POSTER 8

Effect of Dynamic Components on Interface Forces in Special Seating for Children with Cerebral Palsy

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Summary
Dynamic seating systems aim to accommodate movement and lessen the contact pressure between user and seat. This latter assumption was experimentally tested. Footrest forces decreased with dynamic backrest components. Peak forces on the footrest and backrest were up to 2.5 times bodyweight during extensor spasm.

Aims and Objectives
This study aimed to collect force data on a Mygo™ seating system when used with children with CP, to inform future seating design. We aimed to build a fully mobile data acquisition system with swappable rigid and dynamic components, to collect force data on wheelchair components for up to 6 hours continuously. It was hypothesised that the forces imparted on the chair would decrease with the use of dynamic components.

Background
Children with severe extensor muscle tone are expected to obtain the most benefit from dynamic features of specialised seating. However, little evidence has been gathered to demonstrate that such users would gain functional advantages from the incorporation of dynamic components in the seating design.

This project was undertaken to design a fully mobile data acquisition system to determine forces imparted by users who were children with CP on their seating during activities of daily living and, in particular, during extensor spasm.

The seating system was fitted with one hundred strain gauges to determine the forces and moments in three dimensions in key components on the backrest and footrests. Strain gauges were arranged in full Wheatstone bridge circuits, which produced output signals that were collected via a 20 channel data acquisition system. The data were continuously streamed at 10 Hz to an on-board ultra-mobile PC for permanent storage. Lithium-ion batteries were connected to the strain gauge amplifiers to ensure full mobility and to power data collection for up to a six hour period.

The raw strain data was converted into force and moments by using a full calibration matrix determined by mechanical stress testing of the components. The force data was then used to inverse engineer the resultant forces acting on the backrest and each footrest, assuming static equilibrium. The position of the resultant force on the backrest, termed the centre of pressure (COP), was also calculated.

Following ethical approval, 5 boys and 7 girls were recruited, with a mean age of 7.43 +/- 2 and a mean bodyweight of 188 +/- 40 N. The strain-gauged chair was adjusted to match the participants' own chair, and data was recorded during a typical weekday. Halfway through the session, the dynamic component was changed to the rigid component.

No significant differences were found in the mean and peak contact force on the backrest between rigid and dynamic backrest seating components. The average moment about an anterior-posterior axis of the left-footrest was significantly less in the dynamic system compared to the rigid system (p=0.04). Likewise the average and peak force and moments on the right footrest decreased for the dynamic. The lateral distance of the COP from the centre line for the rigid and dynamic seating systems were 0.10 and 0.06 m to the left respectively. The vertical positions of the COP of both systems were 0.13 m above the level of the seat plane. The average force on the backrest was 0.6 bodyweight, with 0.1 BW downward on each footrest. These proportionality constants can be used to approximate the imparted force by children on their own seating throughout daily activity based on their body weight. The peak force depended on the severity of spasms, one participant imparted forces on the backrest up to 2.5 BW and also 2.5 BW on a footrest during a strong extensor spasm.

Discussion

A greater range of head and trunk motion on the dynamic seating systems has been observed when users exert forces on the chair's backrest [1-2]. A comparison of the rigid and dynamic backrest seating systems suggested that the force on a dynamic backrest was less than that on an equivalent rigid system when users experienced extensor spasms [2].

Results from 12 children collected throughout a day demonstrated that there was no significant difference in contact forces on the backrest between the rigid and dynamic systems. However, the users may have benefitted from the reclining nature of the dynamic backrest as can be seen by the forces on the right-sided (presumably the dominant side) footrest being reduced. Another important finding was that, while the dynamic backrest was tilted back, subjects were still well positioned in the midline of the seat.

Seat design should safely accommodate the maximum expected loads. Data from a participant who had strong extension patterns over the whole body generated significantly high forces on the backrest and footrest. In this case, the contact forces and shear forces on the backrest were reduced when the dynamic backrest system was used. However, the forces on footrests did not show a difference when compared to the rigid system, in contrast to the response of the average participant. A further study with more focus on children with strong extensor spasms is therefore suggested to clarify the response of dynamic seating in such critical circumstances.

References

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