Biomechanics of Gait on Irregular Surfaces

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Motivation: Fall Prevention

- 30% of older adults fall each year (Tinetti et al. 1988)
- 24% of falls lead to serious injury (Tinetti et al. 1988)
- Loss of independence (Dunn et al. 1992)
- Morbidity (Gryfe et al. 1977)
- Death (Sattin 1992)
Motivation: Fall Prevention

Activities in which fallers were engaged at the time of fall (Berg et al. 1997)

- Walking on Level Ground or Floor: 24%
- Walking on Uneven, Bumpy, Ground or Floor: 24%
- Hurrying to Get Work Done: 12%
- Working in the Yard or Garden: 9%
- Carrying Something Heavy or Bulky: 9%
- Stair Ascent: 7%
- Stair Descent: 7%
- Looking or Turning Around While Standing: 7%
- Playing Sports or Exercising: 7%
- Other: 7%

Percentage of Falls
So, we need a better understanding of how humans safely cross irregular surfaces
Biomechanics of Perturbed Gait

\[ M = F_R \times D \]

\[ F'_R \text{ Pert.} \quad F'_R \]

\[ F_R \]
Effects on Step Pattern
Parameters of Interest

- **Step width** – a key factor in controlling frontal plane stability (Bauby et al. 2000),

- **Stride time variability** - a predictor of fall risk (Hausdorff et al. 2001)
Experiment

- Irregular surface
- Motion capturing system
- Statistics
Age Effect

Step Width Variability [mm]

- High Light Flat Ground
- Low Light Flat Ground
- High Light Irregular Ground
- Low Light Irregular Ground

* indicates statistical significance.
Diabetic Neuropathy

Gradient loss of sensory function in typical patient with neuropathy

- 20-fold risk for falls (Richardson et al. 1992)
Neuropathic Gait on Irregular Surface

- Speed decreased

<table>
<thead>
<tr>
<th>Condition</th>
<th>Step Width Variability [mm]</th>
<th>Step Time Variability [msec]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Surface, Regular Light</td>
<td>40</td>
<td>70</td>
</tr>
<tr>
<td>Irregular Surface, Low Light</td>
<td>30</td>
<td>80</td>
</tr>
</tbody>
</table>

*Statistically significant difference
Irregular surfaces affect

- Step width variability, key factor in the control of frontal plane stability
- Step time variability, associated with fall risk
- Speed, associated with fear of falling
New Emerging Irregular Surfaces

We are concerned!

http://www.pavingexpert.com/tactile01.htm
New Experiment

• Frontal plane stability (i.e. step width)
• Fall risk (i.e. step time variability)
• Time to stop, # of steps to stop
• Balance control during quiet standing (pelvis acceleration)
• Time to accelerate to comfortable speed
New Experiment

- Instrumented indoor ‘street crossing’
- Testing of older and balance impaired people
Thank you!

Questions?