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The Effects of Arm Function in Sitting With Body Weight Support in Cerebral Palsy : A Preliminary Study

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국문요약

뇌성마비 아동의 앉은 자세에서의 부분적 체중지지가 상지 기능에 미치는 영향: 사전연구

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이 연구의 목적은 뇌성마비 아동에게 앉은 자세에서 현수를 이용하여 체중지지를 해주었을 때 상지기능에 어떠한 영향을 미치는지 알아보는 것이다. 연구대상자는 뇌성마비 아동 5명과 뇌종양 아동 1명이었다. 연구대상자에게 harness를 착용하여 부분적 체중지지를 하기 전과 착용한 상태에서 손 뻗기 동작을 3차원 동작분석기를 이용하여 어깨관절과 손뻗기 동작에 걸린 시간을 측정하였고, Box and Block 검사를 실시하여 체중지지 전과 착용 시 상지 기능을 비교하였다. 자료분석은 윌콕슨 부호순위검정을 사용하였다. 어깨관절의 관절 가동범위와 Box and Block 검사에서는 유의한 차이가 없었으나, 팔뻗기 동작의 수행 시간에는 유의한 차이가 있었다($p<.05$). 연구 대상자의 수가 적고,

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대상자 마다 연령 및 손상의 정도가 서로 다르기 때문에 연구결과를 일반화하여 해석하기에는 제한점이 있지만, 앉은 자세에서 harness를 이용하여 부분적 체중지지를 적용하였을 때 상지의 기능 향상에 도움을 줄 수 있으리라 생각하며 향후 다수를 대상으로 한 연구가 필요하리라 생각한다.

핵심단어: 뇌성마비; 상지 기능; 체중지지.

Introduction

Cerebral palsy (CP) is a non-progressive disorder of movement and posture caused by a defect or lesion of the immature brain (Bax, 1964). It occurs in approximately 2.5~5 of 1,000 births in the developed countries. The main motor function problems of children with CP are the delay or arrest of motor development and dysfunction of postural control.

Dysfunction of the postural control mechanism is a key problem in children with cerebral palsy. The postural problems largely interfere with the development of goal-directed motor behavior, social interaction, communication, and daily life activities. Postural control is the base of stability from which any purposeful movement may occur (Boehme, 1988). Mastery of reaching and manipulation relies on adequate postural control. The trunk must be balanced relative to a base of support to allow free movement of the arms and hands (Bertenthal and von Hofsten, 1998). In children with cerebral palsy who display fluctuating or abnormal muscle tone patterns, there is difficulty gaining the proximal dynamic stability necessary for efficient upper extremity function (Sparacio, 1999). Frequently, children with cerebral palsy without stable trunks and experience variation and fluctuation in muscle tone and demonstrate poor reaching and functional activity. They are unable to sustain an upright position and adapt postural adjustments while moving their upper limbs. Several studies of children with CP have demonstrated that a proper sitting position improves postural alignment and stability, and the quality of voluntary arm movements (Bablich et al, 1986; McClenaghan et al, 1992; Reid, 1996).

In an effort to improve trunk stability, postural control and upper limb function in children with cerebral palsy, different therapies, including physical therapy, are directed towards improving the child's ability to control posture. Wright and Nicholson (1973) reported only slight functional gains in quadriplegic infants from physical therapy using a Bobath approach. Ottenbacher and cowokers (1986) used a meta-analysis of nine controlled studies to evaluated quantitatively the effectiveness of neurodeveopmental therapy. They found that subjects who received neurodevelpmental therapy performed slightly better than control subjects who did not, but those results were related to research design characteristics. Shen et al (2003) studied the effect of ergonomic desk design for impoving motor accuracy in the writing performance of cerebral palsy students. Nicholson et al (2001) reported that the functional benefit of lycra garments for children with cerebral palsy is mainly due to improvements in proximal stability. Butler (1998) studied the targeting training that may be an effective means of promoting movement control and functional ability. Park et al (2001) studied the effect of electrical stimulation on the trunk control in young children with spastic diplegic cerebral palsy. Wright and Granat (2000) reported functional electrical stimulation of the upper extremity may be useful to improve their hand function.

Recently, training with the partial body weight support (PBWS) system has been used to increase walking ability in patient with strokes, spinal cord injuries, low back pain, and cerebral palsy (Hesse et al, 1994; Schindl et al, 2000; Wernig and Muller, 1992). Unloading with partial body weight support system helps postural control. The improvements in walking ability seem to favor the concept of a repetitive task-specific approach in patients who are learning walking. There is no study to date that has reported on applying applying PBWS system on the upper extremities.

According to the studies reviewed above, applying partial body weight support may be effective in improving upper extremity function in children with cerebral palsy. The purpose of our study is to provide information regarding the effect of PBWS system on upper extremity function in children with cerebral palsy.

Methods

Subjects

Five boys with CP and one girl with a cerebral tumor are participated in the study approved by their parents. Their mean age was 8.7 years, with a range from 5.1 to 18.0 years.

The children met the following inclusion criteria; (1) ability to sit alone without arm and back support for at least 5 minutes, (2) no severe cognitive or communicative impairment, ie all children could follow instructions, (3) no orthopedic problems in the tested upper extremity. General characteristics of subjects are presented in Table 1.

Instruments and procedures

Partial body weight support system

Unloading with partial body weight support about 20% of body weight involves the use of a traction harness and the application of a vertical traction force while the child sits on a table.

Motion analysis

The CMS-HS[4]) measuring system was used to analyze the kinematic data. This

Table 1. General characteristics of subjects (N=6)

Subject	Sex	Age	Diagnosis	Arm length (cm)	Sitting height (cm)
A	male	6.9	CP	40.30	63.50
B	male	5.2	CP	40.70	62.20
C	male	5.1	CP	45.5	62.30
D	female	5.2	cerebral tumor	45.10	68.70
E	male	18	CP	74.00	95.00
F	male	17	CP	68.00	86.00

system consists of a measuring sensor with stand, a basic CMS-HS unit, markers and a cable adaptor with 10 channels that can be supplied for operation of individual markers. The measuring procedure is based on the determination of the spatial coordinates of miniature ultrasound transmitters. The sound pulse time between the transmitters and the three microphones integrated in the measuring sensor was measured. Triple active reflective markers were placed on the right side of upper extremities at mid point between greater tubercle and lateral epicondyle of humerus, and between lateral epicolyle of humerus and styloid process of ulna. A single active marker was placed on the tip of right index finger.

The Box and Block test

The Box and Block test is used to measure unilateral gross manual dexterity. This test involves the patient moving as many blocks as possible, one by one, from one compartment of a box to another compartment of equal size within 60 seconds. Desrosiers and colleagues (1994) examined the test-retest reliability and construct validity of measurements taken within this instrument in a group of elderly people with upper extremity impairment. The ICCs ranged from .89 to .97, and correlations were demonstrated among the Box and Block test and an upper limb performance measure (ICC=.80～.82), and a measure of functional independence (ICC=.423～.54).

Test protocol

Motion analysis was performed on the six children without and with applying PBWS system. A reach task was carried out with the less affected upper limb. The starting position of the child's arm was on her/his lab. The reach object was then positioned at shoulder level within the range of her/his arm length. Each child began in sitting position with their hands on her/his knees and reached for the object following a verbal signal from

4) Zebris Medizintechnik, GmbH. Isny. Germany.

Table 2. The comparison of shoulder ROM reaching without and with the sling (N=6)

		N	Mean ranks	Sum of ranks	Z	p
With sling - without sling	Negative ranks	2	1.50	3.00	-1.57[a]	.12
	Positive ranks	4	4.50	18.00		

[a]Based on negative ranks

Table 3. The comparison of speed of arm reaching without and with sling condition (N=6)

		N	Mean ranks	Sum of ranks	Z	p
With sling - without sling	Negative ranks	6	3.50	21.00	-2.20[a]	.03
	Positive ranks	0	.00	.00		

[a]Based on negative ranks

the researcher. All were asked to perform the task three times. The Box and Block test was performed without and with applying PBWS system. All were asked to perform the test one time.

Statistical analysis

Non-parametric Wilcoxon tests were used to compare to the kinematic (shoulder ROM, elbow ROM and duration of arm pointing) and Box and Block test score between without and with applying the PBWS system ($p<.05$).

Results

The shoulder flexion range during reaching and the means of the angle change were 48.42±23.92 degrees for children without PBWS, 56.29±20.23 degrees for children with the PBWS system, respectively. There were no significant differences between the two conditions ($p>.05$)(Table 2).

Measuring the speed of arm reaching, the speed was compared between two conditions. The speed in the PBWS condition was faster than without the PBWS condition. The speed of arm reaching in children without PBWS was 322.28±223.07 seconds, 175.80±96.93 seconds in children with PBWS, respectively. There were significant differences between the two conditions ($p<.05$)(Table 3).

Measuring the Box and Block test, the numbers of blocks 15.00±6.63 for children without PBWS and 18.83±8.33 for children with PBWS reached by childeren were. There were no significant differences between two conditions ($p>.05$) (Table 4).

Table 4. The comparison of BOX and Block Test scores without and with sling condition (N=6)

		N	Mean ranks	Sum of ranks	Z	p
With sling - without sling	Negative ranks	2	2.00	4.00	-1.36[a]	.17
	Positive ranks	4	4.25	17.00		

[a]Based on negative ranks

Discussion

Sitting is an important step for children to achieve the upright posture against gravity and also an essential activity to provide the postural background tone required for the functional movement of upper extremities. However, the children with cerebral palsy often show difficulty achieving well-balanced sitting posture (Park et al, 2001). To support their sitting posture and to train their upper extremity, the partial body weight support system was applied to children with CP. We expected that the PBWS system may be effective in improving upper extremity function in children with cerebral palsy, but there was only a significant difference the speed of arm reaching.

This study design has a weakness. The subjects' characteristics were so different that the result of statistical analysis may be misleading. Subject A suffered from spastic quadriplegia with additional athetoid, subject B from spastic diplegia, subject C and F from spastic quadriplegia, subject D from ataxia, subject E from athetoid, and suject F from spastic quadriplegia. Individual scores of subjects are presented in Table 5.

With respect to the results of shoulder angle changes, there were no significant

Table 5. Individual scores of all subjects (N=6)

		Shoulder flexion range (degree)		Speed (msec)		Box and Block test	
		Without	With	Without	With	Without	With
A	SQ with athetoid	29.0±4.2	62.4±18.3	238.7±28.9	165.0±39.0	12	9
B	SD	74.4±2.6	72.3±11.1	85.3±10.2	67.5±10.6	20	32
C	SQ	77.3±2.0	77.±10.9	103.7±7.4	74.0±13.7	13	15
D	Ataxia	55.9±3.3	63.5±11.2	381.0±72.1	225.0±59.0	14	20
E	Athetoid	28.3±6.5	31.2±1.3	465.0±183.8	200.0±14.1	25	24
F	SQ	25.6±1.1	31.2±2.8	660.0±81.2	323.3±17.6	6	13

SQ: spastic quadriplegia, SD: spastic diplegia statistical differences between the two conditions. Children with athetoid type benefited more than children with spastic CP. Whereas the result, duration of reaching, showed significant differences between the two conditions. It is likely that children with spastic CP displayed both hypertonicity in the upper extremities and hypotonicity in the trunk whereas children with athetoid quadriplegia display fluctuating tone patterns that yielded more proximal unsteadiness. These implied that children with athetoid quadiplegia benefited from both shoulder angle changes and duration of reaching when applying the PBWS system. Children with spastic quadriplegia performed the reaching task quickly, but there were no shoulder angle changes when applying the PBWS system. Children with spasticity have limited joint range and dissociation of movements of one part of the body from another. Hanson (1999) studied the benefits of lycra garments and found that children with athetosis, ataxia and hypotonia benefited most.

Reaching and grasping are essential to many parts of daily life; such movements are difficult for many children with CP who have difficulties with sensory and motor impairments (Gordon and Duff, 1999). A number of studies have examined the development of reach and grasping (Henderson and Pehoski, 1995) indicating that theses skills are acquired in children under 2 years of age (von Hofsten and Ronqvist, 1998).

The Box and Block test was performed to evaluate a functional task. When applying PBWS systems the score of Box and Block test of subjects A and E were the same or slightly decreased even though others were increased. Those with athetosis exhibited poor control, lack of fixations, and tended to use extreme ranges of movement. Children with spasticity had limited joint range and dissociation of movements of one part of the body from another; ataxia caused instability and rapid fluctuations in tone from low to normal (Boheme, 1990; Erdhart, 1989). Subject C had difficulty grasping, so score of test did not change.

Recently, dynamic splint have been used to improve the stability of children with CP. Dynamic splints made from lycra are thought to reduce abnormal tone and involuntary movements, increase proximal stability, and improve upper-limb movements in children with cerebral palsy (Blair et al, 1995; Nicholson et al, 2001). However, they are associated with significant practical problems, as they are difficult to put on and are often uncomfortable (Hanson, 1999). Parents and care givers have shown interest in the garment (Scope, 1996) even though they are expensive and in need of further evaluation.

The PBWS system has many advantages. They are easy to apply, comfortable, and not expensive. The major finding of the preliminary study was that applying PBWS the children with cerebral palsy could help to improve functional activities of upper extremities.

Kinematic analysis widely is used to evaluate motion. Kluzik et al (1990) assessed the effects of treatment on reaching in children with spasticiy, and Nicholson et al (2001) studied the benefits of lycra garments using kinematic analysis. No studies to date have reported on the possible effects of PBWS in children with cerebral palsy in this way. This is another advantage of this study.

However, the study design has weaknessess that require comment. The number of subjects was too small to generalize our results. We examined the immediate effect of the PBWS system. Further study is needed to evaluate the training effect of the PBWS system.

Conclusion

There are many factors that contribute to ensuring efficient upper-extremity function in children with cerebral palsy. Accurate and purposeful upper-extremity movement is a key goal for persons with cerebral palsy. The results of this study indicated that speed of reaching when applying the PBWS system is significantly faster than without the PBWS system. The effect was shown to be more beneficial in children with athetoid quadriplegia than those with spastic quadiplegia. Further study needs to evaluate the training effect of the PBWS system.

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