



Introduction to Ergonomics

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.

OSHAcademy Course 711 Study Guide

Introduction to Ergonomics

Copyright © 2017 Geigle Safety Group, Inc.

No portion of this text may be reprinted for other than personal use. Any commercial use of this document is strictly forbidden.

Contact OSHAcademy to arrange for use as a training document.

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:

OSHAcademy

15220 NW Greenbrier Parkway, Suite 230

Beaverton, Oregon 97006

www.oshatrain.org

instructor@oshatrain.org

+1.888.668.9079

Disclaimer

This document does not constitute legal advice. Consult with your own company counsel for advice on compliance with all applicable state and federal regulations. Neither Geigle Safety Group, Inc., nor any of its employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. GEIGLE SAFETY GROUP, INC., DISCLAIMS ALL OTHER WARRANTIES EXPRESS OR IMPLIED INCLUDING, WITHOUT LIMITATION, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Taking actions suggested in this document does not guarantee that an employer, employee, operator or contractor will be in compliance with applicable regulations. Ultimately every company is responsible for determining the applicability of the information in this document to its own operations. Each employer's safety management system will be different. Mapping safety and environmental management policies, procedures, or operations using this document does not guarantee compliance regulatory requirements.

Revised: January 8, 2018

Contents

Course Introduction	1
What is ergonomics?.....	1
The Problem.....	1
An Important Strategy to Solve the Problem	1
Module 1: Defining Ergonomics.....	3
Introduction	3
Ergonomics & Risk Factors	3
Who is at risk?.....	3
Musculoskeletal Disorders (MSDs)	4
Factors Contributing to MSDs.....	5
Symptoms of Workplace Musculoskeletal Disorders (WMSDs).....	5
The Impact of MSDs on Work	6
Module 1 Quiz.....	7
Module 2: Risk Factors Inherent in the Worker	9
Introduction	9
The Musculoskeletal System.....	9
Factors Inherent in the Worker - Age	9
Factors Inherent in the Worker - Gender	10
Factors Inherent in the Worker - Strength and Endurance	10
Factors Inherent in the Worker – Physical Fitness	11
Factors Inherent in the Worker – Anthropometry	12

Module 2 Quiz.....	13
Module 3: Risk Factors Inherent in the Task	15
Risk Factors the Task Brings to the Job	15
Design to Reduce Risk Factors	15
Required Force.....	15
Force-Related Conditions.....	17
Vibration	18
Segmental Vibration	18
Whole Body Vibration.....	18
Duration of Vibration Exposure	19
Repetition.....	19
High Risk Repetition Rates by Different Body Parts	19
Duration	20
Recovery Time.....	20
Posture.....	21
Twisting and Force	22
Velocity/Acceleration.....	22
Heavy Dynamic Exertion	22
Module 3 Quiz.....	23
Module 4: Risk Factors Inherent in the Environment.....	25
What are risk factors the environment brings to the job?	25
Heat Stress	25
Cold Stress.....	25

Lighting.....	26
Noise	27
Psychosocial Risk Factors	27
Psychosocial Factors and MSDs	28
Last Words	28
Module 4 Quiz.....	29
Module 5: Controlling Risk Factors	31
Eliminating Risk Factors	31
Ergonomic Hazard Control Strategies	31
Elimination and Substitution	31
Engineering Controls.....	32
Workstation Design.....	32
Computer Workstations.....	32
Workspace Layout.....	34
Work Surfaces	35
Walking and Standing Surfaces.....	35
Seating.....	35
Storage	36
Work Fixtures and Tools	36
Work Environment.....	37
Administrative Controls	37
Common Examples of Administrative Control Strategies	37
Work Rates.....	38

Job Enrichment	38
Personal Protective Equipment	39
Interim Measures.....	39
Safety System Improvements	39
Module 5 Quiz.....	41

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.

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
-) risk factors inherent in the task
-) risk factors inherent in the environment

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.

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

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.

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.

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.

Module 1 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

- 1. Ergonomics is the science of fitting the job to _____.**
 - a. an average class of workers
 - b. the individual worker
 - c. job classification within an industry
 - d. the gender of the worker

- 2. Musculoskeletal disorders can result when there is a mismatch between the physical _____ of the job and the physical _____ of the worker.**
 - a. demands, requirements
 - b. requirements, capacity
 - c. requirements, requirements
 - d. demands, demands

- 3. The risk for developing MSDs increases when workers _____.**
 - a. work in an awkward position
 - b. use adequate force from time to time
 - c. occasionally lift heavy objects
 - d. repeat the same motion often throughout the day

- 4. Which of the following is not one of the three areas within which ergonomics risk factors exist?**
 - a. The worker
 - b. The procedure
 - c. The task
 - d. The environment

5. MSDs can be prevented by simple and inexpensive changes in the workplace such as ____.

- a. standardizing tasks workers perform
- b. ensuring food processors use straight knives
- c. adjusting the height of work surfaces
- d. increasing the size of items workers lift

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.

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.



The following personal risk factors may be generalized across populations. It's important to understand that when designing a workstation or procedure it should be designed for the specific individual working at that workstation. Below are criteria that should be considered.

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. Other studies have reported a lack of increased risk associated with aging.

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.*

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.

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.

Repetition and static work requires 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 help pump blood supplying oxygen and eliminating carbon dioxide.

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.

So there you have it. Not everything you need to know, but it's a start. The only task left is the module quiz, so let's get to it.

Module 2 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

- 1. Each worker's ability to respond to external demands of a task is _____.**
 - a. the same within groups
 - b. predictable
 - c. different and unique
 - d. impossible to determine

- 2. The musculoskeletal system is made up of all of the following parts, except _____.**
 - a. muscles
 - b. lymph glands
 - c. tendons
 - d. nerves

- 3. What are the two types of muscular endurance?**
 - a. Short-term and long term
 - b. Static and dynamic
 - c. Acute and chronic
 - d. Fast and slow twitch

- 4. Which type of "work" is less tiring and more efficient?**
 - a. Continual
 - b. Isometric
 - c. Random
 - d. Isotonic

5. The study of the difference between body size and proportions by measuring various body characteristics is called _____.

- a. Anthropometry
- b. Ergonomics
- c. Epidemiology
- d. Toxicology

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.

Tools	Equipment
Furniture	Machinery
Materials	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:

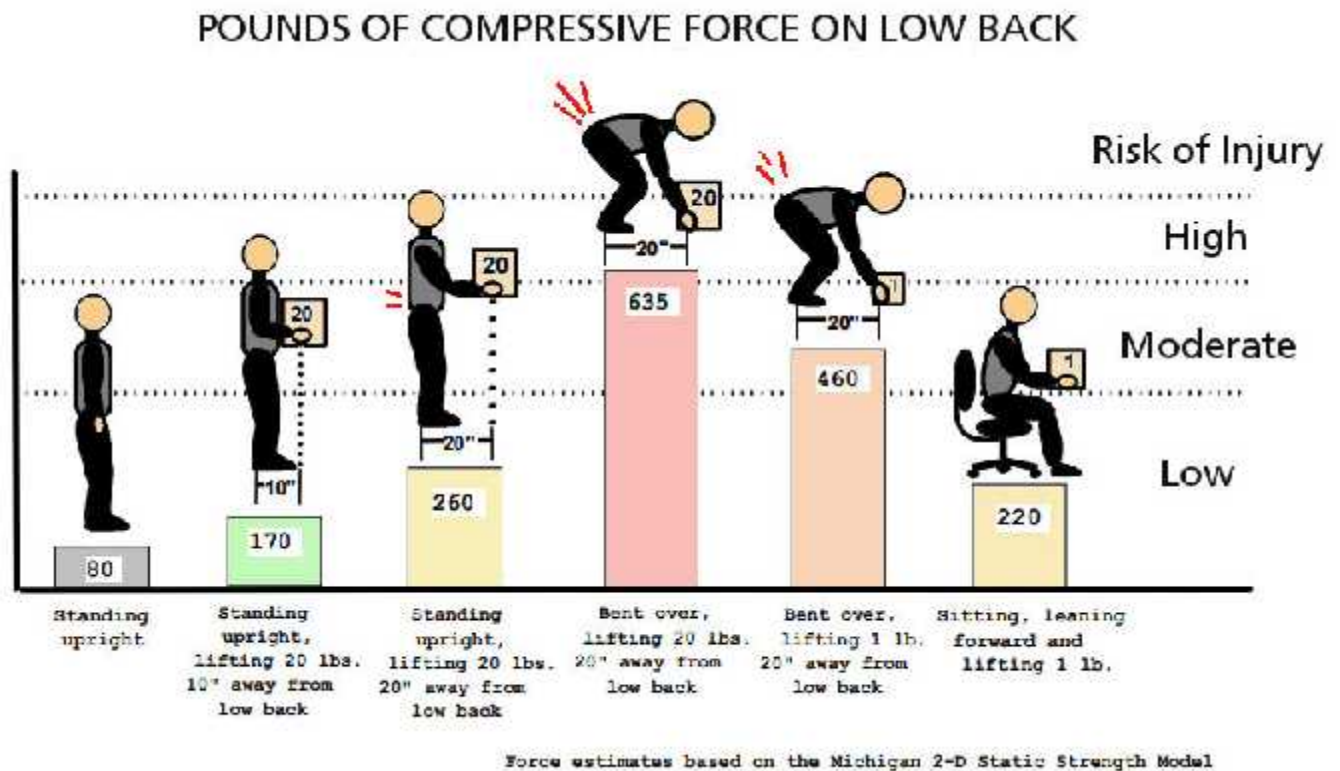
-) Type of grip;
-) Object weight;
-) Object dimensions;
-) Body posture;
-) Type of activity;
-) Slipperiness of object;

-) 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.

Your lifting posture affects your 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)

Force-Related Conditions

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

Symptoms	Possible Ergonomic Cause
Feet/legs ache, varicose veins	Standing in one place too long
Lower back pain	Trunk curved forward while standing or sitting
Shoulder and arm pain	Arms outstretched, sideways, forward or upwards; Shoulders forced up due to position of work
Neck pain	Head inclined too much backwards or forward
Forearm pain	Unnatural grip, static grip too forceful
Wrist pain	Repetitive hand or finger motion

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.

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.

- J 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.
- J 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.

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.

Body Part	Repetitions Per Minute
Shoulder	More than 2½
Upper Arm/Elbow	More than 10
Forearm/Wrist	More than 10
Finger	More than 200

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.

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.

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.

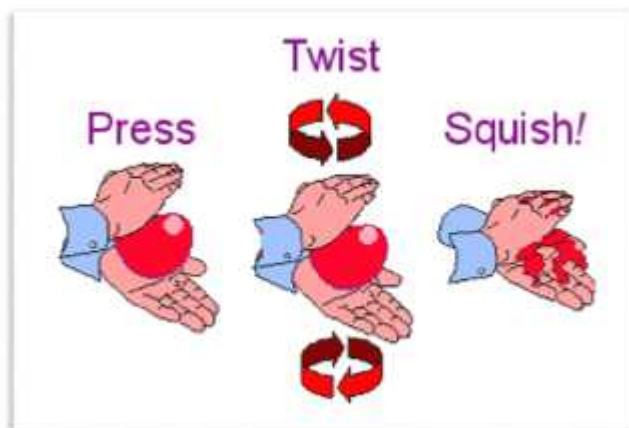
Below are some rules to follow for standing workstations.

-) 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.

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 note:

Steve Geigle here. I'm the founder of OSHAcademy and you'd think I would learn from my own training, but not so. I injured my back over the winter of 2016 by shoveling snow. 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!

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.

Module 3 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

- 1. Which of the following is defined as the amount of physical effort required by the person to do a task and/or maintain control of tools and equipment?**
 - a. Fatigue
 - b. Recovery time
 - c. dynamic exertion
 - d. Forcefulness

- 2. According to the Joyce Institute, compressive forces on the L5/S1 exceeding 550 lbs. causes _____ times the injuries than forces of less than 550 lbs.**
 - a. two
 - b. four
 - c. six
 - d. eight

- 3. Which of the following is a grip strategy to manipulate objects that requires much greater muscle strength?**
 - a. Pinch grip
 - b. Power grip
 - c. Sustained grip
 - d. Intermittent grip

- 4. Which form of exertion combines force, posture, and duration that quickly fatigues our muscles which increases the chances of acquiring a cumulative trauma disorder (CTD).**
 - a. Intermittent exertion
 - b. Repetitive exertion
 - c. Static exertion
 - d. Forceful exertion

5. This term describes a measure of the rest (or low stress activity) period available to the muscle group between similar exertions.

- a. Rest period
- b. Recovery time
- c. Degree of recovery
- d. Muscle group rest time

Module 4: Risk Factors Inherent in the Environment

What are risk factors the environment brings to the job?

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.

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.

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 quantity of light as specified in American National Standard ANSI All.1-1965, "American Standard Practice for Industrial Lighting".
-) 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.

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.

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.

Last Words

There you have it! I hope you have a better understanding of the environmental risk factors impacting MSDs and that you'll be able to apply that knowledge in your workplace. We'll find out, because now it's time complete the quiz.

Module 4 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

- 1. Heat stress can result in _____.**
 - a. heat exhaustion
 - b. heat cramps
 - c. dehydration
 - d. all of the above

- 2. Heat stress is made even more dangerous in the presence of _____ due to the reduced ability of the body to cool itself.**
 - a. low humidity
 - b. high humidity
 - c. greater exertion
 - d. higher force

- 3. Which of the following does NOT usually bring on a high-temperature work conditions?**
 - a. Heat from engines
 - b. Welding
 - c. Low humidity
 - d. Friction

- 4. This condition may result if the worker is exposed to an environment so cold that the body cannot maintain adequate deep core temperature:**
 - a. Hyperthermia
 - b. Hypothermia
 - c. Hyperthermitis
 - d. Hypothermitis

5. Which of the following is a disorder associated with excessive exposure to noise?

- a. Fatigue
- b. Palpitations
- c. Vibration syndrome
- d. Tinnitus

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 Z10-2005, Occupational Health and Safety Management Systems](#), encourages employers to use the hierarchy of hazard control strategies listed below:

1. Elimination
2. Substitution
3. Engineering controls
4. Administrative controls
5. 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, 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. If you have to lift a heavy object, you might substitute the heavy object with an object of less weight.

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.

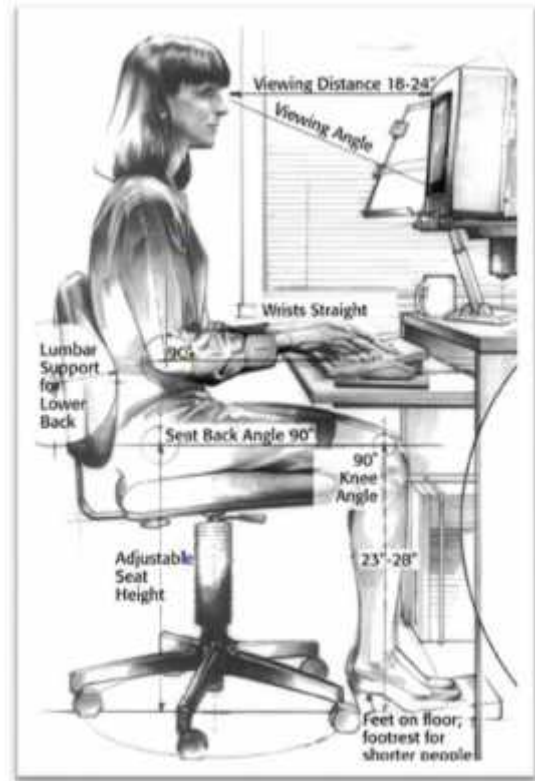
Computer Workstations

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

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



We also recommend arm rests for proper support.

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.

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.

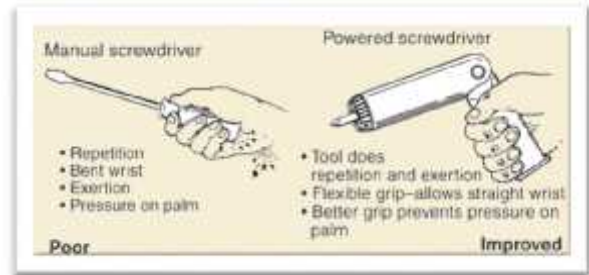
-) Be easily adjustable while seated.
-) Be able to swivel for most tasks.
-) Isolate the worker from whole-body vibration.
-) Have adjustable arm support when appropriate.

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 brings 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.

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.

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.

On the basis of a review of the scientific literature completed in 1994, NIOSH concluded that insufficient evidence existed to prove the effectiveness of back belts in preventing back injuries related to manually handling job tasks [NIOSH 1994]. A recent epidemiological study credits mandatory use of back belts in a chain of large retail hardware stores for substantially reducing the rate of low back injuries [Kraus 1996]. 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. More on [back belts Still more!](#)

Less controversial types of personal equipment are vibration attenuation gloves [NIOSH 1989] and knee pads for carpet layers [Bhattacharya et al. 1985]. 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.

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
- Last Words

Controlling ergonomics hazards requires a balanced approach of both engineering and management control strategies. It's an ongoing effort that needs the help of everyone in the organization.

Module 5 Quiz

Use this quiz to self-check your understanding of the module content. You can also go online and take this quiz within the module. The online quiz provides the correct answer once submitted.

1. Which of the ergonomic control strategies is most effective?

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

2. Which of the ergonomic control strategies attempt to reduce exposure to an existing hazard through procedures and practices?

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

3. 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. Interim measures

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

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

5. Inadequately written safety plans and procedures is an example of a _____.

- a. system implementation failure
- b. system design failure
- c. system personal failure
- d. system management failure