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J Rehabili Health Sci 2009 ; **7** : 33-38

Report

Sit-to-Stand Movement Characteristics of a Child with Diplegic Cerebral Palsy before and after Physical Therapy

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Received October 30, 2009 ; accepted December 21, 2009

Key words : spastic diplegia; sit-to-stand movement; motion analysis; physical therapy

Abstract

Purpose The purpose of this study was to assess the immediate effects of physical therapy (PT) on sit-to-stand (STS) movements in a child with cerebral palsy (CP).

Methods A child with cerebral spastic diplegia, aged 4 years and 1 month, and had no prior surgery, was the case for this study. One PT session based on Neuro Developmental Treatment approach was executed to treat the subject. STS movements data before and after PT which included the total duration of STS movement, and angular movement of each joint were estimated.

Results The total duration of STS movement was 3.47 s before PT, and 1.86 s after PT. As for angular movement, shoulder joint was 12 degrees before PT, and 26 degrees after PT at the end of STS. Moreover, both hip and knee joints after PT were locked together to some extent in a linear pattern extension compared with before PT.

Conclusion These findings indicate that PT may be effective on STS movement in children with cerebral palsy.

1 Introduction

Motor developments of cerebral palsy (CP) have been more overdue or retarded than that of normal children[1]. Since children with CP are characterized by loss of selective muscle control, dependence on primitive reflex patterns for ambulation, abnormal muscle tone, relative imbalance between muscle agonist and antagonist, and deficient equilibrium reactions[2]. Especially, children with CP have difficulty in anti-gravity motor developments as in sit-to-stand (STS) movement because STS movement requires forward and upward displacement of the body's center of mass in order to shift the body mass over the feet. As the support base is narrowed down to an area limited by the feet, adequate body balance, equilibrium reaction and coordination of muscle activation are required simultaneously[3]. Children with CP, therefore, have difficulties in these activities and use various compensatory patterns for accomplishing these activities. In order to facilitate more efficient motor function, it is important for physical therapists to understand kinematic characteristic of CP movements.

In recent years, several research studies on motion analysis of STS movement have been reported[4-7]; particularly, Park's studies have shed some light on CP STS movement[5-7]. His first study focused on the kinematic characteristic of STS movement in children with CP, aged 2 to 6, in preambulatory status[5]. Compared with normally developed children, the pattern of STS movement in spastic diplegia was characterized by slow speed, increased anterior pelvic tilt, and early abrupt knee extension. In terms of intervention, Park has also reported the effect of ankle-foot orthoses (AFO) and botulinum toxin on STS movement[6,7]. However, the effect of physical therapy (PT) on STS movements has not been clarified. Therefore, the purpose of this study was to assess the effects of PT on STS movements of a child with CP.

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2 Methods

2-1 Subject

A cerebral spastic diplegia male, aged 4 years and 1 months, and had no prior surgery, was the subject. He was born at 30 weeks gestation, birthweight 1784 g. He was able to sit without support, but was not able to stand from a chair independently. Classification by Gross Motor Function Classification System (GMFCS)[8] was level IV. He could not extend knee joints fully; moreover, his trunk and hip joints were flexed on standing. Muscle tone was hypertonic at iliopsoas, adductor magnus, hamstrings, and triceps surae. The right side muscle tone was more hypertonic than that of the left side. There were no limits of range of motion (ROM) on both lower limbs. The subject has received PT intervention at 2 years 8 month, once a week. The purpose of this study was explained to the parents orally and in writing, and written consent was obtained.

2-2 Motion procedures

In order to assess STS movements during one PT session, a motion analysis system (APAS-system: made by Ariel Dynamics company) with 2 digital cameras (30fps) were used. Since the subject has difficulty in standing independently, a handrail assisted him. Two cameras, placed on the less spastic side (left side), were used to record STS movements. The reason that the cameras were placed on the less spastic side was to record and show the full extent of the subject's motor ability. Markers were placed unilaterally on the following body landmarks: lateral aspect of the 5th metatarsal head, lateral malleolus, lateral femoral condyle, greater trochanter, acromion, olecranon, processus styloideus radii, and the center of the jaw. Moreover, the head protector that markers were placed on the top of head was worn.

A chair, as high the subject's knee joint in sitting position, was prepared. The handrail, as high as the subject' s shoulder joint in sitting position, was placed at a distance equaled to the length of the upper extremity of the shoulder joint, 90 degrees flexed. Both feet were kept shoulder width apart on the floor. These settings were similar as in Wilson's study [4].

Motion procedures were as follows:(i) in the initial sitting position, trunk was extended as straight as possible, and hands were on knees; (ii) sole of the feet to the floor; (iii) knee flexion angle was approximately 90 degrees; (iv) standing by gripping onto a handrail; and (v) in standing position, trunk and knees were extended as straight as possible. STS movements were performed in bare feet, and there was no time restriction. The subject executed the STS movements three times; for the purpose of analysis, one steady movement, which was performed completely stopping at standing, was selected. The initial point of STS (T1) was defined as the point at which the hands gripped onto a handrail, and the end point of STS (T3) was defined as the point at which the motion of the head and trunk stopped.

The transitional point of STS was measured from the data on the two cameras (T2, the point when weight is off the buttocks). The duration of the 2 phases (phase I, forward transfer, phase II; standing up) of STS from the 3 transitional points were also assessed. STS movements data during PT which included the total duration of STS movement, stick picture, and angular movement were collected and compared.

Stick picture framed the lines of the lateral aspect of the 5th metatarsal head, lateral malleolus, lateral femoral condyle, greater trochanter, acromion, olecranon, processus styloideus radii, the top of head, and the center of the jaw on sagittal plane. Finally, angular movement of each 6 joints (trunk, shoulder, elbow, hip, knee, and ankle) was defined as in Fig 1.

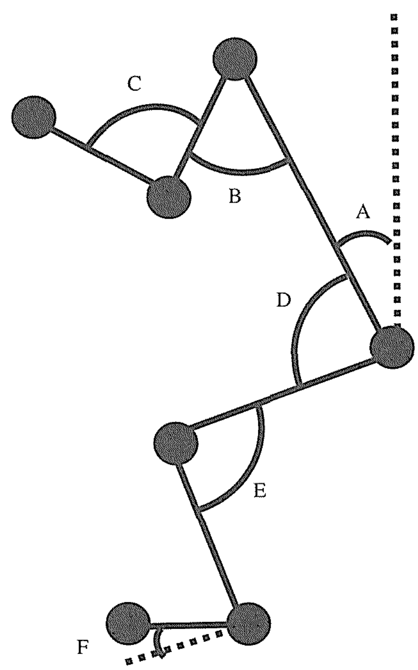

Fig. 1 The definition of each joint range of motion.

∠A : Trunk, ∠B : Shoulder, ∠C : Elbow, ∠D : Hip, ∠E : Knee, ∠F : Ankle

Angular movement of the trunk was defined as between the lines from the greater trochanter and the vertical line through the greater trochanter. In a similar way, angular movement of the shoulder was defined as between the line from the acromion to the greater trochanter and the line from the greater trochanter to the olecranon. Angular movement of the elbow was defined as between the line from the greater trochanter to the olecranon and the line from the olecranon to the processus styloideus radii. Angular movement of the hip was defined as between the line from the acromion to the greater trochanter and the line from the greater trochanter to the lateral femoral condyle. Angular movement of the knee was defined as between the line from the greater trochanter to the lateral femoral condyle and the line from the lateral femoral condyle to the lateral malleolus. Angular movement of the ankle was defined as between the vertical line from the lateral femoral condyle to the lateral malleolus and the line from the lateral malleolus to the lateral aspect of the 5th metatarsal head.

Collected data of each joints were recorded by time.

2-3 Setting of physical therapy

Neuro Developmental Treatment (NDT) approach was executed to treat the child. PT sessions were administered by a 5-years- experienced physical therapist for 40 minutes[9]. A 35cm-high chair with toys placed on it was prepared. Subject positioned himself in front of the table, both hands on it, and tried to hold knee standing position by using the table as support in order to reach for and play with the toys (Fig 2A). As subject tried to hold and regain his balance, the physical therapist applied intervention by manipulating his bilateral scapula, a key point in NDT modality, which facilitated trunk extension. This in turn enhanced his body righting and equilibrium reactions (Fig 2B).

3 Results

3-1 The total duration of sit-to-stand movement

The total duration of STS movement was 3.47 seconds before PT, and 1.87 seconds after PT. As for the duration of both phases, the duration after PT was shorter than that before PT (Table 1).

Table 1 The duration of STS movement on each phase during PT

	Before PT (s)	After PT (s)
Phase I	2.05	0.81
Phase II	1.42	1.05
Total	3.47	1.86

3-2 Stick picture and Angular movement of each joint

Stick pictures of STS movement and the kinematic

A) B)

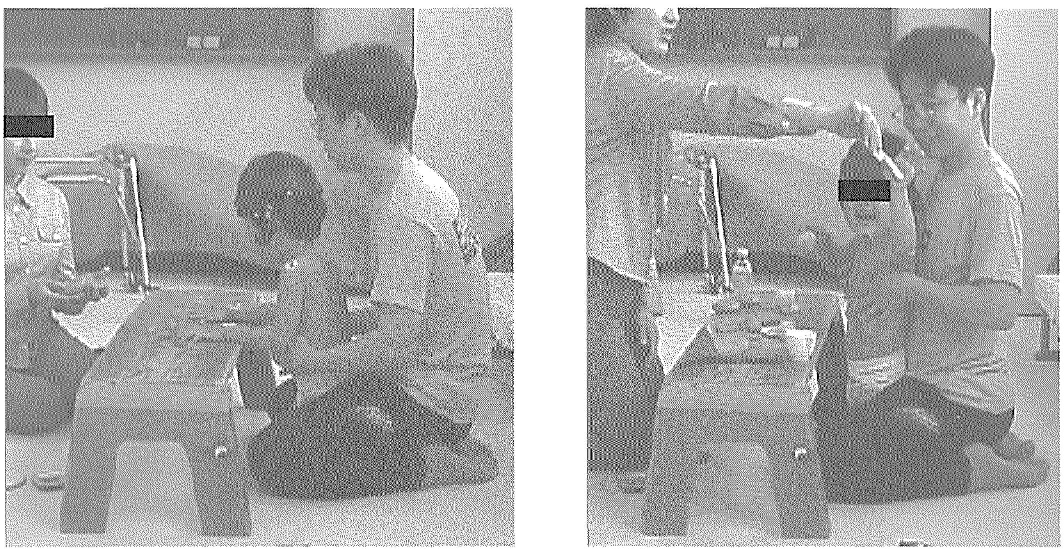

Fig. 2 Physical therapy intervention for the subject.

(A) Positioning (B) Facilitation for his body righting and equilibrium reactions.

curves of each joint during PT are shown in Fig 3,4.

One of the characteristic points was the movement of upper limb (Fig 4). Angular movement of shoulder joint was 12 degrees before PT, and 26 degrees after PT at the end of STS (T3) (Table 2).

Another point also represented the movement of lower limb (Fig 4). As for the angular movement before PT in phase I, ankle joint was not fully dorsiflexed. In phase II, knee joint was more extended than hip joint. In contrast, ankle joint after PT was dorsiflexed from 8 to 14 degrees in phase I. Moreover, both hip and knee joints after PT were locked together in a linear pattern of extension in phase II.

4 Discussion

The purpose of this study was to assess STS movements of a child with cerebral spastic diplegia during one PT session, based on objective kinematic data.

Trunk flexion in STS movement shifts the body's center of mass forward[3,10]. However, ankle joint before PT was in plantarflexion in phase I (Fig 4). This phenomenon should made it difficult for the feet to be the stable base of support. Therefore, this curtailed the function of shifting the body's center of mass by trunk flexion. This presumption explains for the longer duration of STS movement as compared with the duration in phase I after PT.

In addition to the difficulty in shifting the body's center of mass, shoulder joint moved from flexion to extension (Fig 4). This phenomenon demonstrates one of the compensatory movements of CP[1]. This compensatory movement might lead to excessive co-contraction between muscle agonist and antagonist on lower limbs. Therefore, in phase II, knee joint was more extend than hip joint.

It could be assumed that STS movement before PT was inefficient. Due to the immature righting and equilibrium

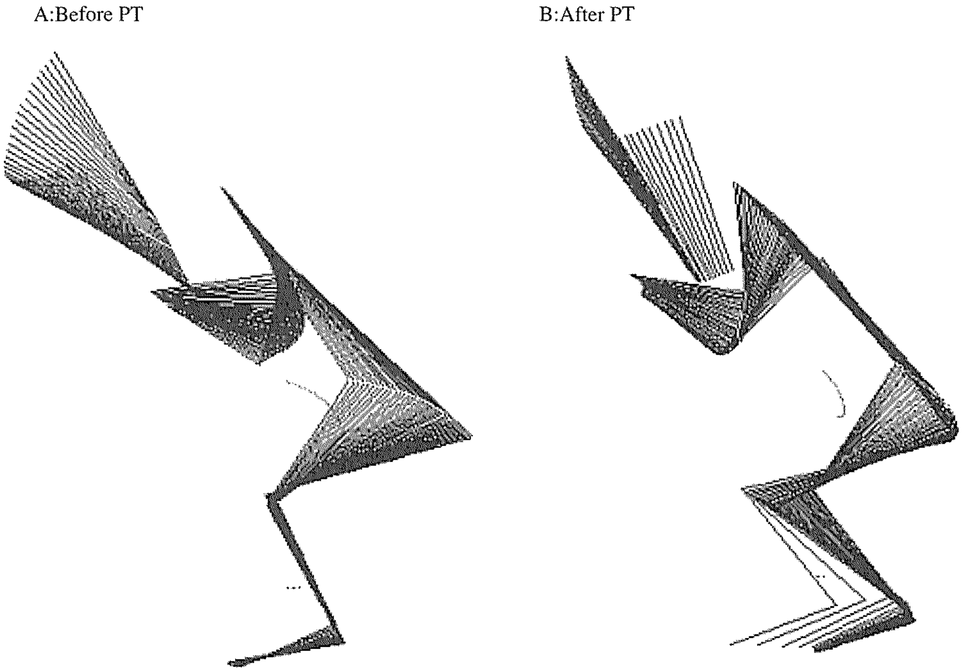

Fig.3 Stick pictures of STS movement during PT.

Table 2 Angular movement of each joint on 6 transitional points during PT

	Trunk		Shoulder		Elbow		Hip		Knee		Ankle	
	Before PT	After PT	Before PT	After PT	Before PT	After PT	Before PT	After PT	Before PT	After PT	Before PT	After PT
T1	28.0	23.4	42.6	55.8	54.8	60.8	80.6	86.7	98.2	80.6	-7.2	8.5
T2	33.2	31.7	28.5	48.0	42.8	50.0	91.5	97.1	104.0	90.3	7.3	14.0
T3	30.9	31.0	12.6	26.3	53.7	56.1	111.9	128.8	124.3	131.7	7.9	7.4

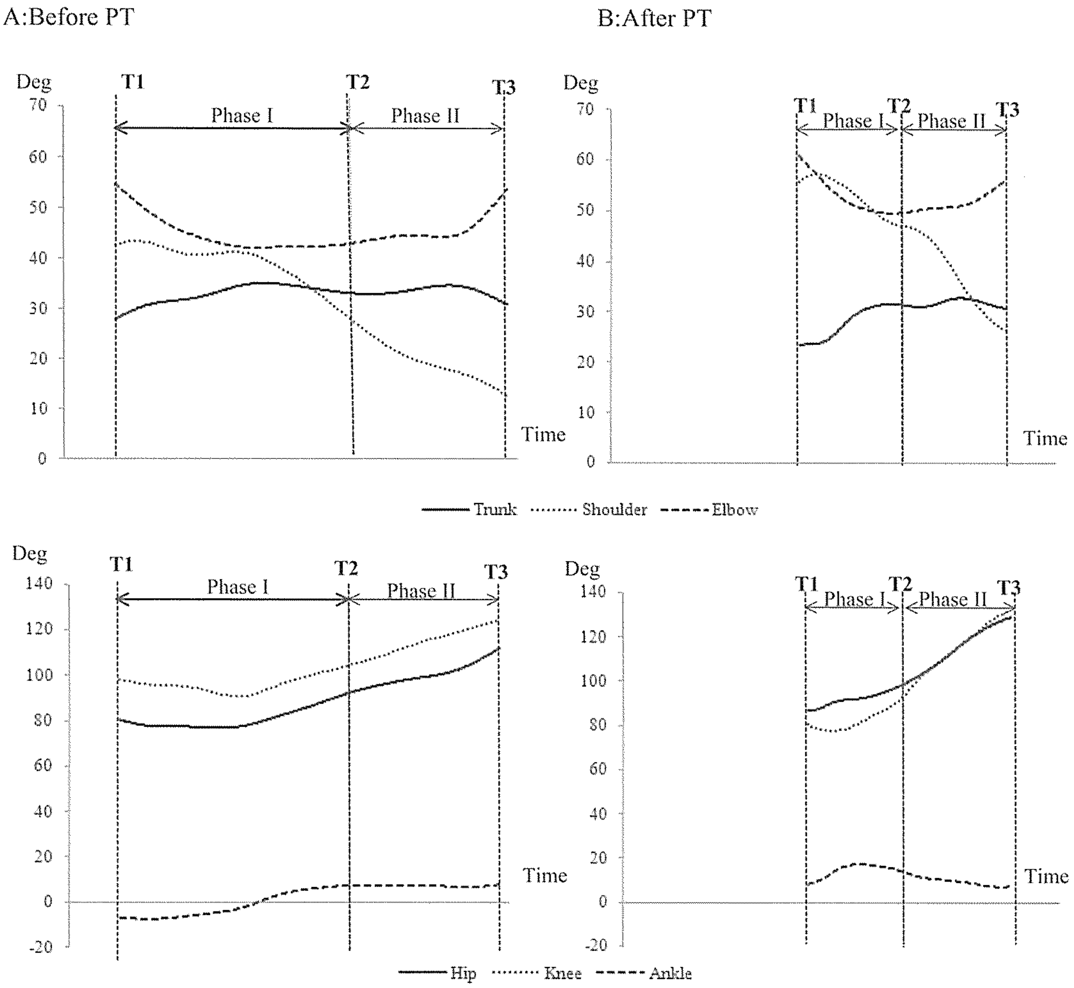

Fig.4 Angular movement of each joint during PT.

Increasing degree for the hip and knee angular movements indicates extension. Whereas, increasing degree for the trunk, shoulder, elbow and ankle angular movements indicates flexion (dorsiflexion).

reactions on anti-gravity, CP movement was characterized by abnormal movement patterns and compensatory movement. Thus, to facilitate righting and/or equilibrium reaction and coordination, PT for CP will lead to the inhibition of abnormal movement patterns.

Compared with STS movement before PT, there were contrasting findings on STS movement after PT.

One finding was a reduction of the duration of STS movement. As for the trunk angle, there was no difference on the trasitional point (T2) between the 2 conditions – before and after PT. On the other hand, ankle joint after PT was maintained in dorsiflexion. These phenomenons explain that the body's center of mass shifts more efficiently forward by the flexion of trunk movement. That is to say, more selective muscle control led to the flexion of trunk movement on STS movement after PT.

In phase II, the task was performed while maintaining the ankle joint in dorsiflexion. As for the STS movement in healthy young subjects, hip and knee joint locked together in a linear pattern extension[11,12]. Although the standard measurement reference of ROM in this study was different from earlier studies, hip and knee joints after PT were locked together to some extent in a linear pattern extension compared with before PT. This coordination movement might lead to inhibit compensatory movement, which characterized the shoulder joint motion (Fig 4). These phenomenons suggest that the subject's righting and/or equilibrium reaction and the body coordination were improved by PT. Thus, it could be assumed that STS movement after PT was more efficient in term of selective muscle control.

Using hinged AFO and botulinum toxin type A injection, the initial angle joint of ankle dorsiflexion was increased on STS movement in Park's studies[6,7]. Although a statistical analysis was not conducted, the findings of this study showed that the effect of PT intervention was not only observed on the ankle joint but also on the shoulder, hip and knee joints, which was different from Park's studies[6,7]. Although the reproducibility of PT intervention is still in question, this could facilitate CP motor function and participation in the community.

These findings lead us to conclude that PT was effective on STS movement in a child with CP. Understanding kinematic characteristic of CP movements is important for physical therapists in order to provide effective intervention which will eventually lead to more efficient motor function and community participation.

As for the limitations of this study, a single subject and the subject's less spastic side generated all the data. Moreover, there was no baseline for STS movement based on objective kinematic data in this study. Thus, the effect of PT on STS movements has not been fully clarified. To have a better understanding of the effect and assessment of PT modality on CP, further studies on the revised design involving more subjects are needed.

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