ERGONOMICS

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Introduction

Some of the tasks we perform at work, such as lifting, reaching, and repeating the same movements can strain our bodies. In some situations, these tasks can result in an injury to the muscles, tendons, ligaments, nerves, blood vessels, and joints of the neck, shoulders, arms, wrists, legs, and back. This type of injury is called a musculoskeletal injury, or MSI.

MSI is a common type of workplace injury in all industries in the United States.

What is MSI?

Musculoskeletal injury (MSI) is an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft tissue including a sprain, strain and inflammation, that may be caused or aggravated by work.

Signs and Symptoms of MSI

It is important for employers and workers to recognize the early signs and symptoms of MSI. If treatment is needed, it can be started right away. You can also take steps in the workplace and outside it to avoid making the condition worse.

A sign can be seen, for example:

- ❑ Swelling
- ❑ Redness
- ❑ Difficulty moving a particular body part

A symptom can be felt, for example:

- ❑ Numbness
- ❑ Tingling
- ❑ Pain

If you are experiencing signs or symptoms of MSI, inform your supervisor and report to the first aid attendant, if there is one.

Signs and symptoms of MSI may appear suddenly, from a single incident that causes an injury, or they may appear gradually over a longer period. Do not ignore early signs and symptoms of MSI. You may need treatment or may need to take steps to prevent the injury from getting worse.

Potential Health Effects

An MSI can affect your ability to perform tasks at work. Early signs or symptoms of MSI's can progress into conditions such as the following, which can have long-term effects:

- ❑ Muscle strains to the neck, back, shoulders, or legs
- ❑ Tendonitis (swelling of a tendon)
- ❑ Carpal tunnel syndrome (pressure on a nerve in the wrist, resulting in numbness, tingling, pain, or weakness in the hand, wrist, or forearm)

Treatment

Treatment will vary according to the type of MSI. Treatment can include the application of cold or heat, medication, physical therapy, and even surgery. An MSI may be treated more effectively if it is discovered and reported early.

Risk Factors

The factors that contribute to the risk of MSI are called risk factors. A risk factor is something that may cause or contribute to an injury. Two or more risk factors can be present at one time, increasing the risk of injury.

Workers may not always be able to identify all the risk factors in a task. However, it is important for workers to recognize situations when they are at higher risk. For example, if a worker must bend awkwardly to lift a heavy object in a cramped area, the worker will be exposed to a greater risk of MSI than a worker who uses a mechanical lifting device or one who has enough room to follow safe lifting procedures.

The primary risk factors for MSI are the physical demands of a task:

- ❑ Force
- ❑ Repetition
- ❑ Work posture
- ❑ Local contact stress

Note: *For each of these risk factors, duration and magnitude must be considered.*

Other risk factors that can affect these physical demands include:

- ❑ **Layout and condition of the workplace or workstation-** for example, a workstation that is too high or too low can create awkward working postures.
- ❑ **Characteristics of objects handled-** for example, and object that is slippery or has no handles may cause awkward postures and require greater force to handle the object in a stable manner.
- ❑ **Environmental conditions of the workplace-** for example, cold temperatures or drafts reduce blood flow to the hands and arms, requiring more grip force.
- ❑ **Organization of work tasks-** for example, a worker performing a variety of different tasks throughout the day is likely at less risk of injury than a worker who has little variety and is exposed to the same risk factor for a longer time.

The mere presence of MSI risk factors may not in itself result in an injury. It depends on, for example, how great the force is and how long the worker is exposed to the risk. It can also depend on individual characteristics that vary from worker to worker (such as height, gender, and the body's ability to deal with the risk factors).

The primary risk factors for MSI are explained on the following pages, along with examples and illustrations of some work activities that may expose workers to these risk factors. You will probably be able to identify the same risk factors in some of your activities outside the workplace.

Force

The force that a worker exerts on an object is a primary risk factor. Muscles and tendons can be overloaded when you apply a strong force against an object. Holding a lighter object for long periods of time can also expose workers to a risk of MSI.

There are three types of activity that require force:

- ❑ Force involved in lifting, lowering, or carrying
- ❑ Force involved in pushing or pulling
- ❑ Grip force

Lifting, lowering, or carrying

Lifting, lowering, or carrying an object or person requires force. A worker needs to exert more force to lift a heavy object than a light one.

Pushing or pulling

Force is needed for pushing or pulling an object. Pushing may be less of a risk than pulling because it uses stronger back muscles.

Grip force

Additional grip force is needed in situations such as the following:

- ❑ The worker is gripping a small tool.
- ❑ The worker is handling slippery or odd-shaped objects that are difficult to hold.
- ❑ Objects are too large for a comfortable grip.
- ❑ Objects are grasped or handled using a pinch grip instead of a power grip.
- ❑ Vibrating tools or equipment are used.
- ❑ The worker is wearing heavy or bulky gloves that make gripping more difficult.
- ❑ Handles or grip spans are too large or too small.
- ❑ The handles on tools have an awkward shape.
- ❑ The workers hands are cold.

Finger and Hand Grips

- The tip grip (pinching) is a position grasp used for precise manipulations.
- The side grip is also classified as a precision grip. Repeated use of these grips creates stress on the two tendons controlling the thumbs and fingers.
- The power grip requires the thumb to align with the long axis of the forearm and the wrist assumes a slight ulnar deviation. The posture may be stressful when combined with high repetition and extreme force.

Repetition

Repetition involves doing a task that uses the same muscles over and over with little chance for rest or recovery. This applies to both large and small muscles. Repetition puts workers at a higher risk of injury when other risk factors are also present (such as an awkward posture or heavy force).

Situations that increase the risk of MSI include the following:

- There is not enough variety in the worker's tasks to give muscles a rest or opportunity to recover.
- The worker is unaccustomed to the task, for example, when starting a new job or returning from a prolonged absence from work, or when the equipment or workstation has changed.

Work Posture

Posture refers to the position of different parts of your body. Muscles, tendons, and ligaments must work harder and can be stressed when you are in an awkward posture. Awkward posture occurs when any joint of your body bends or twists excessively, outside a comfortable range of motion. If the position is held long enough for you to feel aches and pains, then your muscles have been held in one position for too long. A posture held for a long time is called a static posture.

Various work activities can result in awkward postures:

- Leaning sideways, such as when reaching into a low drawer to one side (awkward back posture).
- Bending down to work at a low level (awkward back posture).
- Reaching overhead (awkward shoulder posture).
- Flaring the elbows out to the side (awkward shoulder posture).
- Bending the wrist when moving objects or keyboarding (awkward wrist posture).
- Bending the neck down, such as looking at small components in poor lighting conditions (awkward neck posture).
- Twisting part of the body, such as twisting the neck to view documents while keyboarding for a long time (awkward neck posture).

The effects of awkward posture can be made worse by:

- Applying force in an awkward position, such as lifting a heavy object with arms above the body or using a strong grip with a bent wrist.
- Holding an awkward position for a prolonged period (static posture), such as holding a telephone between the head and shoulder.

Local Contact Stress

Local contact stress occurs when a hard or sharp object comes in contact with the skin. The nerves and the tissues beneath the skin can be injured by the pressure.

Here are some examples of activities that can result in local contact stress:

- Ridges and hard edges on tool handles digging into the hand
- Edges of work surfaces digging into the forearm or wrist
- Striking objects sharply with the hand, foot, or knee (such as striking the carpet stretcher with the area above the knee when laying carpet)

The effects of local contact stress can be made worse if:

- The hard object contacts an area without much protective tissue, such as the wrist, palm, or fingers
- Pressure is applied repeatedly or held for a long time

Duration and Magnitude

Duration, or "how long", should be considered along with the four primary risk factors rather than separate from them. The amount of risk depends on how long (the total time in the work day) the worker is exposed to the risk factor.

The person looking at risk factors should consider questions about duration for each factor:

- ❑ How long is the worker using force (for example, to lift or grip an object)?
- ❑ How long does the worker perform a repeated task?
- ❑ How long does the worker perform a task with an awkward body posture?
- ❑ How long is one part of the body exposed to the local contact stress?

Magnitude, or "how much," should also be considered for each risk factor:

- ❑ How much force is the worker using?
- ❑ How fast is the worker doing the repeated movements?
- ❑ How severe is the awkward posture?
- ❑ How hard is the edge digging into the skin, causing local contact stress?

Multiple risk factors

More than one risk factor can occur at the same time. The more risk factors in the task, the greater the risk of injury. This example is used to show how several risk factors might occur at one time.

Task: A worker repeatedly bends to lift boxes from a pallet to a storage shelf.

Risk factors:

- ❑ Force- lifting the heavy weight of the box with one hand
- ❑ Awkward posture- worker bent forward at the waist
- ❑ Awkward posture- forward reach of right shoulder
- ❑ Local contact stress- worker grasping narrow plastic strapping
- ❑ Repetition- worker performing similar lifting task all day

Identifying risk factors

Employers are required to identify factors in the workplace that may expose workers to a risk of MSI. Employers must consult with the joint health and safety committee or the worker health and safety representative, if there is one, when doing this risk identification.

To start this process, employers need to identify risk factors associated with each job according to priority, one job at a time.

Identifying jobs with a higher risk of MSI

To determine which jobs are at a higher risk for MSI and should be given priority, employers should examine first aid records and claims history for MSI. If workers have already had an MSI or they have signs or symptoms of MSI, their jobs will likely have a higher risk of MSI. Priority for risk identification should therefore be given to jobs in the following situations:

- ❑ A worker has already had a work-related MSI claim
- ❑ A worker reports to first aid with an MSI
- ❑ A worker has reported signs or symptoms of MSI

Risk identification must also take place before any problems or injuries are reported so that risk factors can be eliminated or minimized and injuries prevented. The employer might set priorities for preventive risk identification by interviewing workers, taking a survey, or observing workers on the job. In addition, paying attention to the following situations can help prevent injuries:

- ❑ A worker or supervisor observes high exposures to risk factors in a job, for example, during workplace inspections and observations of current work methods.
- ❑ A new job is introduced, or a process changes.

How employers can identify risk factors

After identifying particular jobs that pose a risk of MSI to workers, the employer needs to identify the MSI risk factors for each of those jobs. The employer must consult with the joint health and safety committee or worker health and safety representative about risk identification. The employer may also consult with workers, since they often know the job best.

There are several tools (such as checklists and worksheets) for identifying risk factors in a job. These tools help identify risk factors that require further investigation to assess the risk to workers. These tools should take duration and magnitude into account along with the risk factors to help the employer establish priorities for risk control. Employers may use other methods to identify risk factors as long as they consider the risk factors listed in the Occupational Health and Safety Regulation.

How workers can help identify risk factors in their jobs

Workers can help in the process of identifying risk factors. Workers often have the best insights into the demands of their job and are in a good position to help identify risks and prevent MSI. Workers must report any work-related injuries and signs or symptoms of MSI without delay.

If a worker reports an injury requiring medical attention or an unsafe condition that could lead to injury, the employer must investigate. An investigation will help to identify risk factors that contributed to the injury or condition and lead to implementing controls to eliminate or minimize the risk factors.

Think about your job and all the different duties. For each duty, try to identify which, if any, of the four primary risk factors (force, repetition, work posture, local contact stress) are present. Then consider these questions:

- ❑ Does the total time (duration) you spend doing a particular duty increase the physical demands on your body?
- ❑ Do any of the following increase the physical demands on your body?
  - Layout of your workplace or workstation (such as work surfaces that are too high or too low or that result in excessive reaching distances)
  - Characteristics of the objects you handle (such as objects that are too large to handle or that have their weight unevenly distributed)
  - Environmental conditions (such as an atmosphere or objects cold enough to make the hands cold while the worker handles objects)
  - Organization of your work duties (such as a lack of variety of task, with the result that your muscles do not have a chance to rest and recover)

After you answer these questions, you will have a fairly food idea of what risk factors you are exposed to in your work. You can probably see which duties place you at the most risk of MSI and where changes are most needed.

You may also have some suggestions for practical solutions to reduce or eliminate some of these risk factors. Discuss your answers and suggestions with your supervisor. You might also talk to members of the joint committee or your worker health and safety representative about the risks of MSI.

Cumulative Trauma Disorders

Musculoskeletal injuries caused by working are common. The majority of these injuries are not accident related broken bones or strained ligaments. They usually develop over a period of time as a result of repeated stress on a particular body part. The condition is often ignored until the symptoms become chronic and permanent injury occurs. Cumulative trauma disorders (CTDs) and repetitive motion injuries are terms used to refer to certain musculoskeletal injuries.

A key reason for the increase in CTDs is the increase in production due to automation. The assembly line, computerized office machines, and electronic checkout stations in grocery stores are examples of workstations that require a high volume of output.

One simple, strain-producing task may be repeated several thousand times a day. High production demands do not allow much time for rest and recovery.

The aging work force relates to the incidence of CTDs because the ability to withstand shock, chronic strain, and stress decreases as an individual ages. Also, awareness of the causes and nature of CTDs has increased. Employers and employees can recognize tasks that cause or contribute to these disorders.

Recent studies have shown that a great deal of workers' compensation costs is due to CTDS. CTDs are responsible for many cases of lost work time. Early detection of CTDs can be difficult because the disorders often develop slowly over months or years. Therefore, preventing CTDs is important. Prevention can, in part, be accomplished by tool and workstation redesign and better work methods.

Work Area Design

A workstation should be designed to accommodate the person who actually works on a given job. For example, workstations should not force workers into awkward body positions. Workstations should be easily adjustable and selected to fit specific tasks, so that they are comfortable for the workers using them. The workspace should be large enough to allow for the full range of required movements, especially where knives, saws, hooks, and similar tools are used.

Methods for reducing extreme and awkward postures include:

- Adjustable fixtures and rotating tables so that the position of the work can be easily manipulated.
- Workstations and bins that can accommodate the heights and reach limitations of a wide range of workers.
- Work platforms that move up and down for certain operations.

Examples of methods to reduce the need to use excessive force include:

- Adjustable fixtures that allow operations and movements to be easily made.
- Properly located bins so that workers do not have to toss products and by-products.
- Mechanical or powered devices that eliminate the need for extreme manual force.
- The suspension of heavy tools.

Minimization of Manual Materials Handling

Manual materials handling is another area in which injuries to employees can occur. This type of work entails lifting, bending, and twisting, which can cause great damage to the human body if done improperly.

Lifting puts stress on two main body systems. One is the musculoskeletal system and the other is the cardiovascular system. Since the problem associated with the cardiovascular system deals with oxygen consumption or increased heart rate, the focus of most information regarding lifting has been the musculoskeletal system.

Most studies use criteria such as "stress in relation to capability over a given amount of time" as an index of the associated strain.

Mechanical Aids

One way to reduce manual materials handling problems is by using self-leveling dispensers, such as the spring-loaded tray dispensers used in many cafeterias.

The way these mechanisms work is that when a load is removed, the platform rises in order to maintain the top layer at a constant level. A worker does not have to bend over or stretch upward to receive work. Instead, work can be reached at a constant height. These dispensers can eliminate unnecessary motion and thereby reduce worker fatigue.

Many other types of mechanical aids are available to assist employees during manual materials handling.

Hooks, bars, rollers, jacks, platforms, and trestles (or A frames) are examples of simple job aids. Drum handling units are in common use and exist as either a trestle or lever. In most cases, the engineer or ergonomist can find off-the-shelf aids readily available to fit the lifting task and to minimize the amount of manual lifting.

Other available equipment which will minimize, if not eliminate, manual materials handling includes the standard industrial equipment classes of conveyors, hoists and cranes, industrial vehicles (such as towmotor or forklift trucks), and positioners. Positioners are defined by the International Material Management Society as equipment used to transfer material from workplace to materials handling equipment, or vice versa. Positioners include manipulators, dumpers, up-enders, positioning tables, lifts, jacks, and transfer machines.

Today, with so much equipment available to the plant engineer or ergonomist, manual materials handling can be reduced, if not eliminated, for most tasks.

Carpal Tunnel Syndrome

Carpal Tunnel Syndrome (CTS) is a common nerve CTD. Workers, from aircraft assemblers to office assistants, are at risk for CTS. It is a progressively disabling and painful condition of the hand. CTS results from injury to the median nerve, which is located in the wrist. It is a nerve entrapment that develops from the buildup of pressure on the median nerve as it passes through the carpal tunnel. This is a dime size passage between the carpal (wrist) bones and the anterior transverse carpal ligament. Since musculoskeletal strain from repeatedly flexing the wrist or applying arm-wrist-finger force does not cause observable injuries, it often takes months or years for workers to detect damage.

Symptoms of CTS include weakness, clumsiness, numbness, pain, tingling, and a lack of sweating in parts of the hand innervated by the median nerve. CTS has been reported to occur from two to ten times as frequently in women as in men. The condition is progressive and can lead to compensable hand disabilities.

In the early stages, the signs and symptoms of CTS may be fleeting, intermittent, and vague. One of the first symptoms is awakening at night because the hand is aching, tingling, and numb. The term "nocturnal numbness" is often applied to CTS because symptoms are often severe during sleep. CTS usually affects the dominant hand. These symptoms may continue for months or even years.

The patient may attribute the strange feelings to poor circulation from having slept on his or her hand during the night.

At first, rubbing or shaking the hand can make the feelings go away. Gradually though, the feelings begin to persist. As pressure on the median nerve mounts, the thumb and the first three ringers increase in numbness. The pain becomes more intense, sometimes spreading to the forearm and even up into the shoulder. Eventually as the disease progresses, the person begins to lose control of the hand, and may drop things or be unable to turn a key in a lock.

CTS is considered an occupational disease, as it is often associated with the performance of particular repetitive tasks. The reason that some people develop this condition while others do not is not known. A higher incidence of CTS among the female population is difficult to explain. Smaller hands and wrists may be at more risk.

One study found that the use of vibrating tools is strongly associated with CTS. Repetitive motion tasks which involve the wrists were also found to be associated with CTS. The use of vibrating tools may involve repetitive wrist movements. This association may partially relate to the link between vibration and CTS.

Tests used to determine the presence of CTS:

Phalen's wrist-flexion test - The patient props his or her elbows on a table and allows the wrists to drop into complete flexion for 30 to 60 seconds. If paresthesia and numbness occur almost immediately, the test is considered positive.

Forced wrist-flexion test - The patient props his or her elbows on the table, one wrist is held and the other is in complete flexion for 20 to 30 seconds. If the patient has CTS, symptoms should occur immediately.

Tinel's sign test - A percussion hammer is used to tap the patient at the wrist crease. If the patient feels a tingling in the hand along the median nerve distribution, the test is positive.

Electroneuromyography - A physician performs this test, which requires an electromyograph and related equipment. Its purpose is to measure the median nerve's conduction velocity, the speed at which nerve impulses translate into muscle responses. If the velocity measures 5 milliseconds or more below normal, chances are the median nerve is compressed in the carpal tunnel. A negative result, however, does not rule out CTS since a median nerve may be compressed yet its conduction velocity may remain normal. Electroneuromyography is the most reliable of these tests used to determine the presence of CTS.

Other Cumulative Trauma Disorders

Although CTS is the best known of repetitive motion disorders, other disorders can also be disabling.

Other CTDs include:

Tenosynovitis - Tenosynovitis is the inflammation of the tendons and sheaths. It is often associated with tasks demanding extreme wrist deviation. For example, wrist deviation is required to hold an in-line nut-runner in a horizontal position.

Trigger finger - Trigger finger is a form of tenosynovitis which results when any finger must be frequently flexed against resistance. It may be avoided by designing tool handles for operation by the thumb, by more than one finger, with lower force requirements, or by not requiring constant pressure.

De Quervain's Disease - In De Quervain's disease, the tendon sheath of both the long and the short abductor muscles of the thumb narrows.

The disease is common among women workers, particularly those who perform repetitive manual tasks involving radial or inward hand motion and firm grips.

Tennis Elbow - Also called epicondylitis, this form of tendinitis is an inflammatory reaction of tissues in the elbow region. In an industrial environment, tennis elbow may follow effort requiring palm-upward hand motion against resistance, such as using a screwdriver, or the violent upward extension of the wrist with the palm down. The condition may be avoided by ensuring that the rotation axis of the tool or machine coincides with the rotation axis of the forearm.

White Finger - White Finger Disease or Raynaud's Syndrome occurs when blood vessels and nerves in the hands constrict from conditions such as cold temperature, vibration, or emotion. The hands, fingers, or finger tips may become cold, blue, numb, and lose fine manipulative ability. Upon recovery, the hands become red, accompanied by a burning sensation. It can be confused with the one sided numbness of carpal tunnel syndrome.

Corrective actions to prevent CTDs include:

Adjusting the height of work tables, conveyors, and seats automating tasks to eliminate manual handling; reducing the frequency of tasks or increasing the frequency to a point where automation is necessary; reducing the size or weight of loads; providing arm rests; redesigning hand tools so that the axis of rotation or application of force coincides with the axis of rotation of the arm; providing operator training; using careful preplacement screening to identify high risk employees; changing load positions in relation to the body or hands; minimizing the time that a load is held in the hands; eliminating gloves if they cause a problem or trying different gloves.

Among recommendations to help prevent the development of CTS are these:

- ❑ Low frequency vibration in hand tools should be eliminated or reduced.
- ❑ Wrist deviation from the straight position should be minimized especially where a great deal of force must be exerted.
- ❑ Where possible, a closed fist (rather than a pinch) should be used to reduce tendon tension.

Medical Treatment of Cumulative Trauma Disorders

Correct diagnosis of a musculoskeletal injury is important to avoid the stressful activity that caused the injury, and to lead to effective treatment. Diagnosis includes identifying the affected part of the body, determining the extent of injury, and determining what caused the disorder. The patient's description will aid in determining what area is painful, how and when the pain started, and what tasks are difficult.

The physical examination consists of initial inspection for asymmetry or irregularities such as swelling cysts. Limitations in the patient's range of motion may indicate a joint, muscle, or tendon problem.

Once the disorder is located and the degree of damage is determined, proper treatment must be developed.

Successful therapy may require weeks or months. During this time the patient's work activities may be restricted. An additional strategy could involve limiting movement of the injured area and possible splinting, the application of heat or cold, medication to reduce inflammation and swelling, and special exercise.

If conservative approaches fail, special drugs or surgery may be required. It is important that the worker not continue performing the same job or task that caused the injury. The worker could be reassigned, or the task should be redesigned.

Hand Tools

Each year, hand tools are the source of 7 to 8 percent of all compensable injuries.

Improper use of hand tools and defective tools can cause biomechanical stress and injuries. Types of injuries frequently reported include broken bones, contusions, loss of eyes and eyesight, and puncture wounds. Additionally, fingers, tendons, and arteries are severed from the use of cutting tools.

Basic safety precautions mandate that tools always be kept in good condition and be used properly. Workers should be careful to use the proper tool for the job performed.

Hand and Wrist Postures

Some hand tools may force the wrist to assume awkward postures. The wrist position affects the effective strength of the contracting muscles. Therefore, as the angle of the joint increases or decreases from the neutral position, there is more stress on the tendons.

- ***Ulnar deviation*** is the bending of the wrist toward the little finger.
- ***Radial deviation*** is the bending of the wrist toward the thumb.
- ***Extension*** is bending the wrist up and back.
- ***Flexion*** is bending of the wrist down towards the palm.

A job requiring repeated ulnar deviation, extension, or flexion can lead to tenosynovitis of the tendons on the back of the hand. Similarly, severe radial deviation can cause elbow soreness.

Visual Display Terminals (VDTs)

A hidden toll is taken on employees who daily sit in front of their flickering display screens. They pay this price with sore necks and shoulders, cramped fingers, tired eyes, strained backs, numb buttocks, and aching legs and feet. Tension headaches are common. It may be possible to trace these ailments directly to improper workspace layout.

A standard visual display terminal is an electronic device that displays information on a screen and works on a principle similar to that of a television set. The picture tube is called a cathode ray tube (CRT). It contains a source of electrons which, when beamed across the phosphor-coated screen, produces a visible image. The operator manipulates the image through specific commands entered through a keyboard or a pointing device such as a mouse.

Because work involving sustained use of VDTs can be repetitious and confining, special attention must be paid to the user's comfort. Traditional ergonomic considerations include chair and table selection, rest breaks, office noise, light, and temperature. However, VDT use poses unique questions, such as:

- What type of screen image, character size, and screen brightness is optimal for the task?
- How can screen glare and reflections be eliminated?
- What type of keyboard is best for the user and the task?
- Where should the screen, document holder, and accessories be placed?

Workstation Design

The equipment should be suited to the job. It should be set and spatially organized such that:

- Forced air exhausts are not directed toward the user.
- Workstation adjustment controls are convenient and easy to use.
- Equipment with the longest and/or most frequent eye contact lies in the centre of the work field.
- Equipment handled the most lies within the optimal range of reach.
- Glare is avoided.
- Pronounced visual contrast differences between important subjects is avoided.

Visual Display Screens

The primary viewing area should be between 0 and 60 degrees below the horizontal line of sight. The screen should be tilted so that the middle of the screen is perpendicular to the viewing angle. The top row of data should not lie above eye level, and observation angles greater than 40 degrees should be avoided. To avoid distracting reflections, it may be necessary to tilt the screen or to use screen filters.

European standards recommend that the observation distance between the eye and cursor be between 17 and 24 inches, or 450 and 600 mm in an upright sitting position. ANSI recommends that the minimum viewing distance be 12 inches or 305 mm. ANSI also specifies several optical quality requirements.

The contrast ratio between the characters and the background should be at least 3:1. Small characters must have a higher minimum contrast. "Jittering" displays should be eliminated. The discrete dots that make up the characters should not be perceptible. The characters must appear solid to the viewer.

Saturated blue on a dark background, thin lines, or high resolution information for text should be avoided.

Pure red in displays should also be avoided to help colour-blind people read displays.

Keyboards

ANSI recommends that the keyboard permit the user to keep an angle between the upper arm and forearm at 70 to 90 degrees. The angle may increase if the operator is leaning back, but the maximum angle should not exceed 135 degrees. The keyboard should consist of the QWERTY layout, with "ASDFJKL;" as the home keys.

The keyboard should be stable for normal keying functions. A number keypad should be provided if the main task involves numerical data input from the keyboard. To reduce user discomfort, alternative keyboards may be needed, such as split-fixed or split and vertical inclined styles.

Document Holders; Footrests

Document holders and footrests should be provided, if needed by individual operators. The document holder should be adjustable and extensible.

Work Surfaces

The work surface should provide adequate leg room so that the legs are not cramped. The height of the leg clearance should be at least equivalent to the highest point on the thigh or knee. ANSI recommends that when the leg is perpendicular to the floor, minimum leg clearance depth under the work surface is 60 percent of the buttocks-to-knee length. The size of the work surface should also accommodate the task.

Work Chairs

The height of a chair should allow the user to place the feet firmly on a support surface. The maximum seat depth should allow contact with the seat back at the lumbar region while allowing clearance behind the knees. Minimum seat width should be 18 inches or the thigh breadth of the seated user, whichever is greater.

If the chair design requires the user's feet to be flat on the floor, the seat pan angle should keep the angle between the upper and lower leg between 60 and 100 degrees. In addition, the angle between the seat pan and back should allow the user to maintain a working posture in which the torso-thigh angle is not less than

90 degrees (100 degrees is preferred). Chairs should have back rests with lumbar support.

If the chairs have arms, the distance between the armrests should be a minimum of 18.2 inches. Appropriate chair castors should be provided.

Noise and Temperature

Noise should be reduced to a maximum of 55 decibels and sporadic noises above normal ambient sound levels should be prevented. ANSI recommends that surface temperatures of equipment intended to be touched not exceed 95°F. Air drafts should not be allowed to flow under desks. Care should be taken to see that heat does not build up under desks as well.

Illumination

Lighting of a sufficient intensity is essential to adequately perform visual tasks and to reduce worker fatigue. How a space is used and what it is used for influences how lighting should be applied. Other factors that influence lighting design for a task include appearance, economics, building costs, energy consumption, and the quality of lighting desired. Factors affecting the visual environment include lighting fixtures, visual tasks, lighting maintenance, lighting system design, and the individuals' eyesight.

The Nature of Light

The nature of light is determined by its quantity and quality. Light quantity is the amount of illumination cast upon the task and surrounding area. Light quality includes the color of the light, the direction and diffusion of the light, and the amount and type of glare from the light.

Quantity of Illumination

The quantity of illumination relates to the amount of light that exists or is required at a workplace. The amount of light necessary for effective work depends on the nature of the work, the sharpness of a worker's vision, and the environment in which the work is done.

The absolute minimum amount of light required for reading, writing, and many manual tasks is approximately one footcandle (2). As a reference point, a light in an indoor exit sign has at least five footcandles.

In the design of good lighting, safety and welfare should be taken into account as well as visual efficiency.

In some jobs where visual demands are not great, it is normal for recommended levels of illumination to be based on safety, welfare, and amenity (creation of a pleasant environment). The minimal amenity level is 20 footcandles. When light levels fall below 20 footcandles, workers usually have a negative reaction to the lighting.

Too much light can be as damaging as too little. There is great variation between the amounts of illumination required by a younger worker and an older worker. The quantity of illumination needed depends upon the age of a person who must see to do the task, the reflecting characteristics present, the amount of light needed to do a task, and the speed and accuracy required of the person performing the task. As the illumination upon a task increases, so does the luminance (light reflected upward) and, as a result, the accuracy and speed of vision improves. The best ergonomic solution for these varying needs is to provide general workplace lighting and supplement it with specific task lighting.

Lighting systems should be designed to provide a uniform distribution of light over the entire work area. To ensure that a given illumination level will be maintained, give more light initially than is minimally required. The reason for this is that such factors as dirt, use, and time deteriorate lighting.

At any given time, most people have lights that appear dull and which no amount of cleaning will improve. Generally, this happens when 80 percent of the stated life of the bulb or light has been used. The best ergonomic solution is to replace it at this point.

Tables exist to provide the recommended levels of illumination for visual performance of young adults with normal vision. The IES Lighting Handbook provides such data for various industries. Illumination recommendations are intended as guides for lighting levels from an overall operational standpoint. The lighting levels are not recommended in order to ensure safety and are not, therefore, a basis for regulatory minimum illumination.

Quality of Illumination

The quality of illumination pertains to the distribution of brightness in a visual environment. A good quality of illumination means that all brightness contributes favorably to visual performance, visual comfort, ease of seeing, safety, and aesthetics for the specific visual task involved.

A worker can normally see the task itself, the immediate background to the task, and the general surroundings.

The eyes tend to be attracted to the brighter and more colorful parts of the field of vision. Therefore, light and color can be used to direct the focus of attention to the task. Lighting should be directed to the work, or special local lighting should be provided to match the needs of the work and the general lighting levels.

The level of brightness required for any task is determined by the degree of detail the operator has to meet, the time allowed for seeing, and the reflection characteristics of the task. The general level of brightness in the room also contributes to the level of brightness required for a task. In practice, it is advisable to plan the illumination first in relation to what the operator requires to accomplish the task and then to plan the brightness of the other parts of the room to provide proper emphasis, visual comfort, and interest.

Poor quality industrial illumination is easy to recognize. It presents uncomfortable and hazardous situations.

Certain tasks, such as distinguishing fine details, require higher quality illumination than do others.

Also, work areas in which visual tasks are severely demanding and which are performed over a prolonged period of time require higher quality illumination.

Slight glare conditions may result in a loss of seeing efficiency and undue fatigue. Some factors that affect the quality of light include glare, shadows, colors, veiling reflections, and luminance distribution.

The Effect of Glare on the Quality of Light

Glare is a disturbance of the retina's ability to adapt to amounts of light. It may cause discomfort or reduce the ability to see, or both. It occurs when some parts of the field of view are excessively bright in relation to the general level of brightness. A common example is presented by a person who is trying to watch a television set in a bright room. The ergonomic solution is to lower the lighting in the room.

The degree of glare resulting directly from light sources depends on such factors as the brightness and sizes of the sources, their position in the operator's field of view, and the average brightness of the surroundings against which they are seen. Glare can cause discomfort without affecting the operator's ability to see the work, especially in very bright surroundings. Ensuring that lights are placed above the line of sight will help eliminate glare.

There are three major types of glare. They are absolute, adaptive, and relative glare. Absolute glare exists when luminosity is so high that adaptation is impossible. Adaptive glare exists when adaptation to a certain amount of light has not yet been reached.

Relative glare is present when there is too much of a contrast in the visual field.

In addition, glare can be classified as direct or specular.

Direct glare results from a light source, whereas specular glare is created by reflection from a bright surface.

Direct glare can be reduced by:

- ❑ Avoiding bright light sources within 60 degrees of the center of the visual field.
- ❑ Using shields, hoods, and visors to keep the direct light source out of the viewers' eyes.
- ❑ Using indirect lighting.
- ❑ Using several low intensity sources of light rather than one high intensity source.

Specular glare can be reduced by:

- ❑ Using diffuse light.
- ❑ Using a dull matte surface (flat paints, desk blotters) rather than polished surfaces.
- ❑ Arranging direct light sources so that the viewing angle to the work is not equal to the angle of incidence from the source.

Kinds of Light Sources Used in the Industrial Environment

Daylight and electrical light are the two major sources of light used in industrial sites. Artificial light is commonly used in industrial buildings during daytime to provide additional local lighting on the work to provide special effects, such as modeling, silhouettes, and specular reflections, or to illuminate surfaces inaccessible to the daylight. There are many instances where the amount of daylight in a building is inadequate or obstructed, and artificial lighting may be required as permanent supplement to daylight.

Daylight, however, is by far the best light source if it is available.

There are many different types of electrical light sources, and the choice for any particular situation depends upon the level of illumination required and the standard of color judgment involved in the visual task.

Economic factors also influence the selection of electrical light sources.

Lighting for Video Display Terminals

ANSI recommends eliminating intense sources of light from the VDT user's peripheral field of vision. A nominal lighting strength of 300 to 500 lux is recommended whereby the intensity of lighting upon the work table at the display should never reach 300 lux. (One footcandle equals approximately 10 lux.)

Work areas with nominal lighting intensity at 750 lux must be individually tested to determine whether the area is suited for display workstations. In rooms with nominal lighting intensity of 1000 lux or higher, there should not be any display workstations, unless special precautions are taken, such as using micromesh or glare filters (polarized and/or nonreflective coating should also be considered). See table

Screen Reflection Reduction Methods

Location	Measure
At source	Cover windows. Place light fixtures properly. Use directional lighting.
At workstation	Move station. Tilt screen. Use screen filters or hoods. Use reverse video.
Between source and workstation	Hang or erect partitions.

VDT Workstation Accessories

VDT workstation accessories are available to help provide a comfortable workstation and reduce fatigue.

One accessory is the keyboard arm rest. Because typists frequently rest their wrists on the keyboard or tabletop while typing, excessive strain is placed on tendons controlling the fingers and hands.

The wrist rest elevates and rests the wrists and reduces tendon stress. (The usual recommendation is to use the wrist rest during pa uses in typing.)

The keyboard drawer slides under a desk when not in use, allowing efficient use of desk space. When the drawer is extended, the keyboard can be raised or lowered.

The extension arm allows the operator to place the monitor in a comfortable location for maximum efficiency. The extension arm rotates, extends, and retracts a swiveling monitor platform for viewer comfort and glare reduction.

The worker should plan to alternate VDT work with other tasks that do not require similar, close-work skills. Managers should be conscious of this work routine when planning a day's work schedule. Frequent breaks should be provided to allow the operator to stretch, move, and other non-hand intensive tasks.

Recommended work/break intervals are:

One break (5–10 minutes) for every hour of keying moderate work loads, with more frequent, short mini breaks or pauses (30–60 seconds) for more intense VDT use.

The key to a comfortable and productive office environment is recognition of each worker as an important individual with individual needs. Such recognition will increase morale and heighten productivity.

Key questions

If you may be exposed to a risk of MSI in your job, you must be educated in risk identification related to your work. This includes recognizing the early signs and symptoms of MSI and their potential health effects.

You should be able to answer the following questions:

- ❑ What are some early signs and symptoms of MSI?
- ❑ What person would you report these signs and symptoms to?
- ❑ What can happen if you ignore early signs and symptoms of MSI?
- ❑ What are the risk factors in your job that could lead to MSI?

Summary

Risk identification is just one step in eliminating or minimizing the risk of MSI to workers. Once risk factors have been identified, the employer must do a risk assessment to find out how great the risk is.

Not all risk factors are necessarily severe enough or occur for a long enough time to cause or contribute to an injury.

Risk assessment should be carried out by people who understand the work process, the MSI risk factors, and the principles of risk assessment and control. When doing a risk assessment, the employer must consult with workers who have signs or symptoms of MSI and with a representative sample of workers who carry out the work being assessed.

The sample should include workers who represent a range of characteristics such as gender, age, and height.

The risk assessment may determine that control measures are needed to eliminate or minimize the risk.

Some examples of control measures are mechanical lifting devices, adequate recovery time from repetitive tasks, adjustable workstation heights, and padding on sharp edges of work surfaces.

Workers may also need to be trained in safe work procedures for some tasks, such as adjusting their workstation to fit the task correctly.

If the employer provides any mechanical aids (such as knee pads), workers must be trained to use them.

Ergonomic Safety Analysis

Contributing Factors (CF)	Reason for CF	Comments	Ergonomic Improvements