Good morning, everyone. I am Michael Lin from the Harvard School of Public Health. Today I am going to present our study on evaluating the effect of four different pointing designs on upper extremity posture and muscle activity during mousing tasks.
Take Home Message

- Rollermouse allowed users to operate with a more neutral hand posture and lower forearm muscle activity. User reported ease and comfort when using it.
Prolonged mouse use is associated with MSD risk factors include non-neutral postures, specifically related to extreme ulnar deviation, wrist extension and forearm pronation, and sustained muscle activity. And there are many alternative computer input devices, such as the track ball and a Contour Roller Mouse, exist with the goal of providing neutral postures and some also change the functional interface. Previously, the design and placement of these pointing devices have been explored based on their effect on shoulder and upper limb posture and their corresponding muscle activity. However, changes in the hand posture for pointing device comparison, are rarely explored in detail.
Although some previous studies have found inconclusive results comparing different pointing devices, their focus were mostly on shoulder and wrist. We have realized that all four different pointing devices selected in this study have different ways for users to hold them and different ways to control them using their fingers. Therefore, we decided to focus on hand posture and forearm muscle activity to evaluate and compare four selected pointing devices.
To evaluate the efficacy of various pointing devices in changing upper extremity posture, postural variability, and forearm and shoulder muscle efforts.
Variables

- Subjects (22~46yo)
- Conditions
  (mouse/trackball/touchpad/rollermouse)
- Tasks

• Measured:
  - Hand and finger Posture
  - Forearm muscle activity
  - User experience

Subject: 12 adults averaged 27 (22~46 yo) 6 male 6 female No prior injury
Subjects were allowed to adjust their chair location to where they think they are relaxed
Mouse- standard mouse from Lenovo
Trackball mouse – Logitech Trackman Marble
Touchpad- Addeso Smart Cat 4 button Touchpad
Roller Mouse – Contour RollerMouse Free 2
Solitaire was the standard game that comes with Microsoft Windows.
No prior training was given to any users as we were hoping to allow users to use the device they way they would use it fresh out of the box.

## Tasks

- **Solitaire**
  - 100% mouse task
  - 3 minutes

- **Web Surfing**
  - 90% mouse, 10% keying
  - 5 minutes
As you can see on the picture on the top right corner. This would be a normal set up for all users to be connected with both the EMG probes and sensors for the 3D posture monitoring system.
Other than a more numerical measure coming from the equipment, we also designed a survey which is a direct feedback from users regarding their difficulties, discomfort, and pain during the experiment. This bar here is example of the visual analog scale which they would be marking when asked about level of difficulties.
Marker Setup
RESULTS:
Posture – Finger Spread

Distance (mm)

- Index to Middle Finger
- Middle to Ring Finger

Mouse  Track Ball  Touchpad  Rollermouse
Finger Flexion/Extension
Significant for tasks means there is a learning effect. Significant for interaction means different condition has different learning effect
Note that here, larger angle means more flexion and therefore the user’s hand would be more relaxed
RESULTS:
Muscle Activity

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Extensor Digitorum</th>
<th>Extensor Carpi Ulnaris</th>
<th>Extensor Carpi Radialis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouse</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Track Ball</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Touchpad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rollermouse</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
User Experience

- Difficulty
- Discomfort

- Mouse
- Track Ball
- Touchpad
- Rollermouse

User Experience (mm)
Conclusion

- Design does effect hand postures as hypothesized.

- Design of Rollermouse was associated with a more neutral hand posture

- Also associated with lower forearm muscle activity

Overall, the study demonstrated that there are different degrees of exposures to non-neutral postures and sustained muscle activity that are dependent on the design and the placement of the pointing devices. For pointing devices selected in our study, Centrally located devices were associated with a more neutral shoulder and wrist posture. Moreover, using hand posture monitoring, we were able to further distinguish rollermouse from the rest of the devices as it produced significantly lower inter-fingertip spread, smaller finger extension, and lower forearm extensor muscle activity.
Take Home Message

- Rollermouse allowed users to operate with a more neutral hand posture and lower forearm muscle activity. User reported ease and comfort when using it.

(Talk about your limitations of your study here but only verbally) lab study nature, need to do it in real work place
Acknowledgement

- Jack Dennerlein, PhD  Harvard School of Public Health  Northeastern University
- Justin Young, PhD  Kettering University

- This study was funded in part by NSF Grant and gifts from industry including Contour Design Inc, MicroSoft, and Office Research Committee (OERC).
Questions?

- Thank you for your attention
- Michael Y. Lin
- Email: mlin@mail.harvard.edu
Extra Material
## Posture – Finger Spread

<table>
<thead>
<tr>
<th>Distance (mm)</th>
<th>Condition</th>
<th>P-Value</th>
<th>Mouse</th>
<th>Track Ball Mouse</th>
<th>Touchpad</th>
<th>Roller Mouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thumb to Index</td>
<td></td>
<td>0.06</td>
<td>54(4)</td>
<td>62(4)</td>
<td>55(4)</td>
<td>58(4)</td>
</tr>
<tr>
<td>Index to Middle</td>
<td>&lt;0.0001</td>
<td>37(2)^A</td>
<td>30(2)^B</td>
<td>29(2)^B</td>
<td>21(2)^C</td>
<td></td>
</tr>
<tr>
<td>Middle to Ring</td>
<td>&lt;0.0001</td>
<td>28(3)^A</td>
<td>28(3)^A</td>
<td>24(3)^B</td>
<td>23(3)^B</td>
<td></td>
</tr>
<tr>
<td>Ring to Little</td>
<td>0.16</td>
<td>40(4)</td>
<td>42(4)</td>
<td>45(4)</td>
<td>41(4)</td>
<td></td>
</tr>
</tbody>
</table>
Significant for tasks means there is a learning effect. Significant for interaction means different condition has different learning effect

Note that here, larger angle means more flexion and therefore the user’s hand would be more relaxed
### Muscle Activity

<table>
<thead>
<tr>
<th>Percentage MVC</th>
<th>Condition</th>
<th>Value</th>
<th>Mouse</th>
<th>Track Ball Mouse</th>
<th>Touchpad</th>
<th>Roller Mouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extensor Digitorum</td>
<td>P-Value</td>
<td>&lt;0.0001</td>
<td>8.7(0.7)^B</td>
<td>10.2(0.7)^A</td>
<td>7.9(0.7)^B,C</td>
<td>6.9(0.7)^C</td>
</tr>
<tr>
<td>Extensor Carpi Ulnaris</td>
<td></td>
<td>&lt;0.001</td>
<td>8.9(1.9)^A,B</td>
<td>10.2(1.9)^A</td>
<td>7.8(1.9)^B</td>
<td>8.4(1.9)^B</td>
</tr>
<tr>
<td>Extensor Carpi Radialis</td>
<td></td>
<td>&lt;0.0001</td>
<td>7.6(1.0)^A</td>
<td>8.3(1.0)^A</td>
<td>7.8(1.0)^A</td>
<td>6.6(1.0)^B</td>
</tr>
</tbody>
</table>
## User Experience

<table>
<thead>
<tr>
<th>Condition</th>
<th>P-Value</th>
<th>Mouse</th>
<th>Track Ball Mouse</th>
<th>Touchpad</th>
<th>Roller Mouse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feedback</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficulty</td>
<td>&lt;0.001</td>
<td>0.6(0.4)B</td>
<td>2.6(0.4)A</td>
<td>2.6(0.4)A</td>
<td>1.5(0.4)A,B</td>
</tr>
<tr>
<td>Discomfort</td>
<td>0.05</td>
<td>0.9(0.5)</td>
<td>2.1(0.5)</td>
<td>1.2(0.5)</td>
<td>0.8(0.5)</td>
</tr>
</tbody>
</table>
Note that we did test on interaction between condition and tasks, but there was no significance found. Therefore, we did not present them here.
# Muscle Activity at 50th Percentile

<table>
<thead>
<tr>
<th>Percentage MVC</th>
<th>Condition</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P-Value</td>
<td>Mouse</td>
</tr>
<tr>
<td>Middle Trapezius</td>
<td>0.28</td>
<td>2.9(0.4)</td>
</tr>
<tr>
<td>Anterior Deltoid</td>
<td>0.47</td>
<td>0.8(0.2)</td>
</tr>
<tr>
<td>Middle Deltoid</td>
<td>0.10</td>
<td>1.4(0.3)</td>
</tr>
<tr>
<td>Posterior Deltoid</td>
<td>0.40</td>
<td>1.1(0.2)</td>
</tr>
<tr>
<td>Extensor Digits</td>
<td>&lt;0.0001</td>
<td>8.7(0.7)</td>
</tr>
<tr>
<td>Extensor Carpi Ulnaris</td>
<td>&lt;0.0001</td>
<td>8.9(1.9)</td>
</tr>
<tr>
<td>Extensor Carpi Radiantis</td>
<td>&lt;0.0001</td>
<td>7.6(1.0)</td>
</tr>
</tbody>
</table>

- *Note: Mean and SE are in percentage of EMG value for muscle Maximum Voluntary Contraction*
- *1Repeated Measures ANOVA with subject as a random variable, condition of 4 pointing devices as fixed effects.
- *2For each dependent variables, values with the same superscript letters indicate no significant difference and groupings are ranked such that A>B>C>D.*

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Limitation

- Real life task vs designed tasks
- Pointing Device Variation
- Clinical relevance of data
  - Neutral posture range
  - Muscle activity, physical response vs Risk of MSD

Different pointing devices have different features that provide experiences that may differ from our study.
Posture monitoring is limited by the camera angle.