Use of the Industrial Lumbar Motion Monitor™ (iLMM™) and LBD Risk Assessment System
Training Topics

• Introduction, uses of the iLMM™
• Research leading to the development of the iLMM™
• Design of the iLMM™ and components
• Details of the Ballet™ 2.4 Software
• Workshop
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iLMM™ Lumbar Motion Monitor
Applications

- LBD risk model
- Specific trunk motions
Applications
• Specific trunk motions
Applications
• Assessment of low-back functionality
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Goals of LMM Development

• To quantify in industry the workplace and trunk motion factors associated with manual materials handling
• To associate these factors with LBD risk
• To determine the degree of exposure associated with degree of risk
Why This Level of Evaluation and Analysis?

- Limitations with other assessment tools
  - NIOSH LE (1981) – Low sensitivity, High specificity
  - NIOSH LE (1991) – High sensitivity, Low specificity
  - Most Low-Back assessment tools are static (no motion parameter built into tools)
## Correct Classification of 1981 NIOSH Lifting Guide

<table>
<thead>
<tr>
<th>NIOSH Lifting Index</th>
<th>LBD Injury Rates via OSHA 200 logs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=124)</td>
</tr>
<tr>
<td>Lifting Index $\leq 1$</td>
<td>91% (n=113)</td>
</tr>
<tr>
<td>Lifting Index $1 &lt; \leq 3$</td>
<td>9% (n=11)</td>
</tr>
<tr>
<td>Lifting Index $&gt;3$</td>
<td>0% (n=0)</td>
</tr>
</tbody>
</table>

* Statistically significant at $\alpha = 0.05$
Correct Classification of 1991 NIOSH Lifting Guide

<table>
<thead>
<tr>
<th>NIOSH Lifting Index</th>
<th>LBD Injury Rates via OSHA 200 logs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (n=124)</td>
</tr>
<tr>
<td>Lifting Index ≤ 1</td>
<td>55% (n=68)</td>
</tr>
<tr>
<td>1&lt; Lifting Index ≤ 3</td>
<td>22% (n=27)</td>
</tr>
<tr>
<td>Lifting Index &gt;3</td>
<td>23% (n=29)</td>
</tr>
</tbody>
</table>

Note: No correlations are statistically significant
Why This Level of Evaluation and Analysis?

- Limitations with other assessment tools
- Includes knowledge of the effects of moving in multiple planes of motion
Spine Planes of Motion

- **Forward bending** (sagittal plane)
- **Side bending** (frontal plane)
- **Twisting** (transverse plane)
Spine Loading Forces

- Compression
- Lateral Shear
- Anterior / Posterior (A/P Shear)
Typical 3-D Movements of a Low-Injury Rate Job
Typical 3-D Movements of a High-Injury Rate Job
Range of Motion Differences

* Significant Odds Ratio

<table>
<thead>
<tr>
<th></th>
<th>Sagittal*</th>
<th>Lateral</th>
<th>Twisting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>35</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>High Injury</td>
<td>40</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Low Injury</td>
<td>25</td>
<td>20</td>
<td>20</td>
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</tbody>
</table>
Maximum Velocity Differences

- **Sagittal**: High Injury is significantly higher than Low Injury.
- **Lateral**: No significant difference between High and Low Injury.
- **Twisting**: High Injury is significantly higher than Low Injury.

* Significant Odds Ratio
Development of LMM Risk Assessment Model

400+ jobs from ~50 different industries

- Automobile assembly
- Chemicals & related products
- Electrical & electronic equipment
- Food processing
- Glass production
- Lumber and wood construction
- Machined products manufacturing
- Metal fabrication
- Miscellaneous production
- Paper good production
- Printing and publishing
- Rubber & plastics production
- Truck assembly
- Vehicle parts/accessories production
Data Collected

100+ Total Measures

- Distance of object from employee (moment)
- Object weight
- Start / finish heights of lifts
- Lifting frequency
- Employee anthropometry, injury history, job satisfaction
- 3-D trunk position, velocity, & acceleration
Injury Classification

• “Low” Rate of Low-Back Disorders:
  Zero incidences / 200,000 hours & zero turnover

• “High” Rate of Low-Back Disorders:
  12+ incidences / 200,000 hours
Research Question and Answers:

Question:
• Which factors best distinguish between high- and low-injury jobs?

Answer:
• Variables found to best assess risk:
  • Lifting frequency
  • Maximum moment
  • Maximum sagittal flexion
  • Average twisting velocity
  • Maximum lateral velocity

Data gathered from the LMM
Why This Level of Evaluation & Analysis?

• Limitations with other assessment tools
• Includes knowledge of the effects of moving in multiple planes of motion
• More predictive than other assessments
Odds Ratio Comparisons

- NIOSH 1981: 3.5
- NIOSH 1991: 3.0
- LMM Risk Assessment: 10.8
Why This Level of Evaluation & Analysis?

• Limitations with other assessment tools
• Includes knowledge of the effects of moving in multiple planes of motion
• More predictive than other assessments
• Allows one to look at trade-offs
## Company: Truck Assembly

### Job: Door Hang

<table>
<thead>
<tr>
<th>Lift rate (Lifts/hour)</th>
<th>12.8</th>
<th>46</th>
<th>85.2</th>
<th>117</th>
<th>147</th>
<th>176</th>
<th>208</th>
<th>247</th>
<th>306</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Twisting Velocity (deg/sec)</td>
<td>0.4</td>
<td>1.3</td>
<td>2.4</td>
<td>3.3</td>
<td>4.2</td>
<td>5.0</td>
<td>6.0</td>
<td>7.1</td>
<td>8.7</td>
</tr>
<tr>
<td>Maximum Moment (Nm)</td>
<td>2.5</td>
<td>9.0</td>
<td>16.6</td>
<td>22.8</td>
<td>28.6</td>
<td>34.3</td>
<td>40.6</td>
<td>48.2</td>
<td>59.7</td>
</tr>
<tr>
<td>Maximum Sagittal Flexion (degrees)</td>
<td>0.7</td>
<td>3.4</td>
<td>4.4</td>
<td>6.0</td>
<td>7.5</td>
<td>9.0</td>
<td>10.7</td>
<td>12.7</td>
<td>15.7</td>
</tr>
<tr>
<td>Maximum Lateral Velocity (deg/sec)</td>
<td>1.8</td>
<td>6.3</td>
<td>11.7</td>
<td>16.7</td>
<td>20.1</td>
<td>24.2</td>
<td>28.6</td>
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<td>42.1</td>
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Probability of High Risk Group Membership
Company: TV Manufacture
Job: Small Panel Inspect

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<th>Lift rate (Lifts/hour)</th>
<th>Average Twisting Velocity (deg/sec)</th>
<th>Maximum Moment (Nm)</th>
<th>Maximum Sagittal Flexion (degrees)</th>
<th>Maximum Lateral Velocity (deg/sec)</th>
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Probability of High Risk Group Membership
Why This Level of Evaluation & Analysis?

• Limitations with other assessment tools
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• More predictive than other assessments
• Allows one to look at trade-offs
• Tool is validated
Comparisons: Back Injury Rates & Risk Predictions

**Risk Assessment**

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<thead>
<tr>
<th>Job Change Category</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Med</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
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</tbody>
</table>

**Injury Rate**

<table>
<thead>
<tr>
<th>Job Change Status</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBD Incidence Rate /100 FT Emps.</td>
<td>15</td>
<td>0</td>
</tr>
</tbody>
</table>

- **High**
- **Med**
- **Low**
Reference Publications


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iLMM™ Components

- **iLMM™**
  - Accommodates most heights, spine lengths
  - Digital telemetry transmitter & receiver
  - Rechargeable AA batteries, charger
  - Hard-wire data cable

- **Color-coded waist & shoulder harnesses**
  - Accommodates 5th to 95th percentile people
  - Leg straps

- **Computer**

- **Ballet 2.4 software**
Peripheral Components to Consider

- Tape measure
- Heavy-duty scale or push-pull gauge
- Extension cord
- Power strip
- Data collection forms
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Ballet™ 2.4 Software
Initial Screen

Hot Buttons

Database Structure

Database Info
Ballet™ 2.4 Software Calibration Screen

Calibrate LMM

Instructions:

1) Select LMM Size: Medium

2) Place LMM in its case and click "Adjust".

Motion Traces
Ballet™ 2.4 Software
Data View Screen

- **Trunk Kinematic Traces**
- **Selected Runs (up to five)**
- **Trunk Kinematic Data**
Ballet™ 2.4 Software
Data Analysis Screen

Company: Safeway
Job: Bakery Manager
Average Probability of Low Back Disorder Risk: 67%

LBD Risk Value
Important Notes, Tips, and Limitations

• Can **export** summary or all motion data (60 Hz) into Excel (NOTE: **only** exports in **metric units**)

• To change the moment arm (lift origin & destination), you must change the input under the “**Runs**” category (NOT “Tasks”) within Ballet™ 2.4 for it to change the LBD Risk Model “**Analyze**” output.

• The NIOSH Lift Equation & Psychophysical functions within Ballet™ 2.4 do **NOT** function properly.
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Data Collection and Analysis Steps

1. Review job and task requirements, individuals to be monitored
2. Input information into software
3. Set up iLMM for use
4. Put iLMM and harnesses on individual
5. Gather needed data
6. Review data for accuracy
7. Compute LBD risk using model
Questions? → Contact:
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