Low Back Disorders and Patient Handling

William S. Marras, Ph.D., CPE
Honda Professor and Director
Biodynamics Laboratory
Spine Research Institute
The Ohio State University
Columbus, Ohio

http://spine.osu.edu

Most Frequent Nonfatal Occupational Injuries and Illness: # cases, 2013 (BLS Dec. 2014)

Most Frequent Nonfatal Occupational Injuries and Illness Requiring Days Away from Work, Transfer or Restriction 2013 (BLS Dec. 2014)

National Statistics Relative to Patient Handling Risk, 2011 (BLS 2012)

Review Study of Low Back Pain (LBP) Prevalence

Work-related back pain in nurses
Hignett, S.

- LBP point prevalence = 17%
- LBP annual prevalence = 40-50%
- LBP lifetime prevalence = 35-80%

The cumulative weight lifted by a nurse in one typical 8-hour shift is equivalent to 1.8 tons (Tuohy-Main, 1997)
LBP Prevalence/Risk and Patient Handling

Work-relatedness of low back pain in nursing personnel: A systematic review
Yassi, A and Lockhard, K

- Systematic review of literature
- Considered 987 studies; 89 studies met eligibility criteria
  Bradford Hill considerations used (Mix of 21 longitudinal, 36 cross-sectional, 23 biomechanical/ergo, and 9 review studies)

Conclusions
- Patient handling confers the highest risk; other duties confound dose-response
- Associations were strong, consistent, temporally possible, plausible, coherent, and analogous to other exposure-outcomes.
- Risk OR=1.2-5.5 depending on LBP definition

Current State of LBP Treatment

- A precise diagnosis is unknown in 80% to 90% of patients with low back pain (Deyo & Weinstein, 2001)
- Few diagnosed through imaging (10-15%)
- Spend $90 Billion per year treating back problems in the U.S. (about the same as we spend on cancer) (JAMA, 2011)
- Cost of treatment increased 65% in 8 years (Martin, et al., 2008)
- Less than 50% of surgeries are successful (Weinstein, 2006)
- Value of prevention

Low Back Pain Risk Factor Environment

Social & Org. Factors
Individual Factors
Physical Factors

(NRC/IOM, 2001)

Surveillance Studies with Biomechanical Implications

What triggers an episode of acute low back pain? A case-crossover study

- 999 patients with new episode of acute LBP
- Evaluated exposures to 12 triggers within 96 hrs of pain onset
  OR for LBP & heavy loads = 13.6 (age 20), 6.0 (age 40), & 2.7 (age 60)
  OR for LBP & distraction during activity = 25.0
  OR for LBP & fatigue = 3.7
  Risk greatest between 7 AM and noon

Biomechanical Implications

Expanded OSHA 300 log as metric for bariatric patient-handling staff injuries
Randall, S. B., Pories, W. J., Pearson, A., Drake, D.J.

- Patients with BMI > 35 = < 10% of patients
- Handling patients with BMI > 35 associated with:
  Turning and Repositioning patient implicated in:
    - 31% of cases
    - 29.8% injuries
    - 27.9 % lost time
    - 37.2% restricted time
  Usually performed using biomechanics and NOT equipment
Biomechanics is More than Strength

Traditional Biomechanical Logic
Load – Tolerance Relationship and Risk

Risk of Injury
Tolerance
Loading Pattern

Spiral Load
Time

(McGill, 1997)

Intervertebral Disc

Disc Degeneration

How Cumulative Trauma Develops in the Spine

Disc Nutrition Pathways
How Cumulative Trauma Develops in the Spine

Vertebral Endplate

Microfractures

Vertebral Endplate

Scar Tissue Development

How Cumulative Trauma Develops in the Spine

Vertebral Endplate

Vertebral Body

Vertebral Endplate

Disc

Disc Degeneration and Cumulative Trauma

Scar Tissue

Vertebral Body

Vertebral Endplate

Disc

Vertebral Endplate

Compression

3400-6400 N Limit (NIOSH, 1981)

Spine Tolerance Limits

Anterior/Posterior (A/P) Shear

750-1000 N Limit (McGill, 1994; Yingling 1999)

Lateral Shear

750-1000 N Limit (Miller, 1986)

Biomechanical Modeling of the Low Back

Can we assess specific spine tissue loads in-vivo?

Spine Loads Results from the Reaction of Internal Forces to External Forces

Internal Force

External Force
Our Early Patient Lifting Studies

A comprehensive analysis of low-back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques.

W. A. Musgrave, K. L. Young, B. C. Kowaluk, and P. R. Bofinger
Biodynamics Laboratory, The Ohio State University, 1951 Neil Avenue, 214 Baker Science, Columbus OH 43210, USA

Keywords: Patient handling; Spinal loads; Biomechanics; LBD

Although patient handling affects low-back injuries in an alarming rate worldwide, there has been limited research quantifying the risk for the specific tasks performed by the patient handler. The overall study aimed to quantify the risk for back injuries associated with patient lifting tasks performed by orthopedic nurses. The incidence of LBD in orthopedic patient handling was quantified, with the development and implementation of a novel methodological model quantifying patient handling risk. The patient handling database used in this study was characterized for the purpose of establishing a model for quantifying low-back disorder risk.
Patient Lifting Origins/ Destinations
- Bed to/from wheelchair with arms
- Bed to/from wheelchair with one arm removed
- Portable commode chair to/from hospital chair

Patient Transfer Techniques
- 1 person hug
- 2 person hook and toss
- 2 person gait belt

Pre-Lifting during Patient Handling

Spine Compression as a Function of Transfer Technique

Patient Repositioning Techniques
Spine Compression as a Function of Repositioning Technique

Implication from our First Study

- Risk associated with one- or two- caregiver patient lifting
- Conclusion - There is no safe way to lift a patient manually!
- The magnitude of spine loading is so great that any benefit of using proper body mechanics is negligible
- Suggestion – Must employ patient lifting device

Body Mechanics?

Physical therapists vs. nurses in a rehabilitation hospital: comparing prevalence of work-related musculoskeletal complaints and working conditions


- Compared LBP rate in 26 PTs vs. 54 nurses in a Rehab. Hospital
- LBP was more prevalent in PTs than nurses
- Conclusion: should initiate a “no-lift” policy

Patient Handling Interventions

The Effect of Ergonomic Interventions in Healthcare Facilities on Musculoskeletal Disorders

The high incidence of work-related ill-health in the healthcare industry is due to the nature of patient handling activities. The effect of ergonomic interventions in improving patient handling safety is not well documented. This study aimed to evaluate the effectiveness of interventions to improve the safety of patient handling activities. The study was conducted in a hospital setting and involved the implementation of two interventions: reducing the number of body movements and the use of patient lifting devices. The results showed a significant reduction in musculoskeletal disorders following the implementation of these interventions. The study demonstrated that ergonomic interventions can improve the safety of patient handling activities in healthcare facilities.

- Intervention Effectiveness (prospective observation of 100 units)

Patient Handling Musculoskeletal Disorder Rate Changes (#MSDs/employee-hours worked) x 100,000

<table>
<thead>
<tr>
<th>Type of Intervention</th>
<th># Units</th>
<th>Decreased or no change</th>
<th>Increased</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Bending</td>
<td>16</td>
<td>12 (75%)</td>
<td>4 (25%)</td>
<td>0.056</td>
</tr>
<tr>
<td>Zero Lift</td>
<td>44</td>
<td>32 (72.7%)</td>
<td>12 (27.3%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Reduce Carrying</td>
<td>8</td>
<td>7 (87.5%)</td>
<td>1 (12.5%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Multiple Interventions</td>
<td>32</td>
<td>26 (81.3%)</td>
<td>6 (18.7%)</td>
<td>0.001</td>
</tr>
<tr>
<td>All</td>
<td>100</td>
<td>77 (77.0%)</td>
<td>23 (23.0%)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

(Fujishiro, et al. 2005)
Our Previous Studies

- Risk associated with one- or two- caregiver patient lifting
  - Conclusion - There is no safe way to lift patient manually!
  - Suggestion - Employ Patient Lifting assistance device
- Intervention Effectiveness (prospective observation of 100 units)
  - Conclusion – Often observe significant reduction in risk
  - Not all interventions created equally!
  - 23% of lift interventions had increased reporting

Do Interventions Impact LBP Risk?

Does rare use of assistive devices during patient handling increase the risk of LBP? A prospective cohort study among female healthcare workers

- \( N = 1,478 \) no-LBP female healthcare workers at start of study / observed those who got LBP
- OR for infrequent LBP & occasional use of assistive devices = 1.21
- OR for frequent LBP LBP & RARE use of assistive devices = 1.78
- Conclusion – Rare use of assistive devices increases LBP risk

Lifting Transformed into Pushing and Pulling

Pushing/Maneuvering Patients

Patient Lift Devices

Ceiling lift
- Likorall 243 ES (230 Kg capacity)

Floor based lift
- Liko Viking L (250 Kg capacity)

Experimental Conditions

- Lift system
  - Ceiling based
  - Floor based – large wheel vs. small wheel
    - Large wheels (5 inch diameter rear; 4 inch diameter front)
    - Small wheels (3 inch diameter rear; 2 inch diameter front)
- Floor Surface
  - Hard Floor
  - Carpet
Patients

- Patient weight
  - 125 lb (56.8 Kg)
  - 160 lb (72.7 Kg)
  - 360 lb (163 Kg)

Course Path and Required Control

Ceiling Lift Trial and Analysis

Risk Exposure Quantification:
Patient Handling

Risk Exposure Quantification:
Patient Handling using Floor Lift
Risk Exposure Quantification:
Patient Handling using Floor Lift

Results:
Spine Load Magnitudes

Compression as a Function of Vertebral Level

Lateral Shear as a Function of Vertebral Level
A/P Shear as a Function of Vertebral Level

<table>
<thead>
<tr>
<th>Level</th>
<th>A/P Shear (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L5/S1 Inferior</td>
<td>1200</td>
</tr>
<tr>
<td>L5/S1 Superior</td>
<td>1300</td>
</tr>
<tr>
<td>L4/L5 Inferior</td>
<td>1400</td>
</tr>
<tr>
<td>L4/L5 Superior</td>
<td>1500</td>
</tr>
<tr>
<td>L3/L4 Inferior</td>
<td>1600</td>
</tr>
<tr>
<td>L3/L4 Superior</td>
<td>1700</td>
</tr>
<tr>
<td>L2/L3 Inferior</td>
<td>1800</td>
</tr>
<tr>
<td>L2/L3 Superior</td>
<td>1900</td>
</tr>
<tr>
<td>L1/L2 Inferior</td>
<td>2000</td>
</tr>
<tr>
<td>L1/L2 Superior</td>
<td>2100</td>
</tr>
<tr>
<td>T12/L1 Inferior</td>
<td>2200</td>
</tr>
<tr>
<td>T12/L1 Superior</td>
<td>2300</td>
</tr>
</tbody>
</table>

**Significant Effects**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Lateral Shear</th>
<th>Compression</th>
<th>A/P Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Handling System</td>
<td>0.003*</td>
<td>0.015*</td>
<td>0.060</td>
</tr>
<tr>
<td>Patient Weight (Weight)</td>
<td>0.124</td>
<td>0.069</td>
<td>0.057</td>
</tr>
<tr>
<td>Required Control over System</td>
<td>0.006*</td>
<td>0.105</td>
<td>0.001*</td>
</tr>
<tr>
<td>System*Weight</td>
<td>0.015*</td>
<td>0.139</td>
<td>0.133</td>
</tr>
<tr>
<td>System*Control</td>
<td>0.106</td>
<td>0.002*</td>
<td>0.001*</td>
</tr>
<tr>
<td>Weight*Control</td>
<td>0.496</td>
<td>0.695</td>
<td>0.497</td>
</tr>
<tr>
<td>System<em>Weight</em>Control</td>
<td>0.154</td>
<td>0.081</td>
<td>0.070</td>
</tr>
</tbody>
</table>

L3 A/P Shear a Function of Required Control

<table>
<thead>
<tr>
<th>Control</th>
<th>A/P Shear (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight</td>
<td>1200</td>
</tr>
<tr>
<td>Gradual Turn</td>
<td>1300</td>
</tr>
<tr>
<td>Sharp Turn</td>
<td>1400</td>
</tr>
<tr>
<td>Bathroom</td>
<td>1500</td>
</tr>
</tbody>
</table>

**L3 A/P Shear as a Function of Floor Based Systems and Required Control**

<table>
<thead>
<tr>
<th>System</th>
<th>A/P Shear (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling Lift</td>
<td>0</td>
</tr>
<tr>
<td>Sm Wheel Carpet</td>
<td>100</td>
</tr>
<tr>
<td>Sm Wheel Carpet</td>
<td>200</td>
</tr>
<tr>
<td>Lg Wheel Carpet</td>
<td>300</td>
</tr>
<tr>
<td>Lg Wheel Carpet</td>
<td>400</td>
</tr>
</tbody>
</table>

Risk Exposure Quantification:
Maneuvering within bathroom space

Potential Interventions
Summary of Patient Push Findings

- A/P shear is mechanism of risk when pushing patients
- Floor based risk increases with increased required control
  - Controlling lift in confined space (bathroom) poses greatest risk
  - Turning (gradual or sharp turn) poses next greatest risk
  - Pushing without turning has minimal risk (but greater than ceiling lift)
- No increased risk with ceiling lift as a function of control
- Operating floor based lifts on carpet or with small wheels greatly magnifies risk
  - Small wheels and carpet together create hazardous conditions when control is required.

The Power of Social Contagion

Low Back Pain Risk Factor Environment

Social & Org. Factors
Individual Factors
Physical Factors

The Influence of Psychosocial Stress, Gender, and Personality on Mechanical Loading of the Lumbar Spine (Marras et al., 2000)

Study Procedure
1. Un-Stressed Session - Perform Lift Tasks
2. Experiment Interruption / Experimenters Called Out of Room
3. Stressed Session - Perform Same Lift Tasks

Non-Physical Factors Affect Spine Loading:
Individual & Psychosocial Factors

Spine Loading Response to Psychosocial Stress

Variability of biomechanical responses to psychosocial stress among 25 subjects
Differences in Spinal Loads Between Personality Traits in Response to Psychosocial Stress (Marras et al., 2000)

Musculoskeletal Control and Tissue Load

Wellness and Wellbeing

Five Core Interconnected Dimensions of Wellbeing

- Career Wellbeing: How do you occupy your time?
- Social Wellbeing: Strong relationships and love
- Financial Wellbeing: Managing your economic life to reduce stress and increase security
- Physical Wellbeing: Good health and enough energy
- Community Wellbeing: Sense of engagement and involvement where you live

Health Care Costs are Directly Related to the Number of Thriving Dimensions

Turnover Costs: 35-52% Lower for Thriving Employees

(Rath and Harter, 2010)
Wellbeing can offset the effects of age in health-related costs

- Health-related costs for a 60-year-old with high wellbeing are lower than those for a 30-year-old with low wellbeing

(Rath and Harter, 2010)

Conclusions

- Low back forces and pain are initiated by spine loading due to a MIX OF:
  - Physical Work
  - Psychosocial and Organizational
  - Individual Factors
- Appreciation for trunk muscle coactivity is the key to understanding loading conditions

Conclusions

- There is no safe way to lift a patient manually (loads are too great for body mechanics to make a difference)
- There is surveillance evidence that interventions can help control risk
- Lifting devices can help but the degree of control required greatly influences risk
- Use ceiling lifts if at all possible
- When using floor mounted lifts –
  - Use extreme caution when turning and controlling patient within the bathroom (this is where the risk occurs)
  - Don’t use small wheels with floor based systems!

Thank You!

Website: spine.osu.edu
E-mail: marras.1@osu.edu