The Effects of Sitting Positions on Trunk Extension for Children with Motor Impairment

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The purposes of this study were to identify an objective, reliable and clinically useful measure for assessing changes in trunk alignment and to evaluate which of five sitting positions was the most effective in encouraging trunk extension. Fifteen children ages two to six years with a diagnosis of a neurologically based motor impairment and weak trunk musculature were measured using the modified Schober Measurement for spinal extension in each of five randomly ordered positions. Significant differences were noted among the five positions. The ability to quantitatively identify those positions most likely to increase function and active control of the trunk is critical knowledge in the evaluation and management of children with motor disability.

Children with neurological motor impairment demonstrate a variety of different movement deficits but also exhibit typical clinical patterns and characteristics. One freguently encountered pattern is a kyphotic sitting posture secondary to weak trunk musculature.[1] Because the ability to sit with an erect spine and control the spine is a precursor to performing many daily activities,[2] a kyphotic trunk position can be debilitating. With a kyphotic trunk posture, the upper extremities are often used to provide the external support not provided by the trunk and associated musculature.[3] With the lack of adeguate trunk muscle strength necessary for spinal stability the potential exists for deviations in the development of a natural spinal curve.[2-6] Additional mechanical compensations and dysfunctions may also develop.[2-6] Some of these additional problems include low back dysfunction,[6] structural changes in the spine,[7] and increased energy consumption during activities of daily living.[8-10]

In an attempt to manage the kyphotic spine, several positioning and handling strategies have been used.[1] Unfortunately except for some recent work evaluating sitting orientation and its effect on upper extremity function and tonic muscle activity,[11-13] little has been done to objectively substantiate the benefit of various sitting strategies. The purposes of this study were to identify an available objective method for assessing changes in trunk position and to evaluate the impact of various sitting positions on trunk posture. From clinical observations it was supposed that sitting positions that encourage forward lean of the trunk would increase active trunk extension when compared to other sitting positions.

METHOD

Subjects

The subjects for the study were 15 children between the ages of two and six years. Each had a diagnosis of developmental delay and/or moderate to severe hypotonic or hypertonic cerebral palsy with distributions of diplegia and guadriplegia. For each child there was recorded weakness of trunk musculature. Additionally, each child was rated on a scale of 1 to 4 to document their trunk control (Table 1). This was based on their ability to maintain an upright trunk after being placed on a bench with hips and knees at 90 degrees and feet resting on the floor. The child was initially centered and stabilized by the examiner, but hand support was then withdrawn. Ratings were given after one minute of sitting with stand by assist but no physical contact. The average sitting skill of the group was represented by an ability to maintain sitting on a bench for 0–2 minutes, typically with spinal kyphosis and the pelvis rotated back with weight bearing posterior to the ischial tuberosities

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Table 1
Subject Characteristics

Subject	Age (year/month)	Diagnosis	Functional Trunk control*
1	3/5	Moderate spastic diplegia	2
2	3/11	Severe spastic quadriplegia	2
3	2/11	Moderate central hypotonia	3
4	2/0	Moderate spastic quadriplegia	2
5	5/8	Moderate central hypotonia	2
6	3/11	Spastic encephalopathy	3
7	4/10	Moderate spastic diplegia	3
8	3/0	Severe spastic quadriplegia	2
9	2/1	Developmental delay	2
10	6/3	Developmental delay	2
11	2/7	Static encephalopathy	3
12	4/0	Static encephalopathy	3
13	4/11	Central hypotonia	2
14	4/9	Static encephalopathy	3
15	4/5	Developmental delay	3

* Trunk Control: 1 = Unable to extend trunk against gravity while sitting on a stool and maintain midline position for more than one minute; 2 = Maintains upright sitting posture for more than five minutes with thoracic and lumbar kyphosis and/or hyperextension of the head (posterior sitting); 3 = Same as number 2 but can be facilitated into and maintain straight sitting for 0–2 minutes; 4 = Maintains a straight posture for more than five minutes.

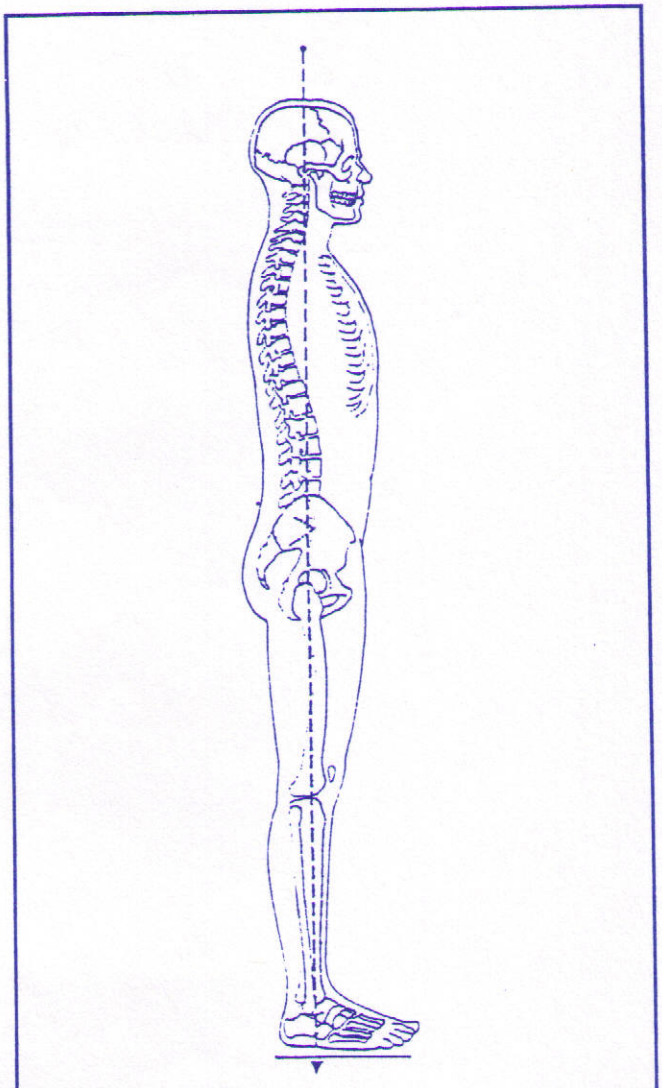

Figure 1. An ideally aligned erect posture when viewed from the side.

(posterior sitting). The rating was done by one therapist experienced in pediatric physical therapy. Some of the subjects demonstrated variations in muscle tone, postural compensations, and fixations such as upper extremity retraction, excessive head/neck extension, and increased upper extremity support, and varying levels of endurance which could potentially impact on their ability to maintain sitting. However, these were as consistent as possible across all five sitting positions. Informed consent was obtained for all subjects.

Instrumentation

Sitting terminology selected for this study was based on earlier descriptions of the posture.[14] Straight sitting is described as the pelvis rotated forward, weight bearing over the ischial tuberosities, the back straight, and the lumbar spine moving towards lordosis. Anterior sitting is described as trunk straight forward, weight bearing anterior to the ischial tuberosities. Posterior sitting is described as spinal kyphosis, pelvis rotated back, and posterior to the ischial tuberosities. Kyphosis is defined as an abnormally increased convexity in the anterior-posterior curvature of the spine resulting in a deviation from an ideally aligned erect posture when viewed from the side (Fig. 1).

Trunk extension was measured using the modified Schober Measurement of Spinal Extension (MSM).[15] The MSM is useful in measuring change in curvature between two positions and is easy to use within a clinical setting. This method of measurement is supported by the American Academy of Orthopedic Surgeons and has been shown to have a correlation of .97 with comparative x-ray.[15,16] In other words, there was only 3 degrees difference between measurements using the MSM compared to measurements from x-rays. The original Schober Method of Measurement is performed by palpating the most superior aspects of the posterior iliac crests bilaterally and making an initial mark on the vertebrae of the corresponding level. The Modified Schober Method differs from the original test in that additional marks are placed 10 cm immediately above and 5 cm immediately below the initial mark. The additional markings have been demonstrated to significantly decrease the potential for measurement error.[16] The distance between the top and bottom marks is measured using a cloth tape measure laid along the spinal column. The shorter the distance between the two marks the greater the spinal extension demonstrated by the patient. The MSM has been found to show test-retest reliability of .98.[17] In addition, the measuring therapist collected test-retest data on the first five children. Both test were performed on the same day. Three of the five positions were randomly selected for analysis. A mean difference of .257 cm. between test-retest measurements was found.

Procedures

The child was placed in each of five randomly assigned sitting positions during an approximately 30-minute morning session unrelated to any therapy sessions. The five different session positions evaluated included floor sitting in a tailor-fashion, level setting with hips and knees at 90 degrees, bench sitting with the bench tilted forward 20 degrees using angled blocks, bench sitting forward 30 degrees, and sitting in a commercial chair (Ther Adapt Product, Inc., Bensonville, IL 60616). This chair allows for adjustment of seat height, knee pad angles and has an adjustable lumbar support. However, the lumbar support was not used in this study due to difficulty in accurately measuring trunk extension while it was attached (Fig. 2).

Figure 2. Ther Adapt Posture Chair, Preschool-Primary Size.

Each child was placed by an assistant and the child was then asked to maintain quiet sitting for one minute. The assistant provided the same visual and verbal encouragement during all positions. The children were instructed to maintain hands in their laps and after one minute trunk extension measurements were recorded. Benches and chairs were measured and fitted to the child prior to positioning for testing. Benches were fitted to obtain a 90 degree hip and knee flexion angle and the Ther Adapt chair was adjusted to obtain a stabilized sitting posture deemed appropriate by the examining physical therapist. A non-skid surface was also added to the bench to keep the children from sliding in all three bench sitting positions.

Data Analysis

The 75 measurements taken represented 5 randomly acquired measurements of spinal extension for each of the 15 children (Table 2). They were analyzed using a randomized complete block design with

Table 2
Mean Schober Measurements in cm by Position

Subject	Floor Sitting	Ther Adapt Chair	Bench Sitting	Bench Sitting: 30 Degrees	Bench Sitting: 20 Degrees
1	16.5	12.75	14.25	13	13.5
2	16	12.3	14.5	13	13.5
3	14	11	14	12	11.5
4	15.25	11.6	13.75	12.75	13
5	15	13	14.5	13	14
6	15.5	13.5	15.5	14.7	14.5
7	17	13.5	15.5	14.5	15
8	15.2	11.5	15	13.8	14.5
9	15.5	13	14.5	13	14
10	15.5	13	15	14.5	14.5
11	18	15.5	15.2	14	14.5
12	18	16	15.3	15.5	15
13	16.5	14	16.3	14.4	14.5
14	15.6	14	15	14.5	13.5
15	17	14	15.5	13	14

the 15 subjects representing the blocks and the 5 randomly assigned positions as the treatments. Tukey's Multiple Comparisons Test for mean differences was also performed to identify significant means of differences between sitting positions.

RESULTS

The randomized complete block design demonstrated a true mean difference among the sitting positions ($p = .0001$) (Table 3). The design appeared effective as blocking on individual subjects was successful in reducing the sum of sguares for error. The Ther Adapt chair was consistently found to provide the best position for increasing trunk extension while sitting. There was a mean difference of 3 cm, ranging from 2–3.8 cm between measurements of trunk extension while sitting in the Ther Adapt chair compared to sitting on the floor. Clinically, the mean differences appeared to be significant when compared to visual observations of the different sitting positions. Tukey's Multiple Comparison of Mean Differences across positions showed significance to the .01 level between the Ther Adapt and the floor sitting positions and a difference to the .05 level between all angled bench sitting positions and floor or level bench sitting (Table 4). There was no statistically significant difference between any of the three angled positions at the .01 level. There was, however, a significant difference ($p = .05$) between the Ther Adapt chair and bench sitting with a 20 degree forward tilt.

Table 3
Trunk Extension Differences Between Positions in cm

	Bench Sitting (14.920 cm)	Bench Sitting: 20 Degrees (13.967 cm)	Bench Sitting: 30 Degrees (13.710 cm)	Ther Adapt Chair (13.243 cm)
Bench sitting (14.920 cm)	0	.257*	1.210	.467*
Bench sitting: 20 Degrees (13.967 cm)	.257	0	.925	.723
Bench sitting: 30 Degrees (13.710 cm)	1.210	.925	0	1.677
Ther Adapt chair (13.243 cm)	.467*	.723	1.627	0
Floor sitting: (16.037 cm)	2.327	2.070	1.117	2.793

* Not significant; significance established to .05 level (minimum significant difference = .636 cm).

Table 4
Significant Difference of the Complete Model

Source	SS	df	MS	F Value	Pr > F
Sitting Positions	74.217	4	18.55	48.6	.0001
Subjects	53.411	14	3.81	9.99	.0001
Model (Subjects and Children)	127.628	18	7.090	18.57	.0001
Error	21.379	56	.382		

DISCUSSION

One of the functions of the spinal column is to maintain the center of gravity of the trunk and head over the supported pelvis. This is necessary to provide adeguate space for pulmonary function, to transmit loads from upper extremities to lower extremities, and to allow for change in positions while carrying loads.[18] In order to meet these needs, the trunk musculature must assist the spine with overall stability. Our results show that the seating position that puts the child in an anterior sitting posture tends to increase trunk extension more than the level bench or floor sitting positions. Previous research[3,11] has shown that lumbar spinal muscle activity increases when the seat is tilted forward. Conversely EMG analysis reveals that muscle activity in the same area is at its lowest level during posterior sitting. There is also some new preliminary research suggesting that the lower paraspinal muscles have a very direct role in maintaining trunk extension while sitting.[19,20] Our subjective observations over the last six months suggest that when children are positioned to encourage an anterior sitting posture, trunk extension does increase and over time it appears to improve their ability to sit up straighter. However, the long term effects will need to be analyzed on a more objective basis. Our subjective observations also suggest that upper extremity function is not compromised even though an increased effort is reguired to maintain trunk extension in the anterior sitting position. This too warrants further study.

SUMMARY

Trunk extension is a component of overall trunk control and important to the attainment of independent sitting, trunk mobility, and functional activity. A kyphotic spine has been demonstrated to interfere with these goals and additionally to increase physiological risks. This study suggests that sitting in an anterior sitting posture is the preferred position to facilitate increased trunk extension. This study also explains a quick and objective method for measuring change in trunk extension posture.

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