Ergonomic Interventions in the Building and Construction Industry

James T. Albers, Ph.D.,
National Institute for Occupational Safety & Health(NIOSH)

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Jim Albers, Cherie Estill & Steve Hudock
National Institute for Occupational Safety & Health (NIOSH)
4676 Columbia Parkway, MS C-24
Cincinnati, OH 45226-1998

Safety & Health Through Research & Prevention

Presentation Topics

- Background
- Work-related musculoskeletal disorders
- Ergonomic principles
- WMSD risk factors in construction
- Controlling exposures to WMSD risk factors
- Construction ergonomic interventions

Program Background

- Federal occupational health & safety research agency established by the OSH Act (1970)
  - Responsible for conducting research and making recommendations for the prevention of work-related disease and injury
  - Part of the Centers for Disease Control and Prevention (CDC) in the Department of Health and Human Services

Ergonomic Engineering Interventions for the Construction Industry

- Purpose – to advance the development and dissemination of practical control technologies to reduce construction workers' exposures to recognized WMSD risk factors
- Methods – assess technologies according to their effect on reducing WMSD risk factors and effects on safety, acceptability and cost effectiveness

Current program activities

- Intervention effectiveness research
  - Screw-gun extender for overhead tasks
  - Concrete screeding & finishing techniques
  - Automatic tier for tying (fixing) concrete reinforcement steel
  - Overhead rotary-hammer drill stand
  - Manual hand tool design
- Meetings
  - Exploring Ergonomic Interventions for the Mechanical and Electrical Construction Trades – February 2002

Current activities, cont.

- Safety in Design – September 2003
- Ergonomic Interventions for Concrete & Masonry Trades – March 2004

- Publications
  - In print: *Proceedings of a Meeting to Explore Ergonomic Interventions for the Mechanical & Electrical Trades*
  - Planned: *Simple Solutions-Ergonomic Interventions for Construction Work*

Occupational Ergonomics

- Goals
  - Decrease injuries & illnesses
  - Improve human performance
- Disciplines
  - Human Factors
  - Biomechanics
  - Work Physiology
  - Engineering Psychology
  - Engineering Anthropometry

Benefits of Applying Ergonomics Principles to Construction

- Safer jobs with fewer injuries
- Increased efficiency and productivity
- Improved work quality and fewer errors
- Improved worker morale

Work-Related Musculoskeletal Disorders

- Soft tissue injuries involving the nerves, tendons, muscles, ligaments, joints, cartilage, or spinal discs
- Acute or 'immediately occurring' strain, sprain, or tear
- Chronic injury developing over time
  - Cumulative trauma disorders (CTD)
  - Repetitive strain injury (RSI)
  - Occupational overuse injury
  - Wear and tear injury

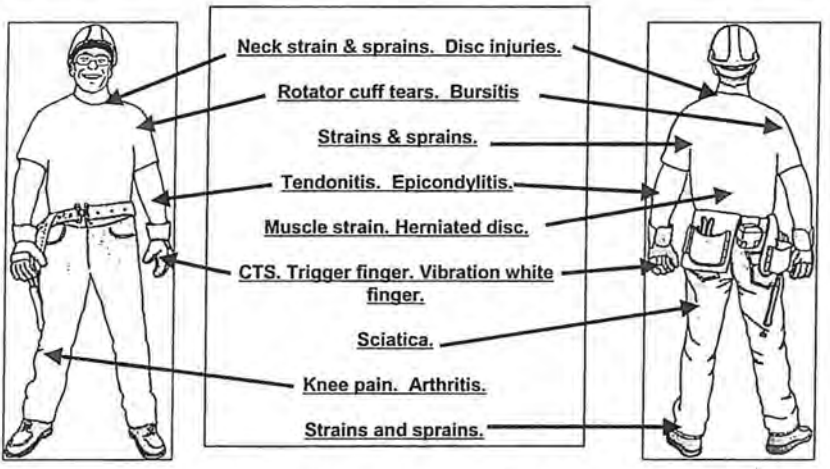
Strains, Sprains, & Tears

- Injury to the soft tissues
- Usually the result of single incident
- Caused by combination of physical exertion, awkward posture, or fast body movement

Cumulative Trauma Disorders (CTDs)

- Injury to the soft tissues that develops over time – weeks, months or years
- Types of disorders
  - Inflammation of the tendon (tendonitis) and tendon sheath (tenosynovitis)
  - Joint disorders
    - Bursitis (knees, shoulders & elbows) & arthritis
  - Nerve disorders
    - Carpal tunnel syndrome
  - Neurovascular disorders
    - Vibration white finger
    - Thoracic outlet syndrome

Soft tissue injuries affecting construction workers



From Physical Stress Management by Sheet Metal Occupational Health Institute Trust.

Construction workers' self-reported symptoms & treatment for WMSDs

- 70% of construction workers reported low-back symptoms during the previous year and 31% reported that they had visited a physician for those symptoms. (1)
- 51% of electricians reported back symptoms during the previous year and 34% said they visited a physician for those symptoms, also 47% reported hand/wrist symptoms. (2)

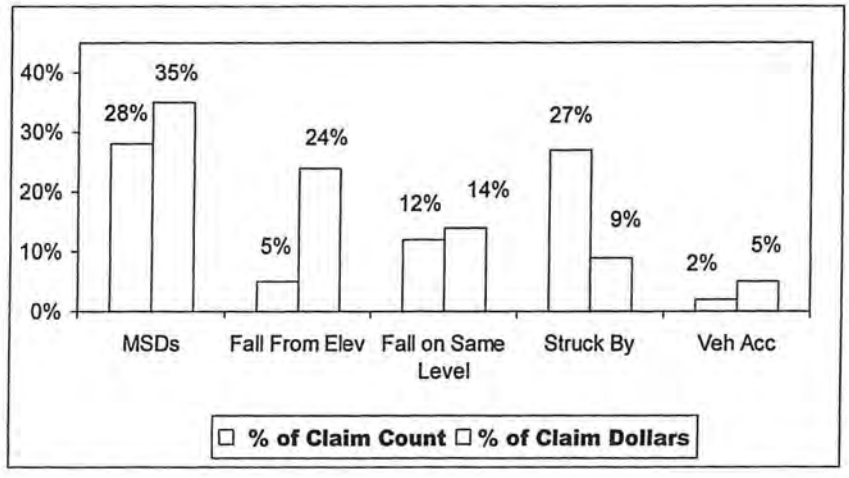
(1) Cook TM, JC Rosecrance, and CL Zimmerman [1996]a. The University of Iowa Construction Survey, Biomechanics and Ergonomics Facility Report E1-96. CPWR: Washington DC, April.
(2) Hunting KL, et al. [1994] Musculoskeletal Symptoms among Electricians. *Am J Ind Med 25*(2):149-163.

Washington State Upper Extremity (UE) WMSD claims (1987-1999) study

- Construction industry sectors accounting for high UE WMSDs rate ratios and claims incidence rates
  - Wallboard installation (shoulder, elbow, CTS)
  - Roofing (shoulder, elbow, hand-wrist, CTS)
  - Fence erection (shoulder, elbow)
  - Commercial concrete construction (rotator cuff syndrome)
  - Masonry (rotator cuff syndrome, elbow)
  - Insulation installation (rotator cuff syndrome, elbow)
  - Glass installation (elbow)
  - Building construction, not otherwise classified (noc) (epicondylitis)
  - Reinforced steel installation (hand-wrist)

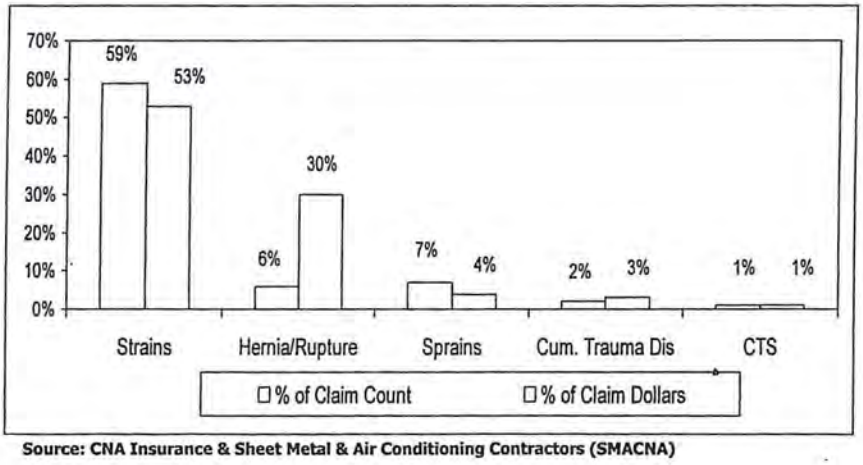
Source: Silverstein B, Welp E, Nelson N, Kalat J [1998] Claims Incidence Rates of Work-Related Disorders of the Upper Extremities: Washington State, 1987 through 1995. *American Journal of Public Health 88*(12):1827-1833.

WMSD Impact on Mechanical Trades WC Claims & Costs 1999-2001



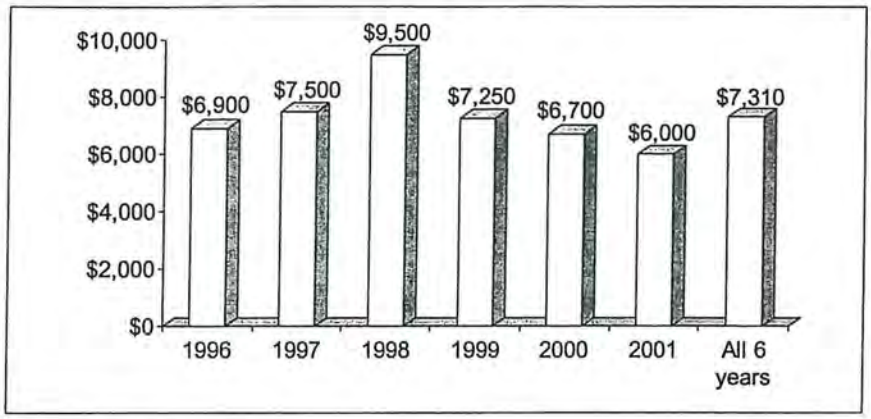
Source: CNA Insurance & Sheet Metal & Air Conditioning Contractors (SMACNA)

WMSD Frequency for Mechanical Trades WC Claims 1999-2001



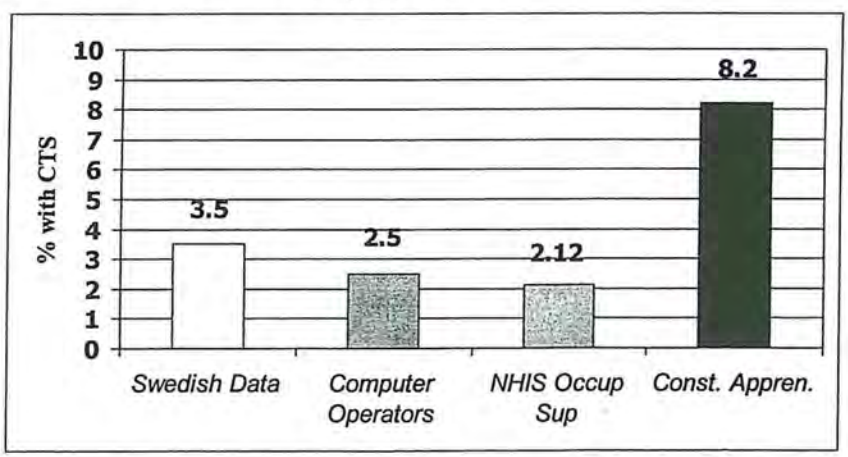
Source: CNA Insurance & Sheet Metal & Air Conditioning Contractors (SMACNA)

Average cost of Mechanical Trades WMSD Claims 1996-2001



Note: 2001 costs incomplete.
Source: CNA Insurance & Sheet Metal & Air Conditioning Contractors (SMACNA)

Carpal Tunnel Syndrome (CTS) Prevalence Comparison



Rosecrance JC, Cook TM, Anton DC, Merlino LA [2002]. Carpal tunnel syndrome among apprentice construction workers. Am J Ind Med *42*:107–116.

Characteristics of WMSD Risk Factors

- Job or task condition that increases the risk of developing a work-related musculoskeltal disorder
- WMSD risk increases with frequency and duration of exposure to risk factors
- Exposure to multiple risk factors
- Presence of a risk factor does not guarantee an injury will occur

Work-related musculoskeletal disorder (WMSD) risk factors

- Using repeated motions or movements
- Using forceful exertions
- Working in a sustained or awkward posture
- Contact with vibrating tool or equipment
- Tools & other objects pressing on the body
- Exposure to extreme temperatures

(Hsiao and Stanevich, 1996)

Controlling exposures to WMSD risk factors

- Substitution
- Engineering controls
- Administrative controls
- Personal protective equipment

Controlling Exposure to WMSD Risk Factors

Substitution

- Remove risk factors from work process by substituting
  - Redesign building systems
    - Upstream design change to eliminate exposure to risk factors
  - Mechanize/automate task
    - Substitute mechanical power to eliminate or reduce physical effort
  - Use different materials
    - Change the size or weight of building materials

Controlling Exposure to WMSD Risk Factors

Engineering controls

- Use tools and equipment to reduce or eliminate exposure to risk factors
  - Increase mechanical advantage
  - Reduce repetitive motion
  - Reduce static and awkward postures
  - Reduce contact stress
  - Sit-stand stools
  - Add handles for carrying materials

Changes in work practices

- Work tables to work at standing height
- Require two workers to lift heavy object
- Learn easier techniques from more experienced workers

Controlling Exposure to WMSD Risk Factors

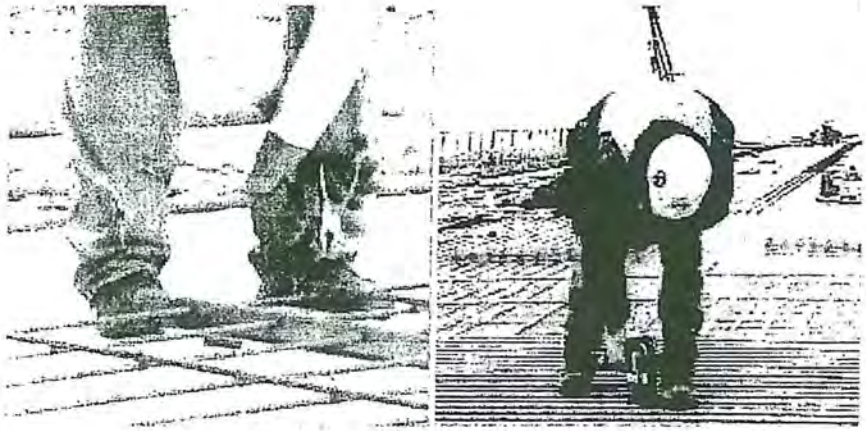
Administrative controls

- Change work organization to reduce exposure to risk factors
  - Rotate workers on problem jobs
  - Include soft-tissue injury hazards in job hazard analyses & other OS&H activities
  - Promote injury reporting
  - Rest breaks
  - Lifting policy
    - Weight limits and two-person lifting

Personal protective equipment

- Worker uses/wears a device to reduce the intensity of a risk factor
  - Knee protection
    - Knee pads or pant leg insert
  - Neck pillow
  - Shoe inserts/anti-fatigue mat
  - Vibration exposure reducing gloves
  - Training & education

Construction problems and interventions



Potential soft tissue injury hazards on construction sites

- Material and equipment handling
- Awkward and static working postures
- Operating tools and equipment
- Repetitive tasks
- Hand-arm and whole body vibration

Risk Factors
Manual Material Handling

- Lifting materials and equipment below knees and above shoulders
- Excessive weight, unbalanced loads, and poor hand coupling
- Bending and twisting torso
- Pushing and pulling heavy objects
- External contact pressure on the shoulders, hands, etc.

Interventions
Manual material handling

- Optimize weight of tools and containers
- Mechanical lifting devices
- Optimize coupling for containers & equipment
- Establish lifting limits
- Carts & dollies with good casters
- Store materials between knee & shoulder height
- Maintain open & clear pathways/remove obstacles between workers and loads
- Deliver materials close to use location
- Site planning & cooperation

Risk factors

Working postures

- Bending forward to work at floor level
- Working with arms above shoulders
- Exerting forces when the hands, wrists, and arms are in awkward postures
- Working in confined and obstructed areas
- Stooping or unprotected kneeling
- Extended standing on concrete

Interventions

Working postures

- Powered person lifts
- Devices to extend the reach of the tool for floor level or overhead work
- Portable waist height work 'tables'
- Sit-stand stools & squatting 'assists'
- Anti-fatigue mats and shoe inserts
- Adjustable bi-level masonry scaffolds
- Improve access to heavy equipment
- Training & conditioning (least effective)

Risk factors
Tools & Equipment

- Manual & powered hand tools
  - Handles & grips – short, hard, 'sharp' edge, too large or small, wide lever span, no spring return
  - Poor grip design (pistol vs. in-line)
  - Shape promotes non-neutral hand & wrist postures
  - Heavy & unbalanced
  - Inadequate repair or maintenance
- Powered tools and equipment
  - One-finger trigger
  - Excessive vibration
  - High torque

Interventions
Tools & equipment

- Manual & powered
  - Optimize mechanical advantage
  - Compressible circular or oval shaped grips
  - Optimize handle, e.g., bend, lengthen
  - Low weight and balanced
  - Periodic inspection, repair and maintenance
- Powered
  - Lower vibration levels
  - Multi-finger, i.e., strip trigger
  - Torque control device
  - Tool fixture/stand

Risk factors
Repetition and force

- Installing and tightening fasteners
- Pulling and pushing materials, e.g., concrete screeding, electrical conductors
- Using manual tools, e.g., tin snips, hammer
- Continuous kneeling
- Use hand, knee or other body part as 'hammer', e.g., carpet installation 'knee-kicker'

Interventions
Repetition and force

- Automate the task
- Change process
  - Beam clamps vs. inserted fastener
  - Mechanical assists
- Substitute materials/components
- Mechanize
- Tool stand
- Substitute powered for manual hand tool
- Job rotation
- Micro-breaks and stretching
- Tool maintenance
- Keep cutting tools sharp

Fasten materials to deck

Task: Drive fasteners into ground level substrate

Trades: Carpenters, Roofers, Sheet Metal Workers

Problem: Stress to knees, back, and hands-wrists when using pistol type nailer, screw-gun or powder actuated tool

Solution: Use fastener that allow workers to do their job standing up

Source: Multiple

Work at ceiling level

Task: Install mechanical/electrical systems or building components near ceiling

Trades: Plumbers/Pipefitters, Electricians, Carpenters, Sheet Metal Workers, others

Problem: Unstable footing on ladder increases instability & reduces mechanical advantage

Solution: Use a lift to raise worker to the work location

Source: Multiple

Fasten systems to ceiling

Task: Drive fasteners for ceiling system

Trade: Multiple trades

Problem: Shoulder, neck and arm strain due to sustained overhead work using a screw-gun

Solution: Use 1 m long extension for driver to reduce awkward and static postures

Source: Streimer Sheet Metal (Portland, OR) & SMOHIT

Compact soil

Task: Operate soil compacting equipment

Trade: Laborers

Problem: Hand-arm vibration

Solution: Use vibrating compactor or plate compactors with vibration reduction features

Source: Laborers' Health & Safety Fund, Washington, DC

Install electrical conductors

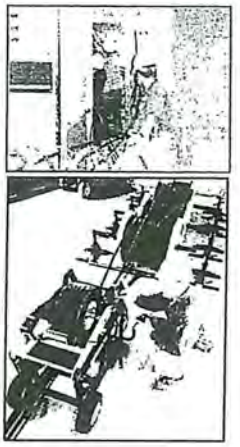
Task: Pulling wire off spool

Trade: Electricians

Problem: Excessive Physical force used during manual pulling and feeding electrical conductors

Solution: Use mechanical cable feeder & tugger

Source: Rosendin Electric (San Jose, CA)



Install reinforcement steel

Task: Tie wire around intersecting reinforcement steel (rebar) using pliers

Trade: Ironworkers, 'rodbusters'

Problem: Rapid & forceful hand exertions using awkward hand postures and deep forward flexion

Solution: Use automatic rebar tier with extension arm

Source: Multiple

Store materials

Task: Store building materials on site until needed

Trade: All trades

Problem: Lifting hazards for materials stored at ground level or above shoulder height

Solution: Store materials between knee and shoulder height

Source: Multiple

Finish cement

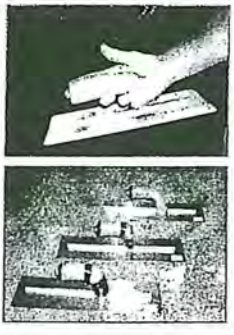
Task: Smoothing concrete with hand trowel

Trade: Cement finishers, plasterers

Problem: Trowel metal 'neck' (between wood handle & blade) presses against hand

Solution: Wrap material around neck to reduce contact stress

Source: Build it Smart, Seattle, WA



Build brick or block structure

Task: Load blocks & bricks on scaffold, grasp and lift blocks & bricks

Trade: Mason Tender, Mason, Bricklayer

Problem: Repetitive forward & lateral bending; twisting; extended reach

Solution: Use adjustable bi-level masonry scaffold

Source: Multiple

Finish drywall

Task: Apply finishing compound to drywall

Trade: Drywall finishers (e.g., Plasterers, painters)

Problem: Manual 'mud box' requires high push forces to apply compound

Solution: Use spring powered mud box. Springs provide 75% of force to push the compound on the wall

Source: Midstate Education & Service Foundation, Ithaca, NY

Build concrete deck

Task: Distribute and level (screed) concrete with hand held wood or metal 'striker'

Trade: Cement finishers, laborers

Problem: Repeated and sustained forward bending, forceful grasping, and pulling striker

Solution: Use powered screed

Source: Multiple

Acknowledgements

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For more information

Jim Albers, MPH, CIH
NIOSH
4676 Columbia Parkway, MS C-24
Cincinnati, OH 45226-1998
Ph: 513-533-8168
Fax: 514-533-8956
E-mail: JAlbers@cdc.gov

보건분야-교육자료
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한국산업안전공단
산업안전보건연구원

목 차

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