NIOSH National Institute for Occupational Safety and Health

Ergonomics and Risk Factor Awareness

The goal of this training is to provide you, the mine safety director/supervisor, with an understanding of how to identify and reduce risk factors that may lead to cumulative injuries or work-related musculoskeletal disorders (MSD). Along the way, you will discover what ergonomics is and how it can help you take a more proactive approach to reducing these injuries. You will also learn what risk factors contribute to these injuries and why it is important to reduce your workers' exposure to these risk factors. You will understand more about what musculoskeletal injuries are, how they progress, what causes them and what controls you can use to reduce exposures. The last section of this training is focused on interactive case studies. You will identify risk factors as you view workers performing their jobs.

We hope this training provides you with a reason to stop waiting for your cumulative injuries to appear and start targeting the risk factors that contribute to the injuries. The idea is to have a more ***proactive*** approach to resolving your injury problem - target and eliminate the risk factor and you eliminate the injury.

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Part 1 - Ergonomics

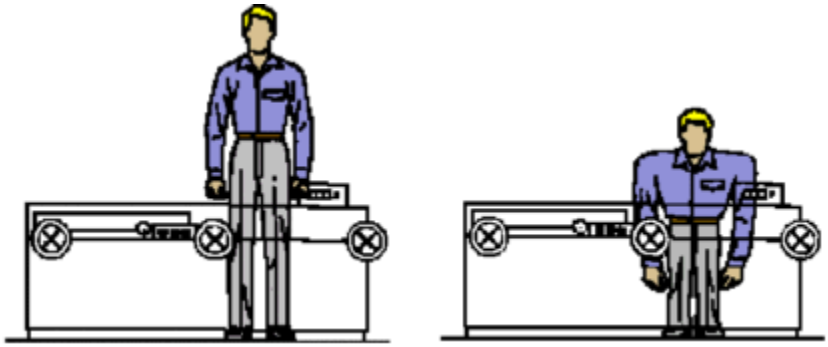
What is Ergonomics?

Definition: Ergonomics seeks to match the physical and cognitive requirements of the job to the capabilities of the worker. This is achieved by designing workplaces, environments, job tasks, equipment, tools and processes to suit the worker's capabilities.

Said another way, ergonomics is the scientific study of people at work. Ergonomics looks at the tasks workers do, the tools and equipment they use, and the environments they work in. The goal of ergonomics is to have job tasks, tools, equipment and workplaces fit the worker's capabilities. Physical capabilities, such as muscular strength and endurance, and cognitive abilities, such as attention span, working memory and reaction times, are considered in the design of the job. An important goal of ergonomics is making sure the demands of the job do not go beyond what a worker can do safely. Effective use of ergonomic practices will assist in maintaining high levels of productivity, can avoid painful and costly employee injuries, and increase worker satisfaction.

Ergonomics is about the design of jobs, tools, equipment and the environment

The drawings below illustrate an example of a problem that can occur when ergonomics is not considered in the design process. The drawing on the left shows a lathe with a "normal" sized man standing next to it. The drawing on the right is the same lathe with a man having the body he would need to operate the lathe as it was designed. Because workers are not built this way, the "normal" worker would be required to bend over, move and reach to the right and left to operate this lathe. Certainly, not an ideal situation.



An example of Ergonomics solving a problem

Problem: Chock blocks are used to ensure vehicles do not drift when parked. Some employees have to chock their vehicles several times a day. Because the chock blocks were connected with a rope, performing this task resulted in excessive stooping and bending. Muddy or wet conditions made the task even more unpleasant.

Solution: To correct this problem the Field Maintenance Department constructed a handle from conduit and attached it to the chock blocks. This modification allowed employees to place the chock blocks in front and behind the tire, and to remove the chock blocks with little or no stooping. The handle also helped alleviate problems during extreme weather conditions.

Ergonomics is also about how people do their jobs

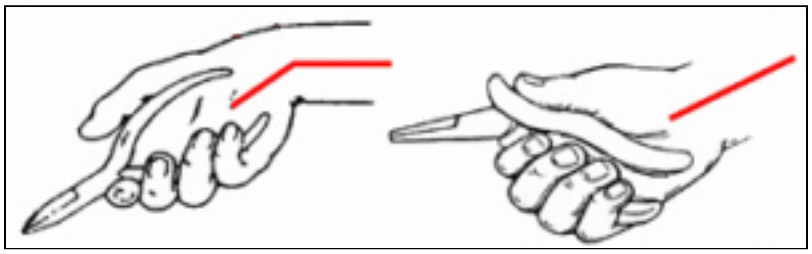
Workers using the most carefully designed tools and equipment could still be at risk if they do not use proper techniques and work practices. For example, consider lifting an object from the floor. A ***poor*** work practice would be to bend at the waist, keeping the legs straight. A ***better*** work practice would be to bend your knees, getting as close to the object as possible, and keeping your trunk upright.

So, ergonomics is not only about the design of the tools and equipment needed to perform a job, but also how workers use the tools and equipment while performing the job.

Ergonomics Is how you do a job - Lifting

- Plan the lift before you start. Check the route and be sure the path is clear.
- Get a firm footing. Keep your feet shoulder-width apart and center yourself over the load.
- When you lift, keep the back in its natural "S" curve rather than rounded in a "C" curve.
- Use both hands and keep the load close to the body.
- Size up the load before you lift and make sure that the item is not too heavy or bulky to manage alone. If it is, get help.
- Avoid reaching over an obstacle to lift a load.
- Avoid twisting, turning and abrupt motions while lifting. Instead, lift, turn and take a step.
- When team lifting, pick one person to call the signals. Avoid walking backward.
- Push, don't pull. You can push almost twice as much as you can pull.
- Place lighter items on the top and bottom shelves. Place heavier items on shelves between the knees and shoulders.

Ergonomics is how you do a job - Using hand tools



- Select hand tools that allow the user to maintain a neutral posture for the arm and wrist. Avoid extreme or awkward joint positions (i.e., bent wrist position).
- Keep forceful gripping to a minimum.
- Avoid prolonged gripping of the hand tool.
- Sharpen tool to reduce required forces.
- Minimize torque on the wrist and forearm when possible.
- Avoid pressure points on sensitive areas such as the palm.
- Avoid repetitive finger action.
- Select power or pneumatic tools with built-in vibration dampening.
- Soft coverings on a tool handle protect the hands from heat and cold and help reduce pressure points and slipperiness of the grip.
- Select hand tools that fit the hands of the worker. A tool that is too large or too small will produce stress in the hand and wrist. As a general rule, the ideal handle diameter for a man is 1.5 inches, and 1.3 inches for a woman.
- For trigger-activated tools, choose a grip size that allows activation with the middle part of the fingers. Activation with the fingertips can create nodules on nerve sheaths and cause *trigger finger*.
- The majority of commercially available tools are designed for the right hand. Ideally, tools should be symmetrical or be easily altered to be used by either the right or left hand.

Ergonomics Is how you do a job - Using joysticks

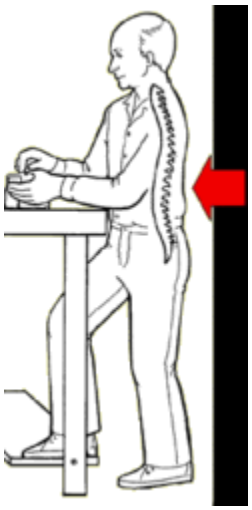
- Keep the wrist in a neutral position - The wrist is straight and not deviated to the side, flexed or extended.
- Keep arms close to the body in a relaxed position.
- Use an armrest to support the arms and adjust it so the shoulders are in a relaxed position.
- If the joysticks are adjustable, take time to place them in a position that allows a comfortable position - arms should be close to the body and avoid reaching for the controls.
- The joysticks should be held loosely with the fingers and palm. Avoid using just the fingertips to move the joysticks. Use smooth, controlled motions. Do not use quick, forceful movements of the arms.

Ergonomics is how you do a job - Sitting postures

Muscle tension can increase when you remain in the same posture for long periods of time. Taking a break to rest, stretch or move around for two or three minutes every 20 to 30 minutes can make a big difference in reducing fatigue, stiffness and discomfort. Postures can be changed throughout the day by changing chair height or seat angle, standing rather than sitting, or repositioning armrests.

- Learn adjustment features available on the workstation.
- Adjust the chair or stool for overall comfort and support.
- Adjust the height of the chair about two inches below the back of the knees when standing.
- If working at a work table, adjust the height of the chair so the forearms are about the same height of the work surface.
- When sitting, allow a two-inch clearance between the back of the knees and the front of the seat cushion.
- Set the seat back position between 90 and 105 degrees.
- Position the chair close to the work surface to reduce excessive reaching.
- Relax shoulders and upper arms and position them perpendicular to the floor.
- Keep arms and elbows close to the body.
- Place thighs and forearms parallel to the floor.
- Place feet on the floor or on a footrest.
- Use padding on seats to reduce pressure points and the effects of vibration, jolting and jarring.

Ergonomics is how you do a job - Standing postures



- Relax the shoulders.
- Maintain the S-curve in the back.
- Keep the head aligned above shoulders, shoulders above hips.
- Relieve back pressure by placing one foot on a footrest or a platform, and periodically shift from one foot to the other.
- Change positions often to prevent static postures.
- Avoid bending the head forward and downward for long periods of time. Muscle fatigue in the neck and shoulders increases when the head is bent forward and downward.
- Wear comfortable shoes - consider using shoe insoles.
- Use anti-fatigue mats when feasible.
- Avoid uneven or sloped surfaces.
- Take frequent breaks (2-3 minutes every 30 minutes), exercise and stretch throughout the shift.

Ergonomics has many benefits

Ergonomics improves jobs to make them safer for workers. Modifying jobs so they better match worker capabilities can prevent injuries and illnesses.

Ergonomics has other benefits in addition to making jobs safer. Ergonomics can also:

- Improve the quality of work and increase productivity
- Enhance the quality of life for the worker
- Reduce fatigue and discomfort

Because ergonomics can make jobs easier to do, workers may be less tired and have less discomfort from performing job tasks. Consequently, workers can concentrate on doing their job instead of thinking about how tired they are or how their body is hurting. If a worker goes home feeling better, he or she can then enjoy life more!

Ergonomics summary

Remember,

- Ergonomics is about modifying the job to suit the worker.
- Ergonomics considers changes to tasks, tools, equipment and environments to improve jobs.
- Ergonomics also considers how workers do their job.
- Besides making jobs safer, ergonomics can reduce fatigue and discomfort, enhance the worker's quality of life in general, improve the quality of work, and increase productivity.

Part 1 Review - Ergonomics

The questions below will test your understanding of what Ergonomics is. The answers are at the end of this document.

1. Ergonomics is the scientific study of people at work.
    a. True
    b. False

2. The goal of ergonomics is to have job _____, _____, and _____ fit the worker's capabilities.
    a. Tasks, tools and equipment
    b. Schedules, pay and equipment
    c. Tools, location and tasks
    d. All of the above

3. Ergonomics seeks to match the physical and the _____ requirements of the job to the abilities of the worker.
    a. Education
    b. Cognitive
    c. Pay
    d. Experience

4. The main benefit of ergonomics is to:
    a. Make jobs safer
    b. Make jobs more productive
    c. Increase the number of workers performing a job
    d. a and b

Part 2 - MSDs

What are MSDs

MSDs are illnesses and injuries that occur at work and affect one or more parts of the soft tissues and bones of the body's musculoskeletal system. The soft tissues can include muscles, tendons, ligaments and cartilage. The nerves and blood vessels servicing the musculoskeletal system can also be affected.

There are many types of MSDs. While MSDs typically occur in the hand, arm, shoulder and lower back, they can also occur in the neck, upper back, leg and ankle.

MSDs: Acute vs. Cumulative Injuries

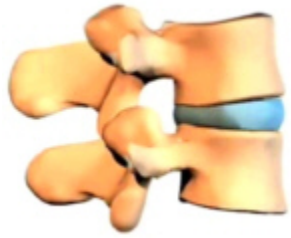
Acute injuries occur instantly, such as an injury resulting from falling off a ladder. It is usually easy to identify the cause of an acute injury. Most frequently reported injuries can be considered acute injuries. Examples include fractures, cuts and bruises. These injuries can affect any part of the body, including internal organs.

Cumulative injuries occur over time. It may not always be easy to identify the cause of a cumulative injury. Because MSDs are not typically the result of a single event, they are considered cumulative type injuries. Since MSDs take time to occur, workers developing a MSD may experience early indicators that something is wrong. These indicators are often called signs and symptoms.

MSD Examples: Low Back Disorders

Let's take a look at how the spine works to further understand how a MSD develops.

Vertebrae are the bones of the spine. Their function is to provide support and to protect the spinal cord. Between each vertebrae is a disc. The disc is actually a large, round ligament that connects the vertebrae together. The disc generally acts like a shock absorber.

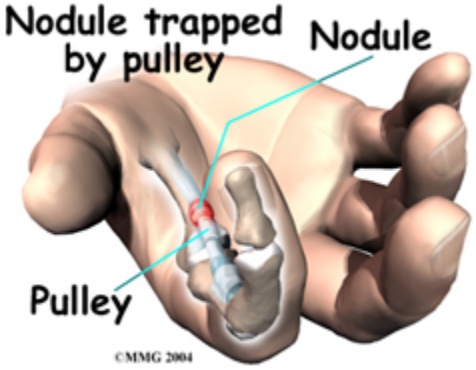


The disc allows movement of the spine and helps transmit forces between vertebrae. As we use our backs each day, the disc is subjected to different types of stress. Repeated twisting, bending and lifting place perhaps the greatest stress on the spine, especially the disc. Bending over compresses the disc on one side, and may cause it to bulge. If the pressure is great enough, the disc may be damaged.

Over time, with repeated twisting, bending and lifting, the disc continues to be damaged as the tears become larger. Eventually, the damage becomes so severe a herniated disc occurs. In this injury, a tear in the disc allows material from the center of the disc to move into the spinal canal. If a spinal nerve is compressed by the disc material, there can be pain, numbness, and weakness along the path of the nerve.

Other examples of MSDs include trigger finger, carpal tunnel syndrome, and tennis elbow.

Trigger Finger

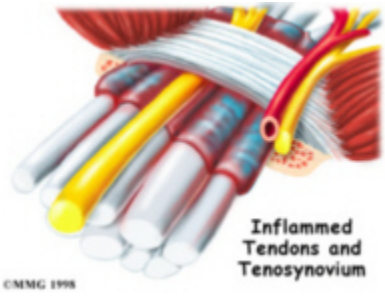


Trigger finger affects the movement of the tendons as they bend the fingers to form a fist. The tendons that move the fingers are held in place on the bones by a series of narrow ligaments. These ligaments form an arch or tunnel on the surface of the bone for the tendon to run through along the bone.

When trigger finger occurs, the constant irritation from the tendon repeatedly sliding through the tunnel causes the tendon to swell in this area and form a nodule. Repeated trauma from pistol-grip power tools, or long hours of grasping a steering wheel can cause trigger finger.

The symptoms of trigger finger include pain and a clicking sensation when the finger is bent. Tenderness usually occurs over the area of the nodule. The clicking sensation occurs when the nodule moves through the tunnel. If the nodule becomes too large, it may pass under the ligament but then get stuck. If the nodule cannot move back through the tunnel, the finger will be locked in a flexed trigger finger position.

Carpal Tunnel Syndrome



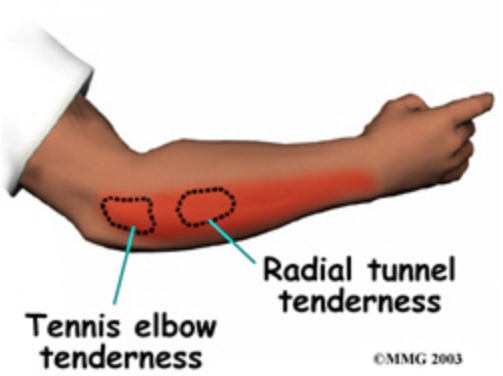
In the wrist, the carpal bones and ligament form an opening or "tunnel." This opening is called the carpal tunnel. The median nerve and all the tendons attached to the muscles that flex or bend the fingers pass through the carpal tunnel.

Any condition that makes the area inside the carpal tunnel smaller, or increases the size of the tissues inside the tunnel can lead to carpal tunnel syndrome. Certain conditions that occur at work have been associated with the development of carpal tunnel syndrome. An example would be bending the wrist many times and applying force at the same time. This condition can cause the tendons to thicken from the irritation and inflammation. As the tendons increase in size, the space within the carpal tunnel decreases, causing the median nerve to be squeezed. This pressure results in damage to the median nerve.

Symptoms of carpal tunnel syndrome include numbness, tingling and pain in the hands (thumb and first three fingers). Symptoms are often most acute at night, while sleeping. Pain may spread up the arm to the shoulder and to the side of the neck. Advanced cases may also result in weakness and clumsiness of the hand as the thumb muscles weaken. It may become difficult to grab a steering wheel, telephone or hammer.

Tennis Elbow

Tennis elbow is a painful disorder of the elbow. Although tennis players may develop tennis elbow, this term is misleading because most people who get it do not play tennis. Tennis elbow is often related to other types of activities, such as painting, hammering, and lifting.



Tennis elbow is associated with jobs that require repeated or forceful movements of the fingers, wrist, and forearm. It can develop when exerting too much force at once or small amounts of force over a long time period. Movements associated with the development of tennis elbow include:

- simultaneous rotation of the forearm and bending of the wrist
- stressful gripping of an object in combination with inward or outward movement of the forearm
- jerky, throwing motions
- hammering movements

The symptoms of tennis elbow are tenderness and pain at the lateral epicondyle (the bony structure on the outside of the elbow). The pain can spread down the forearm to the middle and ring fingers. The forearm muscles may also feel sore, and it may be difficult to straighten your arm. The pain may feel worse when the wrist is bent backwards, when rotating the forearm and hand, as occurs when using a screw driver, or when grasping an object, such as a milk carton. The discomfort can last from a few weeks to years. If sufficient time is not allowed for the strained tendon to heal, the tendon may be permanently weakened.

Symptoms of MSDs

Symptoms may occur during the early stages of a MSD and are indicators that something is wrong or there might be a problem. Symptoms may occur anytime, not just at work. It is common for symptoms to occur sporadically, sometimes they are present and sometimes you feel fine.

Examples of symptoms include:

- fatigue
- aching
- tingling
- numbness
- muscle tightness
- cramping
- burning sensation
- pain

If you ignore these symptoms, signs of a MSD may occur.

Signs of MSDs

Signs of MSDs may result in a functional loss - that is, a person with a MSD may not be able to bend over to tie their shoe laces. Signs are objective findings and can be measured or observed.

Range of wrist motion

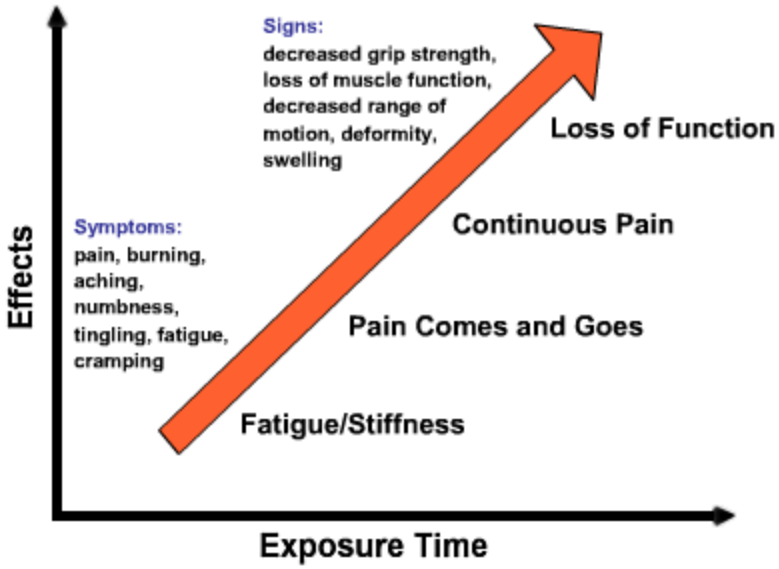
Examples of signs include:

- decreased grip strength
- loss of muscle function
- decreased range of motion
- deformity
- swelling
- decreased nerve conduction
- change in skin color when exposed to cold or vibration

If you ignore these signs, permanent damage may occur.

MSD Injury Progression

This is an example of how a MSD may develop. Early in the development of a MSD, symptoms such as fatigue or stiffness may occur. As your exposure continues, pain may be experienced. You may not feel the pain all the time, but instead it may come and go. If your exposure continues, the pain may eventually become constant. Finally, with continued exposure during this work task, you may have a loss of function such as decreased strength and chronic pain.



MSDs Summary

A MSD may result in a permanent loss of function. Even surgery may not be able to repair all the damage that has occurred. As with many other types of diseases and disorders, the sooner treatment is sought, the greater likelihood full recovery may occur. Also, the sooner corrective action is taken, the less time is needed to fully recover. It is generally easier to recover from a symptom than a sign.

Remember, MSDs:

- Affect the bones and soft tissues of the musculoskeletal system, including the nerves and blood vessels servicing the musculoskeletal system
- Can occur in the back, neck and both the lower and upper extremities (arms and legs)
- Generally develop over a period of time
- Are often accompanied by symptoms and signs, indicating something is wrong
- Take longer to heal, the longer treatment is delayed
- Can result in permanent loss of function

Part 2 Review - MSDs

The questions below will test your understanding of MSDs. The answers are at the end of this document.

1. MSDs are injuries and illnesses that affect:
    a. Muscles and tendons
    b. Ligaments and cartilage
    c. Blood vessels and nerves
    d. All of the above

2. An example of a MSD is:
    a. Carpal tunnel syndrome
    b. Headache
    c. Bruise
    d. Broken bone

3. MSDs usually occur in the:
    a. Abdomen
    b. Chest
    c. Arm
    d. Head

4. MSDs are an acute type injury.
    a. True
    b. False

5. Symptoms of a MSD include:
    a. Fatigue
    b. Muscle tightness and aching
    c. Numbness and tingling
    d. All of the above

6. A sign of a MSD is:
    a. Increase in range of motion
    b. Decreased grip strength
    c. Increased shoulder strength
    d. Back pain

7. Which series indicates a likely progression of a MSD:
    a. Injury sign symptom
    b. Sign injury symptom
    c. Symptom sign injury
    d. Injury symptom sign

8. The longer you wait to treat a MSD, the longer it will take to recover.
    a. True
    b. False

9. An employee who develops a MSD will always recover and regain normal function once the exposure is reduced.
    a. True
    b. False

Part 3 - Risk Factors

What is a Risk Factor?

A risk factor is an action or condition known to contribute to discomfort, injuries and illnesses. The term "risk" implies there exists some potential or probability for an effect to occur. Also, the effect may vary in severity. The effect from exposure to risk factors is difficult to predict, since the effect depends on:

- who is doing the work
- the combination of risk factors present
- the duration of exposure
- the frequency of exposure
- the level or intensity of exposure

Risk Factor Effects

Just because your job may have exposure to one or more risk factors, it does not mean you will definitely get a MSD. However, if an exposure continues over a long period of time, the chance for developing a MSD increases. The effects from an exposure to risk factors are more likely if:

- a worker is exposed to extreme levels of risk factors
- there are multiple risk factors present
- the worker has a pre-existing weakness due to genetics, or a past injury or illness

Risk Factors

There are four main risk factors that can lead to a MSD:

1. Forceful Exertions - Work requiring a lot of physical effort
2. Awkward or Static Postures - Positioning the body in a non-neutral posture, or staying in the same posture for a prolonged period of time
3. Repetitive Motions - Work requiring the same movements with the same muscle groups many times
4. Vibration - Hand-arm and whole body vibrations, jolting and jarring

Risk Factor - Forceful Exertions

A lot of physical effort...

- Heavy lifting
- Carrying heavy objects
- Forceful pushing or pulling
- Forceful gripping
- Shoveling damp or heavy materials

Hand scaling from a bucket. Miners must often use forceful exertions to remove loose rock from the rib.

The amount of force or physical effort needed to do a task depends on many factors. The weight and shape of the object can affect the amount of physical effort needed. Another factor includes the location of the object. Is the object below your knees or above your shoulders? Do you have to reach in front of your body, or twist to the side? Do you have to bend over and reach into a large bin? Is the ground uneven or sloped, or is your work space restricted? All of these situations can increase the amount of physical effort.

Examples of Forceful Exertions - Heavy or Frequent Lifting

Lifting continuous miner power cable. Continuous miner cable weighs about 7 pounds per foot. Moving long sections of cable can often result in high forceful exertions. Working in restricted spaces makes the task even more difficult.

Lifting bags of rock dust from the storage area. Forceful exertions occur when lifting the bags and then when they are restacked for transportation. A bag of rock dust weighs 50 pounds.

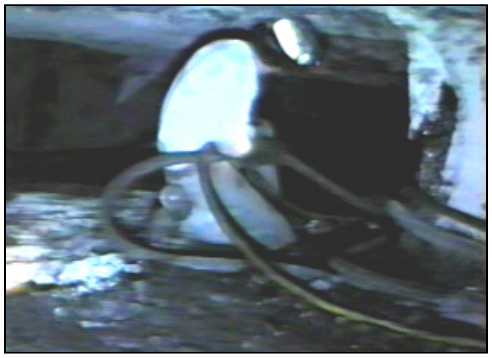
Workers lift bags of blasting materials and then support them while pouring the materials into the bin. Forceful exertions occur when lifting the bag into place and when holding the bag to pour the material.

Examples of Forceful Exertion - Forceful Gripping

Handling concrete blocks with a pinch grip results in a forceful exertion. The maximum force generated during a pinch grip is about 20 percent of the maximum than can be generated during a power grip. When using a pinch grip a worker is more likely to be working at a higher percentage of his/her maximum capability.

Supporting heavy tools, like a large impact wrench, during maintenance work often results in forceful exertions.

Examples of Forceful Exertion - Pushing or Pulling



Pulling continuous miner cable can result in forceful exertions that can be made more difficult by the restricted spaces found in low seam coal mines and poor ground conditions. Continuous miner cable weighs about 7 pounds per foot.

The amount of force generated when pulling dragline cable depends on the length of the cable being moved and the ground conditions. Dragline cable weighs about 12 pounds per foot.

The greatest exertion usually occurs when starting to unwind the fuel hose from the storage reel.

Pushing on a socket wrench may result in forceful exertions near one´s maximum capacity.

Risk Factor - Awkward or Static Postures

Poor positioning of the body...

- Elbows above shoulders
- Extended forward reaches
- Extreme wrist bending
- Pinch grips
- Kneeling or squatting
- Moving the head to the side, forward or backward
- Twisting the trunk
- Stooping
- Reaching behind the body

Miners working in low seam coal mines often use awkward postures because of the restricted spaces found in this type of mine.

When you work, you are active and your posture frequently changes. It is important to avoid postures with your joints at extreme angles. A good rule of thumb is to work with your joints at about the mid-point of their range of motion. When you do this, you have a neutral posture. For example, if you are using your arm, it would be good to bend your elbow around 90 to 100 degrees. Poor positioning of the body can also effect how much force you can exert. Extreme postures significantly decrease the amount of force you can exert.

Some jobs may require you to stay in the same position for long periods. In these situations, it is important to frequently alter your posture, even if only small changes can be made. During breaks, do stretches or take a walk.

Examples of Awkward Posture: Reaching

Mechanic reaching overhead to rewind a hose places his elbow above his shoulder.

Workers sometimes use an excessive forward reach when placing an empty bulk bag on the forklift tines prior to filling the bag with product.

Examples of Awkward Posture: Twisting the Head

When aligning the prill auger above blast holes to dispense an explosive mixture, the miner turns his head to the left and looks over his shoulder while reaching backward with his right hand to operate the dispensing control.

Examples of Awkward Posture: Stooping

Mechanics often assume awkward postures, such as stooping, to access equipment parts when repairing heavy equipment.

Miners often stoop when tying off blast holes prior to a shot. The miner maintains the stooped posture until the tie is completed. The frequency of using the stooped postures depends on the number of blast holes for the shot. Several hundred blast holes may be tied for a single shot.

Examples of Awkward Posture: Kneeling or Squatting

Mechanics often kneel when repairing equipment when it is located on or near the floor.

To operate a roof bolter in a low seam mine the miner often kneels on one or both knees.

Examples of Awkward Posture: Static Postures

Often, the head is in a static position when looking downward at the weld joint. The neck and upper back muscles not only support the weight of the head when in this position, but also the weight of the welding helmet.

Risk Factor - Repetitive Motions

Doing the same movements many times...

- Using equipment controls
- Machine paced assembly tasks
- Packing or unpacking items
- Quality control inspections
- Using computers (keyboard and mouse)

Repetitive motions are usually performed with small muscle groups, like your hand and finger muscles, and often do not have high force demands. The motions, or cycle times, can be repeated from every few seconds to every few minutes and are repeated for two or more continuous hours during the work shift. The more repetitive the motion, the more frequent the muscle contractions occur. When muscles contract repeatedly, fatigue may be experienced. Over a period of time, the repetitive motions, particularly when combined with excessive force or awkward posture, may lead to inflammation and soreness.

Examples of Repetitive Motions: Using Equipment Controls

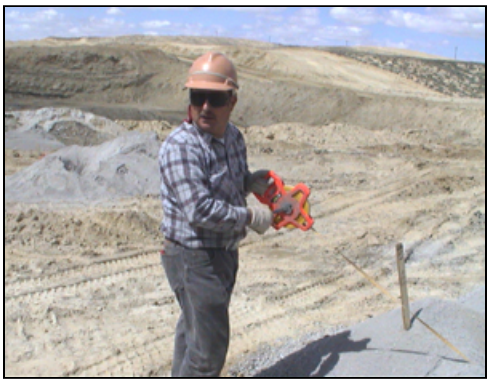
Repetitive motions occur when operating a loader to fill a haul truck. The arms/shoulders move the steering wheel and shift lever, while the foot/leg pushes on pedals.

Repetitive motions occur when operating a loader to fill a haul truck. The arms/shoulders move the steering wheel and shift lever, while the foot/leg pushes on pedals.

Turning a water pump switch off and on while spraying haul roads is repetitive motion if it is done frequently.

Examples of Repetitive Motions: Using Hand Tools

Using hand tools, such as a wrench to tighten bolts, can involve repetitive motions.



Workers use a hand crank to rewind a tape after measuring the depth of blast holes. This task is repetitive depending on the depth and number of blast holes.

Examples of Repetitive Motions: Computer Use

Performing intensive keying for several hours a day

Using a mouse for several hours a day

Risk Factor - Vibration

Hand-Arm Vibration is transmitted to the hands through direct contact with a vibrating source, such as a tool. The frequency range for hand-arm vibration is typically between 8 and 1,500 hertz. Some effects of this type of vibration include tingling sensation, numbness and decreased ability to manipulate the vibrating equipment. Prolonged hand-arm vibration may result in vibration white finger, or Raynaud´s phenomenon, when the blood vessels constrict and the fingers appear blanched or white.

A worker is exposed to vibration from direct contact with a vibrating source that transmits energy to the body through contact with the hands, feet, or buttocks.

Whole Body Vibration is transmitted to the body usually through a seat or platform. The frequency range for whole body vibration is typically between 1 and 80 hertz. Long term whole body vibration exposure is associated with back problems, while short term exposure is associated with headaches, nausea, motion sickness or an urge to urinate.

Jolting and Jarring is the shock the body experiences when riding in mobile equipment on rough, unpaved roads or haulageways. When the equipment runs over a bump or hole in the road, the body is quickly propelled upward and then falls downward into the seat. The amount of shock that is felt depends on many factors, such as the equipment suspension, type of seat and roughness of the road or haulageway. Jolting and jarring can lead to back injuries. Jolting and jarring can also occur when operating mining equipment such as a mechanical scaler.

Examples of Vibration Exposure - Hand-Arm Vibration

Using grinders, sanders, jig saws or other hand tools that typically produce moderate vibration levels

Using jack hammers, pneumatic wrenches, chipping hammers, or other tools that typically generate high vibration levels

Examples of Vibration Exposure: Whole Body Vibration

Operating underground mining equipment such as a LHD, rockdrill or roof bolter

Operating heavy equipment, such as a haul truck, dozer or loader

Examples of Vibration Exposure: Jolting and Jarring

Operating a mechanical scaler

More Risk Factors

In addition to the four main risk factors, there are other risk factors associated with MSDs that are important to know. These risk factors include:

- **Contact Stress/Pressure Points** - Occurs when a body part is pressed against a sharp edge or ridge. Examples include forcefully holding a tool that has ridges on the handle, or resting your wrist or arm on a sharp edge of a work station, such as a desk top or control table.
- **Torque Reaction** - Occurs when tightening nuts with a power tool. When the nut can no longer be tightened and the power tool is still operating, the arm is jerked by the tool as the rotating socket quickly stops.

Ergonomics also addresses some other risk factors related to environmental conditions. These risk factors, which can affect body systems other than the musculoskeletal system, include heat stress, cold stress, altitude and inadequate lighting.

Root Causes

Now that we have learned about risk factors, let's try to understand why they exist. To do this, we are now going to learn about root causes.

Definition: A root cause is one of many factors that contributes or creates an undesired outcome, and if eliminated would have prevented the undesired outcome. In other words, root causes are specific underlying causes or sources of a problem.

Root Causes and Ergonomics

For ergonomics, the undesired outcome that we want to prevent is usually a musculoskeletal disorder, or MSD. As we have already discussed, causes that we usually associate with MSDs are risk factors, such as awkward postures or forceful work. However, we need to understand why risk factors occur when doing work tasks. To do this, information is needed about the task and how it is done, and also about the tools and equipment needed to do the task. For example, it is important to know the following information:

- Process used to do the task
- Effort or strength required
- Location of parts, equipment or tools
- Position of parts, equipment or tools
- Design of parts, equipment or tools
- Frequency of task
- Duration of task
- Speed of work or time to do each cycle
- Environmental factors (restricted work space)
- Training provided to workers
- PPE worn to do task
- Productivity levels

Example: Identifying Risk Factors and Root Causes

Now, let's look at an example.

First, look at the picture the worker operating a hydraulic pit stations. This task is being done at a phosphate mine. The worker operates a water cannon to mix water with the phosphate so it can be piped to a processing plant. This task is done during 12-hour shifts, with 15-minute breaks every four hours.

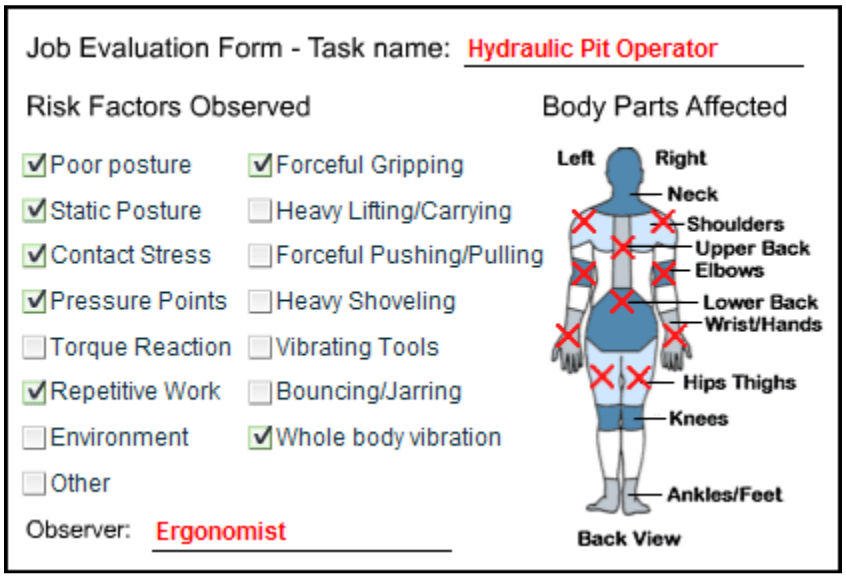
Try to first determine potential risk factors and affected body parts associated with this task.

Example: Risk Factors Answers

The risk factors occurring when this task is performed are checked on the left side of the form, while the x's on the body figure indicate the most likely body parts that may be affected by this task.

The poor postures observed include bending the wrist from side to side and up and down. The workers also maintain a static posture by sitting during most of the work shift. The pressure point or contact stress occurs when the workers rest their arms against the sharp edge of the control table. Because the workers operate the controls during the entire shift, this task is considered repetitive work. Sometimes the workers hold and move the control with a forceful grip.

If you did not identify these risk factors, go back and look at the picture again. See if you can tell when all of the risk factors occur.



Example: Root Causes Answers

Look at the picture again and determine *why* there are risk factors occurring with this task.

The root causes for the risk factors observed when operating the hydraulic pit station are listed in the table. If you have problems understanding the causes, look at the picture again and look for the root causes listed in the table.

What To Consider	Root Causes
Process used to do the task	
Effort/strength required	Use of quick, forceful gripping actions to position controls when moving tree stumps and logs.
Location of parts, equipment or tools	Location of control causes leaning in and reaching.
Position of parts, equipment or tools	Flat control table top increases reaches.
Design of parts, equipment or tools	Sharp edge on control top causes contact stress; type of control causes frequent and exaggerated movements; poor seat - no arm rests/allows vibration exposure.
Speed of task	Work pace controlled by dragline production.
Frequency/Repetition of tasks	Work pace controlled by dragline production.
Duration of tasks	12-hour shifts with few breaks.
Productivity levels	
Environment	
Training/PPE	

From the information gathered for this task, the root causes are primarily related to the design and positioning of the workstation equipment (joysticks, control table top and chair) and the length of the work shift. This information will be helpful when redesigning this workstation to eliminate the risk factors.

Risk Factor Summary

Remember,

- A risk factor is an action or condition known to contribute to discomfort, injuries and illnesses.
- Exposure to risk factors may or may not result in a MSD.
- The effect of exposure to risk factors is determined by many characteristics of the exposure, such as the duration and frequency of exposure.
- MSDs are more likely to occur if there is exposure to multiple risk factors.
- A worker with a pre-existing condition may be more likely to experience a MSD following exposure to risk factors.
- Main risk factors include forceful exertions, awkward postures, repetitive motions and vibrations.
- Root causes are specific, underlying causes of a problem.
- Eliminating root causes can prevent the occurrence of MSDs.

Part 3 Review - Risk Factors

The questions below will test your understanding of Risk Factors. The answers are at the end of this document.

1. The effect from exposure to a risk factor does not depend on:
    a. The combination of risk factors present
    b. The duration of exposure to the risk factor
    c. The frequency of exposure to the risk factor
    d. The time of day the exposure occurs

2. All workers exposed to the same risk factors will develop a MSD.
    a. True
    b. False

3. Exposure to risk factors are more likely to result in a MSD if:
    a. A worker is exposed to extreme levels of risk factors
    b. A worker has had a previous injury
    c. There are multiple risk factors present
    d. All of the above

4. Major risk factors include:
    a. Forceful exertion, lighting and vibration
    b. Repetition and age of worker
    c. Awkward posture, repetition and shift length
    d. Vibration, repetition and awkward posture

5. When operating a powered hand tool, potential risk factor or factors could be:
    a. Whole body vibration
    b. Forceful exertion
    c. Hand arm vibration
    d. b and c

6. Risk factors could include:
    a. Environmental heat stress
    b. Contact stress
    c. Torque reaction
    d. All of the above

7. An example of a forceful exertion is shoveling wet or heavy materials.
    a. True
    b. False

8. The amount of physical effort needed to lift an object only depends on the weight of the object.
    a. True
    b. False

9. A good rule of thumb is to work so your joints are:
    a. At the same angle during the entire work shift.
    b. At a position that you can feel your muscles stretching.
    c. At about the midpoint of their range of motion.
    d. Fully flexed.

10. Which of the following postures is not considered an awkward posture?
    a. Squatting
    b. Twisting the trunk to lift an object
    c. Working with your elbows above your shoulders
    d. Sitting at a desk with your feet resting on the floor

11. Work is considered repetitive if you do it every shift at least one time.
    a. True
    b. False

12. An example of repetitive work includes:
    a. Operating machine controls
    b. Shoveling
    c. Answering the phone
    d. a and b

Part 4 - Prevention

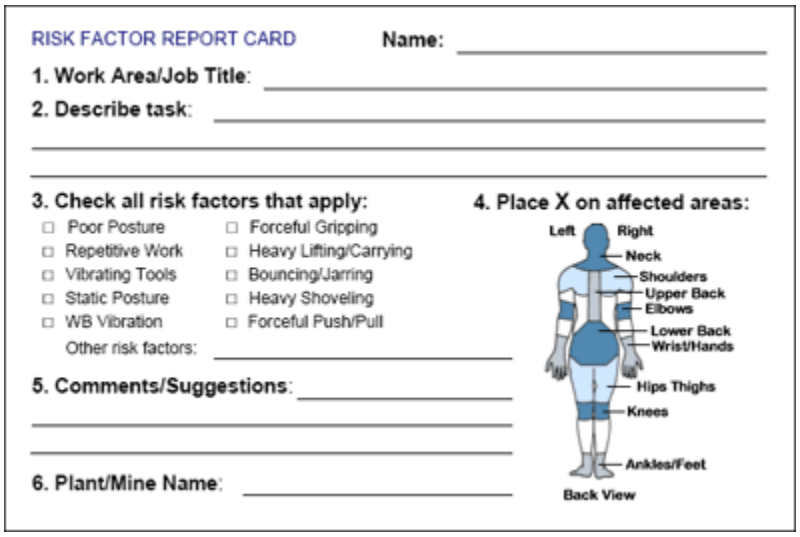
How To Prevent MSDs

You can prevent MSDs by:

- Identifying and reporting risk factors at your work place, and
- Controlling risk factors by applying ergonomics - *designing tasks, tools, equipment, and workstations based on worker capabilities*.

Reporting Risk Factors

Once you identify a risk factor, it is important to report it. Each company will have its own method for reporting risk factors. Some companies may choose to report risk factors following the same procedure as for reporting safety and health hazards. The Risk Factor Report Card is an example of a form that is convenient for employees to inform management of risk factors. The card allows the employee to report the risk factors associated with the task, the presence of any body discomfort, and comments or suggestions that may be useful.



RISK FACTOR REPORT CARD Name: _____

1. Work Area/Job Title: _____
2. Describe task: _____

_____

_____

3. Check all risk factors that apply:

- ☐ Poor Posture
- ☐ Repetitive Work
- ☐ Vibrating Tools
- ☐ Static Posture
- ☐ WB Vibration
- ☐ Forceful Gripping
- ☐ Heavy Lifting/Carrying
- ☐ Bouncing/Jarring
- ☐ Heavy Shoveling
- ☐ Forceful Push/Pull

Other risk factors: _____

4. Place X on affected areas:

5. Comments/Suggestions: _____

_____

_____

6. Plant/Mine Name: _____

Do Not Focus On Injuries!

Many times an injury or many injuries occur before we realize there is a problem. This is called being reactive. Although it is essential to react, this reaction can no longer prevent the injury. There is a better way to prevent MSDs.

Target Risk Factors

Take a ***PROACTIVE APPROACH*** to maintaining your safety and health at work.

By targeting Risk Factors you can prevent the injuries and illnesses ***before they occur***. Now that you are knowledgeable about these risk factors from Part 3, you are able to identify them and reduce the exposures.

Controlling Risk Factors

Control	Definition	Effectiveness
Engineering	Exposure levels of risk factors are reduced or eliminated through design of the methods, tools, and equipment or workstations	Highest level of protection
Administrative	Exposure levels of risk factors are not eliminated, but are reduced through scheduling, training and procudures	Good interim solution - can be effective in combination with other controls
Personal Protective Equipment	The presence or level of risk factors is not reduced or eliminated, but the exposure level of the individual worker is reduced through the introduction of a barrier between the risk factor and the worker	Lowest level of protection

The best way to reduce the chance of a MSD is to control risk factors using Engineering Controls. This is the preferred method for protecting employees because the risk factor is actually reduced or eliminated. And while engineering controls can be costly and take more time to implement, this is not always the case. In fact, some engineering controls can be very inexpensive.

Only when engineering controls are not feasible, from either a technical or cost perspective, should Administrative Controls be considered. Because administrative controls are only effective if they are strictly followed, it is very important that management fully supports their use.

Personal Protective Equipment (PPE) is the least desirable type of control. PPE merely creates a barrier between the employee and the risk factor. It does not actually reduce or eliminate the risk factor. The effectiveness of the barrier depends on many things and therefore cannot guarantee a level of protection from the risk factor. An example is anti-vibration gloves. Depending on the frequency of the vibration and the type of anti-vibration material used in the gloves, they may or may not be an effective barrier to the vibration. Also, employees need to constantly use the gloves for them to be effective.

Engineering Controls to Reduce Risk Factors

Use Engineering Controls to reduce or eliminate Risk Factor exposures by:

- redesigning workstations
- modifying work methods
- purchasing tools and equipment with ergonomic features
- redesigning work layouts
- improving maintenance access
- improving environmental conditions

Hydraulic lift installed on a dragline improves access and eliminates climbing a vertical ladder.

Water pump switch in a water truck was moved from the dash and relocated to the center console, which eliminates unnecessary reaching to operate the switch.

Small lifting table is used to hold parts when repairing equipment.

Light-weight welding helmets (right) reduce the effort needed to hold your head in a bent position while welding.

Scissors-lift table is used to position and work on parts when repairing equipment.

Tractor with a cable attachment is used to move dragline cable when positioning the dragline.

Armrests can be adjusted so the worker's arms are supported and placed in a comfortable position.

Anti-fatigue mats placed in high traffic areas improve walking conditions and reduce fatigue.

Adjustable joysticks can be placed close to the operator, which improves postures and eliminates reaching for the controls.

Magazine sidewalks eliminate the uneven walking surfaces while moving blasting supplies.

Heavy pneumatic wrench is attached to a counterbalance weight and suported by an overhead crane when changing the cutting edges on a blade.

Administrative Controls to Reduce Risk Factors

Examples of administrative controls that can reduce exposures to risk factors:

- Reduce shift lengths or limit the amount of overtime.
- Rotate workers through several jobs with different risk factors and exposure levels.
- Schedule more frequent breaks so workers can rest and recover.
- Schedule employees to work in areas when the risk factor level may be reduced (Schedule employees to work around heat-generating equipment when the equipment may not be operating, such as during an off shift.)
- Vary the tasks within a job based on risk factor exposures to prevent continuous exposure to to the same risk factor.
- Reduce the work pace to reduce repetitive motion risks.
- Revise work practices to reduce exposure to risk factors (Require two employees to perform a lift instead of one employee).
- Avoid incentive programs that may lead to increased exposure levels, primarily repetitive motions.
- Train employees in the recognition and reporting of risk factors.

Personal Protective Equipment (PPE) to Reduce Risk Factors

Examples of PPE that can reduce exposures to risk factors:

- Anti-vibration gloves
- Knee pads
- Shoe insoles
- Cold weather clothing
- Cooling devices

To be effective, PPE must be properly worn and maintained.

MSD Prevention Summary

Remember,

- Identify and report risk factors at your work place to prevent MSDs.
- Approaches to controlling risk factors include engineering controls, administrative controls, and personal protective equipment.
- Engineering controls are the preferred method for controlling risk factors because the exposure is either reduced or eliminated.
- Personal Protective Equipment is the least preferred method because the PPE only provides a barrier between the worker and the risk factor.
- Control risk factors by applying ergonomic interventions - *designing tasks, tools, equipment and workstations based on worker capabilities*.

Part 4 Review - Preventing MSDs

The questions below will test your understanding of how to prevent MSDs The answers are at the end of this document.

1. The best approach to preventing MSDs is to identify, report and control risk factors.
    a. True
    b. False

2. Types of controls used to reduce or eliminate risk factors include:
    a. Attending meetings
    b. Engineering controls
    c. Hard hats and safety shoes
    d. All of the above

3. Personal protective equipment is the best method to control risk factors.
    a. True
    b. False

4. Personal protective equipment for risk factors includes:
    a. Knee pads and anti-vibration gloves
    b. Hearing protection and respirators
    c. Cooling devices and air conditioning
    d. Wrist splints and shoe insoles

5. Rotating workers through several job tasks with different risk factors and exposure levels is an example of an administrative control.
    a. True
    b. False

6. Taking a break and stretching can help reduce exposure to an risk factor.
    a. True
    b. False

7. Engineering controls reduce or eliminate risk factors by modifying:
    a. The color of the walls in your work area
    b. The ventilation levels to control the amount of oxygen in the air
    c. Workstations and equipment
    d. The workers doing the job

8. Using a lifting device to move a heavy object is an example of:
    a. Personal protective equipment
    b. An administrative control
    c. An engineering control
    d. Something a worker would do only if no one else was watching

Links to more information on MSDs

- NIOSH Safety and Health Topic: Ergonomics and Musculoskeletal Disorders
  http://www.cdc.gov/niosh/topics/ergonomics/
- Preventing Work-Related Musculoskeletal Disorders - A DoD information Guide for Supervisors and Workers
  (https://www.denix.osd.mil/denix/Public/Library/Ergonomics/Musculoskeletal/wmsd.html
- OSHA Safety and Health Topics: Ergonomics
  http://www.osha.gov/SLTC/ergonomics/

Exercises

Exercise 1: Dragline Operator

For this exercise, you will complete a job evaluation form while looking at a picture of a person operating a dragline. Your task is to identify the risk factors (fill in the the check boxes) and potential body parts affected (mark the desired area of the human figure). When you finished the form, go to the next page to compare your answers with those given by an Ergonomist. Try to see the risk factors that the Ergonomist observed and to understand how those risk factors could affect the different body parts.

The operator spends 10 hours of a 12-hour shift sitting in a chair and manipulating two joysticks to control the dragline. The operator occasionally reaches for other controls, and may take breaks when another operator is available. The average cycle time is approximately 60 seconds - fill the bucket, swing it to the dump point, dump the bucket, and then return the bucket to fill it again.

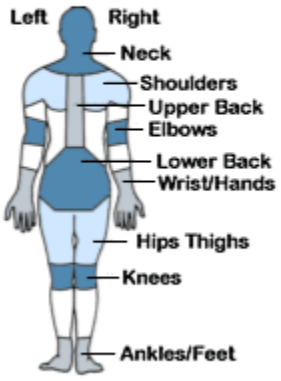
Job Evaluation Form - Task name: _____

Risk Factors Observed

- ☐ Poor posture
- ☐ Static Posture
- ☐ Contact Stress
- ☐ Pressure Points
- ☐ Torque Reaction
- ☐ Repetitive Work
- ☐ Environment
- ☐ Other
- ☐ Forceful Gripping
- ☐ Heavy Lifting/Carrying
- ☐ Forceful Pushing/Pulling
- ☐ Heavy Shoveling
- ☐ Vibrating Tools
- ☐ Bouncing/Jarring
- ☐ Whole body vibration

Observer: _____

Body Parts Affected



Back View

Exercise 1: Dragline Operator - Answers

Job Evaluation Form - Task name: Dragline Operator

Risk Factors Observed

- [x] Poor posture
- [x] Static Posture
- [ ] Contact Stress
- [ ] Pressure Points
- [ ] Torque Reaction
- [x] Repetitive Work
- [ ] Environment
- [ ] Other
- [ ] Forceful Gripping
- [ ] Heavy Lifting/Carrying
- [ ] Forceful Pushing/Pulling
- [ ] Heavy Shoveling
- [ ] Vibrating Tools
- [ ] Bouncing/Jarring
- [ ] Whole body vibration

Observer: Ergonomist

Body Parts Affected

Root Causes

Causes	Answers
☑ Process used to do task	Manually operate 2 joysticks
☐ Effort/strength required	
☑ Location of parts, equipment or tools	Joysticks are located on consoles in front of each side of the seat
☑ Position of parts, equipment or tools	Joysticks cannot be adjusted
☑ Design of parts, equipment or tools	Limited adjustments on chair and arm rests. Arm rests are small. Joysticks have a large throw.
☑ Speed of task	Average is 60 seconds.
☑ Frequency/Repetition of task	Task is repeated every 60 seconds during entire shift
☑ Duration of task	12 hour shift (total break time = 2 hours)
☑ Productivity levels	Required to maintain productivity levels
☑ Environment	Height of spoil pile; depth of pit; content of material being moved (rocks vs. soil)
☐ Training/PPE	

Exercise 2: Dozer Maintenance

For this exercise, you will complete a job evaluation form while looking at a picture of a person performing dozer maintenance. Your task is to identify the risk factors (fill in the the check boxes) and potential body parts affected (mark the desired area of the human figure). When you finished the form, go to the next page to compare your answers with those given by an Ergonomist. Try to see the risk factors that the Ergonomist observed and to understand how those risk factors could affect the different body parts.

This task is done once or twice a month. The worker must remove several dozen bolts to replace the cutting edges from the dozer blade. The pneumatic wrench weighs approximately 25 pounds.

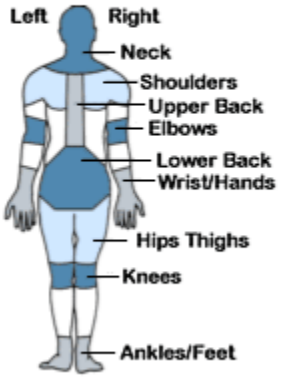
Job Evaluation Form - Task name: _____

Risk Factors Observed

- ☐ Poor posture
- ☐ Static Posture
- ☐ Contact Stress
- ☐ Pressure Points
- ☐ Torque Reaction
- ☐ Repetitive Work
- ☐ Environment
- ☐ Other
- ☐ Forceful Gripping
- ☐ Heavy Lifting/Carrying
- ☐ Forceful Pushing/Pulling
- ☐ Heavy Shoveling
- ☐ Vibrating Tools
- ☐ Bouncing/Jarring
- ☐ Whole body vibration

Observer: _____

Body Parts Affected



Exercise 2: Dozer Maintenance - Answers

Job Evaluation Form - Task name: Dozer Maintenance

Risk Factors Observed

- [x] Poor posture
- [ ] Static Posture
- [ ] Contact Stress
- [ ] Pressure Points
- [x] Torque Reaction
- [ ] Repetitive Work
- [ ] Environment
- [ ] Other
- [x] Forceful Gripping
- [x] Heavy Lifting/Carrying
- [ ] Forceful Pushing/Pulling
- [ ] Heavy Shoveling
- [x] Vibrating Tools
- [ ] Bouncing/Jarring
- [ ] Whole body vibration

Observer: Ergonomist

Body Parts Affected

Root Causes

Causes	Answers
☑ Process used to do task	Remove bolts with 1/2-inch impact wrench
☑ Effort/strength required	Impact wrench weighs 25 pounds
☑ Location of parts, equipment or tools	Bolts are accessed from the underside of the blade
☑ Position of parts, equipment or tools	Limited position of blade - raised off the floor
☑ Design of parts, equipment or tools	Impact wrench weight and vibration level
☐ Speed of task	Task completed twice a month
☑ Frequency/Repetition of task	Task completed twice a month
☐ Duration of task	
☐ Productivity levels	
☑ Environment	Restricted work space
☑ Training/PPE	No anti-vibration gloves

Glossary

Acute Injury

An injury that occurs instantly, such as fractures, cuts and bruises.

Administrative Control

Reducing exposures to risk factors by managing the exposure times of workers through job rotation, work procedures, scheduling, etc.

Awkward posture

If a job task looks uncomfortable, it probably is and this increases the chances for injury. Whenever possible strive to arrange the work environment or work processes to allow employees to work from comfortable, neutral posture. Excessive bending, reaching, awkward neck, back, and arm positions should be eliminated.

Carpal tunnel syndrome

A compression of the median nerve as it passes through the carpal tunnel in the wrist.

Chronic low back pain

General soreness and fatigue of the low back. Pain is usually constant, and it accompanies most activities.

Constriction

Binding, squeezing, or shrinking blood vessels so that circulation is reduced.

Cubital tunnel syndrome

Compression of the ulnar nerve as it passes through the notch of the elbow.

Cumulative Injury

An injury that develops gradually, such as sprains and strains, herniated discs, tendonitis and carpal tunnel syndrome.

Cumulative trauma disorder

Injuries and illnesses that affect one or more parts of the soft tissues and bones of the musculoskeletal system, and/or nerves and blood vessels servicing the musculoskeletal system. Generally occurs as a result of exposure to repeated stresses over a period of time.

Degenerative disc disease

Wear and tear of the discs that separate the vertebrae of the spine.

DeQuervain's Disease

An inflammation of the tendon and/or its sheath at the base of the thumb.

Digital neuritis

Compression of the nerves along the sides of the fingers or thumbs.

Discomfort

Mental or physical distress. Examples of physical distress include aches and pains your body is experiencing. Examples of mental distress include loss of a loved-one, pressure to perform at work, or lack of sleep.

Engineering controls

A method of controlling and preventing worker exposure to risk factors or hazards by redesigning equipment, tools, and work stations.

Epicondylitis

An inflammation of the tendons at the elbow. Also called tennis elbow (lateral or outside part of the elbow), or golfer's elbow (medial or inside part of the elbow).

Ergonomics

Ergonomics is the field of study that seeks to match the physical and cognitive requirements of the job to the abilities of the worker. This is achieved by designing workplaces, environments, job tasks, equipment, and processes to suit the worker´s abilities. Ergonomics is the scientific study of people at work.

Ergonomics program

A systematic method (similar to an accident prevention or quality improvement program) used to evaluate, prevent and manage work related musculoskeletal disorders. The four elements of a typical ergonomics program are worksite analysis, hazard prevention and control, medical management, and training and education. To implement an ergonomics program, some companies use an ergonomics team or committee. This team would be responsible for identifying and correcting musculoskeletal hazards in the workplace.

Fatigue

A condition that results when the body cannot provide enough energy for the muscles to perform a task. It results in an incapacity to continue to perform work at the same rate.

Force

The amount of physical effort a person uses to do a task.

Forceful Exertion

Forces exerted by muscles when lifting, lowering, pushing, pulling, carrying or grasping.

Ganglionic cyst

Swelling of the tendon and sheath due to the build up of synovial fluid inside the sheath. The cyst usually causes a bump under the skin.

Hand arm vibration

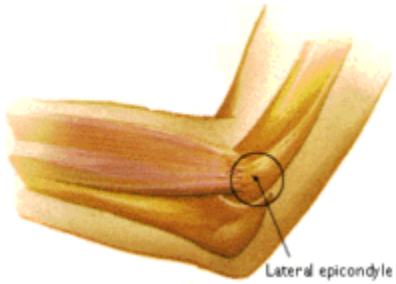
Vibration (generally from a hand tool) that goes through the hand, then travels through the rest of the body.

Hazard prevention and control

Eliminating or minimizing the hazards identified in the worksite analysis. It involves changing the jobs, workstations, tools or environment to fit the worker. Hazard prevention and control is an element of the ergonomics program.

Lateral Epicondyle

The bony prominence on the outside portion of the elbow.



Mechanical contact stress

The contact of the body with a hard surface or edge that results in the compression of tissue. Can also result when using a part of the body as a hammer or striking instrument.

Musculoskeletal disorders

Illnesses and injuries that affect one or more parts of the soft tissue and bones in the body. The parts of the musculoskeletal system are bones, muscles, tendons, ligaments, cartilage, and their associated nerves and blood vessels.

Neutral posture

Comfortable working posture that reduces the risk of musculoskeletal disorders. An ideal posture for the upper body would have arms at your sides, elbows bent, wrists straight, and your eyes looking straight ahead.

Non specific backache

General soreness and fatigue of the low back.

Osteoarthritis

Most common type of arthritis, especially among older people. Sometimes called degenerative joint disease or "wear-and-tear arthritis." Unlike other types of arthritis, it only affects the joints, not internal organs. It causes persistent stiffness and swelling of the joints.

Personal protective equipment (PPE)

Gloves, kneepads and other equipment that may help reduce hazards until other controls can be implemented, or to supplement existing controls.

Raynaud's Phenomenon

A constriction of the blood vessels in the hands and fingers. Also called "white finger."

Repetitiveness

Performing the same motions repeatedly. The severity of risk depends on the frequency of repetition, speed of the movement or action, the number of muscle groups involved, and the required force.

Risk factors

An aspect of a job that increases the worker's chance of getting a work related musculoskeletal disorder.

Root Cause

A root cause is one of many factors that contributes or creates an undesired outcome, and if eliminated, would have prevented the undesired outcome. In other words, root causes are specific underlying causes or sources of a problem.

Rotator cuff tendinitis

Inflammation of one or more tendons at the shoulder. Also called "Pitcher's Shoulder."

Severity rate

The cost in terms of lost workdays (or dollars) of new injuries and illnesses. It is calculated as the number of lost work days per total number of hours worked by all employees during a specified time period.

Signs of a MSD

Signs are indicated by a functional loss. Signs are usually objective and can be mearured. Examples of signs include decreased grip strength, loss of muscle function, decreased range of motion, or localized deformity or swelling. If you ignore these signs, a MSD may occur.

Sprain

Over stretching or overexertion of a ligament that results in a tear or rupture of the ligament.

Static loading (or sustained exertions)

Physical effort or posture that is held and requires muscle contraction for more than a short time. As muscles remain contracted, the blood flow to the muscles is reduced. (Also sustained exertions.)

Strain

Over stretching or overexertion of a muscle or tendon.

Symptoms of a MSD

Symptoms occur during the *early* stages of a MSD and are indicators that something might be wrong. Symptoms tend to be subjective and in general cannot be measured. Examples of symptoms include fatigue, aching, tingling, numbness, muscle tightness, cramping, burning sensation and pain.

Tendonitis

Inflammation of the tendon inside the sheath.

Tennis Elbow

The muscle that straightens or extends the fingers is attached to the elbow with a tendon. Tennis elbow, or lateral epicondylitis, occurs when this tendon becomes irritated and inflamed. The pain is most common on the outer side of the elbow.

Tenosynovitis

Inflammation of the sheath around the tendon.

Thoracic outlet syndrome

Compression of the nerves and blood vessels between the neck and shoulder often associated with prolonged overhead work.

Trigger finger

A common term for tendinitis or tenosynovitis that causes painful locking of the finger(s) while flexing.

Ulnar nerve entrapment

Compression of the ulnar nerve as it passes through the wrist, often associated with prolonged flexion and extension of the wrist and pressure on the palm.

Vertebrae

Vertebrae (singular: vertebra) are the individual bones that make up the vertebral column (aka spine).There are thirty-three vertebrae in humans.

Vibration (Hand-Arm)

Vibration can be defined as continuous movement about a fixed point, or oscillations from a position of equilibrium. The movement can be periodic or random. Hand-arm vibration occurs when using power tools, either hand-held tools or stationary tools that transmit vibration through the work piece.

Vibration (Whole-Body)

Vibration can be defined as continuous movement about a fixed point, or oscillations from a position of equilibrium. The movement can be periodic or random. Whole body vibrations occurs when riding in equipment or standing/sitting on surfaces (platforms or floors) that vibrate. The level of exposure when riding in a vehicle depends on the road conditions, the vehicle suspension, the seat suspension and the speed of the vehicle.

White Finger Disease

A constriction of the blood vessels in the hands and fingers. The fingers will appear white, usually with exposure to cold. Also called Raynaud´s Phenomenon.

Work practice controls

Procedures for safe and proper work that are used to reduce the duration, frequency or severity of exposure to a hazard. They include work methods training, job rotation, and gradual introduction to work. Work practice controls are part of hazard prevention and control.

Work site analysis

A safety and health review that addresses work related musculoskeletal disorders. It is a structured way of identifying jobs and workstations that may contain musculoskeletal hazards, the risk factors that pose the hazards, and the causes of the risk factors.

Review Question Answers

Part 1 - Ergonomics

Question	Answer	Explanation
1	**a**	Ergonomics looks at the tasks workers do, the tools and equipment they use, and the environments they work in. The goal of ergonomics is to have job tasks, tools, equipment and work places fit the worker's capabilities.
2	**a**	When improving jobs, ergonomics considers changes to tasks, tools, equipment and environments.
3	**b**	The goal of ergonomics is to have job tasks, tools, equipment and work places fit the worker's capabilities. Physical capabilities, such as muscular strength and endurance, and cognitive abilities, such as attention span, working memory and reaction times, are considered in the design of the job.
4	**a**	Ergonomics improves jobs to make them safer for workers. Modifying jobs so they better match worker's capabilities can prevent injuries and illnesses.

Part 2 - MSDs

Question	Answer	Explanation
1	**d**	MSDs are illnesses and injuries that occur at work and affect one or more parts of the soft tissues and bones of the body's musculoskeletal system. The soft tissues can include muscles, tendons, ligaments and cartilage. The nerves and blood vessels servicing the musculoskeletal system can also be affected.
2	**a**	Carpal Tunnel Syndrome is a painful disorder in the hand caused by inflammation of the median nerve in the wrist bone. Carpal Tunnel Syndrome is commonly caused by combining repetitive motion of the wrist with excessive force or extreme flexion or extension.
3	**c**	While MSDs usually occur in the hand, arm, shoulder and lower back, they can also occur in the neck, upper back, leg and ankle.
4	**b**	Because MSDs are not typically the result of a single event, they are not considered cumulative type injuries.
5	**d**	Some symptoms of MSDs include: fatigue, aching, tingling, numbness, muscle tightness, cramping, burning sensation, and pain.
6	**b**	Other examples of signs of a MSD include loss of muscle function, decreased range of motion, and localized deformity or swelling.
7	**c**	The symptoms usually lead to signs, which lead to an injury.
8	**a**	As with many other types of diseases and disorders, the sooner treatment is sought, the greater likelihood that full recovery will occur.
9	**b**	A MSD may result in a permanent loss of function. Even surgery may not be able to repair all the damage that has occurred.

Part 3 - Risk Factors

Question	Answer	Explanation
1	**d**	The effect from exposure to risk factors depends on who is doing the work, the combination of risk factors present, the duration of exposure to the risk factor, and the frequency of exposure to the risk factor. The time of day of the exposure is ***not*** a factor!
2	**b**	Just because your job may have exposure to one or more risk factors, it does not mean you will definitely get a MSD.
3	**d**	The effects from exposure to risk factors are more likely if a worker is exposed to extreme levels of risk factors, there are multiple risk factors present, or the worker has a pre-existing weakness due to heredity, or a past injury or illness.
4	**d**	The four main risk factors are Forceful Work, Awkward Posture, Repetitive Work and Vibration Exposure.
5	**d**	Using a powered hand tool could potentially involve forceful work and hand-arm vibration.
6	**d**	Risk factors other than the 4 major ones include contact stress, heat stress, cold stress, restricted work spaces and inadequate lighting.
7	**a**	Other examples of forceful exertions include heavy lifting, carrying heavy objects, forceful pushing or pulling and forceful gripping.
8	**b**	Weight is only one factor in the amount of force needed to lift an object. Others are its shape, location (below your knees or above your shoulders, off to the side) and work space restrictions.
9	**c**	When your joints are at the mid-point of their range of motion you have a neutral posture.
10	**d**	Examples or **poor** positioning of the body includes elbows above shoulders, extended forward reaches, extreme wrist bending, pinch grips, kneeling or squatting, turning the head to the side, twisting the trunk, and stooping with the trunk bent over more than 20 degrees.
11	**b**	Repetitive motions are repeated every few seconds!
12	**d**	Shoveling and operating machine controls are repetitive since they can be done every few seconds.
13	**b**	A worker is exposed to vibration from direct contact with a vibrating source, which transmits energy to the body through contact with the hands (**hand tools**), feet (**platforms**), or buttocks (vehicles).

Part 4 - Prevention

Question	Answer	Explanation
1	**a**	You can help prevent MSDs by identifying and reporting risk factors at your work place, and controlling risk factors by applying ergonomics principles.
2	**b**	Other controls include Administrative and Personal Protective Equipment.
3	**b**	Personal Protective Equipment is the least desirable type of control. It merely creates a barrier between the employee and the risk factor. It does not actually reduce or eliminate the risk factor.
4	**a**	Other personal protective equipment that can reduce exposure to risk factors includes shoe insoles, hearing protection and cooling devices.

5 **a** Rotating workers can reduce overall exposure to risk factors.

6 **a** Workers need to rest and recover from exposures to risk factors.

7 **c** Engineering Controls can reduce risk factors by improving workstations and equipment.

8 **c** Engineering Controls affects the way parts, tools and materials are transported and manipulated.