Seating Orientations and Upper Extremity Function in Children with Cerebral Palsy

OLUNWA MAFIANA NWAOBI

This study was conducted to determine the effect of body orientation on upper extremity function in children and adolescents with cerebral palsy. Thirteen children between ages 8 and 16 and diagnosed as having spastic or athetoid cerebral palsy were placed randomly in different seating orientations (30°, 15°, and 0° of posterior inclination and 15° of anterior inclination). In each seating position, the subject performed an upper extremity activity on cue. The tests were repeated in reverse sequence. Mean performance times were different at all seating orientations for both types of subjects. Performance time was lowest at the 0-degree orientation during the retest for the subjects with spasticity and highest at 15-degree anterior inclination during the retest for the subjects with athetosis. The results of this study show that orientation of the body in space affects upper extremity function and emphasizes the importance of positioning for maximizing upper extremity function.

Key Words: Activities of daily living; Arm; Cerebral palsy; Equipment, general; Physical therapy.

One of the goals in the management of patients with cerebral palsy is for them to attain some degree of independent function, which includes self-control over their environment. In a typical situation, the head or upper extremity, depending on which has more voluntary muscle control, can control a device that activates or produces the desired outcome.

Researchers studying children with neuromotor disorders have demonstrated the importance of proper seating and positioning for individuals with limited postural control and poor sitting balance. To maximize the individual’s functional potential when positioned in adaptive seating, determining and understanding the functional effects of factors identified as crucial to adaptive seating and the effects of different spatial relationships between various body segments are necessary. For example, Nwaobi et al conducted a clinical study to demonstrate the effect of hip flexion angle in sitting on upper extremity function in children and adolescents with spastic cerebral palsy. Upper extremity movement time was measured when the hip was positioned at 50, 70, 90, and 110 degrees of hip flexion. Movement was fastest at 90 degrees and slowest at 50 degrees. The effects of orientation of the body relative to the vertical plane on abnormal muscle activity in this patient population also have been investigated. In that study, tonic activity of the muscle monitored by electromyography was least when the body was placed in the upright position, as compared with the reclined position. Although the relationship is unclear, hyperactive muscle activity has been linked to decreased voluntary motor performance in individuals with upper motoneuron lesions. Body orientation in space, therefore, because of its effect on abnormal reflexes, also could affect voluntary motor function.

The purpose of this study was to measure the performance time of a prescribed upper extremity activity in four different seating orientations relative to the vertical plane to determine the effect of body orientation on voluntary motor function. The null hypothesis for this study was that no difference would occur in performance time of an upper extremity function in different seating orientations.

METHOD

Subjects

Thirteen children with cerebral palsy, aged 8 to 16 years, participated in this study. Three were classified as athetoid and 10 as spastic. Based on the clinical evaluation conducted by the therapist, all of the subjects had Fair to Poor gross upper extremity control, Poor fine motor skills, and Fair head and trunk control (on a Good-Fair-Poor-No scale). None of the children were mentally retarded. All subjects were unable to ambulate independently and required the use of adaptive seating for upright positioning.

None of the subjects was taking any medication, and all were receiving physical therapy once or twice a week. Informed consent was obtained according to the procedures approved by the university’s Institutional Review Board.

Instrumentation

The positioning device was a multi-adjustable seating system with a hydraulically powered, independent adjustment for hip and knee positions, thigh length, and orientation in space (Fig. 1). Incorporated in the hydraulic system was a damping mechanism that ensured that the transition from one orientation to another occurred slowly and without any jerking motion. Jerking
motions, sudden changes of the positioning device, and unusual ambient noises might startle the subject, which potentially could influence the results obtained.

Upper extremity function was monitored using a system consisting of a touch-activated switch, an Apple computer,* and a video monitor. The switch was mounted on an adjustable lap tray so that it was located for all subjects on the same sagittal plane as the midline of the body. The lap tray was positioned horizontal to the subject’s xiphisternum, and the switch was positioned at the same horizontal distance from the xiphisternum at all orientations tested. When the system initially was activated by the researcher, it provided a visual cue on the video monitor for the subject to perform horizontal adduction of the dominant upper extremity from an abducted position to the midline of the body to touch and activate the switch (Fig. 2). The system, controlled by computer software, subsequently cued the subject automatically.

The initiation of movement temporarily lagged in the visual cue in all instances. The subjects were required to return their upper extremity to and touch a designated area of the starting position after each activation of the switch without assistance. The position of the touch-activated switch and the starting position were determined individually for each subject. This movement was selected because of its similarity to movements performed in the seated position to reach control switches. The movement also included most of the components of everyday functional movements such as stability, mobility, and coordination. The time to complete the prescribed repetition of the activity (performance time) was calculated using computer software originally developed at the Hugh MacMillan Center in Ontario, Canada. The initial activation of the system started the timer, which did not stop until the 10th and final activation of the switch. No specific restrictions were imposed on shoulder or elbow positions or movements in moving from the starting position to the switch. Before the initial activation of the system, the subject’s upper extremity was supported by the lap tray at the starting position. Ambient noise level during the tests was low. Trials were repeated after distractions during the tests, although such distractions occurred infrequently.

An electric goniometer† was attached to the subject’s left hip joint to monitor its position, which was maintained at 90 degrees (± 2°) by adjusting the seat surface inclination independently. The axis of the goniometer coincided with the subject’s greater trochanter. The actual position of the hip was provided instantly through an analog-to-digital converter‡ and displayed on a video screen.

Procedure

The subject was seated in the positioning device. The subject’s head and neck were supported in a neck collar, and the trunk was supported by the backrest of the device so that the head, neck, and trunk were in the same vertical plane. A chest panel provided a four-point anterior support for the trunk. The subject’s knee and ankle were placed at 90 and 0 degrees, respectively, and the foot was supported on a platform without straps. The goniometer was positioned at the subject’s left hip, and the pelvis was stabilized with a lap belt.

An inclinometer† attached to the backrest guided the positioning of the subject’s head, neck, and trunk in four seating orientations relative to the vertical plane: 1) 0 degrees in the vertical plane, 2) 30 and 15 degrees posterior to the vertical plane, and 3) 15 degrees anterior to the vertical plane (Fig. 1, inset). The sequence of seating orientations tested was random and different for each subject. A rest period of five minutes after each orientation change allowed the subject to adapt to the new position. Functional activity commenced at the end of the rest period.

The subjects were instructed to move their arm from the starting position (shoulder abduction) to the midline position (shoulder adduction) to touch the switch on cue from the video monitor and to withdraw their hand as quickly as possible. The movement was repeated 10 times. Functional performance time was calculated as the time interval between the first cue to move the arm and the 10th and final activation of the switch. At the completion of all four test orientations, they were repeated in reverse sequence to evaluate further both the reliability of the results for each position and the influence of time on the results. This procedure provided a total of eight functional performance values for each subject.

Data Analysis

The mean performance times for all subjects were calculated for each body orientation, and the differences were tested for statistical significance using an analysis of variance (ANOVA). The ANOVA was not performed on the data obtained from the three subjects with athetoid cerebral palsy based on my experience from previous studies, the variability between the two types of cerebral

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* Apple Computer, Inc, 20525 Mariani Ave, Cupertino, CA 95014.

† Exact Level Tool Manufacturing, Inc (Div of Hyde Manufacturing), 54 E Ford, South Bridge, MA 01550.
TABLE 1
Performance Times (in seconds) at Different Seating Orientations for Subjects with Spastic Cerebral Palsy (n = 10)

<table>
<thead>
<tr>
<th>Position</th>
<th>Initial Tests</th>
<th>Repeat Tests</th>
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</thead>
<tbody>
<tr>
<td>30°</td>
<td>54.5</td>
<td>44.0</td>
</tr>
<tr>
<td>15°</td>
<td>47.6</td>
<td>32.8</td>
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<tr>
<td>0°</td>
<td>38.0</td>
<td>44.2</td>
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<tr>
<td>15°A</td>
<td>48.6</td>
<td>53.0</td>
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</table>

<table>
<thead>
<tr>
<th>SEM</th>
<th>3.54</th>
<th>2.58</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.58</td>
<td>3.95</td>
<td>2.62</td>
</tr>
<tr>
<td>3.77</td>
<td>1.25</td>
<td>0.83</td>
</tr>
<tr>
<td>3.95</td>
<td>1.25</td>
<td>0.76</td>
</tr>
</tbody>
</table>

*15°A = 15° of anterior inclination.

TABLE 2
Performance Times (in seconds) at Different Seating Orientations for Subjects with Athetoid Cerebral Palsy (n = 3)

<table>
<thead>
<tr>
<th>Position</th>
<th>Initial Tests</th>
<th>Repeat Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>30°</td>
<td>96.3</td>
<td>130.0</td>
</tr>
<tr>
<td>15°</td>
<td>71.5</td>
<td>68.5</td>
</tr>
<tr>
<td>0°</td>
<td>64.0</td>
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<tr>
<td>15°A</td>
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<table>
<thead>
<tr>
<th>SEM</th>
<th>2.3</th>
<th>2.65</th>
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<tr>
<td>1.57</td>
<td>1.32</td>
<td>0.77</td>
</tr>
</tbody>
</table>

*15°A = 15° of anterior inclination.

palsy, and the small sample size. A Scheffé multiple range post hoc test was conducted to determine any significant differences.

RESULTS
The lowest mean performance time was recorded at the 0-degree orientation position during the retest for the subjects with spastic cerebral palsy (Tab. 1), and the highest mean performance time was recorded at 15 degrees of anterior inclination during the retest for the subjects with athetoid cerebral palsy (Tab. 2). Generally, performance times were lower for the subjects with spasticity than for those with athetosis. Also, performance times during the repeat trials were lower than the initial trials for the subjects with spasticity, but higher for those with athetosis (Fig. 3). The ANOVA performed on the mean performance times of the subjects with spasticity indicated a statistically significant difference ($F = 63.2, p < .05$). The null hypothesis stated for this study, therefore, was rejected. The Scheffé multiple range test indicated that, at the .05 level of significance, the performance times obtained at 0 degrees were different from those obtained at the other orientation positions. Performance times during the initial and retest trials at 15 degrees of posterior and anterior inclination were not significantly different, but they were different from those at 30 degrees.

DISCUSSION
Persons with cerebral palsy often have difficulty in learning and performing voluntary movements, in part because of abnormal or primitive postural reflexes and the resulting effect of either restricted or exaggerated movement patterns. Abnormal movements distract and discourage the patient from efficiently performing voluntary movements. One goal of therapy, therefore, particularly in children and adolescents who are required to function in school or at work, is to position them so as to minimize abnormal reflexes and muscle tone and to maximize function. Without the appropriate seated posture, the individual may be unable to function normally, either academically or socially.

The results of this study suggest that the orientation of the body in space affects upper extremity function, at least for children with the types of disorders involved in this study. Performance times of the subjects with athetosis generally were higher than those of the subjects with spasticity, perhaps as a result of prevailing abnormal involuntary neuromuscular activities and consequent movement incoordination. The differences and variability among subjects in each group emphasize the need for intragroup evaluation of research data obtained for persons with cerebral palsy.

The high levels of upper extremity performance demonstrated by both categories of subjects in the 0-degree orientation position (upright position) may be the result of either better control of or a decrease in abnormal neuromuscular activity in the upright position.
Tonic muscle activity has been found to be significantly lower in the upright position than in the reclined position.4

Another consideration in this regard is that the 15- and 30-degree posterior and the 15-degree anterior orientations affect the subject's need for horizontal eye contact with the environment; most patients with cerebral palsy struggle to right themselves from these positions. Biomechanically, more effort also is required to perform the movement in the 15- and 30-degree posterior orientations, specifically because of the resistance of gravity. Thus, although the child may appear to be comfortable and well seated in these positions, the results of this study show that these are not the preferred positions for maximizing the type of upper extremity function used for this study. Lower performance times recorded during the retest trials for the subjects with spasticity may be an indicator of the positive effect of practice on motor skills. Fatigue and perhaps an increase in the intensity and frequency of abnormal movement patterns, however, may have caused the increase in performance time for the subjects with athetosis. Subjective findings during the study also indicated that for the subjects with athetosis, movements requiring wide ranges of motion of more than one or two body segments (eg, a movement involving the shoulder, elbow, and wrist) were ineffective and difficult to execute and control. Those movements, however, that occurred over short ROMs and involved fewer body segments at the same time (eg, a movement involving the elbow and wrist) were easier to perform.

CONCLUSION

The results of this study show that the orientation of the body in space affects upper extremity function. The level of performance was highest in the upright seating orientation. The results also imply that the upright orientation should be used during physical therapy directed at reeducating and strengthening voluntary movement patterns in these individuals.

Acknowledgments. I acknowledge the assistance of Douglas Hobson, Carl G. Shaw, and Glenn Ellis and the editorial suggestions of Jerry Langford and Susan Taylor.

REFERENCES