Low Back Biomechanics and Patient Handling

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Review Study of Low Back Pain Prevalence

Work-related back pain in nurses
Hignett, S.
(2008) *J. Advanced Nursing* 23(6), p. 1238-1246

- 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

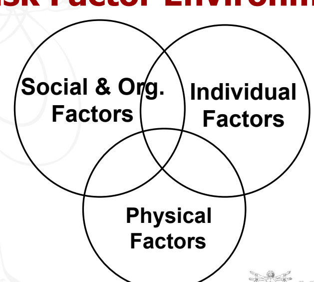
Work-relatedness of low back pain in nursing personnel: A systematic review
Yassi, A and Lockhard, K
(2013) *Int. J. Occ. and Environ Health*, 19(3), p. 223-244

- 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.

Establishing Causality: Bradford Hill

1. Strength of Association
2. Temporal Association
3. Consistency of Association
4. Specificity of Association
5. Dose-Response Relationship
6. Biological Plausibility

Low Back Pain Risk Factor Environment



(NRC/IOM, 2001)

Studies with Biomechanical Implications

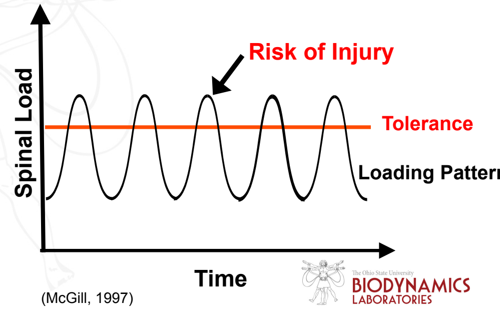
Expanded OSHA 300 log as metric for bariatric patient-handling staff injuries
Randall, S. B., Pories, W. J., Pearson, A., Drake, D.J.
(2009) *Surg Obes Relat Dis*, 5(4), p. 463-468

- 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

Biomechanical Logic

Load – Tolerance Relationship and Risk

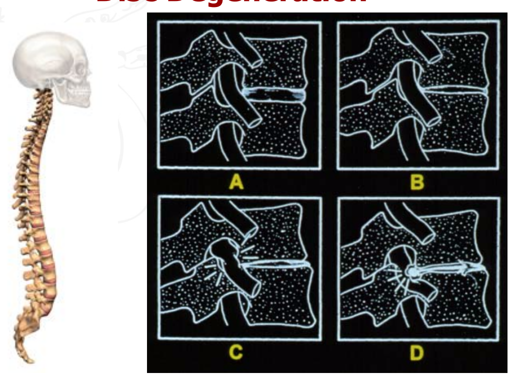


(McGill, 1997)

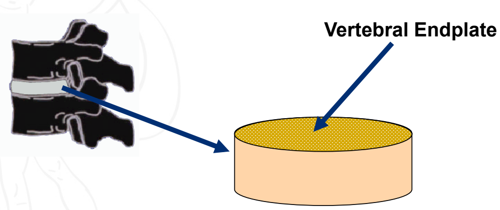
Intervertebral Disc

- 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)

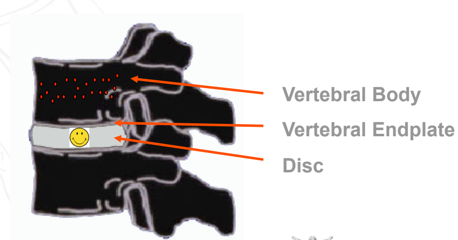
Disc Degeneration



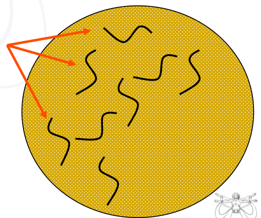
How Cumulative Trauma Develops in the Spine



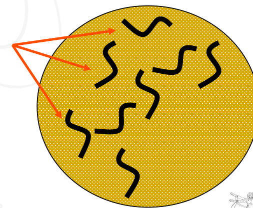
Disc Nutrition Pathways



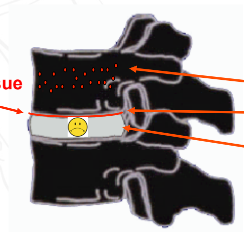
How Cumulative Trauma Develops in the Spine



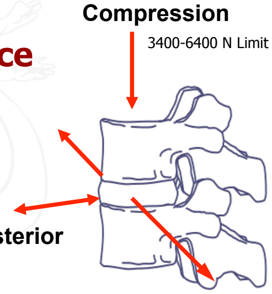
How Cumulative Trauma Develops in the Spine



Disc Degeneration and Cumulative Trauma



Spine Tolerance Limits



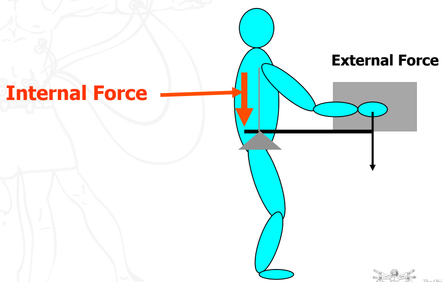
Biomechanical Modeling of the Low Back

Can we assess specific spine tissue loads?

The Development of a *Personalized* Biomechanical Model

- Unique to the subject/patient (muscle control, imaging, structure characteristics)
- Driven by muscle activities characteristic of pathology
- Show tissue compromise
- Predict tissue breakdown
- Use to understand biochemical triggering
- Can assist in understanding impact of interventions (surgical vs. conservative)

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



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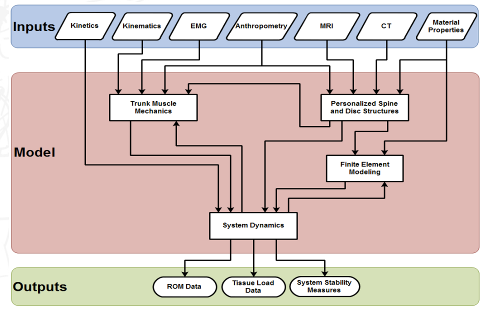
Personalized Model Structure



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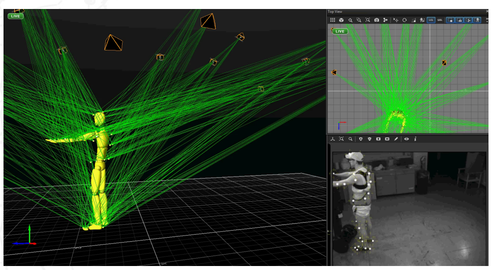
Laboratory Assessment of Push-Pull



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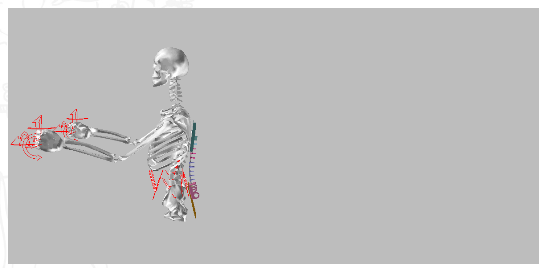
Assessment of Spine Forces Based Upon Task



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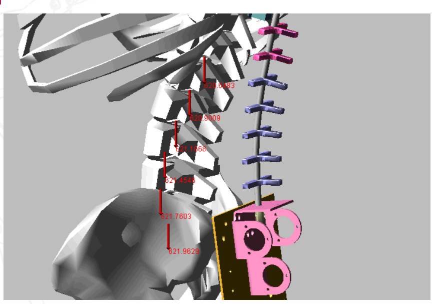
Spine Loads at Different Levels



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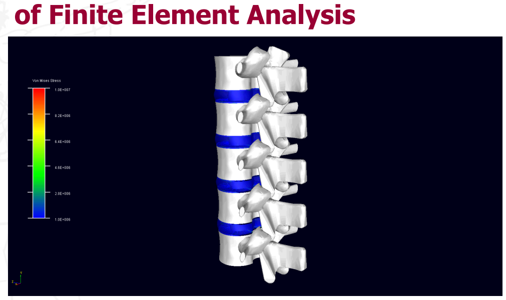
Specific Tissue Loads with Inclusion of Finite Element Analysis



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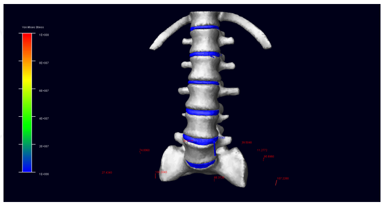
Patient Specific Anatomy



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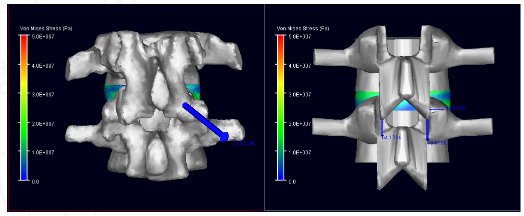
Individual Anatomy Affects Spine Loading



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Our Early Patient Lifting Studies

Ergonomics, 1999, vol. 42, no. 7, 904 – 926

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

W. S. Marras*, K. G. Davis, B. C. Kirking and P. K. Bertsche

Biodynamics Laboratory, The Ohio State University, 1971 Neil Avenue, 210 Baker Systems, Columbus OH 43210, USA

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

Although patient handlers suffer from low-back injuries at an alarming rate worldwide, there has been limited research quantifying the risk for the specific tasks performed by the patient handlers. The current study used both a comprehensive evaluation system (low-back disorder risk model) and theoretical model (biomechanical spinal loading model) to evaluate risk of LBD of 17 participants (12 experienced and five inexperienced) performing several patient handling tasks. Eight of the participants were female and nine were male. Several patient transfers were evaluated as well as repositioning of the patient in bed;

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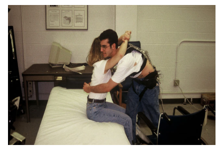
Patient Lifting Origins/ Destinations

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



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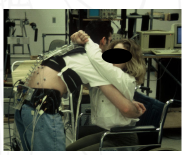
Transfer Techniques

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



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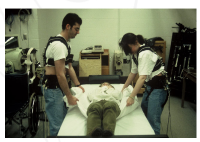
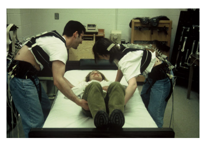
Repositioning Techniques





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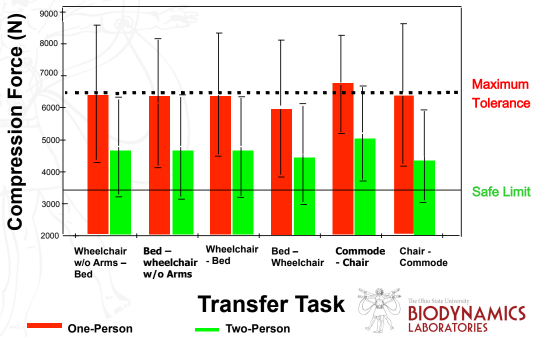
Spine Compression as a Function of *Transfer* Task



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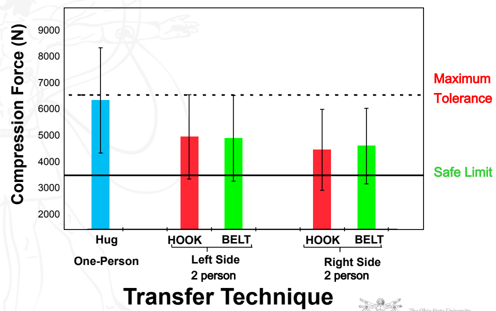
Spine Compression as a Function of *Transfer* Technique



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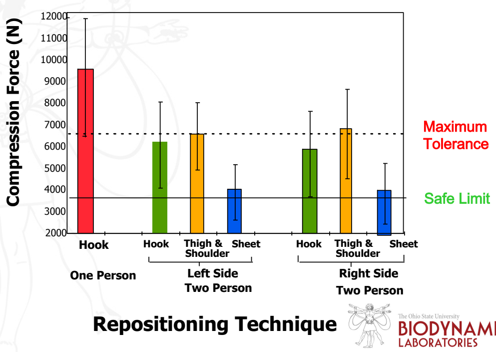
Spine Compression as a Function of *Repositioning* Technique



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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)**

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Patient Handling Interventions

AMERICAN JOURNAL OF INDUSTRIAL MEDICINE 48:338–347 (2005)

The Effect of Ergonomic Interventions in Healthcare Facilities on Musculoskeletal Disorders

Kaori Fujishiro, PhD,[1*] Jean L. Weaver, PT,[2] Catherine A. Heaney, PhD,[3] Christopher A. Hamrick, CPE,[4] and William S. Marras, PhD[5]

Background *The high incidence of musculoskeletal disorders (MSDs) among healthcare workers suggests that the introduction of ergonomic interventions could be beneficial. While laboratory studies have clearly documented the efficacy of ergonomic devices, few studies have examined their effectiveness in the healthcare workplace.*
Methods *This study evaluated a statewide program that provided ergonomic consultation and financial support for purchasing ergonomic devices, which aid in patient handling and lifting. Changes in MSD rates between baseline (1 year pre-intervention) and post-intervention (up to 2 years) periods were examined in 100 work units in 86 healthcare facilities*

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Patient Handling Musculoskeletal Disorder Rate Changes (#MSDs/employee-hours worked)*200,000

Type of Intervention	n	Baseline median (Range)	Follow-up median (Range)	Rate Ratio (FU/ BL MSD rate)
Reduce Bending	**16**	**9.89 (0.0-42.65)**	**6.65 (0.0-59.51)**	**.66**
Zero Lift	**44**	**15.38 (0.0-87.59)**	**9.25 (0.0-28.27)**	**.54**
Reduce Carrying	**8**	**6.47 (0.0-15.80)**	**0.33 (0.0-6.70)**	**.15**
Multiple Interventions	**32**	**11.98 (0.0-60.34)**	**7.78 (0.0-25.94)**	**.56**
All	**100**	**12.32 (0.0-87.59)**	**6.64 (0.0-59.51)**	**.52**

(Fujishiro, et al. 2005)

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

Type of Intervention	# Units Decreased or no change	Number of Units Increased	P-value
Reduce Bending	12 (75%)	4 (25%)	0.056
Zero Lift	32 (72.7%)	12 (27.3%)	0.002
Reduce Carrying	7 (87.5%)	1 (12.5%)	0.031
Multiple Interventions	26 (81.3%)	6 (18.7%)	0.001
All	77 (77.0%)	23 (23.0%)	<0.001

(Fujishiro, et al. 2005)

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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

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Lifting Transformed into Pushing and Pulling

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Pushing and Pulling

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Pushing/Maneuvering Patients

Ergonomics
Vol. 52, No. 3, March 2009, 384–397

Taylor & Francis

Lumbar spine forces during manoeuvring of ceiling-based and floor-based patient transfer devices

W.S. Marras*, G.G. Knapik and S. Ferguson

Biodynamics Laboratory, The Ohio State University, 1971 Neil Ave., Columbus, Ohio 43210, USA

Patient handling continues to represent a high risk task for low back pain (LBP) among health caregivers. Previous studies indicated that manual transfers of patients impose unacceptable loads on the spine even when two caregivers perform the transfer. Patient lift devices are considered a potential intervention; however, few biomechanical analyses have investigated the spine loads and LBP risk associated with these transfer devices. This study analysed the 3-D spine forces imposed upon the lumbar spine when 10 subjects manipulated ceiling-based and floor-based patient lifts through various patient handling conditions and manoeuvres. The results indicated that ceiling-mounted patient lift systems imposed spine forces upon the lumbar spine that would be considered safe, whereas floor-based patient handling systems had the potential to increase anterior/posterior shear forces to unacceptable levels during patient handling manoeuvres. Given these findings, ceiling-based lifts are preferable to floor-based patient transfer systems.

Keywords: low back pain; low back disorders; patient transfer; patient handling; patient lifting; safe patient handling; spine biomechanics

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Patient Lift Devices

Ceiling lift

Likorall 243 ES
(230 Kg capacity)

Floor based lift

Liko Viking L
(250 Kg capacity)

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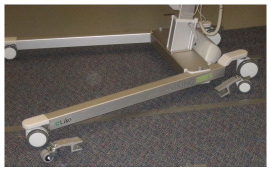
Experimental Conditions

- 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



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Patients

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

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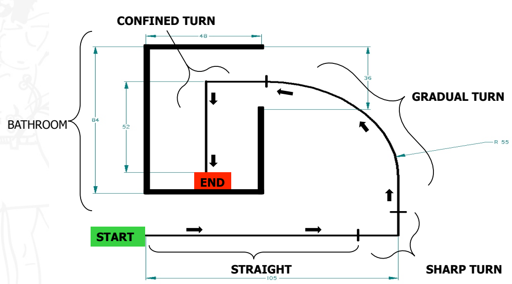
Course Path and Required Control



NOTE: All dimensions are in inches

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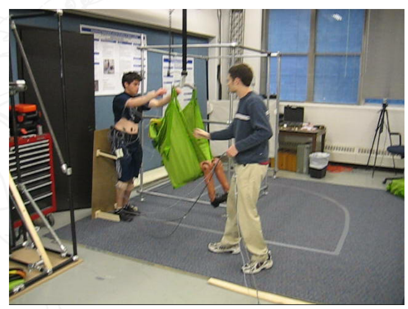
Course Path and Required Control



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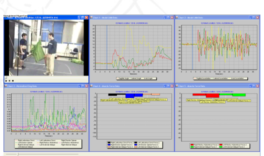
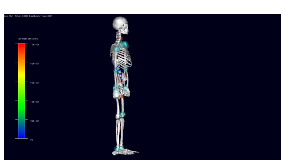
Ceiling Lift Trial and Analysis





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Floor Based Lift used on Carpet

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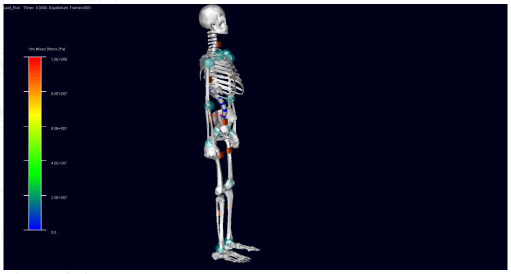
Floor Based Lift used on Carpet



Results:

Spine Load Magnitudes

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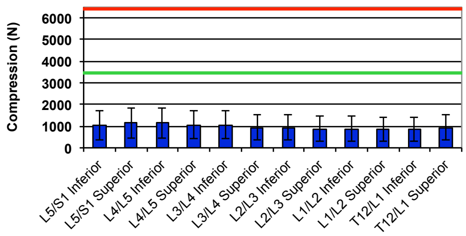
Compression as a Function of Vertebral Level



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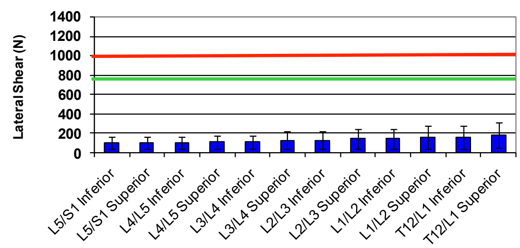
Lateral Shear as a Function of Vertebral Level



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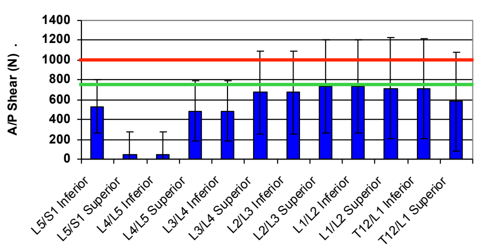
A/P Shear as a Function of Vertebral Level



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Significant Effects

	Lateral Shear	Compression	A/P Shear
Patient Handling System (System)	0.003*	0.015*	0.060
Patient Weight (Weight)	0.124	0.069	0.057
Required Control over System (Control)	0.006*	0.105	0.005*
System*Weight	0.015*	0.189	0.133
System*Control	0.106	0.002*	0.001*
Weight*Control	0.496	0.695	0.497
System*Weight*Control	0.154	0.081	0.070

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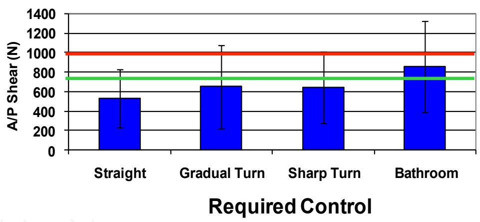
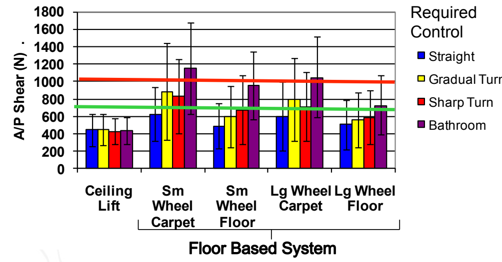
L3 A/P Shear a Function of Required Control



* Significant (p<0.005)

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

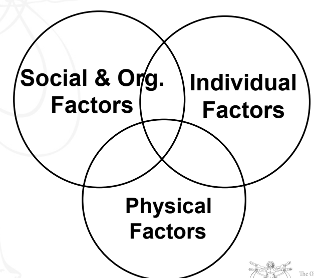


* Significant (p<0.001)

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.

Low Back Pain Risk Factor Environment



Non-Physical Factors Affecting Spine Loading:

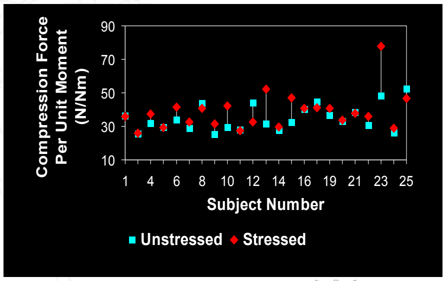
Individual & Psychosocial Factors

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**

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



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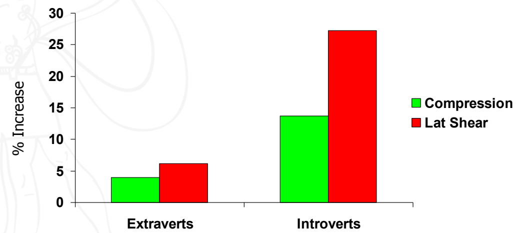
Differences in Spinal Loads Between Personality Traits in Response to Psychosocial Stress (Marras et al., 2000)



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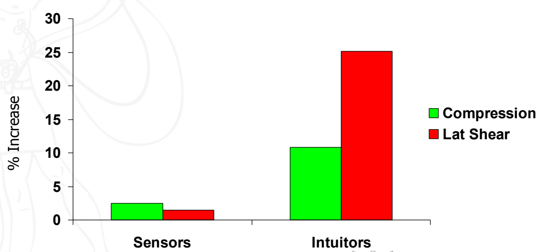
Differences in Spinal Loads Between Personality Traits in Response to Psychosocial Stress (Marras et al., 2000)



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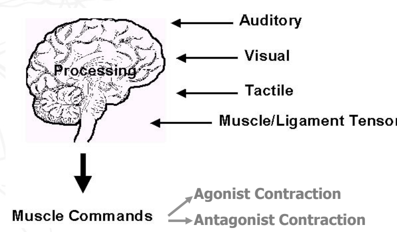
Musculoskeletal Control and Tissue Load



Antagonist *Cocontraction* Leads to Increased Tissue Load

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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!

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Thank You!

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