Low Back Pain Development and Patient Handling

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National Statistics Relative to Patient Handling Risk

- Lost time injuries in the U.S. in 2007 (BLS, 2008)
  1. Laborers & material movers (79,000 cases)
  2. Heavy and tractor-trailer drivers (57,050 cases)
  3. Nursing aides, orderlies, and attendants (44,930 cases)

- Musculoskeletal Disorder Rates in 2007 (BLS, 2008)
  - Highest National Rate - Nursing aides, orderlies, and attendants (252/10,000 workers) was 7x the National average
  - Laborers and freight handlers (149/10,000 workers)
  - Delivery truck drivers (117/10,000 workers)

- In 2007 the trunk was the body part most often injured accounting for 33% of all injuries and illnesses (BLS, 2008)

Low Back Pain (LBP) Statistics for Nurses

- 52% of nurses complain of LBP (Nelson, 2003)
- 12% of nurses leave the field because of LBP (Stubbs et. al., 1986)
- 20% transfer to a different unit because of LBP (Owen, 1989)
- 38% have LBP severe enough to have lost time (Owen, 2000)
- 38% new LBP cases per year (Yip, 2004)

Recent Studies Indicating Low Back Pain Prevalence

- Low Back pain Among Nurses: A follow-up beginning at entry to the nursing school
  - Followed 174 nursing students for 7.5 years
  - 1 year prevalence = 54% for 1st year students
  - 57% for 1st year as nurse
  - 64% for 5th year as nurse
  - OR for LBP & Twisting = 6.2 (1.7-2.3) and LBP & Bending = 7.5 (2.9-20)
  - OR for Sciatica = 6.9 (2.1-23)
  - Conclusion – Lifetime prevalence of LBP increases sharply during nursing school
  - Nature of association is unclear but LBP is exacerbated during nursing

Recent Studies Indicating LBP Prevalence and Risk and Patient Handling

- Work-related back pain in nurses
  - LBP point prevalence = 17%
  - LBP annual prevalence = 40-50%
  - LBP lifetime prevalence = 35-80%

Low Back Surgery

- “No operation in any field of surgery leaves in its wake more human wreckage than surgery on the lumbar discs” (DePalma and Rothman, 1970)
- Surgical success rates for discectomy = 42.6% (vs. 32.4% non-operative) (Weinstein et al. 2006)
- Cost of treatment has increased 65% in 8 years (after adjusting for inflation) (Martin, et al., 2008)
- Value of prevention
What do We Know About Low Back Pain Causality?

Risk Estimates for Work-Related Physical Risk Factors and Back Disorders

<table>
<thead>
<tr>
<th>Physical Work-Related Risk Factor</th>
<th>Null Association</th>
<th>Positive Association</th>
<th>Attributable Fraction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual material handling</td>
<td>4</td>
<td>24</td>
<td>17</td>
</tr>
<tr>
<td>Frequent bending and twisting</td>
<td>2</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Heavy physical load</td>
<td>0</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Static work posture</td>
<td>3</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Repetitive movements</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Whole-body vibration</td>
<td>3</td>
<td>16</td>
<td>1</td>
</tr>
</tbody>
</table>

(NRC/IOM, 2001)

Low Back Pain Risk Factors

(NRC/IOM, 2001)

- Physical Factors
  - Biomechanical Loading
  - Biomechanical / Physiologic Tolerance
- Individual Factors
  - Age, Gender, etc.
  - Pain Perception
  - Genetic Factors
- Psychosocial Factors and Organizational Factors
  - Job Satisfaction
  - Job Monotony
  - Job Control

Low Back Pain Risk Factor Environment

(NRC/IOM, 2001)

Physical Factors

Recent Surveillance Studies with Biomechanical Implications

A study of work stress, patient handling activities, and the risk of LBP among nurses in Hong Kong

Yip, Y. (2001) / Adv Nurs, 36(6), 794-804

- Prevalence = 40.6 for LBP
- OR for LBP & repositioning = 2.07
- OR for LBP & assistance during walking = 2.11
Recent Studies with Biomechanical Implications

Expanded OSHA 300 log as metric for bariatric patient-handling staff injuries
- 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

Recent Studies with Biomechanical Implications
Risk Factors for LBP and Patient Handling of Nursing Personnel
- 1yr prevalence = 69.7 %
- Found lifting heavy objects, work experience, age, and sitting habits (together) have OR = 2.81 (1.88-4.20) for LBP
- Conclusion - Limit patient lifting to 47 Kg (104 lbs)

Physical Factors: Overexertion During Lifting (BLS, 2007)

Risk of Injury
- The cumulative weight lifted by a nurse in one typical 8-hour shift is equivalent to 1.8 tons (Tuohy-Main, 1997).

Biomechanical Logic: Load – Tolerance Relationship

Intervertebral Disc
- The primary source of low back pain is suspected to be the disc (Nachemson, 1976; Videman and Battie, 1996; An, 2004)
- Noxious stimulation of the disc produces symptoms of low back pain
- Annular tears and reduced disc height are associated with low back pain (Videman et al., 2003)
- Mechanical load can be the stimulus for pain (Marras, 2000)

How Cumulative Trauma Develops in the Spine

Vertebral Endplate
Disc Nutrition Pathways

Vertebral Body
Vertebral Endplate
Disc

How Cumulative Trauma Develops in the Spine

Vertebral Endplate
Microfractures

How Cumulative Trauma Develops in the Spine

Scar Tissue Development

Disc Degeneration and Cumulative Trauma

Vertebral Body
Vertebral Endplate
Disc

Spine Tolerance Limits

Compression
3400-6400 N Limit (NIOSH, 1981)

Anterior/Posterior (A/P) Shear
1000 N Limit (McGill, 1994; Yingling 1999)

Lateral Shear
1000 N Limit (Miller, 1986)

Endplate Compression Tolerance

(Jager and Luttmann, 1991)
Recent Studies with Biomechanical Implications

Dose-response relations between occupational exposures to physical and psychosocial factors and the risk of low back pain

- Followed 523 patient handlers in nursing homes in The Netherlands prospectively over 1 year
- Quantitatively monitored patient lifting and observed new LBP episodes
- Trunk flexion over 45 deg association with LBP risk
  \( OR = 3.18 \) (1.13-9.00)

Spine Loading During Patient Handling

Can we assess specific spine tissue loads?

Low Back Pain: Understanding Back Function

Spine Loads Results from the Reaction of Internal Forces to External Forces
Trunk Muscle Coactivity

![Graph showing trunk muscle coactivity across different muscles.](image)

(Marras et al., 2005)

Biologically Assisted (EMG)-Assisted Biomechanical Models

The OSU Biodynamic Model

The Control System

Laboratory Assessment of Push-Pull

Assessment of Spine Forces Based Upon Task
Spine Loads at Different Levels

Specific Tissue Loads with Inclusion of Finite Element Analysis

Patient Specific Anatomy

Our Early Patient Lifting Studies

A comprehensive analysis of lumbar and thoracic load and spinal loading during the transferring and repositioning of patients using different techniques.

W. A. Blanke, K. G. Clow, K. P. Kirou and P. K. Brindley

Biodynamics Laboratory, The Ohio State University, 275 West 12th Ave. 250 Basic Science Center, Columbus, OH 43210

Keywords: Patient loading; Spinal loads; Biomechanics; EMG

Although patient transfers often result from patient injuries or an existing care needs, there has been recent research addressing the task of the patient task performed by the patient transfers. The transfer study and both a comprehensive analysis of the transfer process and the anatomic and mechanical considerations of the patient transfers. The patient transfer process, including (1) assessment and (2) performance of the patient transfers, was observed and recorded. The study was evaluated in conjunction with clinical protocols and the patient transfers were evaluated in conjunction with the clinical protocols.

Patient Lifting Origins/ Destinations

1. Bed to/from wheelchair with arms
2. Bed to/from wheelchair with one arm removed
3. Portable commode chair to/from hospital chair

Transfer Techniques

1. 1 person hug
2. 2 person hook and toss
3. 2 person gait belt
Repositioning Techniques

Spine Compression as a Function of Transfer Task

<table>
<thead>
<tr>
<th>Transfer Task</th>
<th>Maximum Tolerance</th>
<th>Safe Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheelchair w/o Arms – Bed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bed – Wheelchair w/o Arms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheelchair – Bed</td>
<td></td>
<td></td>
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<tr>
<td>Bed – Wheelchair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commode – Chair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chair – Commode</td>
<td></td>
<td></td>
</tr>
</tbody>
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Spine Compression as a Function of Transfer Technique

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<thead>
<tr>
<th>Transfer Technique</th>
<th>Maximum Tolerance</th>
<th>Safe Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hug</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Side</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hook &amp; Belt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spine Compression as a Function of Repositioning Technique

<table>
<thead>
<tr>
<th>Repositioning Technique</th>
<th>Maximum Tolerance</th>
<th>Safe Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh &amp; Shoulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thigh &amp; Shoulder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheet</td>
<td></td>
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</tr>
</tbody>
</table>

Biodynamics Laboratory Previous Studies

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

Patient Handling Interventions

The Effect of Ergonomic Interventions in Healthcare Facilities on Musculoskeletal Disorders

In a study conducted at a major US healthcare facility, ergonomic interventions were implemented in a randomized controlled trial involving 100 units. The interventions included the use of lifting belts, Ergonomic chairs, and patient handling training. Results showed a significant decrease in musculoskeletal injuries among nurses and caregivers. Intervention effectiveness (prospective observation of 100 units)
### Patient Handling Musculoskeletal Disorder Rate Changes

<table>
<thead>
<tr>
<th>Type of Intervention</th>
<th>n Baseline (Range)</th>
<th>Follow-up (Range)</th>
<th>Rate Ratio (FU/BL MSD rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Bending</td>
<td>16</td>
<td>9.89 (0.0-42.65)</td>
<td>6.65 (0.0-59.51)</td>
</tr>
<tr>
<td>Zero Lift</td>
<td>44</td>
<td>15.38 (0.0-87.59)</td>
<td>9.25 (0.0-28.27)</td>
</tr>
<tr>
<td>Reduce Carrying</td>
<td>8</td>
<td>6.47 (0.0-15.80)</td>
<td>0.33 (0.0-6.70)</td>
</tr>
<tr>
<td>Multiple Interventions</td>
<td>32</td>
<td>11.98 (0.0-60.34)</td>
<td>7.78 (0.0-25.94)</td>
</tr>
<tr>
<td>All</td>
<td>100</td>
<td>12.32 (0.0-87.59)</td>
<td>6.64 (0.0-59.51)</td>
</tr>
</tbody>
</table>

(Fujishiro, et al. 2005)

### Patient Handling Change in MSD Rates per Intervention (baseline to follow-up)

<table>
<thead>
<tr>
<th>Type of Intervention</th>
<th># Units Decreased or no change</th>
<th>Number of Units Increased</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce Bending</td>
<td>12 (75%)</td>
<td>4 (25%)</td>
<td>0.056</td>
</tr>
<tr>
<td>Zero Lift</td>
<td>32 (72.7%)</td>
<td>12 (27.3%)</td>
<td>0.002</td>
</tr>
<tr>
<td>Reduce Carrying</td>
<td>7 (87.5%)</td>
<td>1 (12.5%)</td>
<td>0.011</td>
</tr>
<tr>
<td>Multiple Interventions</td>
<td>26 (81.3%)</td>
<td>6 (18.7%)</td>
<td>0.001</td>
</tr>
<tr>
<td>All</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!
  - 27% of zero lift interventions had increased reporting

### Lifting Transformed into Pushing and Pulling

- Does changing patient handling from a lifting activity to a pushing activity eliminate the risk to the caregiver?
- Is there a difference in pushing ceiling mounted vs. floor based patient lifting devices?
Pushing/Maneuvering Patients

Approach
- Use OSU Personalized Biodynamic Model to realistically assess spine loads when pushing patient with ceiling lifts vs. floor-based lifts

Task
- Push a patient lifting device through a course that contains many of the typical challenges within a health care facility

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 (short pile)
- Patient weight
  - 125 lb (56.8 Kg)
  - 160 lb (72.7 Kg)
  - 360 lb (163 Kg)
- Course control required
  - Straight
  - Sharp (90 deg) turn
  - Gradual turn
  - Sharp turn in confined space (bathroom)

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

Course Path and Required Control

NOTE: All dimensions are in inches
Ceiling Lift Trial and Analysis

Floor Based Lift used on Carpet

Floor Based Lift used on Carpet

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

![Graph showing shear forces at different vertebral levels](image)

**Significant Effects**

<table>
<thead>
<tr>
<th></th>
<th>Lateral Shear</th>
<th>Compression</th>
<th>A/P Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Handling System (System)</td>
<td>0.001*</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 (Control)</td>
<td>0.065*</td>
<td>0.105</td>
<td>0.100</td>
</tr>
<tr>
<td>System*Weight</td>
<td>0.045*</td>
<td>0.189</td>
<td>0.133</td>
</tr>
<tr>
<td>System*Control</td>
<td>0.105</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>

* Significant (p<0.005)

L3 A/ P Shear as a Function of Required Control

![Graph showing shear forces for different control levels](image)

L3 A/ P Shear as a Function of System and Required Control

![Graph showing shear forces for different systems and control levels](image)

L3 A/ P Shear as a Function of Lift System, Floor, and Required Control

![Graph showing shear forces for different systems, floors, and control levels](image)

L3 A/ P Shear as a Function of System Wheel Type and Required Control

![Graph showing shear forces for different wheel types and control levels](image)
**Discussion**

- Ceiling lifts impose lowest (and safest) load on the spine
  - No risky conditions were identified for this condition
- Floor-based lifts can impose significant biomechanical risk to the spine but depends upon conditions of use
- Risk occurs primarily to the upper lumbar vertebrae (L3 and above)
  - Previous studies have not studied those levels
  - May help explain the 27% of LBP associated with pushing and pulling
  - These results may explain why interventions are not always effective

**L3 A/P Shear as a Function of Patient Weight**

- 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.

**Obesity Trends Among U.S. Adults between 1985 and 2008**

**Definitions:**
- **Obesity**: Having a very high amount of body fat in relation to lean body mass, or Body Mass Index (BMI) of 30 or higher.
- **Body Mass Index (BMI)**: A measure of an adult’s weight in relation to his or her height, specifically the adult’s weight in kilograms divided by the square of his or her height in meters.

Study Procedure

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

Differences in Spinal Loads Between Personality Traits in Response to Psychosocial Stress (Marras et al., 2000)

Variability of Biomechanical Responses to Psychosocial Stress (Marras et al., 2000)
Musculoskeletal Control and Tissue Load

- Auditory
- Visual
- Tactile
- Muscle/Ligament Tone

Agonist Contraction

Antagonist Contraction

Antagonist Cocontraction Leads to Increased Tissue Load

Working with Low Back Pain

The Effects of Working with Low Back Pain Spine Loading

- Peak Compression Force per Sagittal Moment (N/Nm)
- Peak Lateral Shear Force per Sagittal Moment (N/Nm)

LBP Group
Asymptomatic Group

Compress Force  Lateral Shear Force

(Marras, et al., 2005)

Dynamic Spine Loading

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)
  - Use extreme caution when using these systems on carpet
  - Don’t use small wheels with floor based systems!

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
Concern for man and his fate must always form the chief interest of all technical endeavors...

Never forget this in the midst of your diagrams and equations

- Albert Einstein

Thank You!

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