The Biomechanical Basis for Ergonomics in High Exertion Tasks

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The issues to be discussed:

1. Why should anybody be concerned about high exertions?

2. What is the science that allows us to understand the adverse affects of high exertions?

3. How is the science being applied to reduce the problems with high exertions in the workplace?

4. What role does Digital Human Modeling have in the design of future workplaces?
Why should others be concerned?

One of the most basic requirements to achieve a good Quality of Life is to live without pain or fear of being injured.

Per: A.H. Maslow (1908-1970)

Fundamental knowledge from the field of Human Factors and Ergonomics, has been developing and applied in the workplace for over 70 years. Unfortunately, in 2007 over 4 million workers reported serious injuries or lost time due to workplace conditions and tasks in the US.

(per GAO-10-10 report)

The **workplace** is where we spend almost one-third of our adult life--it affects us in many ways. No one wants to spend that much of their life in pain or fear of injury.
Many different jobs have imbedded high exertion tasks!

Shipping and Distribution

Equipment Maintenance

Stock Handling

Patient Handling

Vehicle Assembly

Construction
Occupational Low Back Pain alone is a major medical issue in many industries:

<table>
<thead>
<tr>
<th>Industry Group</th>
<th>Annual % of workers Reporting lost time due to Low Back Pain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare services</td>
<td>15%</td>
</tr>
<tr>
<td>Construction</td>
<td>11%</td>
</tr>
<tr>
<td>Transportation, public utilities</td>
<td>9%</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>7%</td>
</tr>
<tr>
<td>Wholesale, retail trade, distribution</td>
<td>7%</td>
</tr>
<tr>
<td>Insurance and Banking</td>
<td>2%</td>
</tr>
</tbody>
</table>

US BLS (1991)
When Disc Compression force becomes too high the disc fails and can cause impingement on Lumbar Nerve Roots (Sciatica).
Compression Force Applied to Disc (pounds)

Note: Compression failure values apply to 20 to 40-year old males/females (Jager and Luttmann, 1992)

Also, NIOSH limit does not include repetitive stress and complex loading of motion segments.
Existing **3DSSPP software** allows simulating most manual Materials handling tasks and predicting static strengths, balance and low back loads.
With equalized lumbar load moments in both tasks.

Based on 3DSSPP analyses.
Low Back Pain Risk Factors were found to include dynamics of task

<table>
<thead>
<tr>
<th>Factors</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Workplace Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Ave. weight handled</td>
<td>2.76</td>
</tr>
<tr>
<td>Max. weight handled</td>
<td>3.17</td>
</tr>
<tr>
<td>Ave. moment (L5/S1)</td>
<td>4.08</td>
</tr>
<tr>
<td>Max. moment (L5/S1)</td>
<td>5.17</td>
</tr>
<tr>
<td><strong>Trunk Motion Factors</strong></td>
<td></td>
</tr>
<tr>
<td>Sagittal Plane (flex/ext)</td>
<td></td>
</tr>
<tr>
<td>Ave. angular velocity</td>
<td>3.33</td>
</tr>
<tr>
<td>Max. angular velocity</td>
<td>1.73</td>
</tr>
<tr>
<td>Lateral Plane (lat. Flexion)</td>
<td></td>
</tr>
<tr>
<td>Ave. angular velocity</td>
<td>1.73</td>
</tr>
<tr>
<td>Max. angular velocity</td>
<td>1.55</td>
</tr>
<tr>
<td>Horizontal Plane (twist)</td>
<td></td>
</tr>
<tr>
<td>Ave. angular velocity</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Marras et al. 1993
Biomechanical Principles (Guidelines) to prevent overexertion related Low Back Pain which have been well accepted in Ergonomics:

1. Keep heavy loads off floor (limit bending lifts).
2. Handle heavy loads close to body and in front of body (don’t twist and lift).
3. Maintain high traction and level floors (limit slips).
5. Rest muscles between high exertions.
Has the biomechanical knowledge had an affect on injuries?

BLS Injury Rates: Motor Vehicles and Car Bodies, SIC 3711

OSHA Citations for Recordkeeping

Ergo Programs in Effect

Year

Rate/100 Employees

Total

Injuries

illness
Proposition: Despite all of our Human Systems Integration knowledge, we don’t seem to apply it soon enough to improve the design of products and workplaces.
Do practicing product and production engineers recognize need for ergonomics in the early phases of design?

Yes!


Why is ergonomics the late comer in Design of the workplace?

A survey of engineering educators disclosed that less than 10% of graduating engineers have taken even one course related to human systems integration.

ret; Chaffin, Human Factors Bulletin, 2005d
Can we use Digital Human Models to address over-exertion injuries during the design of the workplace?
Typical Digital Human Models that are imbedded in commercial CAD systems.

Jack (Siemens)

SafeWork (Dassault)

ProE/Manikin (PTC)

Note: All require sophisticated knowledge of how to position people.

RAMSIS (Human Solutions)

HumanCAD (NextGen Ergo)
So what do we know?

1. The problems of MMH are ubiquitous and complex.

1. There are no silver bullets. Teamwork is essential!

1. Biomechanical models can help us reduce some of the complexity.

1. Workplace designers and engineers must be more aware and proactive in reducing the risk factors.
Final Thought:

The only way to have is to give ---
The only way to keep is to share ---
And the only things worth finding are opportunities to improve people’s lives.

Thank you!