**Hand Tools and Devices**

- Overview of Hand Tool Injuries
- Most Common is Cumulative Trauma Disorders (CTD’s)
- Overview of CTD’s
- Principles of Hand Tool Design
- Standards To Prevent CTD’s
- What Causes CTD’s
- Prevention of CTD’s

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**Introduction**

Cumulative Trauma Disorder (CTD’s)
- symptoms develop gradually
- injury from mechanical stress
- usually due to repeated microtrauma
- do not act until:
  - symptoms are chronic permanent injury
- injury from mechanical stress
- physical ailment or abnormal conditions

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**Introduction**

Risk Factor:
- any attribute, experience, or exposure that increases the probability of occurrence of a disease or disorder
- though not necessarily a causal factor
- many risk factors associated with CTD’s
- example: work, activities
- CTD’s not limited to industry
- Some activities associated with CTD:
  - examples: gripping, twisting, and reaching

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**Introduction**

Increase in Cumulative Trauma Disorders

WHY?
1. an increase in service and high-tech jobs
2. an aging workforce, and
3. a reduction in worker turnover

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**Human Hand**

- Anatomy
  - Carpal Tunnel
    - channel formed by back of the hand and transverse
  - Carpal Ligament
    - Tendons connecting muscles to fingers, radial artery, and median nerve pass through tunnel.
Human Hand

Hand and Wrist Movements
1. Vertical movements with palm facing down
   - Dorsiflexion
   - Neutral
   - Palmar flexion
2. Horizontal movements with palm facing down
   - Radial deviation
   - Neutral
   - Ulnar deviation

Overview of CTD’s

Tendon Disorders:
- tendinitis
- tenosynovitis
- stenosing tenosynovitis (De Quervain’s disease)
- trigger finger (stenosing tenosynovitis crepitans)
- ganglion cyst
- tennis elbow (epicondylitis)

Nerve Disorders:
- carpal tunnel syndrome

Neurovascular Disorders:
- thoracic outlet syndrome
- vibration syndrome

Main Causes of CTD’s
(1) Awkward Posture
(2) Excessive Manual Force
(3) High Rates of Manual Repetition

Principles of Hand Tool and Device Design
1. Maintain a Straight Wrist
   A. Flexor tendons of fingers pass through carpal tunnel at wrist
   B. Wrist aligned with forearm - no problem
   C. Wrist bent (especially palmer flexion or ulnar deviation) requires higher grip strength to be maintained
      Examples include hammer, pliers, pivoting head razor

Problems That May Occur:
Tenosynovitis
- tendon disorder
- general term for a repetitive-induced tendon injury
- the tendon sheath produces extra synovial fluid

Carpal Tunnel Syndrome
- nerve disorder
- repeated or sustain work activities expose the nerves to pressure
- median nerve being pinched
Hand Tools and Devices

1. Maintain a Straight Wrist

Epicondylitis (tennis elbow)
- tendon disorder -- deals with the unsheathed tendons in the elbow
- elbow is vulnerable to many tendon problems due to the imbalance between the forearm muscles and the small area of the elbow

Reduction of grip strength
- occurs when wrist is bent in any direction

Designing to Avoid Problems

** Keep Wrist Straight**

Bend the tools, not the wrist

John Bennet
bent handles (19 +/- 5 degrees)
ulnar deviation reduced

Principles of Hand Tool and Device Design

2. Avoid Tissue Compression

A. Due to considerable forces on the palms and at the wrists

B. Compresses not only tissue, but pressure-sensitive areas over nerves and blood vessels

Problems That May Occur:

Ischemia
- obstruction of blood flow
- leads to numbness, tingling of fingers
- can be temporarily alleviated through rest

Thrombosis
- compression of the ulnar artery

Designing to Avoid Problems

- handles should have large contact surfaces
- distributes force over larger

Finger Grooves - Avoid
- people are different
- thick fingers (grooves will cut into hand)
- small fingers (two fingers fit into one groove)
- instead, increase surface area of handle and use wood, rubber, or soft plastic

2. Avoid Repetitive Finger Action

Problem That May Occur:

Trigger Finger (stenosing tenosynovitis crepitans)
- a form of tenosynovitis
- can flex, but not extend finger
- tendon sheath of a finger becomes swollen and the tendon becomes locked in place
Hand Tools and Devices

3. Avoid Repetitive Finger Action

Designing to Avoid Problems

- use thumb instead
- finger-strap controls are better

- consider males and females
- grip strength directly related to size of object being gripped

4. Design For Safe Operation

A. Eliminate pinching hazards
B. Round sharp edges and corners
C. Brake devices and power switch locations on power tools
D. Consider how tools will be used and misused

Principles of Hand Tool and Device Design

5. Remember Women and Left-Handers

A. Women
   - smaller hands
   - decreased grip strength (2/3 of men)
B. Left-Handers
   - can’t even use some tools (serrated bread knife, scissors)

- 50% of the world population
- 8-10% of the world population

- Vibration - effects on hand and arm

Hand-Arm Vibration Syndrome (HAVS)

- vibration-induced white finger (VWF), vibration syndrome, Raynaud’s phenomenon, dead hand, occupational vasomotor traumatic neuritis, traumatic vasospastic disease
- not fully understood
- probably involves damage to the nerves and smooth muscles of the blood vessels in the hand

Standards To Prevent VWF
- except for NIOSH, other standards use a frequency-weighted acceleration, m/s²
- National Swedish Board of Occupational Safety and Health
- set max. permissible vibration levels for chain saws
- Lowered from 80 N to 50 N (newtons, force)
- Redesigned saws, used vibration damping rubber elements
- VWF incidents decreased from 49% to 28%
- symptoms of 28% less severe
Controlling Hand-Arm Vibration Exposure

1. Select tools with the lowest level of vibration
2. Properly maintain tools and keep cutting tools sharpened
3. Use vibration-reduction gloves
4. Minimize grip force
5. Rotation of tasks between vibrating and non-vibrating
6. Limit time on tasks (daily and weekly)
7. Provide adequate rest

Searching for CTD Indicators

How do you determine whether the workers in a job, work group, plant, or company have symptoms of CTD?

1. Reviewing Available Records
2. Surveying the Workers
3. Analyzing Jobs

Minimum Information Required for Evaluating Records

1. total number of CTD cases reported
2. date of each case
3. department of injured worker
4. number of workers on the same job or in the same department

Incidence Rate

- the number of new cases that come into being during a specified period of time

\[
\text{Incidence Rate} = \frac{\text{# new cases per year} \times 200,000 \text{ work hours}}{\text{# workers in dept} \times 2000 \text{ hours}}
\]

(estimated hours worked)

Example (estimated hours worked):

Department X, with 907 workers, reported 21 cases of shoulder tendinitis in 1983. The department worked no overtime, so the figure of 2000 hours per worker is used. What is the incidence rate?

\[
\frac{21 \times 200,000 \text{ work hours}}{907 \times 2000 \text{ hours}} = 2.31 \text{ cases per 100 workers per year}
\]
Example (actual hours worked): Department A has 450 employees that have worked 900,000 hours. There have been 22 cases of tendinitis reported in 1992. What is the incidence rate?

\[ \frac{\text{new cases per year} \times 200,000 \text{ work hours}}{\text{total hours worked}} \]

4.88 cases per 200,000 work hours (6 cases per 200,000 is acceptable)

Limitations
- Workers memory
- Workers willingness to report
- Unknown in earlier stages

Surveys and Questionnaires
Medical Screening Exams

(2) Analyzing Jobs - already discussed

Work-Methods Analysis
- Gilbreth’s table of work elements
- MTM (Method-Time Measurement system)

Ergonomic Checklist

(3) Preventing CTD’s

Administrative and Engineering

personnel solutions

- redesigning tools, work stations, and jobs

(2) Engineering Controls
- Fit the task to the person
- Consider alternative designs
- Coping with obstacles in redesigning jobs

Design Principles Based on Ergonomics
(1) Reduction of extreme joint movement
(2) Reduction of excessive force levels
(3) Reduction of highly repetitive and stereotyped movements
**Alternative Designs - Human Factors Applications**

**REACH toothbrush** - (designed by Applied Ergonomics)

1. Small bi-level bristle head - concentrate and brush on small area, massage gums, reach back teeth
2. Angled (12 degrees) and shaped handle - easy to use, less wrist bending
3. Contoured thumb area - easy to use

**Writing Instruments**

**KODAK Disc Camera**

1. KAO study of writing tools
2. Trade-off, speed vs. fatigue - felt tip pen best overall

**Other Considerations**

1. Reduction in Grip Strength - may lead to negative consequences
2. Glove too thick - grab tool with little force - Hazardous
3. Irritants in glove - chemicals soaking in, adverse affects