When performing work in awkward postures or with excessive effort, you may experience fatigue, discomfort, and musculoskeletal disorders (MSDs). The basic principles of ergonomics introduced in this course should be a vital component in every industry. This is especially true in the manufacturing, retail, and service industries where there is an increased rate and cost of ergonomic injuries. The main components in this course include risk factor identification, basic workstation design options, and hazard control strategies to eliminate or reduce those risk factors. Take this course prior to taking Course 722 Ergonomics Program Management.
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OSHAcademy Course 711 Study Guide

Introduction to Ergonomics

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This study guide is designed to be reviewed off-line as a tool for preparation to successfully complete OSHAcademy Course 711.

We hope you enjoy the course and if you have any questions, feel free to email or call:

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Revised: August 6, 2019
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Course Introduction

What is ergonomics?

Ergonomics is a way of designing workstations, work practices, and work flow to accommodate the capabilities of workers. Ergonomic design reduces risk factors known to contribute to occupational ergonomic injuries and illnesses, such as sprains and strains and cumulative trauma disorders (CTDs).

If work is performed in awkward postures or with excessive effort, fatigue and discomfort may result. Under these conditions’ muscles, tendons, ligaments, nerves, and blood vessels can be damaged. Injuries of this type are known as musculoskeletal disorders (MSDs).

The Problem

The increased rate and high cost of ergonomic injuries and illnesses such as carpal tunnel syndrome, tendinitis, and MSDs cut across all industries and occupations. Some of the hardest hit are manufacturing, retail, and service industries. Take a look at your OSHA 300 Log. You will probably notice that most (30%-50%) of your recordable injuries are somehow related to ergonomics.

MSDs can increase the cost of doing business both directly and indirectly. Direct costs may include medical services and higher workers’ compensation premiums. The direct cost to close an ergonomic-related workers’ compensation claim can average over $9,000. Indirect costs from increased employee turnover, absenteeism, and retraining may also occur. Productivity, product quality, and employee morale may also suffer. Estimates indicate that the indirect costs associated with MSDs may be four to 10 times higher than the direct costs. Preventing and controlling ergonomic risk factors in the workplace often costs a fraction of what one such claim would cost. In smaller companies, one ergonomic-related claim can mean the difference between being above or below the profit margin.

An Important Strategy to Solve the Problem

OSHA and private consultants can provide customized presentations and training for groups and associations. An ergonomic consultation may include:

- workstation analysis and design;
- task-specific and company-wide risk factor assessment;
- training and education;
- development and implementation assistance for ergonomic programs;
• help prioritizing ergonomic needs; and/or

• answers to questions about current and possible regulatory requirements
Module 1: Defining Ergonomics

Introduction

Webster's New World Dictionary (College Edition) defines ergonomics as "the study of the problems of people in adjusting to their environment; especially the science that seeks to adapt work or working conditions to suit the individual worker."

The word "ergonomics" is from Greek:

- "ergo" means "work,"
- "nomics" means "laws pertaining to, or measure."
- Ergonomics is "the laws pertaining to work, the measure of work."

Ergonomics may also be thought of as the science of fitting the job to the individual worker. When there is a mismatch between the physical requirements of the job and the physical capacity of the worker, musculoskeletal disorders (MSDs) can result.

Quiz Instructions

After each section, there is a quiz question. Make sure to read the material in each section to discover the correct answer to these questions. Circle the correct answer. When you are finished go online to take the final exam. This exam is open book, so you can use this study guide.

1. Ergonomics is the science of fitting the job to ______.
   a. the individual worker
   b. the group of workers
   c. job classifications
   d. the gender of workers

Ergonomics & Risk Factors

Ergonomics studies the various risk factors brought to a job. Listed below are three areas within which ergonomic risk factors exist.

- risk factors inherent in the worker
Workers come in all shapes and sizes, each with unique attributes that present certain ergonomic risk factors to a given job. The task(s) of the job itself can present risk factors that increase the likelihood of an injury. Finally, the workplace environment, within which the worker and job exist, may also contain exposures to risk factors. We will cover each of these risk factor categories in this course.

Who is at risk?

That's a great question. Let's take a look at the factors that increase the risk of an injury. Risk for developing MSDs increases for workers who must:

- repeat the same motion throughout their workday;
- do their work in an awkward position;
- use a great deal of force to perform their jobs;
- repeatedly lift heavy objects; or
- face a combination of these risk factors.

The level of risk depends on how long a worker is exposed to these conditions, how often they are exposed, and the level of exposure.

2. Ergonomic risk factors are inherent in each of the following areas EXCEPT _____.

   a. the worker
   b. the system
   c. the environment
   d. the task
Musculoskeletal Disorders (MSDs)

When there is a mismatch between the physical requirements of the job and the physical capacity of the worker, work-related musculoskeletal disorders (MSDs), also called workplace musculoskeletal disorders (WMSDs), can result. MSDs affect the muscles, nerves, blood vessels, ligaments and tendons.

Workers in many different industries and occupations can be exposed to risk factors at work, such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy loads, working in awkward body postures and performing the same or similar tasks repetitively. Exposure to these known risk factors for MSDs increases a worker's risk of injury.

MSDs represent a wide range of disorders that can differ in severity from mild periodic symptoms to severe chronic and debilitating conditions. Below is a list of examples.

- carpal tunnel syndrome
- tendinitis
- osteoarthritis and rheumatoid arthritis
- fibromyalgia
- rotator cuff injuries (affects the shoulder)
- epicondylitis (affects the elbow)
- trigger finger
- muscle strains and low back injuries

3. Workers are likely to develop musculoskeletal disorders (MSDs) when they ________.
   a. the worker
   b. occasionally lift heavy objects
   c. use a small amount of force
   d. are over 55 years old
Factors Contributing to MSDs

Contributing factors are aspects of work tasks that can lead to fatigue, MSD symptoms and injuries, or other types of problems. These factors may be present in one or more of the tasks employees must perform to accomplish their jobs. The contributing factors you and your employees should be aware of include:

- **Awkward and static postures** - assuming positions that place stress on the body, such as prolonged or repetitive reaching above shoulder height, kneeling, squatting, leaning over a counter, using a knife with wrists bent, or twisting the torso while lifting.

- **Repetitive motions** - performing the same motion or series of motions continually or frequently for an extended period of time;

- **Forceful exertions** - the amount of physical effort required to perform a task (such as heavy lifting, pushing or pulling), handle merchandise, or maintain control of equipment or tools.

- **Pressure points and Contact stress** - pressing the body or part of the body (such as the hand) against hard or sharp edges or using the hand as a hammer.

- **Vibration** - segmental affecting the hands and arms, and whole-body vibration from standing or sitting in vibrating environments.

4. The group of conditions that involve the nerves, tendons, muscles, and supporting structures such as intervertebral discs is called _____.

   a. Musculoperitoneal Diseases (MPDs)
   b. Repetitive Motion Injuries (RMs)
   c. Musculoskeletal Disorders (MSDs)
   d. Forceful Exertion Syndrome (FES)

Symptoms of Workplace Musculoskeletal Disorders (WMSDs)

MSDs in the workplace can cause severe and debilitating symptoms that not only result in illness, but injury. Symptoms of MSDs in the workplace include:

- Pain, numbness, and tingling; reduced worker productivity;
• Lost time from work;

• Temporary or permanent disability;

• Inability to perform job tasks; and/or

• An increase in workers compensation costs.

5. Work-Related musculoskeletal disorders are nothing more than musculoskeletal disorders that are ________.
   a. caused or affected by the local environment
   b. dependent or modified by the work environment
   c. changed or improved by the work environment
   d. caused or made worse by the work environment

The Impact of MSDs on Work

Musculoskeletal disorders are among the most prevalent medical problems in the U.S. They accounted for more than 31% of all injury and illness cases in 2015.

Often MSDs can be prevented by simple and inexpensive changes in the workplace:

• adjusting the height of working surfaces, varying tasks for workers, and encouraging short rest breaks can reduce risks

• reducing the size of items workers must lift or providing lifting equipment also may aid workers

• specially designed equipment, such as curved knives for poultry processors, may help

Medical costs and workers' compensation claims for serious MSDs may total $15,000 to $85,000 or more. It makes sense to give serious consideration to the risk factors in your workplace and the information in this course will help you do that.
<table>
<thead>
<tr>
<th>6. According to the Bureau of Labor Statistics (BLS), Musculoskeletal Disorders (MSDs) account for ____ of all injury and illness cases.</th>
</tr>
</thead>
</table>
| a. the majority  
| b. over 7 out of 10  
| c. about 40 percent  
| d. only a small percentage |
Module 2: Risk Factors Inherent in the Worker

Introduction

It's important to understand that each worker's ability to respond to external demands of a task is different and unique. Workers are all individuals and they should not be lumped together into groups when considering ergonomic design. Stereotyping or making generalities about an employee's ability should not be based solely on any one of the factors such as age, gender, or strength. At the heart of ergonomic design is the idea that equipment should be designed so that it's able to meet the unique needs of each employee, not the general employee population.

1. At the heart of ergonomic design is the idea that equipment should be designed so that ______.
   a. it complies with OSHA ergonomic regulations
   b. it's able to meet the needs of all employees
   c. it's able to meet the unique needs of each employee
   d. it's able to meet the environmental requirements

The Musculoskeletal System

The musculoskeletal system is made up of the soft tissue and bones in the body. Below are the basic parts of the musculoskeletal system.

- **Bones**: the load-bearing structure of the body.
- **Muscles**: tissues that contract to create movement.
- **Tendons**: tissue that connects muscles to bones.
- **Ligaments**: tissue that connects bones to bones.
- **Cartilage**: tissue that provides cushioning and reduces friction between bones.
- **Nerves**: the communication system that links muscles, tendons, and other tissue with the brain.
- **Blood vessels**: tubes that circulate nutrients throughout the body.
2. _____ are tissues that connect bones to bones.
   a. Muscles
   b. Ligaments
   c. Tendons
   d. Nerves

**Factors Inherent in the Worker - Age**

The prevalence of CTDs increases as people enter their working years (ages 25 to 65). By the age of 35, most people have had their first episode of back pain. Once in their working years, the prevalence is relatively consistent. Musculoskeletal impairments are among the most prevalent and symptomatic health problems of middle and old age.

Nonetheless, age groups with the highest rates of compensable back pain and strains are the 20-24 age group for men and 30-34 age group for women. In addition to decreases in musculoskeletal function due to the development of age-related degenerative disorders, loss of tissue strength with age may increase the probability or severity of soft tissue damage from a given injury.

Another problem is that advancing age and increasing number of years on the job are usually highly correlated. Older workers have been found to have less strength than younger workers, although hand strength does not appear to decline with aging. In one study, average hand pinch and grip scores remained relatively stable in their population with a range of 29 to 59 years.

3. Most people have had their first episode of back pain by age _____.
   a. 35
   b. 45
   c. 55
   d. 65

**Factors Inherent in the Worker - Gender**

Whether the gender difference seen with some MSDs in some studies is due to physiological differences or differences in exposure is unclear. One 1991 study found no gender difference in workers compensation claims for CTS. Another study found no gender difference in reporting of neck or upper extremity MSD symptoms among newspaper employees using video display terminals (VDTs).
In contrast, other studies have reported that neck and shoulder muscular pain is more common among females than males, both in the general population and among industrial workers.

An important study noted that significant gender differences in work posture were related to stature and concluded that the lack of workplace accommodation to the range of workers' height and reach may, in part, account for the apparent gender differences. Also, the fact that more women are employed in hand-intensive jobs and industries may account for the greater number of reported work-related MSDs among women. Another study reported that men were more likely to develop deQuervain’s disease* than women; they attributed this to more frequent use of hand tools.

*DeQuervain’s Disease is an irritation and swelling of the sheath or tunnel that surrounds the thumb tendons as they pass from the wrist to the thumb.

4. What is one possible reason for a greater number of musculoskeletal disorders (MSDs) among women?
   a. Women are naturally weaker than men
   b. The lack of workplace accommodation to the most workers' height and reach
   c. Given the same job, women tend to get injured more often
   d. Most men are more arm and hand strength

Factors Inherent in the Worker - Strength and Endurance

Muscular endurance is the ability of a muscle or a muscle group to remain contracted over a period of time. There are two types of endurance: static and dynamic.

Static endurance can be determined by the length of time a limb can maintain a certain position.

Dynamic endurance can be measured by the number of times a limb can perform a movement against a certain resistance.

Muscular strength is the maximum amount of force that a muscle can exert under maximum contraction. The amount of force that can be exerted by the muscles in the arms, legs and back depends on body posture and the direction of force. For example, when standing, you can exert more force when pulling backwards than when pushing forwards.

A study evaluated the risk of back injuries and strength and found the risk to be three times greater in the weaker subjects. They found that job matching based on strength criteria appeared to be beneficial.
5. Fitness for physical activity is can be defined as a combination of all of the following factors EXCEPT _____.

   a. endurance
   b. flexibility
   c. age
   d. coordination

Factors Inherent in the Worker – Physical Fitness

The relationship of physical activity and MSDs is more complicated than just "cause and effect." Physical activity may cause injury. However, the lack of physical activity may increase susceptibility to injury. A lack of physical activity after injury may increase the risk of further injury.

Fitness for most physical activities is a combination of strength, endurance, flexibility, musculoskeletal timing, and coordination. In a study of male fire fighters, physical fitness and conditioning appeared to have significant preventive effects on back injuries. However, the most fit group had the most severe back injuries.

When physical fitness is examined as a risk factor for MSDs, results are mixed. One study reported that only 7% of absenteeism could be explained by age, sex, and physical fitness. On the other hand, another study found that physical capacity was related to musculoskeletal fitness.

Although physical fitness and activity are generally accepted as ways of reducing work-related MSDs, the present epidemiologic literature does not give such a clear indication. However, there is clear evidence that stretching exercises do have a positive effect on the reduction of MSDs.

6. Based on epidemiologic research, there is a relationship between back injury and _____.

   a. the degree to which gender plays a role
   b. the age of the worker
   c. a mismatch of physical strength to job tasks
   d. range of motion over time
Repetition and Static Work Require Energy

Strength is important, but not necessarily the key. "Heavy work" stresses the heart and lungs which may result in rapid fatigue - general or localized. The probability of injury increases as muscles weaken. Consequently, demanding repetitive or static muscular work requires energy, not necessarily strength. You may be strong, but not have sufficient energy to do the task.

- **Isometric (Static) work** occurs when the muscles remain contracted for an extended period of time with no movement, as in holding an object. Muscles do not get the chance to relax and can fatigue quickly.

- **Isotonic (Dynamic) work** involves repetitive contraction and relaxation of the muscles and is less tiring and more efficient than static work. The motion of the muscles also helps pump blood supplying oxygen and eliminating carbon dioxide.

7. Demanding repetitive or static muscular work requires _____, not necessarily _____.
   
   a. energy, strength
   b. strength, energy
   c. endurance, energy
   d. strength, endurance

Factors Inherent in the Worker – Anthropometry

**Anthropometry** is the science of studying the difference in body size and proportions by measuring various body characteristics, including weight, physical range of mobility, and body dimensions. This information is then used by designers to engineer tools, equipment, furniture and workstations for maximum efficiency for each individual worker.

Weight, height, body mass index (BMI) (a ratio of weight to height), and obesity have all been identified in studies as potential risk factors for certain MSDs, especially Carpal Tunnel Syndrome (CTS) and lumbar disc herniation.

The relationship of CTS and Body Mass Index (BMI) has been suggested to relate to increased fatty tissue within the carpal canal or to increased hydrostatic pressure throughout the carpal canal in obese persons compared with slender persons. Carpal tunnel canal size and wrist size has been suggested as a risk factor for CTS, however, some studies have linked both small and large canal areas to CTS.
Anthropometric data are conflicting, but in general indicate that there is no strong correlation between stature, body weight, body build and low back pain. Obesity seems to play a small but significant role in the occurrence of CTS.

8. Which of the following is the science of studying the difference in body size and proportions?

   a. Astronomy
   b. Androphology
   c. Anthropometry
   d. Anthrometrics
Module 3: Risk Factors Inherent in the Task

Risk Factors the Task Brings to the Job

In addition to considering the worker attributes that may increase the risk of injury, we must also analyze the risk factors the work task itself brings to the job. We look at the task variables in the workplace that may increase or decrease the risk of cumulative trauma disorders (CTDs) depending on its design and location.

In large measure, work processes are determined by the factors below.

<table>
<thead>
<tr>
<th>Tools</th>
<th>Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furniture</td>
<td>Machinery</td>
</tr>
<tr>
<td>Materials</td>
<td>Workstation layout</td>
</tr>
</tbody>
</table>

1. All of the following are ergonomic risk factors inherent in the task EXCEPT _____.
   a. fatigue
   b. tools
   c. equipment
   d. workstation layout

Design to Reduce Risk Factors

The objective in designing and locating these workplace objects should be to reduce the following tasks risk factors. A number of questions need to be asked:

Required Force

Forcefulness is the amount of physical effort required by the person to do a task and/or maintain control of tools and equipment. The effort depends on:

- Type of grip;
• Object weight;
• Object dimensions;
• Body posture;
• Type of activity;
• Slipperiness of object;
• Temperature;
• Pinching;
• Vibration;
• Duration of the task; and
• Number of repetitions.

Examples of work activities that exert force on the body include lifting, lowering, pushing, pulling, pinching, pounding, hitting, and jumping.

2. The amount of effort required when moving an object depends on each of the following EXCEPT _____.
   a. the object weight
   b. the type of grip used
   c. the time of day
   d. the object dimensions

**Lifting Posture Affects Risk of Injury**

The weight of the objects you lift is an important factor in determining your risk of injury, and you will want to be especially careful when lifting heavy items such as storage boxes full of files and cases of copy paper. However, weight is not the only thing that determines your risk of injury. The figure below shows the effect that posture can have when combined with lifting different size loads.
According to the Joyce Institute, compressive forces on L5/S1 disc exceeding 550 lbs. (250 kg.) causes four times the injuries than forces of less than 550 lbs. (The Joyce Institute, Principles and Applications of Ergonomics)

3. According to the Joyce Institute, compressive forces on L5/S1 disc exceeding 550 lbs. (250 kg.) causes ______ the number of injuries than forces of less than 550 lbs.

   a. twice
   b. three times
   c. four times
   d. ten times

**Force-Related Conditions**

Let's take a look at five force-related conditions that may increase your risk of injury:
1. **Contact Trauma**: When any part of your body presses against an external object, the resulting sustained force may cause too much mechanical stress on tissues. It is also possible for excessive mechanical stress to be produced from the impact shock of an object against a part of the body.

2. **Grip**: There's a right way and a wrong way to grip an object. This combination of force and posture, if not accomplished correctly, may result in harm to the hand. Two basic grips are used when handling tools, equipment or materials.

   - The **Pinch Grip** depends on the fingers to exert the force and manipulate the object. This grip strategy requires much greater muscle strength and, consequently, is more likely to cause an injury.

   - The **Power Grip** uses the muscles of the entire hand to apply force and manipulate objects. Consequently, it's the most effective, and safest, grip to use.

3. **Static Exertion**: Standing, sitting, or otherwise remaining in one posture for a long duration while you perform a task can increase the likelihood of injury. Static exertion combines force, posture, and duration to create a condition that quickly fatigues our muscles which increases the chances of acquiring a CTD. There will be more risk if there is greater force, awkward posture and longer durations.

### Symptoms of excessive static load

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Possible Ergonomic Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet/legs ache, varicose veins</td>
<td>Standing in one place too long</td>
</tr>
<tr>
<td>Lower back pain</td>
<td>Trunk curved forward while standing or sitting</td>
</tr>
<tr>
<td>Shoulder and arm pain</td>
<td>Arms outstretched, sideways, forward or upwards; Shoulders forced up due to position of work</td>
</tr>
<tr>
<td>Neck pain</td>
<td>Head inclined too much backwards or forward</td>
</tr>
<tr>
<td>Forearm pain</td>
<td>Unnatural grip, static grip too forceful</td>
</tr>
<tr>
<td>Wrist pain</td>
<td>Repetitive hand or finger motion</td>
</tr>
</tbody>
</table>
4. **Gloves**: Have you ever worn thick leather gloves while trying to accomplish some kind of intricate manipulation of small objects? Try it, you will be frustrated. Whenever you wear gloves, more grip force is required to do a particular task. With the need for more force, increased risk of injury occurs.

5. **Bulky clothes**: Wearing bulky clothes, like heavy rain gear or protective clothing for removing hazardous waste, will increase the effort required by muscles to do work. Any time you increase the force necessary to complete a task, risk of injury also increases.

<table>
<thead>
<tr>
<th>4. Which grip strategy used to manipulate objects requires much greater muscle strength, and therefore is more likely going to cause an injury?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Power grip</td>
</tr>
<tr>
<td>b. Sustained grip</td>
</tr>
<tr>
<td>c. Pinch grip</td>
</tr>
<tr>
<td>d. Intermittent grip</td>
</tr>
</tbody>
</table>

**Vibration**

**Segmental Vibration**

When handling vibrating tools for a prolonged duration, vascular insufficiency in the hand and fingers can also result in interference with sensory receptor feedback. If a worker can't "feel" the grip properly, he or she may compensate by applying more force than is necessary to hold and handle an object. Segmental vibration has also been linked to carpal tunnel syndrome.

**Whole Body Vibration**

When the whole body is subjected to vibration, as most commonly experienced by truck drivers, there is an enhanced risk of injury, especially to the lower back.

Whole-Body Vibration usually results from two types of forces acting on the worker.

- A non-cyclical force over a very short period of time (instantaneous shock load). A vehicle striking an obstacle or a sudden drop into a hole may produce these shock loads. If these shock loads are sufficiently great, the operator may be thrown from his seat or struck by objects flying around in the cab.
• The most common whole-body vibration forces are not sudden, but rather occur over a period of time. For example, this type of vibration is usually created by large vehicles as they travel over highways and especially terrain.

Duration of Vibration Exposure

Duration of exposure plays a large role in the effects of vibration forces. Vibration forces delivered over time are more difficult to define than the instantaneous damage caused by high shock loads. The body will respond significantly to vibrations in the range of .5 to 80 Hz (Hertz, cycles/second). Certain parts of the body are resonant at various frequencies in this range. The body's response to vertical vibration will be greatest between 4 and 8 Hz, while vibrations between 2.5 and 5 Hz generate strong resonance in the vertebra of the neck and lumbar region. Vibrations between 20 and 30 Hz set up the strongest resonance between the head and shoulders. Prolonged exposure to these vibration forces in these frequency ranges may create chronic stresses and sometimes even permanent damage to the affected organs or body parts.

5. The most common whole-body vibration forces occur _____.
   a. over an extended period of time
   b. suddenly
   c. over a short period of time
   d. from instantaneous shock loads

Repetition

Repetition is a measure of how frequently we complete the same motion or exertion during a task. The severity of risk depends on the frequency of repetition, speed of the movement or action, the number of muscles groups involved, and the required force. Repetitiveness is influenced by machine or line pacing, incentive programs, piece work, and unrealistic deadlines. For instance, an experienced worker packing apples (piece work) may complete many more similar exertions or movements than a new worker. Unfortunately, he or she may be performing at such a rapid rate that they may be developing a CTD. Repetition alone is not an accurate predictor of injury. Other factors like force, posture, duration, and recovery time must also be considered.

High Risk Repetition Rates by Different Body Parts

From Kilbom [1994]: Repetitive work of the upper extremity; Part II: The scientific basis for the guide. Int J Ind Erg 14:59–86.
<table>
<thead>
<tr>
<th>Body Part</th>
<th>Repetitions Per Minute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoulder</td>
<td>More than 2½</td>
</tr>
<tr>
<td>Upper Arm/Elbow</td>
<td>More than 10</td>
</tr>
<tr>
<td>Forearm/Wrist</td>
<td>More than 10</td>
</tr>
<tr>
<td>Finger</td>
<td>More than 200</td>
</tr>
</tbody>
</table>

**Caution:** Do not judge the risk of MSDs solely on the basis of repetition. Much depends on force and the postural factors that reflect the intensity of each action. In making risk determinations, NIOSH typically supplements repetition measurements with ratings of the forces being exerted and postural deviations of the body parts that may be involved. High repetitiveness, when combined with high external forces and extreme postures, probably represents the highest risk of MSDs.

6. Which of the terms below is defined as a measure of how frequently we complete the same motion or exertion during a task?

a. Frequency  
b. Repetition  
c. Vibration  
d. Dynamic exertion

**Duration**

Duration is a measure of length of time of exposure to a risk factor. Of course, the assumption is that the longer the duration of exposure, the greater the risk of injury. Duration may be measured in seconds, minutes, hours, days, weeks, months, and even years.

As with most individual risk factors, duration must be considered along with other person, task, and environmental risk factors such as the physical conditioning of the worker, posture, force, weight, temperature, stress, etc.
Recovery Time

Recovery time is a measure of the rest (or low stress activity) period available to the muscle group between similar exertions. Recovery time is important in preventing muscle fatigue because oxygen and metabolites are allowed to rejuvenate while uric acid and other waste products are removed from the muscle group. The required recovery time will lengthen as the duration of the task increases.

7. Recovery time needed will _______ as the duration of the task increases.
   a. lengthen
   b. shorten
   c. not change
   d. change randomly

Posture

Posture is the position of the body while performing work activities. Awkward posture is a deviation from the ideal working posture of arms at the side of the torso, elbows bent, with the wrists straight. Awkward postures typically include reaching behind, twisting, working overhead, kneeling, forward or backward bending, and squatting. If the posture is awkward during work, there is an increased risk for injury. The more the joint departs from the neutral position, the greater the likelihood of injury.

Listed below are some specific postures that may be associated with increased risk of injury.

- **Wrist flexion or extension** that occurs regularly is associated with a greater risk of carpal tunnel syndrome.

- **Ulnar deviation of the wrist** of greater than 20 degrees increases the risk of pain and other disease.

- **Shoulder abduction or flexion** of greater than 60 degrees for more than one hour a day increases the risk of acute neck and shoulder pain.

- **Hands working at or above shoulder level** can result in increased risk of tendinitis and various shoulder diseases.

- **Flexion of the neck** - the greater the angle of flexion of the neck, the more quickly potentially severe neck and shoulder pain results.
• **Bending at the lower back** while working increases the likelihood of low back disorders.

**Rules to follow for sitting workstations:**

- The angle between the upper arm and the forearm should be 70 to 135 degrees.
- The angle between the upper and lower leg should be 60 to 100 degrees.
- The angle between the torso and the thigh should be greater than 90 degrees.
- The feet should be placed flat on the floor.

**Rules to follow for standing workstations:**

- The work surface should be 2 - 4 inches below elbow height for precision work.
- The work surface should be 4 - 6 inches below elbow height if lifting light weights and working with bins, tools, and other materials.
- The work surface should be 6 - 16 inches below elbow height if lifting heavy weights.

8. The more the joint departs from the _____, the greater the likelihood of injury due to poor posture.
   
   a. original position  
   b. starting position  
   c. neutral position  
   d. initial position

**Twisting and Force**

Imagine placing a tomato between the palms of your hands and applying direct pressure. It might take a great deal of force to burst the tomato. However, give the motion a twist while applying the pressure and it will take far less pressure to burst the tomato. (If you perform this exercise in class, you better wear an apron!)

Twisting while lifting, pushing, pulling, lowering, or raising may have the same effect on the back. Consequently, twisting while taking any of these actions exposes the back to a much greater risk of injury.
Personal Real-World Example

As the founder of OSHAcademy, you would think I would learn from my own training, but not so. I injured my back over the winter of 2016 while shoveling snow from my driveway. The high-force action of shoveling, lifting and twisting as I threw the snow off to the side eventually ended in severe injury to my lower back, sciatica, and four months of rehabilitation. I learned my lesson after the fact and bought a snow blower!

Steve Geigle (OSHAcademy founder)

9. Which of the following movements will most likely expose the lower back to a greater risk of injury?
   a. Pushing objects
   b. Twisting while lifting objects
   c. Pulling objects
   d. Lowering objects

Velocity/Acceleration

Angular velocity is nothing more than the speed at which the body part moves. Acceleration is the rate of change of the speed at which the body part moves. For example, a drummer's hand/wrist may move very rapidly back and forth while drumming. The faster the back and forth motion occurs, the greater the risk of injury. Other factors like the weight of the object being moved will also increase risk.

Heavy Dynamic Exertion

Work requiring heavy physical exertion places a greater demand on the body's cardiovascular system to provide the necessary oxygen and metabolites to muscle tissue. If a muscle group's demand for metabolites and oxygen cannot be met, that muscle group will become fatigued, increasing the risk of injury. When the muscle is tired and sore, it's fatigued, and injury may more likely occur. If the entire body becomes fatigued, an actual cardiovascular failure may occur.
10. Steve's hand/wrist moves very rapidly back and forth while drumming for a musical group. He may eventually suffer an ergonomic injury due to which of the following risk factors?

a. Impact forces
b. Dynamic exertion
c. Angular velocity
d. Segmental vibration
Module 4: Risk Factors Inherent in the Environment

Heat Stress

Externally generated heat in the workplace can cause an excessive total heat load on the body, which can result in heat stroke, a potentially life-threatening condition. Heat exhaustion, heat cramps, dehydration, electrolyte imbalance, and loss of physical/mental work capacity can also result from heat stress. Heat stress is made even more dangerous in the presence of high humidity due to the reduced ability of the body to cool itself.

High temperature conditions at work may be brought on by:

- Summer heat;
- Tropical heat;
- Heat from engines;
- Heat from chemical processes and reactions;
- Body heat;
- Welding; and/or
- Friction.

1. Heat stress is made even more dangerous in the presence of _____.
   a. high illumination
   b. low humidity
   c. moderate wind
   d. high humidity

Cold Stress

If the worker is exposed to an environment so cold that the body cannot maintain adequate deep core temperature, hypothermia, which can also be life-threatening, may result. Symptoms brought on by cold stress include:
• Shivering;
• Clouded consciousness;
• Pain in the extremities;
• Dilated pupils;
• Reduced grip strength and coordination; and/or
• Possibly ventricular fibrillation.

Low temperature conditions may be caused by:
• Winter cold;
• High altitudes;
• Refrigerated surfaces; or
• Cryogenic lines and equipment.

These can result in muscle strain as well as cold "burns," frostbite, and hypothermia.

2. Connie is exhibiting shivering, dilated pupils, clouded consciousness and reduced coordination. Which of the following conditions is indicated by these symptoms?
   a. Hyperthermia
   b. Dermatitis
   c. Heat stress
   d. Hypothermia

Lighting

Lighting in one workstation may be appropriate, but for another workstation, that same lighting may be potentially harmful. Illumination may be too high, too low, or cause glare. Lighting required for general lighting in general construction areas, warehouses and workplace hallways and corridors is five foot-candles (54 lux). Physical plants, shops, machining areas, equipment and work rooms is 10-foot candles (108 lux), and office areas require at least 30 foot-candles (323 lux) of illumination.
Outside lighting is an important factor to consider. Light for outside work should aid production and, at the same time, be high enough to be safe.

Adequate general and local lighting must be provided for rooms, building, and work areas during the time of use. Below is a list of factors influencing the adequacy and effectiveness of illumination:

- The quality of light in terms of freedom from glare, correct direction, diffusion, and distribution.
- Freedom from shadows and extreme contrasts.
- All skylights, side windows, lamps, and other accessories which are necessary for illumination must be kept clean and in working order.

It's interesting to note that lighting has been used to treat depression associated with light deprivation and may also affect biological clocks and sleep patterns in humans. Although controversial, light has been used to maintain alertness and to increase productivity in shift workers.

3. To prevent excessive glare and eyestrain from an outside window, place the computer monitor ______.
   a. facing the window
   b. directly in front of the window
   c. at a right angle to the window
   d. facing 180 degrees from the window

Noise

Noise is any sound that is unwanted. It can be so powerful as to cause pain in the ears, or it may represent only a nuisance. Its pitch may be quite high or very low; its duration, continuous or intermittent; and its onset, sudden or gradual.

Excessive exposure to noise may lead to hearing disorders including:

- **Deafness**: A deaf person has little to no hearing. Temporary or permanent hearing loss may occur in one or both ears.
• **Tinnitus**: Tinnitus is the hearing of sound when no external sound is present

• **Paracusis**: Paracusis is a form of impaired hearing that results in auditory illusions or hallucinations.

The louder the noise and the longer the duration, the greater the risk of injury. Nuisance noise may interfere with a worker's ability to focus or concentrate on the work at hand, and may therefore, actually be the indirect cause of an accident.

Oregon OSHA conducted measurements and found sound levels produced by computer workstations and associated equipment to be consistently below those that damage hearing. However, equipment noise can still be disruptive, annoying, or distracting, and many people are sensitive to the low-level, high-frequency noise that the Central Processing Unit (CPU) may emit. As a result, ambient sound levels should be kept below 55 decibels on the A-scale (dBA). Also, narrow-band tones above ambient sound levels should be reduced. It is good practice to isolate main CPUs and disk drives and provide noise-control covers on high-speed printers.

4. Abbie works in a job where she is continually exposed to a high level of noise. As a result, which of the following disorders is she most likely to acquire?

   a. Percussion Trauma Syndrome (PTS)
   b. Tinnitus
   c. Vibration Syndrome
   d. Pertussis

**Psychosocial Risk Factors**

A healthy ergonomic work environment depends a great deal on the attitudes of those involved. How management handles or responds to problems or concerns relating to ergonomics may determine the development and the severity of many problems in the workplace. To create a healthy work environment:

• All parties should understand their roles in the overall work process

• End users should participate in the selection of equipment, software, tools and accessories; and
• Employers should provide adequate operator training on the setup, adjustments, and risks associated with performing the job

Psychosocial Factors and MSDs

Various studies suggest perceptions of increased workload, monotonous work, limited job control, low job clarity, and low social support are associated with various work-related musculoskeletal disorders (MSDs). The effects of these factors on MSDs may be, in part or entirely, independent of physical factors.

5. To create a healthy work environment that reduces the risk of ergonomic injuries, management should _____.

   a. let end users select equipment and tools
   b. discourage employee participation
   c. look at employee suggestions annually
   d. purchase chairs based on price
Module 5: Controlling Risk Factors

Eliminating Risk Factors

Ergonomic improvements are changes made to improve the "fit" between a job and the capabilities of the employees performing it. Analyzing jobs to identify factors associated with risks for MSDs lays the groundwork for developing ways to reduce or eliminate ergonomic risk factors for MSDs.

Ergonomic Hazard Control Strategies

To control ergonomic hazards, a hierarchy of controls has been used as a means of determining how to implement feasible and effective controls. ANSI/ASSP Z10-2012, Occupational Health and Safety Management Systems, encourages employers to use the following hierarchy of hazard controls:

1. Elimination
2. Substitution
3. Engineering controls
4. Warnings
5. Administrative controls
6. Personal protective equipment

The idea behind this hierarchy is that the control methods at the top of the list are potentially more effective and protective than those at the bottom for controlling ergonomic hazards. Following the hierarchy normally leads to the implementation of inherently safer systems: ones where the risk of illness or injury has been substantially reduced. Let's take a closer look at the hierarchy of control strategies.

Elimination and Substitution

Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement.

For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard. For example:
• **Elimination** - If you have to work in a space that requires poor work postures, you might eliminate the need to perform the work within that space.

• **Substitution** - If you have to lift a heavy object, you might substitute the heavy object with an object of less weight.

1. Placing products in small boxes instead of larger, heavier boxes, for shipment is an example of which hazard control strategy?
   
   a. Elimination
   
   b. Substitution
   
   c. Engineering
   
   d. Administration

**Engineering Controls**

Engineering controls involve making changes to workstations, tools, or equipment used on the job. These controls are preferred over all others because they make permanent changes that can totally eliminate hazards at the source. Although they may be more expensive to implement than other controls, their effect is often more significant.

Let's take a look at some of the various engineering control strategies that may be effectively used to eliminate hazards.

**Workstation Design**

Aspects of workstations you can change with engineering controls include:

- Workspace layout;

- Work surfaces;

- Standing and walking surfaces;

- Seating;

- Storage;

- Work fixtures; and
• Work environment.

2. Which of the following control strategies includes making changes to workstations, tools, or equipment used on the job to prevent ergonomic injuries?

   a. Engineering controls
   b. Administrative controls
   c. Personal protective equipment
   d. Elimination

**Computer Workstations**

Computer workstations have special considerations you should be aware of. The monitor and keyboard positions, lighting, and seating are especially important in preventing work-related MSDs and eye discomfort. Shared workstations should be easily adjustable so the screen and keyboard can be at the proper level. Take a look at some specific [workstation design considerations](#) and [problems/solutions](#) for computer workstations.

There are five components of proper computer workstation design that you must address to maintain proper posture: the work surface; the keyboard; the pointing device or trackball; the monitor; and the chair.

1. **Work Surfaces**

   o Surface needs to be deep enough to allow proper keyboard positioning and to accommodate a monitor viewing distance of 18-24”.
   
   o Surface needs to be wide enough to accommodate keyboard, mouse, and reference material.
   
   o Surface height (or keyboard height independent of the main surface) should be adjusted for the user or adjustable for multiple users.
   
   o Avoid resting your wrists on a hard or sharp surface (use a wrist rest if necessary).
   
   o Leave enough leg room to allow your legs to move freely.
2. **Keyboards**

Keyboards should be thin and detachable. Must be positioned low enough to keep wrists straight, shoulders relaxed, and elbows angled between 90 and 120 degrees. (A wrist rest can help you maintain straight wrists.) Alternative keyboards now on the market provide additional options which may alleviate discomfort.

3. **Mouse or Trackball**

   - Should be within easy reach and at the same height as the keyboard.
   - Trackballs may be a better alternative because they eliminate some arm movement required by the mouse.

4. **Monitors**

   - Should be positioned so that the top of the screen is slightly below eye level, for a viewing angle of about 30 degrees.
   - The viewing distance should be 18-24”.

5. **Chairs**

   - Should have adjustable back support that presses firmly against your lower back and extends at least up to mid-back.
   - Should have an easily adjustable seat height to permit your feet to rest flat on the ground with a knee angle of roughly 90 degrees. (some people might need a foot rest to achieve this angle.)
   - Should have a rolling, five-pronged base for stability and to prevent unnecessary twisting.
   - Should have adjustable padded arm rests to support the weight of the shoulders and the arm.
   - Should have an adjustable seat pan to allow the computer user to work comfortably in a forward or reclined position.
3. Computer monitors should be positioned so that the top of the screen is _____.
   a. slightly above eye level
   b. slightly below eye level
   c. at eye level
   d. angled slightly down

**Workspace Layout**

Workspace layout and arrangement should be carefully designed so that it meets the requirements listed below:

- The workspace should be adjustable to fit each worker's size.
- The worker should be able to maintain the neutral position and avoid awkward or extended reaches and jerky movements while performing the task.
- A full range of motion with adequate leg room, as well as a variety of working positions to avoid static postures should be provided.
- The worker should have adequate space for access to all necessary tools and equipment, and frequently used tools should be within easy reach.

**Work Surfaces**

- Work surfaces should be at the proper height and angle for the individual worker's size, tools, and equipment used.
- They should permit neutral postures and be adjustable; especially where different kinds of tasks are performed or the workstation is shared.

For example, where workers inspect or assemble small parts, or perform other visually intensive task, work surfaces could be tilted to reduce neck, shoulder and arm strain.

**Walking and Standing Surfaces**

Surfaces on which people stand for long periods should be designed to prevent slipping and provide adequate traction and comfort. Anti-fatigue floor mats, sit-stand stools, and footrests can help make workers more comfortable.
Seating

Seat-height adjustability and lower back support are important for work done for a long time while seated. Some workers may choose to sit part of the time and stand other times to reduce stress on the body from working in one position too long. Chairs or seating should:

- Adequately support the back and legs.
- Have padded seats.
- Have separately adjustable back and seat cushions.
- Permit feet to be supported either on the floor or with a foot rest.
- Be easily adjustable while seated.
- Be able to swivel for most tasks.
- Isolate the worker from whole-body vibration.
- Have adjustable arm support when appropriate.

4. In terms of ergonomics, chairs or seating should _____.
   a. have hard, solid seats
   b. limit swiveling to prevent back injury
   c. adequately support the back and legs
   d. prevent the feet from touching the ground

Storage

Storage areas should be organized so workers maintain good body positions, reduce muscular forces, and avoid excessive reach. Make sure heavy items are stored between knee and shoulder height. Store frequently used items close to the worker.
**Work Fixtures and Tools**

Workers should not have to use their hands or bodies as a vise to hold objects; mechanical devices do this much better. Tooling fixtures and jigs should be set up to avoid awkward postures and excessive forces.

Improper hand tool selection or improper use of tools can cause CTDs. Hand tools should fit the employee's hand; employees with small hands or who are left-handed may need tools that are designed specifically for these situations. Hand and wrist posture are important because they affect how much force the muscles must produce to hold objects. When selecting and purchasing hand tools, the guidelines listed below should be followed.

- Select tools that allow the wrist to be held straight and that minimize twisting of the arm and wrist. Good working posture can be maintained when properly designed tools are used.

- Select tools that allow the operator to use a power grip, not a pinch grip. Minimal muscle force is required to hold objects in a power grip posture. The pinch grip requires excessive fingertip pressure and can lead to a CTD.

- Avoid tools that put excessive pressure on any one spot of the hand (i.e., sides of fingers, palm of the hand).

- For power or pneumatic tools, select tools with vibration dampening built in whenever possible. Provide personal protective equipment such as gel-padded gloves to reduce exposure to vibration.

**Work Environment**

Workplace environmental factors interact with those the worker and the task bring to the job, and they deserve careful consideration. Below is a list of methods to minimize work-environment hazards.

- Isolating equipment or operations that produce loud or distracting noise.

- Making **lights** bright enough without causing glare.

- Isolating hands and feet from cold.

- Reducing whole-body vibration while riding in vehicles or standing near equipment.
• Isolating workers from excessive **heat** by providing adequate cooling and ventilation.

<table>
<thead>
<tr>
<th>5. Tools should be selected that allows the operator to _____.</th>
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<tbody>
<tr>
<td>a. use a strong pinch grip</td>
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<tr>
<td>b. hold the tool with the wrist bent</td>
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<tr>
<td>c. allow maximum wrist twisting</td>
</tr>
<tr>
<td>d. use a power grip</td>
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**Administrative Controls**

Administrative controls are management-dictated procedural and scheduling changes designed to reduce or prevent exposures to ergonomic risk factors. Although engineering controls are preferred, administrative controls may be needed as well, especially when engineering controls cannot totally eliminate a hazard or when engineering controls are not technically feasible. Since administrative controls do not eliminate hazards, managers must continually ensure safe procedures and policies are followed to make sure exposure to hazards is minimized.

**Common Examples of Administrative Control Strategies**

- **Safe procedures** should maintain workers in neutral postures and reduce frequency, duration, and severity of exposure to risk factors. Lifting, carrying, pushing, or pulling objects can strain the back, arms, and shoulders. Strength and lifting limits should not be exceeded; extreme muscular exertion can cause injury. **Effective lifting techniques** should always be used.

- **Broadening or varying the job content** to offset certain risk factors (e.g., repetitive motions, static and awkward postures).

- **Adjusting the work pace** to relieve repetitive motion risks and give the worker more control of the work process.

- **Training in the recognition of risk factors** for MSDs and instruction in work practices that can ease the task demands or burden.

- **Requiring the use of Personal Protective Equipment** (PPE) while performing tasks.

- **Reducing shift length** or curtailing the amount of overtime.
• **Rotating workers** through several jobs with different physical demands to reduce the stress on limbs and body regions.

• **Scheduling more breaks** to allow for rest and recovery.

### Work Rates

The capacity of workers should be considered in establishing production goals. Increased work rates, excessive overtime, and incentive programs for piece work can cause fatigue, increasing the chance for injury.

### Job Enrichment

Tasks involving repetitive motion are major contributors to CTDs. You can minimize repetition by:

- Using automation, such as in stapling, sorting, labeling, or filling operations; and/or

- Changing the job to include tasks that don’t use the same muscle groups.

For example, in a check-sorting operation, instead of having one person open mail, another stamp them and yet another record the figures, each worker could do each of those tasks.

#### 6. Which of the ergonomic control strategies attempts to reduce exposure to hazards through procedures and practices?

- a. Technical controls
- b. Engineering controls
- c. Administrative controls
- d. Interim measures

### Personal Protective Equipment

One of the most controversial questions in the prevention of MSDs is whether the use of personal equipment worn or used by the employee (such as wrist supports, back belts, or vibration attenuation gloves) is effective. Some consider these devices to be ergonomic personal protective equipment (PPE).

Although these devices may, in some situations, reduce the duration, frequency, or intensity of exposure, evidence of their effectiveness in injury reduction is inconclusive. In some instances, they may decrease one exposure but increase another because the worker has to "fight" the device to
perform his or her work. An example is the use of **wrist splints** while engaged in work that requires wrist bending.

NIOSH has concluded that insufficient evidence existed to prove the effectiveness of **back belts** in preventing back injuries related to manually handling job tasks. A recent study credits mandatory use of back belts in a chain of large retail hardware stores for substantially reducing the rate of low back injuries. Although NIOSH believes this study provides evidence that back belts may be effective in some settings for preventing back injuries, NIOSH still believes that evidence for the effectiveness of back belts is inconclusive. Continual long-term use of back belts may weaken back muscles and cause injury when the back belts are not being used.

Less controversial types of personal equipment are **vibration attenuation gloves** and **knee pads** for carpet layers. But even here, there can be concerns. For example, do the design and fit of the gloves make it harder to grip tools?

**Interim Measures**

Interim measures are nothing more than temporary applications of engineering and/or management controls until more permanent solutions can be applied. For instance, if a computer monitor is too low, placing a phone book under the monitor might be an effective temporary solution. Having two people lift heavy objects until a pneumatic lift can be purchased is another example of a temporary fix to the problem.

7. Which of the ergonomic control strategies is considered temporary?
   a. Technical controls
   b. Engineering controls
   c. Management controls
   d. Interim measures

**Safety System Improvements**

An effective ergonomics program operates within a larger safety management system that is composed of many interrelated programs. Each program or "subsystem" includes specific processes that may not interrelate directly to ergonomics. When hazardous conditions and unsafe behaviors exist, it's usually because the safety management system is failing somehow. These failures represent the root causes for accidents and may be categorized as shown below.
- **System Design Failures**: Inadequate design of the safety management system. An example is the failure to write effective safety program plans, policies, processes, procedures and practices to make sure appropriate conditions, activities, behaviors, and practices occur.

- **System Performance Failures**: Failure to carry out the plan as designed. The ability to effectively implement the safety management system is critical to the success of the system. You can develop a wonderfully designed system, yet if it’s not implemented correctly, it won’t work.

A missing or inadequate component in any one of these subsystem processes might have a negative impact on ergonomics. Listed below are examples of safety programs and processes that can be improved:

- Incident/Accident investigation
- Safety communications
- Evaluation and improvement
- Safety training
- Safety accountability
- Hazard identification and control
- Employee involvement

### 8. When hazardous conditions and unsafe behaviors exist, it's usually because _____.

a. employees lack common sense at work  
b. employees have poor attitudes  
c. the safety management system has failed  
d. managers don't care about employees