrating hand tool such as a drill, where the vibration is predominantly felt through the hands and arms.

Because vibrations can be jarring to the soft tissues of the body, fatigue and soft tissue injuries may develop over time. Trying to stabilize a piece of machinery that is vibrating may overexpose the tissues subject to the vibration; this could lead to injury in the long-term.

Hand/Arm Vibration



Hand/Arm Vibration



Hand/Arm Vibration

MSD: Hand-Arm Vibration Syndrome

Exposure to chronic and long duration hand/arm vibration may cause blood vessels in the hand to vasospasm, which can lead to circulation problems in the future. This musculoskeletal disorder is known as White Finger Syndrome. Exposure to cold can increase the detrimental effects of vibration. When using tools in a cold environment either the impact of the vibration and/or the extent of coolness in the environment should be addressed.

First physical signs	• Tingling and numbness in fingers • Swollen and painful fingers • Blanching of the fingers
Advanced physical signs	• Loss of sensitivity to touch • Reduction in grip strength • Physical damage to fingers • Loss of dexterity in fingers • Loss of muscular control • Reduction in sensitivity to temperature and pain • Ulceration of finger tips

Stages of physical damage	1. No interference on individual's work performance 2. Interference in activities at home, but not at work 3. Interference in social, personal and work activities 4. No longer able to work in the same job

Vibration - Reducing the Risk

Minimizing the machine's vibration output at worker interface	• Keep tools and equipment well maintained • Equip older machines with vibration dampening equipment • Purchase newer tools that may have a greater degree of vibration dampening (caution should be used when adding dampening material as it may make use of the tool more physically awkward) • Increase mass of the worker machine interface • Physically isolate the handle of the instrument transmitting the vibration

Minimizing environmental impact	• Wear gloves to increase blood circulation in the hand
	• Ensure proper fitting gloves, as gloves that do not fit properly may cause worker to increase grip force which may increase possibility of MSD development
	  - If gloves are too big, they will be bulky and greater force will be required to grip
	  - If gloves are too small, they may impair blood circulation
	  - Ensure that the gloves chosen will trap excessive amounts of moisture
	• Gloves with texture will create a less slippery interface with equipment
	
	These precautions should result in a reduction of force required to use machinery as well as minimize the impact of the vibration

Decreasing chronic exposure	• Take rest breaks often through the work cycle • Possible job rotation

Other options	• Alter production methods to eliminate the need for vibratory hand tools • Redesign tool to reduce hand/arm vibration • Inadequately maintained hand tools show higher rates of vibration • If workers are reporting symptoms, ensure they see a physician • Keep hands warm using gloves, be cautioned that anti-vibration gloves have not been fully proven to work

Power Tool Considerations	Factors to consider with respect to risk of MSD: • What kind of trigger does the machine have, one finger, multi-finger? • Is the tool heavy? • Is a counterbalance support needed to offset the weight of the tool? • Is the worker exposed to excess vibration through the use of the tool? • Is the environment in which the tool will be used cold?

Once an MSD has been diagnosed the worker should consult with their physician before going back to a job that involves similar high levels of vibration. If caught early, damage may be limited.

Ergonomic considerations to keep in mind when analyzing a job involving vibration:

- Is there an awkward grip required?
- Does the tool require heavy force to operate?
- Does the tool vibrate?
- Is the tool heavy?
- Do the tool handles/gripping surfaces have sharp edges?
- Does holding the tool require a pinch grip?
- Is the trigger awkward?

Things to consider when vibration is involved:

- Is the machinery being used appropriate for the job?
- Is the machinery designed properly?
- Is the machinery well maintained?
- Is the machinery worn out?
- Is the machinery being used outdated for the job?
- Are high amounts of force used in conjunction with the machinery?
- Is there exposure to cool temperature while machinery is being used?
- Do the controls and levers require a high amount of gripping power?
- Does the worker hold or control the machinery in a way that may be awkward and/or stressful on other joints and muscles?

Addressing Manual Materials Handling Concerns

Manual Materials Handling (MMH) refers to:

- Lifting/ lowering materials
- Pushing/pulling materials
- Carrying materials
- Holding materials

Manual materials handling must be considered when:

- It involves exertion of considerable force, because the particular load is heavy
- The cumulative total of the loads during a work day is heavy and/or substantial
- Manual handling work activities are a significant part of the employee's regular job duties

MMH may lead to overexertion and injury, particularly to the back.

Tolerance of spinal disorders depend on:

- Age
- Gender
- Individual susceptibility to back disorders

With typical back pain, most symptoms develop slowly with stiffness, dull aching pain and incapacitating discomfort that can occur hours, days or even years later.

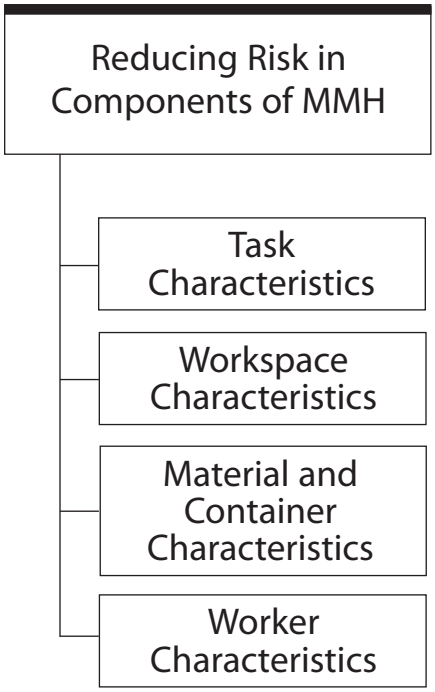
Risk Factors

(associated with low back pain and back disorders)

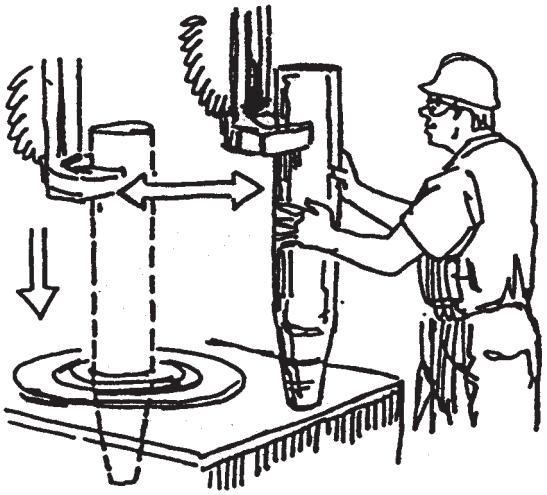
- Awkward positions and degree of forward bending
- High force on the spine
- Frequency of lifting
- Speed of movement sideways bending and twisting
- Duration of lifting activity

Decreasing the risk factors decreases the likelihood that an injury will occur.

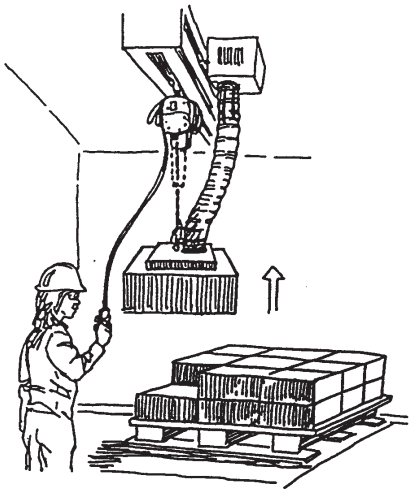
Manual Materials Handling - Reducing the Risk



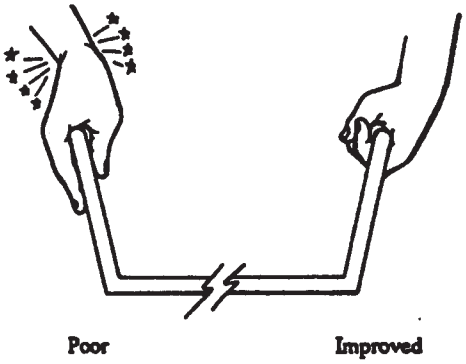
Task Characteristics	• Use lifting aids • Decrease weight of the object • Decrease frequency of lifting • Decrease duration of task • Decrease size of object being handled • Supply properly designed handles on objects • Maintain predictable center of gravity in load • Remove obstacles that may cause awkward posture



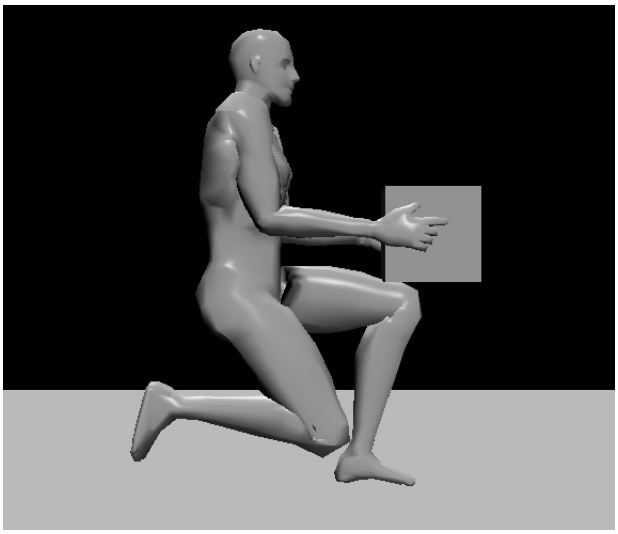
Handling Aid



Handling Aid



Pull better than Push

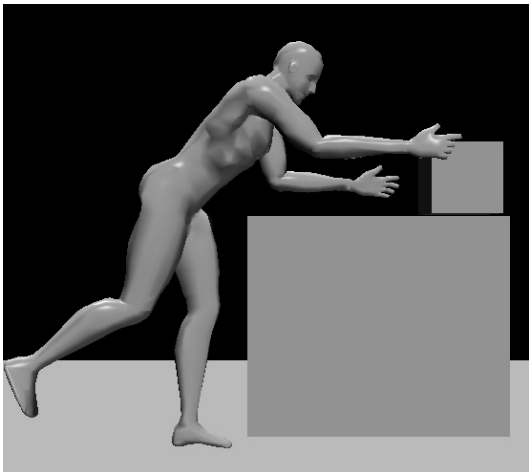


Proper Lift Techniques

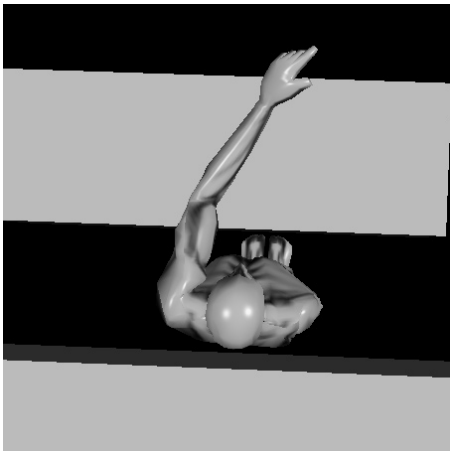
Workspace Characteristics	• Remove obstructions that prevent worker from getting close to object being lifted • Provide enough space to manoeuvre and assume the most favourable lift posture • Begin lift at elbow height • If object to be lifted is below the elbows, decrease height of lift • Provide slip resistant soles, floor mats • Provide good lighting • Maintain a comfortable temperature

Initial Workstation
Risk Factor - Awkward Posture

Redesigned Workstation
Reduction of Risk Factor - Awkward Posture



Reach Obstruction



Confined Workspace

Worker Characteristics	• Select workers physically capable to do the task • Train workers in proper MMH techniques • Train workers in proper relief exercises • Instruct workers to carry out two-handed lifting vs. one-handed • Height of lift start should ideally be above knees • Height at lift end should ideally be at or below shoulder height • Amount of torso twisting required during lift should be eliminated/ minimized • Buddy lifting should be encouraged when loads are excessive

Material and Container Characteristics	• Make materials and containers easily compatible with mechanical aids • Large and bulky loads should have handles for easier grip • Object should be made to allow it to be held at a close distance to the body • Use well fitting gloves when lifting • Weight of object should be posted on object • Push/pull carts should be well maintained • Minimize forces needed to push or pull object i.e., bigger wheels on carts

Workspace Design Solutions that can be Directly Applied to Mining

Task Solutions	• Use lift tables/trucks • Use elevating conveyors • Use hoists • Use mechanical aids • Minimize machine-paced work
Workspace Solutions	• For underground operators, allow skip/cage to accommodate lift trucks and cranes • Smooth floors, provide dollies • Platforms to reach materials • Good lighting • Comfortable temperatures • Slip resistant soles and floors
Worker Solutions	• Have two people on hand to lift • Keep heavy objects close to body • Use two hands • Smooth lifts • No twisting • Power grip vs. pinch grip • Balance container • Rotate jobs • Alternate tasks • Job enlargement • Allow time for job readjustment • Vary posture, use different muscle groups
Material and Container Solutions	• Purchase smaller bags of materials • Handles on containers make them easier to lift • Properly package goods to be lifted, no shift in weight of package, ensure proper handles • Weight of materials clearly marked

Questions to consider:

- Are the work heights appropriate ?
- Are excessive reach distances required ?
- What is the frequency of the task ?
- What are the speed of the movements and duration?
- Are the travel distances far?
- What is the location of objects to be lifted?
- What is the size of object to be lifted?
- What is the height of the object to be lifted?
- What is the height of the lift?

Limiting Risk Factors with Regards to MSDs

Task Considerations

Task Characteristics	• Stressful body positions and movements

Limiting Bending Motions of the Back	• Reduce the vertical distance between the start of the lift and end of the lift • Adjust worker height and provide materials so that the worker can do the work upright • Locate objects needed in the work cycle within arm's reach • Do not use deep shelves or boxes • Provide tilted storage bins • Allow easy access to shelves
Limiting Twisting Motions of the Torso	• Work space should be big enough to allow body to turn fully • Objects should be in comfortable reach • Seated operators should have adjustable chairs
Limiting Excessive Forces	• By using mechanical aids such as hoists, articulating arms, cranes, gravity chutes • If shelves are deep, install wheels so there is easier access to contents especially for heavy objects • If things are going to be stacked, stop at shoulder height to minimize overhead reaches • Heavy objects should be no lower or higher than knuckle height • Keep wheels on carts well maintained • Change MMH activity - Lifting to lowering - Carrying to pulling - Pulling to pushing • Object should be carried close to the body • Handles and hooks make objects easier to carry
Limiting Frequency or Duration of Exposure	• Convert to automation when appropriate • Create a job rotation schedule • Create a work/rest schedule for worker • Reduce amount of overtime when risk factors comprise a large part of work cycle

Material and Container Considerations

Load Characteristics	• Weight of load • Size or bulk • Stability of load • Distribution of weight • Adequacy of gripping surface • Presence of handles on containers

Limiting Exposure of Excessive Forces	• Decrease weight of object • Change from individual handling to bulk handling • Reduce weight of container • Ensure containers have appropriate grip holds • Make sure containers are the appropriate size to handle a manageable weight • Train workers in how to distribute the load evenly within the container
Limiting Stressful Body Positions	• If object is awkward to carry, then either manipulate the object to a better shape or provide handles to make it easier to carry

Worker Considerations

Diversity of Worker	• Age • Gender • Body dimensions of worker • Fitness and strength of worker • Training of worker on work method

Limiting Stressful Body Positions and Movements	• Maintain a straight back when lifting, use the legs to lower body and power the lift • Keep body balanced • When turning with a load, use the feet to turn, not the trunk
Limiting Excessive Forces	• Know what the worker population is, find out their limitations and capabilities, and address these issues through workplace design • When lifting heavy objects it is best to assign two workers to the task so they share the burden of the heavy load, making it easier and less stressful to lift • Lift with a smooth motion; a jerky motion may be stressful on the back • Keep load as close to the body as possible when lifting • Try not to overexert worker by providing too much to carry • Know how much object weighs before lifting it • Switch off between heavy and light loads

Workspace Considerations

Workspace Elements to Consider	• Floor surfaces • Presence of platforms, chairs • Temperature - hot or cold environment • Lighting

Reduce Potential for Accidents	• Keep floors clean from liquids, dirt, cords, debris • Keep walking pathways well lit and free of tripping hazards • Floor surfaces should be even and well maintained • If load needs to be carried up/down stairs or on/off platforms, a mechanical aid should be used • If temperatures are excessively hot, provide frequent rest breaks to reduce fatigue and incidence of accidents

Handling Aids for Manual Materials Handling

- Trucks
- Hand lift trucks
- Two, three, or four wheel vehicles
- Skid trucks
- Mail carts
- Tea wagons

Some Design and Selection Factors for Handling Aids

- Large diameter wheels preferred
- Interaction between floor and wheels should have little friction
- When ramps are available, use a cart if feasible

Mechanical Aid Devices

- Pneumatic or hydraulic scissor lifts
- Spring loaded scissor lifts
- Zero height lift tables
- Turntable lifts
- Portable lift tables

Use of Mechanical Aids

- Adjust table so that starting and finishing points are at the same level
- Keep lift tables well maintained
- Train operators in the use of lift tables

Hoist and Leveling Devices

- Use hoist and leveling devices to transfer heavy or awkward objects from place to place to save workers from heavy physical exertion

Mechanization

Mechanization - using a machine instead of a human to do the work.

Use when:

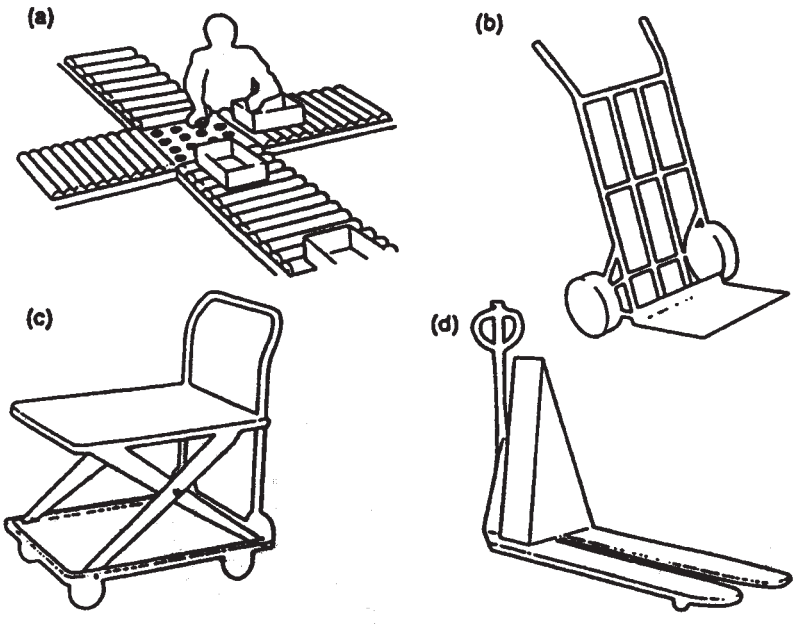
- Large forces are required
- The work is highly repetitive
- The size of the product is always the same
- There is a consistent pattern to the work

Examples:

- Robots
- Hoists
- Lift tables
- Conveyors

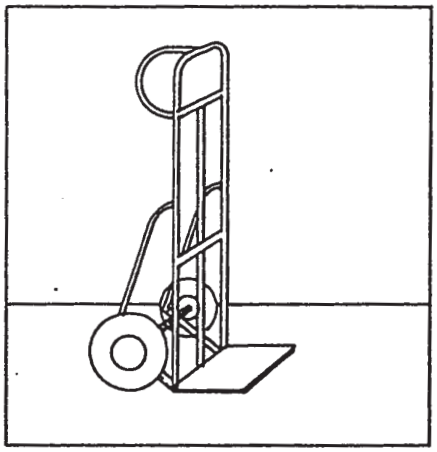
Eliminate /Reduce Handling

Eliminate continual rearranging by redesigning placement of product or materials.

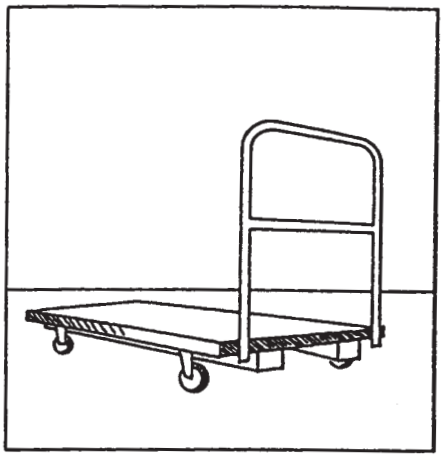


Transport accessories which replace manual carrying: (a) roller conveyor, (b) sack barrow, (c) mobile raising platform, (d) forklift.

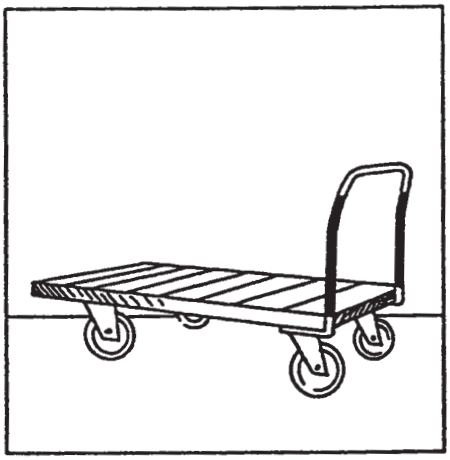
STYLES OF HAND TRUCKS



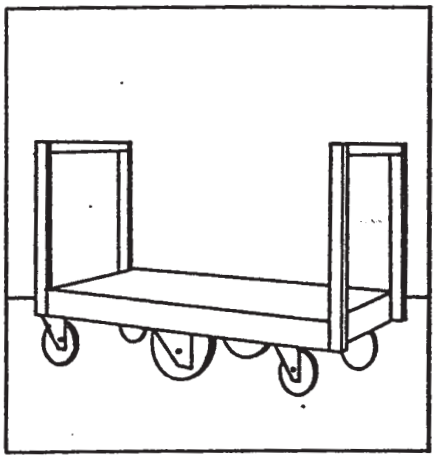
Hand Truck



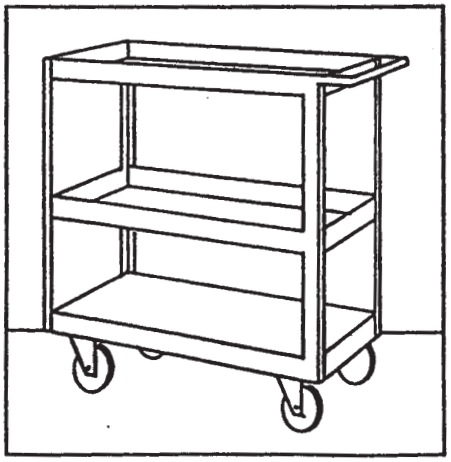
Stock selector type



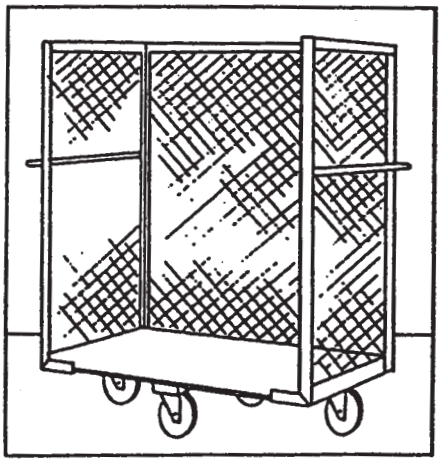
Non-tilt style



Six-wheel tilt style



Shelf style



3-sided style

Environmental Factors

Illumination	Glare and improper lighting can cause a person to shift into an awkward posture
Noise	High levels of noise in the workplace tend to cause increased irritation and distraction, the effect of noise may be reduced with the use of appropriate hearing protection
Temperature	In hot, humid conditions the body has to work harder in general and this may lead to fatigue. Exposure to cold can constrict blood vessels and contribute to MSD development. Decreases in the amount of blood to tissue means a decrease in the amount of nutrients and oxygen to the body part exposed to the cold, resulting in numbness and pain

MINING SPECIFIC TRADES to consider:

- Diamond driller
- Stope miner
- Machinist, impact wrench
- Jack leg driller
- Shoveling, mill
- Mechanic
- Scoop tram operator
- Crusher operator
- Hoist operator
- Mobile equipment operator
- Front end loader operator
- Millwright

Notes

Appendix

Advanced Analysis Techniques

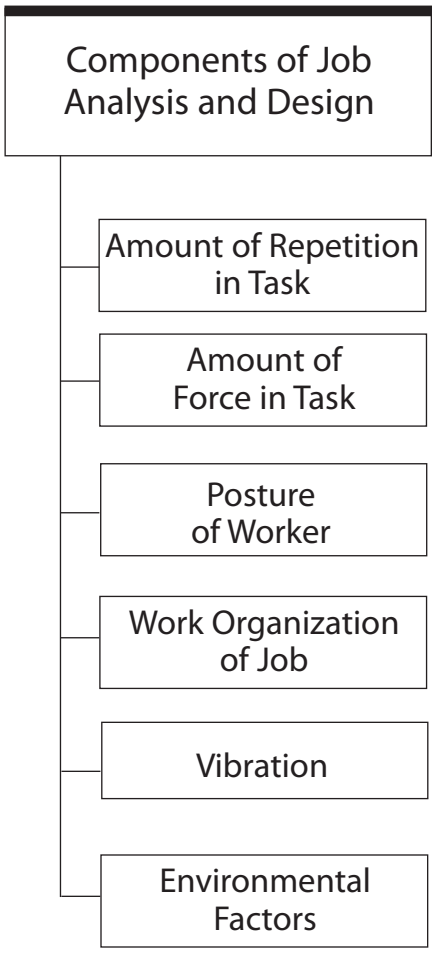
Methods of In-Depth Assessment

Job Demands Analysis

Job Analysis and Control

For jobs identified as high risk, an ergonomic assessment should be conducted. This involves breaking down the physical components of the task and then identifying the motions/actions that give the job its high-risk notation. Develop a solution to minimize the physically negative impact that the motion or risk factors will have on the worker.

Job Analysis and Design



General Principles for Addressing Ergonomic Risk Factors

Repetitive Work

Repetitive Work Consideration	• Frequency of movement • Speed of movement • Duration of movement • Task cycle time • Static work vs. dynamic work

Repetitive Work Solutions	• Adjust workers' expected work output to a less repetitive task cycle • Provide worker rotation, where different muscle groups are used throughout the work day • Enlarge the task cycle so that workers are doing a greater variety of tasks with each cycle

Forceful Exertions

Forceful Exertion Consideration	Refers to overexertion of muscles, tendons, ligaments and joint capsules. Common in: • Pushing/pulling tasks • Lifting • Reaching • Precision work • Stabilization of pneumatic tools

Forceful Exertion Solutions	• Avoid gloves that interfere with grasping an object • Ensure gloves are well fitted • Pick up fewer objects at a time • Select tools that are lighter weight where appropriate • Attach support aids that help bear the weight • Use hoists or mechanical aids to support the work • Use rollers or conveyors to transport materials • Work with gravity instead of against it • Ensure boxes have handles on them

External Trauma

External Trauma Considerations	• Pressure on palms due to short-handled equipment • Leaning on a hard surface with elbows • Kneeling on the floor

External Trauma Solutions	• Use tools with elongated handles • Use rounded edges on handles • Use pliable handle materials • Use tools rather than hands for pounding • Provide padding for body parts exposed to external trauma

Posture of Worker

Posture Considerations	• Extended wrist • Twisted neck • Twisted torso • Flexed forward back • Leaning or bending to the side

Posture Solutions	• Adjust workstation to maintain neutral limb positions • Select or design tools that allows worker to maintain neutral wrist posture • Keep work in front of worker • Keep work within easy reach of worker • Select chairs that have lower back support • Reduce the amount of neck motions required to do the task • Elbows should be at or below shoulder level

Work Organization

Work Organization Considerations	• Work break schedule - examine how often are work breaks are taken throughout the day • Work incentive systems - does the bonus system have the potential to encourage overexertion of the worker • Determine if the worker sets their own pace or is it a deadline/machine that dictates the speed of task

Work Organization Solutions	• Allow worker to take frequent mini-breaks • Allow worker to have some control over work pace • Re-evaluate incentive systems

Vibration

Vibration Considerations	• Vibration to the hand and arm • Whole body vibration • Temperature of environment

Vibration Solutions	• Keep hands warm by wearing gloves, but ensure they are a good fit • Build in a vibration isolation unit • Use light grip on vibrating tool • Dampen vibration at the source • Heat the work area where vibrating tools are used if feasible

Environmental Factors

Environmental Factor Considerations	• Temperature of work area • Humidity of environment • Lighting of task or job area

Environmental Factor Solutions	• Ensure work area is well lit • Use gloves to keep hands warm • Direct exhaust away from worker • Construct equipment handle from materials with low thermal conductivity

Some questions to consider when assessing job demand:

- Is there a prolonged duration of exposure to risk factors?
- How is each individual affected by risk exposure?
- What are the workers comments on risk factors?
- What is the incidence of injury for this particular job?
- Do the WCB statistics show a pattern?

Assessing in-house job demands will indicate the risks and in what priority they should be addressed. It should be noted that the more risk factors present in combination, the higher the risk of injury.

Case Study # 1

Provided by WCB of BC

Diagnosis: Bilateral Carpal Tunnel Syndrome

Work Location: Coal mine in Elk Valley

Occupation: Millwright

Duties Include:

- Use of air and electric impact wrenches which involved static loading and vibration.
- Maintenance of breaker area to include conveyors and associated machinery. This was to not expose the worker to a cold and wet environment.
- Laborious work included hammering steel on steel.
- Ergonomic assessment of the job duties stated that the claimant had a greater tendency for an Activity-related Soft Tissue Disorder at the wrist because of the increase in occupational risk factors. Observations were made that there was extreme awkward posture of the wrist to perform job task.

Chronological Account of Medical Events:

January, 1995
First report of hands becoming numb with use of wrenches and air/electric impact wrenches. No WCB claim was made for this complaint.

Client did have right Carpal Tunnel Release around this time but there was nothing on file regarding this history on his present file.

March 7, 1999
First physician reports to WCB and claim started.

The medical report stated that the client had numbness at right and left wrists. The right wrist much worse than the left wrist. Physician states that the client requires and is awaiting surgery.

March 9, 1999
Client sees hand specialist.

Hand Clinic Report

This patient complains of numbness in his left and right hands, although more severe on the right hand. He has had this problem since working at the coal mine in 1996. He did have Carpal Tunnel Release done by Dr. X. at the time and it seemed to help his symptoms at night, but he has never had return of sensation to the median nerve distribution of his right hand. He does have similar symptoms on his left hand but the symptoms are not quite as severe and he still has reasonable sensation on the left hand side. At the present time he cannot feel small objects in his hand and is having difficulty at work.

On physical examination he has good proximal and distal power to his upper extremities, however, he does have a Tinel's sign that is positive on the right side and as well he has persisting hyperthasia on the right hand side in the distribution of the median nerve. He therefore does not test positive for Phalen's sign because his hands are already numb.

I really think he requires more aggressive surgical release of the right carpal tunnel to see if we can gain some better sensation of function to him. I think that nerve conduction studies at this point are going to show a severe median nerve compression and delay of conduction, and I would rather get going and do another surgical release to see if we could improve this for him. He will then likely be off work for the 6-10 weeks following this surgery.

I will arrange this for him. As far as I understand this is a Workers Compensation Board of British Columbia injury and therefore I will report this as such.

April 22, 1999
Right Carpal Tunnel Release

April 22, 1999
Improved sensation of right hand.

June 8, 1999
No night symptoms.
Better sensation to right hand.
Positive Phalen's at left wrist.

July 5, 1999
Return to same work with employer.

NOTE: Unknown if the client will have surgery on the left wrist

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