Work-related Musculoskeletal Disorders

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Work-related Musculoskeletal Disorders
(NIOSH, 1997)

- 32% (705,800) of work-related injuries arise from overexertion or repetitive motion:
  - 367,424 injuries due to overexertion in lifting (65% back injuries)
  - 93,325 due to overexertion in pushing/pulling (52% back injuries)
  - 68,992 due to overexertion in holding, carrying or turning objects (58% back injuries)
  - 47,861 shoulder injuries
  - 83,483 unspecified overexertion injuries
  - 92,576 repetitive motion injuries (including typing, key entry, repetitive hand tool use, repetitive grasping etc.) 55% affect the wrist, 7% affect the shoulder and 6% affect the back

Workplace Injuries

- Sprains and strains, by far, are the leading occupational injuries (between 30% - 50% for any industry).
- Injuries most commonly occur to the back and upper limbs.
- Repetitive motions, such as typing, resulted in the longest absences from work.
- Carpal tunnel syndrome has the highest median days away from work.

Workplace Injuries

- Sprains and strains are the leading occupational injuries (34% - 51% depending on the industry).

OSHA

"We are compelled to act.
Employees are getting hurt.
Workers are being sent home.
People are suffering."

Charles Jeffress.
Assistant Labor Secretary for
Occupational Safety and Health

OSHA Proposed Rules

- Nov. 23, 1999.
- 310 page document.
- Summarizes > 2,000 articles on work-related MSDs.
- Hundreds of published success stories.
- "High levels of exposure to ergonomic risks increase work-related MSDs".

OSHA’s Pending Ergonomics Regulations
Companies will need to introduce ergonomic programs to protect their employees against MSDs within a 3 year period.

Implement Engineering and Administrative controls

**Upper Body Cumulative Trauma Disorders (CTDs) and Carpal Tunnel Syndrome (CTS).**

**Common Tendon-related MSDs**

- Tenosynovitis – irritation of the synovial membrane surrounding the tendon.
- Tendonitis – irritation or inflammation of a tendon. Accompanied by swelling, pain, “popping” sound as tendon moves and catches on the sheath (e.g. trigger finger, De Quervain’s disease).
- Ganglionic cyst – cyst on the tendon sheath causes a bump under the skin.
- Epicondylitis – inflammation of the unsheathed tendons in the elbow:
  - Lateral epicondylitis - tennis, pitcher’s, bowler’s elbow (outside)
  - Medial epicondylitis - golfer’s elbow (inside)
- Rotator cuff tendinitis – inflammation of the shoulder tendons that rotate the arm inward/outward.
- Bursitis - inflammation of the bursa (small, fluid-filled sacs) in either the elbow, shoulder or knee (housemaid’s knee).

**Common Nerve-related MSDs**

- Carpal Tunnel Syndrome – compression and neuropathy of the median nerve inside of the carpal tunnel of the wrist.
- Thoracic outlet syndrome – compression of the nerves and blood vessels between the neck and shoulder – the neurovascular bundle.
- Vibration syndrome (white finger, Raynaud’s disease) – vasospasms to the hands and fingers causing intermittent blanching.

**Work-related Musculoskeletal Disorders**

**Upper limb anatomy**

- Ulnar and median nerves run down the arm from the spinal cord in the neck.

**Radial Nerve**

**Upper limb anatomy**

**Upper limb anatomy**

**Hand anatomy**
Tendons

- Tendons connect muscle to bone to create movement.

Tendon Inflammation

- Tenosynovitis – synovial sheath inflammation
- Tendonitis – tendon inflammation

Trigger Finger

- Triggering is result of a thickening in the tendon that forms a nodule and/or thickening of the pulley ligament.
- Constant irritation from the tendon repeatedly sliding through the pulley causes the tendon to swell in this area and create the nodule.
- Rheumatoid arthritis, partial tendon lacerations, repeated trauma from pistol gripped power tools, or long hours grasping a steering wheel can cause triggering. Infection or damage to the synovium causes a rounded swelling (nodule) to form in the tendon.
- Symptoms of trigger finger or thumb include pain and a clicking sensation when the finger or thumb is bent. Pain usually occurs when the finger or thumb is bent and straightened. Tenderness usually occurs over the area of the nodule - at the bottom of the finger or thumb.

Guyon’s Tunnel Syndrome

- Ulnar nerve compression as it passes through a tunnel in the wrist called Guyon's canal.
- Caused by overuse of the wrist, especially in tasks bending the wrist down (flexing) and out (ulnar deviation), or put constant pressure on the palm.
- Symptoms include feeling of pins and needles in the ring and little finger, starting in the early morning before waking. This progresses to a burning pain of the wrist and hand, followed by decreased sensation and eventually clumsiness in the hand, including weakness, an inability to spread the fingers, and a weak pinch in the thumb.

De Quervain’s Tenosynovitis

- Pain on the side of the wrist and forearm just above the thumb from the two tendons [abductor pollicis longus (APL) and the extensor pollicis longus (EPL)] used to pull the thumb out and back from the hand.
- Repetitive grasping, pinching, squeezing, or wringing may lead to an inflammation of the tendons and the covering around the tendons, the tenosynovium, which leads to swelling, which further hampers the smooth gliding action of the tendons within the tunnel.
- Soreness on the thumb side of the forearm, pain may spread up the forearm or down into the wrist and thumb. Due to an increase in friction, the two tendons may actually begin to squeak as they attempt to move through the constricted tunnel. This noise is called crepitus.

Ulnar Nerve Innervation

Median Nerve Innervation

- Median nerve innervation of the hand.

Hand Innervation

- Ulnar nerve
- Radial nerve
- Median nerve
Wrist anatomy

- Finger flexor tendons, the median nerve and the radial artery pass through the carpal tunnel in the wrist.
- The ulnar nerve and artery pass outside the carpal tunnel.

Carpal Tunnel Anatomy

- Finger flexor tendons, the median nerve and the radial artery pass through the carpal tunnel in the wrist.

Carpal Tunnel Volume

(Pierre-Jerome et al., 1997)

- 108 wrists (52 CTS patients, 56 controls) studied.
- Fast field echo (FFE) imaging sequence (25 continuous slices) used to obtain axial images from distal radioulnar joint (tunnel inlet) to the metacarpal bases (tunnel outlet).
- Tunnel is irregular conical shape.
- No difference in tunnel volume between cases and controls.

MRI Image of the Carpal Tunnel

- Fast field echo (FFE) image of right wrist, colorized to show the carpal tunnel and thenar muscles.

Carpal Tunnel Anatomy (MRI)

Carpal Tunnel Sonogram
(Univ. Michigan Medical School)

Normal Wrist Function

Carpal Tunnel Syndrome

Tests for Carpal Tunnel Syndrome

- Phalen’s sign
  - does holding wrists in flexion for 60 seconds or less produce symptoms?

Tests for Carpal Tunnel Syndrome

- Tinel’s sign
  - does tapping the wrist at the carpal tunnel produce tingling/numbness?

Tests for Carpal Tunnel Syndrome

- Nerve conduction velocity
  - velocity slows with neuropathy
CTS Surgery

- Various methods that now favor endoscopic surgery involves cutting the transverse carpal ligament to relieve pressure inside the carpal tunnel.

Hand posture: Lateral deviations

Lateral Deviation and ICP

(Rempel, 1992)

Hand posture: Vertical deviations

Vertical Deviation and ICP

(Honan et al., 1995)

Elbow MSDs

- Lateral Epicondylitis (tennis elbow)
  - Tendinitis of the extensor carpi radialis brevis muscle which attaches to the lateral epicondyle of the humerus. It may be caused by a sudden injury or by repetitive use of the arm.
  - Caused by strong gripping with the elbow in an extended position, as in a tennis backhand stroke. It can occur in golf and other sports, and with repetitive use of tools (e.g., mouse).
  - Symptoms include tenderness and pain at the lateral epicondyle, made worse by activities that require extending the wrist or holding an object in the hand with the wrist stiff.

Elbow MSDs

- Medial Epicondylitis (golfer’s elbow)
  - The golf swing is a common activity that can cause the problem. There are many other activities that can result in medial epicondylitis - such as chopping wood with an ax, running a chain saw, and using many types of hand tools continuously.
  - Symptoms include tenderness and pain at the medial epicondyle, made worse by flexing (bending) the wrist. The pain may spread down the forearm. Pain occurs with activities that use the flexor muscles in a bending motion or grasping with the hand.

Elbow MSDs

- Cubital tunnel syndrome
  - Ulnar nerve compression where it crosses the elbow. Symptoms similar to the pain that comes from hitting your funny bone.
  - Ulnar nerve stretches several millimeters when the elbow is bent.
  - Frequent bending of the elbow such as pulling levers, reaching, or lifting are common sources of problems.

Thoracic Outlet Syndrome

- Compression of the neurovascular bundle at the shoulder associated with repetitive activities that require the arms to be held overhead or extended forward.
- Slouching forward and dropping the shoulders causes tension in the muscles at side of the neck and constricting the arteries and nerves.
- Symptoms include pain, weakness, numbness and tingling, swelling, fatigue or coldness in the arm and hand. Symptoms can mimic those of a herniated disk in the neck, carpal tunnel syndrome, and even bursitis of the shoulder.
Rotator Cuff

- Rotator cuff tendons have areas with poor blood supply.
- Excessive force, such as catching a falling heavy object, or lifting an extremely heavy object with the arm extended, can tear tendons.
- Most rotator cuff tears cause a vague pain in the shoulder area, and may result in a "catching" sensation when the arm is moved.

Musculoskeletal Disorders (MSDs)

- Progressive, debilitating injuries.
- Overuse (accelerated joint aging) injuries heralded by discomfort, aches and pains.
- Predictable for populations from occupational risk factors.
- Treatable by appropriate ergonomic intervention.
- Preventable by proactive ergonomic intervention.

Occupational Risk Factors for MSDs

Does repetition and force matter?

(Byl et al., Physical Therapy, 77(3), 269-284, 1997)

- Trained 2 owl monkeys to repetitively close a handpiece (80-g force) for 1.5 hours (~400 squeezes) a day, for 5 weeks.
- Results showed a deterioration in motor control and degradation of hand representation on the somatosensory cortex.

Prevalence of MSD risks

Postural Risks of Computer Use

- Deviated wrists (extension/flexion; ulnar/radial deviation).
- Flexed elbows.
- Abducted shoulders.
- Deviated neck (extended/flexed; twisted; tilted).
- Hunched postures (Homo computerus).

Deviated Typing Posture

(Homo computerus!)

Ergonomic Keyboard Design?

Neutral Zone of Hand Movement

(Hedge, 1998)

Fixed-Angle Split Keyboard Study

(Hedge & Ng, 1995)
Mouse Use and Injuries

Word processing software requires using a mouse >33% of the time (CTD News, 1996).

Graphics software requires using a mouse >66% of the time (CTD News, 1996).

Mouse-related claims have risen from 0 in 1988 to 326,099 in 1993 (Fogelman & Brogmus, 1995).

Mouse-related injuries are linked to mouse design and its position in the workstation.

Wrist Posture and Mouse Use

Some mouse designs can encourage ulnar deviation of the wrist, especially as the mouse is drawn closer to the body.

Does mouse design matter? (Cornell Study, 1999)

What happens to wrist posture with different mouse designs?

Mouse Design and Injury Risk (Cornell Study, 1999)

24 subjects (men/women; 5th/50th/95th %ile).

Microsoft mouse (A) Whale mouse (B).

No differences in ulnar deviation.

Significantly less wrist extension with the Whale mouse.

Mousing Hand Posture (Cornell Study, 1999)

Mouse design has a major effect on wrist extension.

An adjustable design accommodates a range of hand sizes.

A larger, flatter design significantly reduces wrist extension.

Wrist Posture and Trackball Use

Trackball design encourages wrist extension, especially when the trackball is used on a lowered, flat platform.

Neck Posture

Balanced neck posture is important

Head Support Muscles

Neck Discomfort

Poor viewing angle

Poor monitor position

Poor document position

Poor seated posture