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://biodynamics.osu.edu

Most Frequent Nonfatal Occupational Injuries and Illness Requiring Days Away from Work, 2011 (BLS 2012)

*Incidence rate per 10,000 full-time employees

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.
Recent Studies Indicating LBP Prevalence/Risk and Patient Handling

Patient transfers and assistive devices: Prospective cohort study on the risk for occupational back injury among healthcare workers


- Prospective cohort study of work-related LBP risk factors in health care workers
- 5017 female eldercare workers in Denmark
- Daily patient transfers incr. LBP risk (OR = 1.75)
- Attributable fraction risk estimate = 36%

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

(NRC/IOM, 2001)

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

Biomechanics is More than Strength

(Weinstein, 2006)

Traditional Biomechanical Logic

Load – Tolerance Relationship and Risk

(McGill, 1997)

Risk of Injury

Tolerance

Safety Margin

Loading Pattern
**Biomechanical Modeling of the Low Back**

Can we assess specific spine tissue loads *in-vivo*?

**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)

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

**Laboratory Assessment of Push-Pull**

**Assessment of Spine Forces Based Upon Task**

**Spine Loads at Different Levels**
Assessment of Specific Tissue Loads

Our Early Patient Lifting Studies

- Bed to/from wheelchair with arms
- Bed to/from wheelchair with one arm removed
- Portable commode chair to/from hospital chair

Patient Lifting Origins/ Destinations

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

Patient Transfer Techniques

- Bed – wheelchair
- Wheelchair w/o Arms – Bed
- Wheelchair – Bed
- Bed – Wheelchair
- Chair – Commode

Spine Compression as a Function of Transfer Task

- Maximum Tolerance
- Safe Limit

Transfer Task

- One-Person
- Two-Person
Spine Compression as a Function of Transfer Technique

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

Fujishiro, et al. (2005)

<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 (0.0-87.59)</td>
<td>6.64 (0.0-59.51)</td>
<td>.52</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>0.031</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!
  - 23% of zero lift interventions had increased reporting

---

## Intervention Effectiveness

Musculoskeletal pain among critical-care nurses by availability and use of patient lifting equipment: an analysis of cross-sectional survey data


- Evaluated device availability and use in 361 crit. care nurses
- 46% reported employer provided lifts
- Of those that did:
  - Availability of lifts: high = 59%, medium = 25%, low = 14%
  - Use: high = 32%, medium = 31.5%, low = 31.5%
  - ½ as likely to have LBP (compared to nurses w/o lifts)

---

## Lifting Transformed into Pushing and Pulling

### Pushing and Pulling

Pushing and Pulling

---

## Pushing/Maneuvering Patients

Lifting Transformed into Pushing and Pulling

Pushing and Pulling

---

Evaluation

- pusher forces during pushing and pulling of bed-based and floor-based patients using devices

R.K. Stoeckle, S. Koppel and P. Fischer

Bed-based Patient Transfers: A large-scale evaluation of patient handling forces during pushing and pulling of bed-based patients. The study investigates the forces experienced by the pushers during the transfer of patients from bed to wheelchair in different clinical settings. The results indicate that pusher forces are significantly lower when using specialized patient handling devices compared to manual handling.

Bed-based Patient Transfers: A large-scale evaluation of patient handling forces during pushing and pulling of bed-based patients. The study investigates the forces experienced by the pushers during the transfer of patients from bed to wheelchair in different clinical settings. The results indicate that pusher forces are significantly lower when using specialized patient handling devices compared to manual handling.

Floor-based Patient Transfers: A large-scale evaluation of patient handling forces during pushing and pulling of floor-based patients. The study investigates the forces experienced by the pushers during the transfer of patients from floor to wheelchair in different clinical settings. The results indicate that pusher forces are significantly lower when using specialized patient handling devices compared to manual handling.
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

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

Course Path and Required Control

Ceiling Lift Trial and Analysis

NOTE: All dimensions are in inches
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></th>
<th>Lateral Shear</th>
<th>Compression</th>
<th>A/P Shear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient Handling System (System)</td>
<td>0.003*</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 (Control)</td>
<td>0.006*</td>
<td>0.105</td>
<td>0.005*</td>
</tr>
<tr>
<td>System*Weight</td>
<td>0.015*</td>
<td>0.189</td>
<td>0.133</td>
</tr>
<tr>
<td>System*Control</td>
<td>0.0106</td>
<td>0.002*</td>
<td>0.004*</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 as a Function of Required Control

- *Significant (p<0.005)

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.

Obesity Trends* Among U.S. Adults

BRFSS, 1985

(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4" person)

*Not statistically significant
Obesity Trends* Among U.S. Adults
BRFSS, 1986
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1987
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1988
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1989
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1990
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1991
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%  15%–19%
Obesity Trends* Among U.S. Adults
BRFSS, 1992
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1993
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1994
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1995
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1996
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%

Obesity Trends* Among U.S. Adults
BRFSS, 1997
(*BMI ≥ 30, or ~ 30 lbs overweight for 5' 4" person)

No Data  <10%  10%–14%  ≥20%
Obesity Trends* Among U.S. Adults
BRFSS, 1998
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 1999
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2000
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2001
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2002
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2003
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)
Obesity Trends* Among U.S. Adults
BRFSS, 2004
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2005
(*BMI ≥ 30, or ~ 30 lbs overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2006
(*BMI ≥ 30, or ~ 30 lbs. overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2007
(*BMI ≥ 30, or ~ 30 lbs. overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2008
(*BMI ≥ 30, or ~ 30 lbs. overweight for 5’ 4” person)

Obesity Trends* Among U.S. Adults
BRFSS, 2009
(*BMI ≥ 30, or ~ 30 lbs. overweight for 5’ 4” person)
Obesity Trends* Among U.S. Adults
BRFSS, 2009
(*BMI ≥ 30, or ~ 30 lbs. overweight for 5' 4" person)

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 previous years.

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

2006 BMI Comparison

Low Back Pain
Risk Factor Environment

© 2008 Hill-Rom Services, Inc. ALL RIGHTS RESERVED.
The Power of Social Contagion

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

(Marras et al., Spine, 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

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

Spine Loading Response to Psychosocial Stress

(Marras et al., Spine, 2000)

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

Musculoskeletal Control and Tissue Load

(Marras et al., Spine, 2000)
Pain From the Brain: Central Sensitization

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

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

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

(Rath, T. and Harter, J., 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)

Thriving Employees have 62% Lower Health-Related Costs Compared to those Who are Suffering

(Rath and Harter, 2010)

Turnover Costs: 35-52% Lower for Thriving Employees

(Rath and Harter, 2010)
Health Care Costs are Directly Related to the Number of Thriving Dimensions

Pathways to Spine Tissue Force Generation

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

Thank You!

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