

How to identify, control, and reduce musculoskeletal disorders in your workplace!

Introduction to Ergonomics



Presented by the Public Education Section
Department of Business and Consumer Business
Oregon OSHA



OR-OSHA Mission Statement

To advance and improve workplace safety and health for all workers in Oregon.

Consultative Services

- Offers no-cost on-site safety and health assistance to help Oregon employers recognize and correct safety and health problems in their workplaces.
- Provides consultations in the areas of safety, industrial hygiene, ergonomics, occupational safety and health programs, new-business assistance, the Safety and Health Achievement Recognition Program (SHARP), and the Voluntary Protection Program (VPP).

Enforcement

- Offers pre-job conferences for mobile employers in industries such as logging and construction.
- Provides abatement assistance to employers who have received citations and provides compliance and technical assistance by phone.
- Inspects places of employment for occupational safety and health rule violations and investigates workplace safety and health complaints and accidents.

Appeals, Informal Conferences

- Provides the opportunity for employers to hold informal meetings with OR-OSHA on workplace safety and health concerns.
- Discusses OR-OSHA's requirements and clarifies workplace safety or health violations.
- Discusses abatement dates and negotiates settlement agreements to resolve disputed citations.

Standards & Technical Resources

- Develops, interprets, and provides technical advice on safety and health standards.
- Provides copies of all OR-OSHA occupational safety and health standards.
- Publishes booklets, pamphlets, and other materials to assist in the implementation of safety and health standards and programs.
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- Conducts conferences, seminars, workshops, and rule forums.
- Presents many workshops that introduce managers, supervisors, safety committee members, and others to occupational safety and health requirements, technical programs, and safety and health management concepts.

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Examples of Risk Factors in the Person, Job, and Environment

Personal Factors

Age
Sex
Physical Fitness
Body Build
Health
Acclimatization
Nutrition &
Hydration
Motivation
Training
Physical
capabilities
Mental
Capabilities
Emotional
Stability
Ethnic
Characteristics

Job Factors

complexity of Task
Duration of Task
Physical Load
Mental Load
Perceptual-motor Load
Sensorimotor Load
Skill Required

Environmental Factors

Temperature
Humidity
Wind
Long Wave Radiation
Solar Radiation
Dust
Aerosols
Gases
Fumes
Barometric Pressure
clothing

WORK PHYSIOLOGY

A. Definition

The study of the factors influencing performance and fatigue during muscular work

B. Relevance to Ergonomics

1. Localized muscle fatigue and cumulative trauma disorders
2. Whole body fatigue and work-/rest scheduling
3. Heat stress, i.e. metabolic heat burden

II. MUSCLE METABOLISM

A. Production of usable energy source from food

B. Two metabolic pathways

1. Aerobic...using oxygen - preferred
2. Anaerobic...without oxygen - alternative

C. Relevant points

1. When ATP is used, work is done and additional heat is produced.
2. Glucose and oxygen are not stored appreciably in muscle tissue; they are transported to muscle by the blood. Increased muscular work therefore, results in increased heart rate, stroke volume, and blood pressure.
3. Aerobic metabolism is 13 times more efficient than anaerobic metabolism
4. Lactic acid accumulation is believed to account for muscular fatigue and soreness

III. TYPES OF WORK ACTIVITY

A. Dynamic

1. Alternating muscular contraction and relaxation
2. $Work = Force \times Distance$
3. Blood flow is promoted; oxygen and nutrients are adequate and waste products are removed

B. Static

1. Prolonged muscular contraction
2. No measurable work is done
3. Blood flow is inhibited; inadequate oxygen and nutrients reach the muscle, and significant anaerobic metabolism takes place. Lactic acid accumulates.

C. Consequences of static work

1. Rapid localized muscle fatigue and discomfort
2. Greater increases in heart rate, blood pressure and energy consumption than for equivalent dynamic efforts
3. Prolonged recovery times
4. Inflammation and degeneration of tendons, tendon sheaths, discs, and joints

IV. WORKSTATION DESIGN RECOMMENDATIONS BASED ON AVOIDANCE OF STATIC WORK (From Grandjean)

A. Minimize the need to grasp or hold objects

B. Avoid bent working postures

C. Avoid working with arms outstretched — forward, side ways, or overhead

D. Arm movements should be symmetrical

E. Use seated or sit/stand workstations when the nature of the work allows

F. Frequently used tools, controls, and materials should be arranged so arm movements are carried out with the elbows bent and near the body -.

IV. WORK LOAD ASSESSMENT AND WHOLE BODY FATIGUE

A. Job energy requirements (energy cost) vs. employee's ability to expend energy (Physical Work Capacity or Aerobic Capacity)

B. Units

1. Kilocalories per minute (kcal/rnin)
2. Oxygen consumption (liters per minute)
3. One lpm oxygen consumption = 4.8 k-cal/mm

C. Methods of assessing workload

1. Measure oxygen consumption
2. Use tabular values
3. Task analysis
4. Heart rate

D. Methods of determining Physical Work Capacity (PWC)

1. Measure oxygen uptake individually
2. Use "average" values (with caution) -
 - a. "Average" healthy men ages 20 - 30 have a PWC of about 16 kcal/rnin
 - b. "Average" females have about 70% of the PWC of "average" males of the same age
 - c. "Average" male or female at age 60 has about 70% of the aerobic capacity they had' at age 30

E. Recommended Criteria for Acceptable Workload

1. One-third of PWC (about 5 kcal/min)
2. Average heart rate of 110—120 beats per minute tolerable for 8 hours
3. Workload at which pulse rate levels off during work and returns to resting rate after 15 minutes
4. Recovery pulse method (Brouha)
 - a. Requires three pulse rate readings after work period at the following intervals:

0.5	to	1 minute
1.5	to	2 minutes
2.5	to	3 minutes
 - b. Criteria:
 - 1) First reading should be less than 110 beats per minute
 - 2) The difference between the third reading and the first reading should be at least 10 beats per minute

F. Work-Rest Scheduling. Estimates amount of rest time required to assure workload is not excessive.

CAUSES AND PREVENTION OF REPETITIVE TRAUMA DISORDERS

I. INTRODUCTION

A. Definition — Disorders of the musculoskeletal and nervous systems which may be caused or aggravated by repetitive motions or exertions, or by sustained postures.

B. Commonly Affected Occupational Groups (Upper extremity disorders).

1. Assembly line workers (e.g., automobile, appliances, electronics).
2. Garment workers (e.g., fabric cutters, sewing machine operators).
3. Metal fabricators (e.g., press operators, grinding - machine operators).
4. Musicians.
5. Others.

C. Prevalence

1. National Safety Council statistics:

- a. Injuries to the arms, hands, and fingers account for 31 percent of all Workers' Compensation claims.
- b. Injuries to these body parts account for 21 percent of all compensation payments.

2. NIOSH Health Hazard Evaluation:

- a. 15 percent of employees in midwestern assembly plant had "confirmed" cases of carpal tunnel syndrome.
- b. An additional 15 percent of employees in this plant had "suspected" cases of carpal tunnel syndrome.

3. Harvard Garment Workers Study:

- a. Joint pain and disorders experienced by over 25 percent of workforce.
- b. Elevated rates of disorders among stitchers and cutters.
- c. Problems with existing data.

D. Costs:

1. Medical Costs.
2. Compensation Costs.

II. PROBLEMS OF THE BONES AND JOINTS

A. Structure of Joints:

1. The articulating surfaces of bones are covered with a smooth, tough, and slightly flexible material called cartilage.
2. Adjacent bones are held together by ligaments.
3. Synovial membranes secrete synovial fluid which acts as a lubricant between the cartilage surfaces of adjacent bones.

B. Function of Bones:

1. Act as mechanical lever arms.
2. Translate muscle contractions into limb movements and compressive forces.
3. Define shape and size of body segments.
4. Act as load-bearing structures.

C. Common Disorders of Bones and Joints:

1. Fractures — Structural failure of bone tissue usually caused by acute mechanical trauma.
2. Sprains — Stretching or tearing of ligaments usually caused by acute mechanical trauma.
3. Osteoarthritis — Degeneration of the articulating ends of bones caused by systemic disease and/or repeated mechanical trauma.
4. Rheumatoid Arthritis — Degeneration of soft tissue (e.g., ligaments, synovial tissues) caused by systemic disease and/or repeated mechanical trauma.
5. Both on—the—job and off—the—job activities may either cause or aggravate any of the above disorders.

D. Recommendations for Preventing Bone and Joint Injuries:

1. Use machine guards and personal protective equipment to prevent crushing injuries and fractures due to acute mechanical trauma.
2. Reduce the frequency and duration of repetitive exertions.
3. Reduce the force required to perform work tasks.
4. Avoid working postures which require joints to be used near the limits of their range of motion.

III. PROBLEMS OF THE MUSCLES

A. Structure of Muscles:

1. Skeletal muscles are composed of thousands of contractile fibers surrounded by a membrane called the perimysium.
2. The contractile tissue of the muscle is attached to the skeletal bones via non—contractile tissues called tendons.

B. Function of Muscles:

1. Muscle contraction causes the bones to rotate about the joints and results in movement of the limbs.
2. Muscle contraction allows forces to be exerted by the fingers, hands, and other body parts.

C. Common Disorders of Muscles:

1. Strains — Non—specific stretching or tearing of muscle tissue which results in inflammation and pain.
2. Muscle Fatigue — A temporary condition of discomfort and reduction in muscle efficiency that is caused by repeated or sustained forceful exertions.
3. Perimyositis — Inflammation of the perimysium, typically occurring near the point of attachment between contractile tissue and the tendon (example: tennis elbow).
4. These disorders may be caused or aggravated by on-the—job and off—the—job activities.

D. Recommendations for Preventing Muscle Injuries and Disorders:

1. Avoid frequent forceful exertions of any muscle group.
2. Avoid sustained isometric exertions of any muscle group.
3. Use strength data in designing jobs to assure that force requirements will not exceed the capability of the workforce (See Laubach, 1976).
4. Design tasks so that the strongest postures can be used:
 - a. Use handles that can be gripped rather than pinched.
 - b. Select postures which are near the center of the range—of—motion of working joints.
5. If possible, rotate workers among different jobs that do not stress the same muscles.

6. Avoid the use of stiff gloves or other personal protective equipment which offers significant resistance to body movements.

IV. PROBLEMS OF THE TENDONS AND TENDON SHEATHS

A. Structure:

1. Tendons are tough, flexible, non—contractile tissues which connect muscles to bones.
2. Some tendons are surrounded by sheaths (called bursa) at friction points.

B. Function of Tendons and Tendon Sheaths:

1. Tendons act as ropes, and allow muscle contractile forces to be translated to the bones.
2. Tendons sheaths surround the tendons and secrete synovial fluid which acts as a lubricant to reduce friction during movement.

C. Common Disorders of Tendons and Tendon Sheaths:

1. Inflammation of the tendon and/or the surrounding sheath.

a. This disorder may go by several names.

- (1) Tendonitis (also spelled tendinitis)
- (2) Synovitis
- (3) Tenosynovitis
- (4) Bursitis

b. Symptoms may include the following:

- (1) A burning pain or dull ache in area of the inflamed tissue.
- (2) Swelling (not always detectable)
- (3) Snapping or jerking movements of the tendon within the tendon sheath (also called crepitus).
- (4) Onset and relief of symptoms may be sudden.

c. Common sites include the following:

- (1) Finger extensor tendons on the dorsal side of the hand and wrist.
- (2) Finger flexor tendons on the palmer side of the wrist.
- (3) Thumb extensors and abductors (DeQuervain's Disorder).

d. Causes of these disorders include the following:

- (1) Performance of a new or unlearned task which results in frequent stressing of a tendon.
- (2) Acute or repetitive mechanical trauma to a tendon or tendon sheath.
- (3) Repetitive motions which result in the compression or stretching of tendons and/or tendon sheaths.
- (4) Exposure to vibrating tools.

2. Strains — Nonspecific stretching or tearing of tendons tissues.

3. Ganglions:

a. A ganglion is cyst that contains a thick mucous fluid that sometimes forms within a tendon sheath.

b. Common sites include the finger extensor tendons on the dorsal side of the hand and finger flexor tendons on the palmer side of the hand.

D. Recommendations for Preventing Tendon and Tendon Sheath

Injuries:

1. Minimize the frequency of hand actions which require flexion, extension, abduction or adduction of the wrist.
 - a. Design or select hand tools which can be used with a neutral wrist.
 - b. Avoid the use of workplace layouts or jigs which result in the use of extreme wrist postures.
2. Reduce the frequency, duration, and force exerted during hand work.
3. “Acclimatize” new employees who are assigned to jobs which require repetitive hand actions.
4. If possible, implement job rotation.
5. Wrist splints — Do they help or hinder?
6. Use medical history to prevent placing susceptible individuals on “high risk” jobs.

V. PROBLEMS OF THE NERVES

A. Neural Anatomy (upper extremities)-:

1. Nerves are specialized tissues which carry electrical impulses to transmit information between the central nervous system and peripheral parts of the body.
2. Three major nerves (radial, median, and ulnar) exit from the spinal cord in the neck region and innervate the hands.
3. Each nerve innervates a specific region of the hand.

B. Neural Functions:

1. Sensory:

- a. Nerves provide the central nervous system information regarding hand location, movement, and pressure on the skin.
- b. The skin on the palmar side of the hand (particularly the finger tips) is highly innervated and is capable of precise discrimination.
- c. Any decrement in sensory function due to nerve damage may result in serious limitations in the ability to perform precise manual work.

2. Autonomic:

- a. Nerves control blood flow to the hands and fingers.
- b. Nerves control activity of the sweat glands in the hands and fingers; decreased sweat output may reduce ability to securely grasp objects, and may lead to clumsiness.

3. Motor:

- a. Nerves control the contractions of the intrinsic muscles of the hands.
- b. Neural damage may result in muscle weakness and atrophy.
- c. Nerve damage may result in slowed tendon reflexes.

4. Manual Dexterity - The ability to perform hand work is dependent upon proper neural function, and the successful integration and coordination of sensory, autonomic, and motor activities.

C. Common Disorders of the Nerves:

1. Disorders due to mechanical trauma:

a. Digital neuritis.

- (1) This disorder results from the use of hand tools which compress the nerves which innervate the fingers.
- (2) The problem is frequently observed when high grip forces are used to grasp unpadded, small—diameter handles.
- (3) Symptoms include numbness and tingling in the hand and fingers distal to the point of compression.

b. Ulnar neuritis.

- (1) Ulnar neuritis results from compression of the ulnar nerve as it passes around the elbow.
- (2) The problem may be caused by working postures where the elbow is rested on the hard—surfaced bench or table.
- (3) Symptoms include numbness and tingling in the areas of the hand which are innervated by the ulnar nerve.

c. Palmer/Ulnar neuritis.

- (1) Palmer/Ulnar neuritis results from compression of the ulnar nerve as it passes through the palm.
- (2) The problem may be caused by repeated direct blows to the palm (e.g., from operating machines that are activated by palm buttons), or by palmer contact with a vibrating handle.
- (3) Symptoms include numbness and tingling in the areas of the hand which are innervated by the ulnar nerve.

d. Wrist—drop Syndrome.

- (1) Caused by damage to the radial nerve as it passes around the posterior aspect of the humerus.
- (2) Symptoms include weakness and atrophy of the wrist extensor muscles.

e. Thoracic Outlet Syndrome.

- (1) Caused by compression of the neurovascular bundle in the region of the clavicle and the first rib during motions that require extension and abduction of the shoulder.
- (2) Symptoms include vascular changes in the arm and hand, and numbness in the fourth and fifth fingers.

f. Pronator Syndrome.

- (1) This disorder is caused by hypertrophy of the pronator teres muscle in the forearm, and the resulting compression of the median nerve.
- (2) The problem may be caused by tasks that require repeated forceful exertions with a pronated forearm.
- (3) Symptoms include numbness and tingling in the areas of the hand which are innervated by the median nerve.

g. Carpal Tunnel Syndrome — This condition (covered in detail in the next section) is caused by compression of the median nerve as it passes through the bony structures of the wrist.

2. Disorders due to chemical exposures:

a. Heavy Metals

b. Solvents.

D. Recommendations for Preventing Neural Disorders:

1. Disorders due to mechanical causes.

- a. Select tools with handles which do not place concentrated compressive forces over digital nerves.
- b. Design workstations so that it is not necessary to lean on the elbows for extended periods of time.
- c. Design workstations, equipment, and tools so that upper extremity joints are not grossly deviated from neutral positions.
- d. Minimize exposure to vibrating tools.

2. Disorders due to chemical causes.

- a. Ventilation.
- b. Personal protective equipment.
- c. Medical surveillance.

VI. THE CARPAL TUNNEL SYNDROME

A. Description — The Carpal Tunnel Syndrome is a nervous condition of the hand and fingers which, is caused by compression of the median nerve as it passes through the carpal tunnel. The carpal tunnel is a narrow anatomical structure which is formed by bones on three sides, and a ligament on the fourth. The median nerve passes through this “tunnel” along with the tendons that flex the fingers and close the fist (adapted from Armstrong, 1982).

B. Symptoms:

1. Numbness, tingling, and/or burning sensations in the areas of the hand that are innervated by the median nerve.
2. Atrophy of the thenar muscles at the base of the thumb.
3. Dry, shiny skin on the palmar surface of the hand.
4. Clumsiness of the affected hand(s).
5. The symptoms associated with the carpal tunnel syndrome are frequently reported to be most acute at night, and therefore are sometimes never associated with occupational activities. Some people who are afflicted with the syndrome report that they can temporarily alleviate the symptoms by rapidly shaking the affected hand(s).
6. In addition to the above symptoms, carpal tunnel syndrome may result in the loss of manual dexterity and decreased performance on simple hand tasks.
 - a. Handwriting.
 - b. “Pegboard” tests of manual dexterity.
 - c. Increased cycle times for manual assembly tasks.

C. Diagnosis of Carpal Tunnel Syndrome:

D. Causes (adapted from Armstrong, 1982):

Carpal Tunnel Syndrome can be caused or aggravated by both occupational and non—occupational activities. Hand actions that involve repetitive flexing of the wrist, particularly in combination with forceful exertions, can lead to irritation of the synovial membranes that lubricate the tendons in the carpal tunnel. The resulting swelling of the synovial membranes may result in nerve compression. The nerve may also be compressed by the tendons inside the carpal tunnel when the wrist is flexed.

VII. MANUAL MATERIALS HANDLING AND LOW BACK PAIN

A. Commonly Affected Occupational Groups:

1. Truck Drivers.
2. Materials Handlers.
3. Nurses and other Hospital Workers.

B. Prevalence:

1. One—half of all industrial workers are affected by low back pain at some time during their careers.
2. One—quarter of all industrial workers miss at least one day of work as a result of low back pain during their careers.
3. In any given year, approximately two percent of the U. S. workforce will experience a compensable back injury.

C.. Costs:

1. Injuries that occur during materials handling activities are the leading cause of Workers' Compensation payments i the U. S.
2. Back—related Workers' Compensation costs U. S. employers approximately \$20 Billion annually.
3. Back injuries result in approximately 12 million lost workdays each year in the U. S.
4. The cost of an “average” low back case is over \$5500.
5. Indirect costs may raise total U. S. loss to over \$30 Billion annually.

D. Proposed Solutions for Reducing Low Back Injuries:

1. Employee Training.
 - a. Safe lifting techniques.
 - b. Employee aids.
 - c. Research findings.
2. Employee Selection.
 - a. Medical Screening.
 - b. Strength testing.
 - c. Research findings.