Work-related musculoskeletal disorders: The epidemiologic evidence and the debate

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What is a Musculoskeletal Disorder?

• Soft tissue pain, functional impairment and/or diagnosable condition
• Affecting muscle, tendon, peripheral nerve, joint, and/or circulatory tissues
Magnitude

- ~1,000,000 people lose work time annually due to MSDs in the U.S.
- Low back pain affects 30% of all European workers [TUTB 2000]
- About 1/3 of all U.S. lost-time work-related injuries and illnesses are disorders related to overexertion or repetitive motion [BLS]
- $50 billion annually in work related costs
Musculoskeletal Disorders and The Workplace: Low Back and Upper Extremities

Panel on Musculoskeletal Disorders and the Workplace, National Research Council and Institute of Medicine 2001

Charge included: “Evaluate contribution of jobs and job tasks” .... “to the occurrence of musculoskeletal disorders”
When is an “association” evidence of cause and effect?

Step 1: Interpretation of individual studies
Are there alternative explanations for the study findings?
(e.g., bias or confounding)

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Step 2. “Patterns of Evidence”
Is there consistency across different types of research? Is there biological plausibility?

- Epidemiology
- Ergonomics, Biomechanics
- Physiology, Tissue mechanobiology
- Field experience of “best practices”
The Debate: High Background Rate of MSDs

• Common in the general population
• Multifactorial etiology
• What proportion is work-related?
• Not everyone exposed (at work) is affected
MSD Risk Factors in the General Population

There are many risk factors; the presence of one does not negate another.

### Workplace Factors
- Physical loads
- Organizational factors
- Social context

### Individual Factors
- Physical characteristics
- Psychological factors
- Physical activities outside work
Occupational Factors and Disorders of the Hand/Wrist Region
(Silverstein, Fine, Armstrong, 1986-87)

N.B. Crude effect of gender for all H/W disorders.
Analyses also adjusted for age, years on the job, and facility.
The Debate:
MSD Case Identification

Limitations of diagnostic technologies
Symptoms range from specific to non-specific
Occurrence vs. reporting:
- Physiology (pain thresholds)
- Cultural differences
- Psychosocial effects
- Labor relations
Types of Outcome Measures

**Self-Reported Symptoms**
- Presence
- Severity
- Disability

**Self-Reported Work Status**
- Sick days
- Return to work

**Clinical Evaluation**
- Visit only
- Physical exam
- Tests

**Administrative Records**
- Compensation claim
- Sick days
- Return to work

(NRC/IOM, 2001)
One-year cumulative incidence of UE disorders, by baseline index of combined exposures (automobile manufacturing workers: same job at follow-up)

Punnett et al.

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Incidence rates of medical visits for all MSDs, by ergonomic exposure index (automobile manufacturing)

Incidence rate (cases per 1,000 P-Yrs)

Job median exposure index

Punnett, Park, Wegman
Odds ratios for effects of hand-held vibrating tools: high lifetime dose
(Bovenzi, 1994)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Odds Ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper limb pain</td>
<td>3.2</td>
<td>(1.9-5.2)</td>
</tr>
<tr>
<td>Dupuytren’s contracture</td>
<td>3.2</td>
<td>(1.4-7.4)</td>
</tr>
<tr>
<td>CTS (symptoms &amp; PE)</td>
<td>3.2</td>
<td>(1.2-8.7)</td>
</tr>
<tr>
<td>HAV sensorineural disturbance</td>
<td>4.7</td>
<td>(2.8-7.8)</td>
</tr>
<tr>
<td>Muscular weakness</td>
<td>14.7</td>
<td>(3.3-66.6)</td>
</tr>
<tr>
<td>VIWF symptoms</td>
<td>27.3</td>
<td>(13.1-56.6)</td>
</tr>
</tbody>
</table>
The Debate:
Lack of Standardized Exposure Assessment Metrics

• Affects comparability of findings across studies
• Population-specific cut-points between “low” and “high” affect utility for determining exposure-response curves
Intensity of manual material handling associated with elevated risk of low back disorders

<table>
<thead>
<tr>
<th>Condition</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 10 kg frequent vs none</td>
<td>(Magnusson 1996)</td>
</tr>
<tr>
<td>&gt; 10 kg daily</td>
<td>(Alcouffe 1999)</td>
</tr>
<tr>
<td>&gt; 50 lb. frequently</td>
<td>(Liira 1996)</td>
</tr>
<tr>
<td>&gt; 18 kg</td>
<td>(Nuwayhid 1993)</td>
</tr>
<tr>
<td>&gt; 1 on NIOSH lifting index</td>
<td>(Waters 1999)</td>
</tr>
<tr>
<td>Lift 1 pt or transfer 5 pts/shift</td>
<td>(Smedley 1997)</td>
</tr>
<tr>
<td>Heavy load “all the time” vs seldom</td>
<td>(Xu 1997)</td>
</tr>
</tbody>
</table>
Whole-body vibration dose associated with elevated risk of low back disorders

\[ a_z > 0.3, 0.4, 0.5 \text{ m/s}^2 \] (Boshuizen 1990a,b,1992)

\[ a_z > 0.5, 0.6 \text{ m/s}^2 \] (Bovenzi 1992, 1994)

> 4 h/day vs never (Alcouffe 1999)

> 20 h/wk vs <10 h/wk (Pietri 1992; Chiang 1993)

All the time vs seldom (Xu 1997)

Any vs none (Liira 1996; Magnusson 1996; etc.)
Daily duration of non-neutral posture associated with elevated risk of shoulder disorders

> 4 hrs/day \hspace{0.5cm} \text{(Holmstrom 1992)}

> 2 hrs/day

or > 1/min \hspace{0.5cm} \text{(English 1995)}

> 45/hr > 60 deg \hspace{0.5cm} \text{(Ohlsson 1995)}

> 1/min > 90 degrees \hspace{0.5cm} \text{(Punnett 2000)}
The Debate: Validity of self-reported ergonomic exposures

- Misclassification occurs with any exposure measure
- Little evidence of systematic bias
- Self-report of other epi. risk factors (e.g., cigarette smoking) universally accepted
The Debate: Partitioning risk among (related) exposures

The separate and joint distributions of exposures - within a specific study population - determine the statistical power available to examine the risk associated with each one.
Work Organization

The organization of the work process (who does what, how often, and how) determines both:

- physical loading patterns, and
- psychosocial stressors: job demands, decision latitude, social support, job insecurity
Work Organization

- Frequency and duration of hand motions
- Monotonous work with low skill utilization
“Psychosocial” or “Physical” Strain?
“Psychosocial” or “Physical” Risk Factors

Work organization features that imply rapid motions without rest breaks:

- Work without rest breaks or task change, for at least 15% of the shift (Roquelaure 1997)
- Piece-rate vs. hourly wages (Brisson 1989)
- Just-in-time production system (Leclerc 1998)

All associated with elevated risk of MSDs
The Debate: Cross-Sectional Studies

• Only currently employed people
  – Exposed persons developing W-R MSDs may have left employment disproportionately (“healthy worker effect”)

• Concurrent health and exposure data
  – Temporal relationship: Does the health effect precede the exposure?
2. The evidence justifies identifying certain work-related risk factors for the occurrence of MSDs of the low back and upper extremities.

6. Modification of those physical and psychosocial factors at work could substantially reduce risk of symptoms for low back and upper extremity disorders.
Attributable Fraction (AF)

Attributable fraction \( (AF_e = (RR - 1)/RR) \)

Risk in the exposed divided by risk in the unexposed

Interpretation:

Proportion of disease reduced if exposure eliminated

Relative importance of exposure reduction in those settings where the exposure is prevalent

(NRC/IOM, 2001)
## Attributable fractions for occupational physical risk factors and the occurrence of back disorders

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMH</td>
<td>4</td>
<td>24</td>
<td>11-66</td>
</tr>
<tr>
<td>Frequent bending and twisting</td>
<td>2</td>
<td>15</td>
<td>19-57</td>
</tr>
<tr>
<td>Heavy physical load</td>
<td>0</td>
<td>8</td>
<td>31-58</td>
</tr>
<tr>
<td>Static work posture</td>
<td>3</td>
<td>3</td>
<td>14-32</td>
</tr>
<tr>
<td>Whole-body vibration</td>
<td>1</td>
<td>16</td>
<td>18-80</td>
</tr>
</tbody>
</table>
Attributable fractions for occupational **psychosocial** risk factors and the occurrence of **back** disorders

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High job demands (work pace)</td>
<td>1</td>
<td>5</td>
<td>21-48</td>
</tr>
<tr>
<td>Monotonous work</td>
<td>2</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>Low social support at work</td>
<td>0</td>
<td>7</td>
<td>28-48</td>
</tr>
<tr>
<td>Low job satisfaction</td>
<td>1</td>
<td>13</td>
<td>17-69</td>
</tr>
<tr>
<td>High perceived stress</td>
<td>0</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>
### Attributable fractions for occupational **psychosocial** risk factors and the occurrence of **back** disorders (2)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low decision latitude/control</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>High perceived emotional effort</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Perceived ability to return to work</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Perceived work dangerous to back</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Attributable fractions for occupational **physical** risk factors and the occurrence of **upper limb** disorders

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>4</td>
<td>4</td>
<td>53-71</td>
</tr>
<tr>
<td>Force</td>
<td>1</td>
<td>2</td>
<td>78</td>
</tr>
<tr>
<td>Repetition and force</td>
<td>0</td>
<td>2</td>
<td>88-93</td>
</tr>
<tr>
<td>Repetition and cold</td>
<td>0</td>
<td>1</td>
<td>89</td>
</tr>
<tr>
<td>Vibration</td>
<td>6</td>
<td>26</td>
<td>44-95</td>
</tr>
</tbody>
</table>
Attributable fractions for occupational **psychosocial** risk factors and the occurrence of **upper limb** disorders

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Region</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High job demands</strong></td>
<td>All</td>
<td>6</td>
<td>10</td>
<td>33-58</td>
</tr>
<tr>
<td></td>
<td>Elbow/Arm</td>
<td>3</td>
<td>6</td>
<td>50-58</td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>6</td>
<td>6</td>
<td>33-47</td>
</tr>
<tr>
<td></td>
<td>Wrist</td>
<td>4</td>
<td>5</td>
<td>37-56</td>
</tr>
<tr>
<td><strong>Low decision latitude</strong></td>
<td>All</td>
<td>10</td>
<td>6</td>
<td>37-64</td>
</tr>
<tr>
<td></td>
<td>Elbow/Arm</td>
<td>5</td>
<td>1</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>8</td>
<td>6</td>
<td>37-47</td>
</tr>
<tr>
<td></td>
<td>Wrist</td>
<td>8</td>
<td>3</td>
<td>37-84</td>
</tr>
</tbody>
</table>
# Attributable fractions for occupational psychosocial risk factors and the occurrence of upper limb disorders (2)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Region</th>
<th>Null n</th>
<th>Positive n</th>
<th>AF% (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low social support</td>
<td>All</td>
<td>7</td>
<td>7</td>
<td>28-52</td>
</tr>
<tr>
<td></td>
<td>Elbow/Arm</td>
<td>5</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>7</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Wrist</td>
<td>4</td>
<td>3</td>
<td>28-52</td>
</tr>
<tr>
<td>Few rest break opportunities</td>
<td>All</td>
<td>3</td>
<td>3</td>
<td>33-70</td>
</tr>
<tr>
<td></td>
<td>Elbow/Arm</td>
<td>1</td>
<td>1</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>3</td>
<td>1</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Wrist</td>
<td>5</td>
<td>2</td>
<td>33%</td>
</tr>
</tbody>
</table>

*Note: Low job satisfaction not positive in studies reviewed*
Physical Stressors and MSDs

- Repetitive motion
- MMH and manual forceful exertions
- Non-neutral postures (static or dynamic)
- Vibration (whole-body and segmental)
- Cold in repetitive work
Psychosocial Stressors and MSDs

High job demands
  - Rapid work pace
  - Few rest break opportunities
Low decision latitude
Monotonous work (low skill utilization)
Perceived job stress
  - Low job satisfaction
  - Job insecurity
Endorsements of Ergonomics Rulemaking to Prevent Musculoskeletal Disorders

- American Conference of Governmental Industrial Hygienists (1999+)
- European Agency for Safety and Health at Work, EU (1999)
- Washington State Dept. of Labor and Industries
Conclusions

- International near-consensus on occurrence of work-related MSDs
- A sizable proportion of MSDs among exposed workers are preventable
- Voluntary employer efforts are important but not sufficient
Effect modification: Keying speed & type of VDT work (hypothetical)
Average hand forces associated with elevated risk of upper extremity disorders

> 4 kg (Silverstein 1986, 1987; Armstrong 1987)
> 3 kg (Chiang 1993)
> 2.7 kg per hand (Stetson 1993)
> 4 kg carry (Stetson 1993)
> 1 kp (Roquelaure 1988)
Effect modification: Physical load by gender

One-year incidence of UE MSDs in auto manufacturing

Exposure Score

- 0-6
- 7-12
- 13-18
- 19-25

Women

Men

0%

10%

20%

30%

40%

Punnett, et al.

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