Load Redistribution in Standing, Tilt-in-Space, and Reclining Wheelchairs

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Purpose

This study investigated load redistribution during tilt, recline and standing under the weight bearing areas of the body, specifically the seat and back.
Subjects

• 6 able-bodied subjects
  – 2 male, 4 female
  – 21-42 years old (mean: 25)
• 10 subjects with spinal cord injury
  – 8 male, 2 female
  – 19-59 years old (mean: 35.5)
  – C4-T12 levels of injury, ASIA A-D
Instrumentation

• Levo combi power wheelchair
  – Flat foam 3” seat cushion
  – Flat foam 1” back cushion

• Tekscan pressure mapping system
  – Four CONFORMAT 5315QL TEKSCAN sensor mats
Methods

• Pressure mats placed under cushion, backrest, on headrest and footrest
• Subjects transferred to power chair. Neutral position of seating system was level seat and 100 back angle for all configurations
Methods

- 5 angles throughout full range of tilt (55), recline (180) and stand (75)
- Order of position and angles randomized
- Data was collected after one minute at each configuration

Figure 1: Angle definitions & ranges
Data Analysis

• Pressure output converted to force
• Force values normalized to the maximum force for a given mat and seat configuration (recline/stand/tilt)
• Linear regression performed to model the relationship between the angle of recline, stand and tilt and load on the seat/back
**Results**

$R^2$ Values of angle vs. normalized force

<table>
<thead>
<tr>
<th></th>
<th>Ab $R^2$</th>
<th></th>
<th>SC $R^2$</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Seat</td>
<td>Back</td>
<td>Seat</td>
<td>Back</td>
</tr>
<tr>
<td>Recline</td>
<td>0.78</td>
<td>0.88</td>
<td>0.96</td>
<td>0.89</td>
</tr>
<tr>
<td>Stand</td>
<td>0.88</td>
<td>0.73</td>
<td>0.94</td>
<td>0.75</td>
</tr>
<tr>
<td>Tilt</td>
<td>0.84</td>
<td>0.93</td>
<td>0.91</td>
<td>0.93</td>
</tr>
</tbody>
</table>
Results

Seat forces

SC subjects

Recline
Standing
Tilt
Recline trendline
Standing trendline
Tilt trendline

AB subjects

Recline
Standing
Tilt
Recline trendline
Standing trendline
Tilt trendline
Results

Back forces

SC Back

AB Subjects
Discussion

• A linear relationship exists between seat/back load and degree of recline, stand or tilt for both AB and SC subjects

• The slope differed for AB compared to SC subjects indicating that load re-distribution differed between the 2 groups
Discussion

• The maximum decrease in load on the seat occurred at full standing and full recline in SC subjects.
• The maximum decrease in load on the seat occurred at full standing in AB subjects.

<table>
<thead>
<tr>
<th></th>
<th>SC</th>
<th>AB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recline</td>
<td>62%</td>
<td>49%</td>
</tr>
<tr>
<td>Tilt</td>
<td>43%</td>
<td>44%</td>
</tr>
<tr>
<td>Stand</td>
<td>62%</td>
<td>67%</td>
</tr>
</tbody>
</table>
Discussion

The graph illustrates the normalized load against the angle in degrees for SC subjects in three different postures: Recline, Standing, and Tilt. The trendlines for each posture are marked as follows:

- Recline trendline
- Standing trendline
- Tilt trendline

Key points on the graph include:
- The 55° and 66° angles, which are likely critical points for the load-normalized angle relationship.
Conclusion

• Decreases in load on the seat occurred in a linear fashion over the ranges studied, so no threshold point could be identified to define an ‘effective’ tilt, recline or stand.

• Clinicians and users should be aware of the degree of position change since not all users reach the end range of movement.
Conclusion

• The results indicate that standing may be considered as a means of unloading the seat for a weight shift for people with spinal cord injuries.

• Standing provides a functional position from which to continue daily activities while unloading the seat, vs. tilt/recline.

• Additional study is needed to relate position changes to physiological effects to better discern how much position change is needed within a strategy.