Effect of Cushion Type, Back Height and Seated Posture on the Reach of Wheelchair Users with Spinal Cord Injury

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Introduction: Seated posture and trunk control are important factors affecting upper extremity function of wheelchair users. A stable pelvis and trunk are required to provide a base from which upper extremity movement occurs, but, conversely, the ability to move one's trunk and pelvis can increase functional ranges of motion. For wheelchair users, balancing sufficient trunk support with adequate trunk mobility has important functional and medical consequences. The selection of a wheelchair cushion and backrest height are often influenced by the need for functional postural control- including both stability and mobility. Relatedly, cushions and backrests also affect posture. Better understanding of the posture-function and postural support- function relationships are needed to improve trunk control of wheelchair users. This project studied the effects of posture, wheelchair cushion and backrest height on the trunk control and upper extremity reach of wheelchair users with spinal cord injury (SCI).

Statement of Clinical Significance: The posture adopted by wheelchair users is a more important influence on UE function than the cushion or back height used. Sitting with increased posterior pelvic tilt enhanced stability and permitted greater reach. Since subjects adopt different postures when using different cushions and back heights, clinicians should monitor posture while assessing seating and function of wheelchair users.

Methodology: Twenty- two subjects with spinal cord injury were recruited for the study. Subjects sat on three types of cushions-segmented air, contoured viscous fluid/foam, and air/foam- and with two of three back heights-referenced to T12, inferior scapular angle and scapular spine- while performing unilateral and bilateral reaching tasks. Subject inclusion criteria included: being at least 6 months post injury, having an injury level of C5 and below, and being at least 18 years of age. Subjects were tested to determine their spinal injury level according to the American Spinal Injury Association (ASIA) guidelines (15), including sensory dermatomes and manual muscle tests of the upper extremity and trunk. Non-invasive postural measurement was done using a Flock of Birds (FOB) system from Ascension Technologies . Static posture measures were done by configuring a FOB sensor as a pointer permitting digitizing the locations of the ASIS, PSIS, C7, and greater trochanter which were then used to calculate pelvic and trunk orientations. A second FOB sensor was mounted to the sacrum and used to track sacral position in space. This method of measuring posture was shown to be valid in comparison to radiographic measures.[3] UE ROM was measured by monitoring subjects as they perform defined unilateral and bilateral tasks with a motion analysis system. Subjects were seated on a wood and plastic test chair whose seat angle was 5° from the horizontal with backrest angle of 95° to the seat.

The calculated variables were (Figure 1): Pelvic tilt (the angle formed between the line connecting the ASIS and PSIS and the seat surface), Torso angle (the angle formed between the line connecting the sacrum and C7 and the seat surface), ASIA Score: Motor, sensory and total ASIA scores, and the results of 3 reaching tasks: functional reach (FR- unilateral reach in the sagittal plane), Bilateral reach (BR- bilateral reach in the sagittal plane) scores and Reach area (RA- unilateral reach in horizontal plane). Intraclass correlation coefficients were calculated to determine reliability of the three reaching tasks.

Analysis of Variance was performed to identify the effects of cushion type and backrest height on posture (pelvic tilt, torso angle) and reach (FR, RA, BR). These 2x3 ANOVAs used a 0.05 level to judge significance.
Regression models were performed to identify significant predictors of UE reach. FR, RA and BR were individually modelled using cushion type, back height, ASIA score, pelvic tilt and torso angle as regressors.

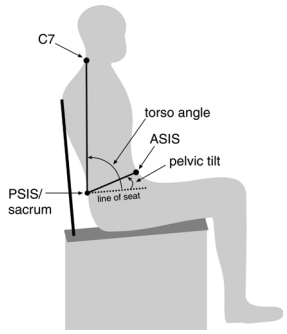

Figure 1. Postural angles and anatomical landmarks

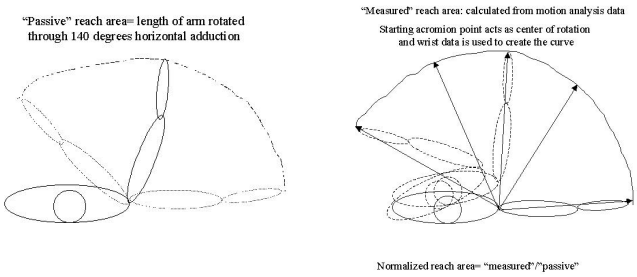

Figure 2. Calculation of normalized Reach Area

Results:

Table 1	pelvic tilt (degrees)	torso angle (degrees)	FR (cm)	RA (dimensionless)	BR (%)
Jay 2	15.3 (12.8)	103.3 (4.63)	28.4 (13.4)	1.23 (0.52)	151.1 (42.8)
Roho Hi Profile	13.7 (10.2)	102.4 (5.35)	29.7 (13.8)	1.15 (0.40)	151.1 (41.6)
Varilite Evolution	16.0 (9.11)	102.7 (4.7)	29.4 (13.5)	1.21 (0.47)	151.6 (42.7)
Higher back configuration (Inf angle or scapular spine)	15.0 (11.4)	102.7 (4.55)	28.9 (14.0)	1.20 (0.46)	150.7 (42.2)
Lower back configuration (T12 or inferior angle)	15.1 (10.2)	102.9 (5.27)	29.5 (13.0)	1.20 (0.46)	1.51.8 (42.1)

The ANOVA analyses resulted in $p>0.6$ for all reach (FR, RA, BR) and posture variables (pelvic tilt, torso angle). Table 1 lists descriptive statistics of reach and posture variables across cushion and backrest.
Within the FR and RA regression models, ASIA score ($p<0.0001$) and pelvic tilt ($p<0.001$) were significant predictors. An increase in ASIA score and pelvic tilt indicate increased FR and RA. The BR models required different analysis. Combining all BR results added torso angle as a significant predictor ($p<0.05$). Cushion type and backrest height did not approach significance in any model ($p>0.55$).
Discussion: All three measures of reach were found to have good test-retest reliability and can be considered acceptable measures of reach by wheelchair users. The results indicate that upper extremity reach is affected by posture but was not influenced by cushions or backrest heights used in this study. Pelvic tilt is a significant predictor of UE reach tasks- unilateral and bilateral sagittal plane and unilateral horizontal plane movements. This is an important finding that corroborates the work of others who felt people with SCI sit with greater posterior pelvic tilt to increase stability and function. However, sitting with posterior pelvic tilt increases loading on the tissues in the sacro-coccygeal area, thereby increasing the risk of pressure ulcers, and may stress the posterior spinal ligaments and intervertebral discs.
References: 1. Sprigle S, Wootten M, Bresler M, Flinn N. Development of a non-invasive measure of pelvic and hip angles in seated posture. Arch Phys Med Rehabil, 83: Nov 2002, *in press*