Low Back Pain Development and Patient Handling

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Background on Back Pain

- Up to 80% of the population will suffer from low back pain at least some time during their life (Luo, 2004)
- We spend $90 Billion per year treating back problems in the U.S. (about the same as we spend on cancer) (JAMA, 2011)
- Low back pain is the 2nd most common symptom-related reason for physician visits (Deyo and Weinstein, 2001)
- Low back pain is 2nd greatest cause of disability in U.S. (Bagnall, 2010)
- 15-20% of Americans report back pain yearly (Deyo and Weinstein, 2001)
- Results in over 100 million lost work days per year (Atlas, 2004)
- Health care expenditures are 60% higher for those with back pain (Deyo and Weinstein, 2001)


*Incidence rate per 10,000 full time employees

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

Studies of Low Back Pain Prevalence

Work-related back pain in nurses

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

Recent Studies Indicating LBP Prevalence/Risk and Patient Handling

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 (1.7-12.3) 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/Risk and Patient Handling

Work-relatedness of low back pain in nursing personnel: A systematic review

- 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)

**Conclusion** – Patient handling confers the highest risk but other duties confound dose-response assessments. Associations were strong, consistent, temporally possible, plausible, coherent, and analogous to other exposure-outcomes. Risk OR 1.2-5.5 depending on LBP defn.

Causality and Low Back Pain

"Another review of nonspecific back pain related to a nonspecific activity guarantees a null finding”

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)
- U.S. has highest back surgery rate in the world (Andersson, 1997)
- 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)
- Increase in complex fusion surgeries increased 15x from 2002 to 2007 with life threatening complications increasing 3x (Deyo et al, 2010)
- Source of pain often unknown (van Tudler et al, 2006)
- Surgical effect size small (Keller, 2007; Deyo, 2004)
- Value of prevention

What do We Know About Low Back Pain Causality?

(NRC/IOM, 2001)
Physical Factors

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

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)

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

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, 2008)
- Disc problems are very common in those reporting LBP (Cheung, et al., 2009)

Disc Degeneration

A

B

C

D
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

Vertebral Endplate

Scar Tissue Development

Disc Degeneration and Cumulative Trauma

Vertebral Body
Vertebral Endplate
Disc

Scar Tissue

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)
Disc Degeneration Rate Increases Once Disc Damage is Present (Adams et al. 2000)

Spine Loading During Patient Handling

Low Back Pain: Understanding Back Function

Biomechanical Modeling of the Low Back
Can we assess specific spine tissue loads?

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

Trunk Muscle Coactivity

(Marras et al., 2005)
Biologically Assisted (EMG)-Assisted Biomechanical Models

The OSU Biodynamic Model

Personalized Biodynamic Model Structure (2012)

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

W. A. Marais, K. J. Evans, R. C. Krueger, and P. E. Biedrzycki

Biodynamics Laboratories, The Ohio State University, 1977 Neil Avenue, 210 Baker Systems, Columbus OH 43222, USA

Keywords: Patient handling; Spinal loads; Biomechanics; 1990.

Although patient handling is an essential part of patient care, there has been limited research quantifying the risk for the specific tasks performed by the nurses handling the patient. This study aimed to quantify the patient handling loads and task demands that are experienced by nurses handling patients in a hospital setting. The data were collected using a portable computerized data acquisition system monitoring changes in spinal loading. A total of 17 patients were involved in the data collection, and the patient handling activities were assessed using a modified NIOSH lifting equation. The results showed that the maximum loads experienced by the nurses are within the safe limits recommended by the NIOSH lifting equation. However, the data also indicated that the nurses are performing a significant amount of lifting tasks that are close to the maximum safe limit, which may increase the risk of low-back disorder.

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

Transfer Techniques

- 1 person hug
- 2 person hook and toss
- 2 person gait belt

Repositioning Techniques

Spine Compression as a Function of Transfer Task

<table>
<thead>
<tr>
<th>Transfer Task</th>
<th>Compression Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-Person</td>
<td></td>
</tr>
<tr>
<td>Two-Person</td>
<td></td>
</tr>
</tbody>
</table>

Maximum Tolerance

Safe Limit

Wheelchair w/o Arms – Bed
Bed – Wheelchair w/o Arms
Wheelchair – Bed
Bed – Commode
Commode – Chair
Recent Biomechanical Studies Confirm our Findings
Characteristic values of the lumbar load of manual patient handling for the application in workers' compensation procedures

- Biomechanical assessment of 13 patient transfer tasks
- Found high lumbar loads where awkward postures are combined with high forces
- Conclusion – prevention measures needed

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
- Intervention Effectiveness (prospective observation of 100 units)
Patient Handling Interventions

The Effect of Ergonomic Interventions in Healthcare Facilities on Musculoskeletal Disorders

Table: Patient Handling Musculoskeletal Disorder Rate Changes

<table>
<thead>
<tr>
<th>Type of Intervention</th>
<th>n</th>
<th>Baseline Median (Range)</th>
<th>Follow-up Median (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>
<td>.66</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>
<td>.54</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>
<td>.15</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>
<td>.56</td>
</tr>
<tr>
<td>All</td>
<td>100</td>
<td>12.32 (0.0-67.59)</td>
<td>6.64 (0.0-59.51)</td>
<td>.52</td>
</tr>
</tbody>
</table>

Recent Intervention Study with Biomechanical Implications

Effect of Transfer, Lifting, and Repositioning Injury Prevention Program on MSD Injury among Direct Care Workers


- One yr. pre- vs. one yr. post- intervention (3 hosp.) design with control group (3 hosp.)
- Multi-factor intervention
- MSD injury rate pre-intervention = 14.7 vs. 8.1 post-intervention
- Significant difference between intervention and control group

Recent Intervention Study with Biomechanical Implications

Musculoskeletal injuries among hospital patient care staff before and after implementation of patient lift and transfer equipment


- Observed injury rates over 13 years during which minimal manual lift policy and mechanical lifts equipment were implemented
- Rates of days away from work declined immediately – before it was reasonable for the intervention to be adopted
- Conclusion – Institution-level changes at the time of intervention can influence results and are only partially consistent with an intervention effect

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 zero lift interventions had increased reporting

Recent Intervention Study with Biomechanical Implications

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Lifting Transformed into Pushing and Pulling

Pushing and Pulling

Research Question

- 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?

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 degree) turn
  - Gradual turn
  - Sharp turn in confined space (bathroom)
Patient Lift Devices

Ceiling lift

Liko 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

- Straight
- Sharp turn
- Gradual turn
- Confined turn
- Bathroom
- Start
- End

NOTE: All dimensions are in inches

Course Path and Required Control

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**
### Significant Effects

<table>
<thead>
<tr>
<th>Lateral Shear</th>
<th>Compression</th>
<th>A/P Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient Handling System (System)</strong></td>
<td>0.003*</td>
<td>0.015*</td>
</tr>
<tr>
<td><strong>Required Control</strong></td>
<td>0.124</td>
<td>0.069</td>
</tr>
<tr>
<td><strong>System*Weight</strong></td>
<td>0.006*</td>
<td>0.105</td>
</tr>
<tr>
<td><strong>System*Control</strong></td>
<td>0.106</td>
<td>0.002*</td>
</tr>
<tr>
<td><strong>Weight*Control</strong></td>
<td>0.496</td>
<td>0.695</td>
</tr>
<tr>
<td><strong>System<em>Weight</em>Control</strong></td>
<td>0.154</td>
<td>0.081</td>
</tr>
</tbody>
</table>

* Significant (p<0.005)

### L3 A/P Shear a Function of Required Control

- **Straight**
- **Gradual Turn**
- **Sharp Turn**
- **Bathroom**

* Significant (p<0.005)

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

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

### 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 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
Discussion

- 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.

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

*Not statistically significant*

**Obesity Trends Among U.S. Adults between 1985 and 2010**

**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.

Obesity Trends* Among U.S. Adults
BRFSS, 1991
(*BMI $\geq 30$, or ~ 30 lbs overweight for 5’ 4” person)

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BRFSS, 1995
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Obesity Trends* Among U.S. Adults
BRFSS, 2012
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Prevalence* of Self-Reported Obesity Among U.S. Adults
BRFSS, 2011
(*Prevalence reflects BRFSS methodological changes in 2011, and these estimates should not be compared to
those before 2011.)

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Low Back Pain
Risk Factor Environment

Social & Org. Factors
Individual Factors
Physical Factors
Non-Physical Factors Affecting Spine Loading:

Individual & Psychosocial Factors

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

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

Variability of Biomechanical Responses to Psychosocial Stress (Marras et al., 2000)

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

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

Musculoskeletal Control and Tissue Load
Working with Low Back Pain

The Effects of Working with Low Back Pain Spine Loading

Dynamic Spine Loading

Role of Wellness in Occupational Low Back Disorders

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

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, T. and Harter, J., 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

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

![Graph showing health care costs](image)

(Rath and Harter, 2010)

**Pain From the Brain: Central Sensitization**

![Brain scans](image)

Functional MRI scans show brain response in pain-sensitive (left) and nonsensitive (right) patients.

http://www.pnas.org/misc/archive062303.shtml

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**Turnover Costs: 35-52% Lower for Thriving Employees**

![Graph showing turnover costs](image)

(Rath and Harter, 2010)

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**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!
Thank You!

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