

Work-related Musculoskeletal Disorders

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Ergonomics: Foundations

- Bernardino Ramazzini (1633-1714).
- Founder of occupational/ industrial medicine.
- Studied occupational diseases and advocated of protective measures for workers.
- Encouraged eventual passage of factory safety and workmen's compensation laws.
- In 1700 he wrote *De morbis artificum diatriba* (Diseases of Workers) describing the health hazards of irritating chemicals, dust, metals, other abrasive agents and repetitive motions for workers in 52 occupations.
 - Bernardino Ramazzini, 1700.
- "[I have seen] workers in whom certain morbid affections gradually arise from some particular posture of the limbs or unnatural movements of the body called for while they work."
- "Such are the workers who all day stand or sit, stoop or are bent double, who run or ride or exercise their bodies in all sorts of [excess] ways."
- "'... the harvest of diseases reaped by certain workers . . .[from] irregular motions in unnatural postures of the body."

Bernardino Ramazzini, 1700.

Standing:

- "Those who work standing ...carpenters, sawyers, carvers, blacksmiths, masons . . .are liable to varicose veins. . . [because] the strain on the muscles is such that the circulation of the blood is retarded."
- "Standing even for a short time proves exhausting compared with walking and running though it be for a long time. . . . Nature delights and is restored by alternating and varied actions."
- Bernardino Ramazzini, 1700.

Sitting

- "Those who sit at their work suffer from their own particular diseases. As noted back in Roman times by the learned slave Plautus, 'sitting hurts your loins, staring, your eyes.' "
- "All sedentary workers...suffer from the itch, are a bad color, and in poor condition.. . . for when the body is not kept moving the blood becomes tainted, its waste matter lodges in the skin, and the condition of the whole body deteriorates."
- Bernardino Ramazzini, 1700.

Repetitive hand motions

- "I have noticed bakers with swelled hands, and painful, too; in fact the hands of all such workers become much thickened by the constant pressure of kneading the dough."

- Bernardino Ramazzini, 1700.

Office work

- “The maladies that affect the clerks arise from three causes: first, constant sitting; secondly, incessant movement of the hand and always in the same direction; and thirdly, the strain on the mind...”
- “The incessant driving of the pen over paper causes intense fatigue of the hand and the whole arm because of the continuous . . . strain on the muscles and tendons.”
- “An acquaintance of mine, a notary by profession, who, by perpetual writing, began first to complain of an excessive wariness of his whole right arm which could be removed by no medicines, and which was at last succeeded by a perfect palsy of the whole arm. . . . He learned to write with his left hand, which was soon thereafter seized with the same disorder.”
 - Upper Extremity Work-related Musculoskeletal Disorders (WRMSDs)

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 or 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

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.

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 a 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.

Upper limb anatomy

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

Radial Nerve

Ulnar Nerve Innervation

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.

Median Nerve Innervation

- Median nerve innervation of the hand.

Median Nerve Innervation

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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 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 back hand 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.

Neck Posture

- Balanced neck posture is important

Head Support Muscles

Neck Discomfort

- Poor viewing angle
- Poor monitor position
- Poor document position
- Poor seated posture

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

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?

Fixed-Angle Split Keyboard Study

(Hedge & Ng, 1995)

Neutral Zone of Hand Movement

(Hedge, 1998)

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.

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.