The Effect of Lumbar Support on Trunk and Pelvis Muscle Activity in a Passenger Vehicle Car Seat

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Aim

- Aim – Study the effect of a 4-way lumbar support on lower trunk and pelvis muscle activity

- To assess the impact lumbar support has on subjective comfort perception

- Determine whether muscle activation levels are correlated with subjective comfort assessments.
Lumbar Support

- 2-way or 4-way adjustable configurations
- Selling point
- Effect on lumbar strain is not well documented

Control for Mercedes 4-way lumbar support
4-way Lumbar Support

- Horizontal directional adjustment
- Vertical directional adjustment

Up-back

Up-Centre (2)
Up-front (3)

Centre-back

Centre (1)
Centre-front

Down-back (4)
Down-centre (5)
Down-front
Outline of study

- ML Mercedes used in the study

- 10 subjects aged between 19-39
  - 5 Male: 172-178.4 cm, 65-79.7 kg
  - 5 Female: 158.6-175.3 cm, 52.6-71.7 kg

Methods:
- Questionnaire/Subjective comfort ratings
- Anthropometry
- FaroArm 3D co-ordinate measurements
- Electromyography (EMG)
- Pressure mapping
- Musculoskeletal modelling

3 x seatback trials (3 min)
3 x cushion trials (1 min)
Subjective comfort ratings

- 9 cm continuous line
  - Aim to reduce bias

- Taken after each cushion trial

Very uncomfortable

Very comfortable
FaroArm 3D co-ordinate measurements

- 6.5 axis FaroArm fusion
- Accurate, high precision portable measuring arm
- Identified lumbar positions
- Identified posture to position AnyBody model
- Measured cushion and seatback dimensions
Electromyography

- Noraxon TeleMyo 2400R G2 wireless EMG system

Muscles measured (L and R side):
- Lumbar ES
- Thoracic ES
- Lower trapezius
- External oblique
- Internal oblique
- Tensor flexors
- Rectus femoris

EMG analyses:
- Band-pass filter, low 18Hz, high 250Hz
- Rectified
- RMS (350 ms)
- Maximum voluntary contractions recorded
- Results as %MVC
Pressure mapping

- Tekscan COMFORMat was used to determine cushion and seatback pressures.
- Centre of pressure was recorded
- Average foot forces were used
- Gravity rate was used for hand forces
Musculoskeletal modelling

- AnyBody ‘seated human’ model from the managed AnyBody repository was used
- Calibrated using EMG data
- Trials were quasi-static
Statistical analysis

- Wilcoxon signed rank sum test was used to determine any significant differences ($p < 0.05$).

- Bi-variate analysis calculated correlation coefficients for EMG-subjective comfort relationship.
EMG Results

- EMG results low, ranging from 0.5-4 %
- Highest values – Internal oblique and lower trapezius
- Some gender variations

![Graph showing EMG results for internal oblique muscles with different markers for male and female genders in different movement directions.](image-url)
EMG Results

- No significant differences between lumbar positions
- Some significant differences between gender

![Graph showing EMG results for Lower Trapezius muscle activity]

- ▲ = Left male
- ■ = Right male
- △ = Left female
- ■ = Right female

% MVC

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central  up  up and forward  down and back  down
AnyBody Analysis

- Only small variations between lumbar positions
- Results slightly higher than EMG data

![Graph showing muscle activation levels for different lumbar positions.](image)

- **\(\Delta\) = L3 Erector spinae
- **\(\Delta\) = L2 Erector spinae
- **\(\Delta\) = T11 Thoracic

<table>
<thead>
<tr>
<th>Position</th>
<th>L3 Erector Spinae</th>
<th>L2 Erector Spinae</th>
<th>T11 Thoracic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central up</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Up</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Up and forward</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Down and back</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Down</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
Subjective comfort scores

- Highest vertical positions = lowest comfort scores
- Significant differences when central and down positions are compared to up, up-and forward positions (p < 0.05)
- Little correlation with EMG measurements
Limitations and Future Recommendations

Limitations
- Short cushion trial
- Small sample size

Future Recommendations
- Similar study looking at long term driving
- Studies using a large sample size
Conclusion

- Musculoskeletal analysis does not provide much insight into comfort for short-term studies
- Short term studies should focus on subjective comfort scores
- Complete long-term study
Questions...