Assessment of Seating Forces Imparted Through Daily Activity by Children with Special Needs

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Abstract

Extensor spasms regularly occur in spastic Cerebral Palsy (CP) children making their bodies unbalanced and causing wheelchair instability. Furthermore the child may be uncomfortable as a result of the high contact forces potentially causing pain and injury, which will impair their functional ability. Dynamic seating systems have been designed to absorb the energy associated with these spasms. For people with physical disabilities, especially patients who have strong extensor spasticity, the dynamic design prevents pressure ulcers and injury from impact. However, the quantitative effectiveness and impact of using dynamic components has yet to be established. Therefore our objective is to compare the imparted forces on equivalent rigid and dynamic seating systems, to understand the interactions between force, wheelchair compliance and physical activity throughout a four hour session of non-laboratory based daily living.

Keywords: *Extensor spasm, rigid and dynamic seating system, strain gauge, activities of daily living.*

Introduction

One-third of children with CP have severely limited mobility [1-3] and they therefore often have a special seating system to aid their mobility and support their activities of daily living. This special seating for children is designed to stabilise the child, balance weight and movement and provide special supports which can be used to assist in positioning the child for physical therapy [4]. Spasticity influences postural sitting, when muscles stretch or experience an extensor spasm; they may produce a strong force between the user and the seating system, in particular the footrests and the back rest. These high forces may lead to awkward postures and physical discomfort leading to pain and injury [5-8] which affect the development of the child's spinal curve [7, 9]. In addition, the high forces produced during the extension indicate that the seating material must be strong, durable and fatigue resistant. Despite the potential importance of these forces in understanding the interactions of the chair and user, they have been rarely quantified.

Our research concerns the biomechanics of seated children with CP and the forces imparted by them during activities of daily living and, in particular, during extensor spasm. This paper details the development of a fully mobile strain-gauged seating system (Mygo, James Leckey Design, Ltd.) and the forces imparted on this rigid backrest system.

Method

Study Device and Data Acquisition System

A seating system (Mygo Seating System from James Leckey Design Ltd., Fig. 1) has been fitted with 100 strain gauges arranged to assess the full three-dimensional strain environment of three key components (Fig. 2): the u-shaped bar at the rear of the seat; the back rest strut; and the foot rests. Data is collected on two places on the u-shaped bar to determine any asymmetry of loading. A fully mobile data acquisition system (DAQ), which includes an amplifier, ultra mobile PC with a lithium-ion power source enabling collection of strain data at 1Hz for up to 6 hours continuously, is stored in the basket of the Otto Bock Kimba chassis.

Figure 1: Strain gauged Mygo seating system on an Otto Bock Kimba Chassis

Force identification

Following calibration, static equilibrium was used to determine the magnitude of the contact force applied by the child on the backrest and left and right foot rests (F_B,

F_{FL}, F_{FR}), which were normalised with respect to bodyweight and averaged across participants.

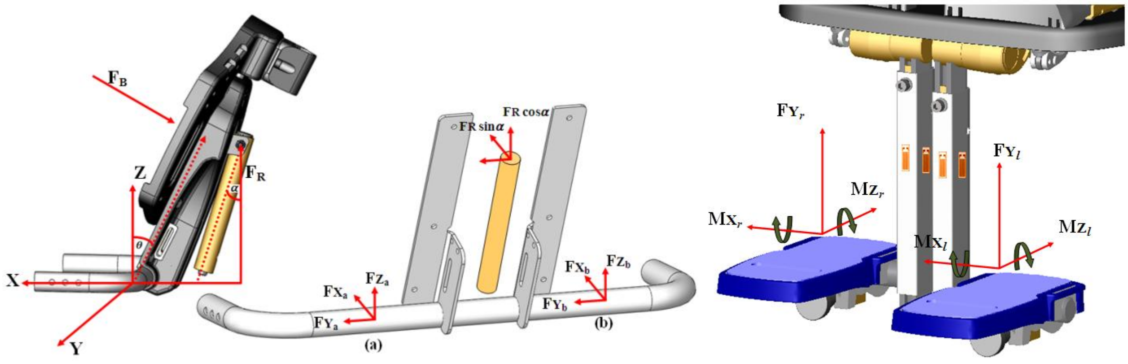

Figure 2: diagram of the footrest showing strain gauge locations on the attachment struts

Experimental setup

Experiments were performed in the participants' school after all ethical and local approvals had been granted. Data collection started after the wheelchair was set up, and the DAQ system was zeroed. After a minute of data collection, minor adjustments to the seating posture were made by physiotherapist. Then the wheelchair was propelled down a ramp to the participants classroom to engage in their normal daily activities. The researcher also simultaneously logged an activity diary to allow the applied forces to be matched with an activity.

Results and discussion

To date, force data has been determined for two female participants (aged X and X) and tabulated in Table 1. Unfortunately, the two participants did not demonstrate an extensor spasm throughout their test period.

Table 1: Median (a) and Peak (b) force magnitude, normalised by bodyweight, on the backrest, F_B, and the left, F_{FL}, and right, F_{FR}, footrests during each activity

Activity	(a) Median Participant 1			(a) Median Participant 2			(b) Peak Participant 1			(b) Peak Participant 2		
	F_B	F_{FL}	F_{FR}	F_B	F_{FL}	F_{FR}	F_B	F_{FL}	F_{FR}	F_B	F_{FL}	F_{FR}
Empty	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.02	0.00	0.01
Adjustment	0.62	0.01	-0.23	1.30	-0.50	-1.71	1.05	-0.75	-1.05	2.07	-1.32	-2.79
Sitting	0.72	-0.01	-0.22	0.74	-0.78	-0.42	0.88	-0.08	-0.33	0.91	-1.02	-0.90
Ramp down	0.76	-0.12	-0.26	0.93	-1.01	-1.62	1.51	-0.71	-1.28	1.40	-2.42	-3.67
Study	0.65	-0.40	-0.30	0.76	-0.74	-0.80	1.77	-0.83	-1.58	1.48	-1.62	-4.30

Initial data have shown that the current setup and protocol enables the 3d determination of the main contact forces during activities of daily living. A similar setup will allow the effectiveness of a dynamic backrest system to be fully investigated and compared to the current rigid system. Only via recruitment of more participants can an understanding of these forces be realised, and the comparative effectiveness of a dynamic backrest system be evaluated.

Future work

On comparing interaction loads between the child and the seating in both seating systems, the same participants involved in the rigid backrest system testing will hopefully provide their assistance in testing on dynamic backrest system.

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