



Original Article

Effects of an underwear-type hip abduction orthosis on sitting balance and sit-to-stand activities in children with spastic cerebral palsy

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Abstract. [Purpose] Hip dislocation and subluxation are common in patients with cerebral palsy (CP). Hip abduction orthoses are used to prevent and treat these problems. This study investigated the effects of an underwear-type hip abduction orthosis on sitting balance and sit-to-stand (STS) activity in children with spastic CP. [Participants and Methods] This trial had a cross-over design. Eight children aged 6 to 18 years old with spastic CP and Gross Motor Function Classification level III and IV were randomly allocated to groups with or without use of the underwear-type hip orthosis. The trunk impairment scale (TIS) score was evaluated and the 5-times sit-to-stand test (FTSST) was conducted with and without the underwear. [Results] The dynamic sitting balance scores in the TIS and FTSST showed significant improvement with use of the orthotic underwear. [Conclusion] The dynamic sitting balance scores of the TIS and FTSST were higher, thus indicating better stability, when wearing the orthosis underwear. Thus, it was suggested that underwear-type hip abduction orthoses are effective for promoting sitting balance and STS activities in children with spastic CP.

Key words: Hip abduction orthosis, Sit-to-stand, Spastic cerebral palsy

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INTRODUCTION

Hip dislocation and subluxation are the most common problems among patients with cerebral palsy (CP)¹⁾, and hip abduction orthoses (HAO) are used for the prevention and treatment of these problems²⁾. Conventional HAO limit hip adduction through a prop on the side of the thigh. For children with CP who have hypertonic hip adduction muscles, it is difficult to maintain hip abduction with conventional HAO because the prop of the HAO bends during movement. Conventional HAO will limit mat activities and sit-to-stand (STS) activities. In the clinic, CP children in wheelchairs with hypertonic hip adduction muscles use the adduction prevention part, which is held in the hip abduction position by a manipulative procedure during the STS activities to facilitate the movements of the trunk and hip muscles³⁾. However, if therapists control the hip joint through a manipulative procedure, then they cannot assist with the other parts. Therefore, it is difficult to perform a manipulative procedure during the mat and gait activities.

Underwear-type HAO that have been developed in recent years are easy to wear, and they maintain hip abduction because

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Table 1. Participant characteristics

| | Children with spastic cerebral palsy (n=8) |
|---------------------|--|
| Male/female (n) | 6/2 |
| Age (years) (range) | 11.0 ± 4.4 (6–18) |
| Height (cm) | 125.4 ± 18.4 |
| Weight (kg) | 29.6 ± 17.1 |
| GMFCS (n) | |
| Level III | 4 |
| Level IV | 4 |
| Palsy type (n) | |
| Diplegia | 5 |
| Quadriplegia | 3 |

Mean ± standard deviation. GMFCS: gross motor function classification system.

**Fig. 1.** The underwear-type hip abduction orthosis (Cosa Active; Otto Bock).

of the internal adduction prevention part. Because underwear-type HAO are physically immobilized by the internal part, they do not bend at the time of movement, unlike conventional HAO. If sitting and STS activities among children with CP improve with the use of underwear-type HAO, then they may be able to move actively, thereby reducing their need for assistance and manipulative procedures from physical therapists and caregivers. Therefore, this study aimed to investigate the effects of underwear-type HAO on the sitting balance and STS activities of children with spastic CP.

PARTICIPANTS AND METHODS

Participants were recruited from three hospitals and medical centers in Tokyo, Saitama, and Kanagawa. The inclusion criteria were as follows: (1) age 6–18 years; (2) diagnosis of spastic CP; (3) gross motor level III or IV according to the Gross Motor Function Classification System (GMFCS) expanded and revised version; and (4) the ability to communicate and follow instructions. The exclusion criteria were orthopedic intervention or botulinum toxin injection to the lower extremities within the past 6 months. Eight children with spastic CP who met the inclusion and exclusion criteria were included in the study (Table 1). Participants and their parents provided informed consent for participation. The study was approved by the Tokyo University of Technology of Health Sciences Ethical Review Board (authorization number: E16HS-014).

This trial had a cross-over design. Using the permuted block method, participants were randomly allocated to one of two groups: the underwear-type HAO-wearing (Cosa Active; Otto Bock) (Fig. 1) group or the non-wearing group. The second measurements were performed on different days within 1 month of the first measurements. Measurements for each group were performed after a 10-minute warm-up. The trunk impairment scale (TIS) score was evaluated and the five times sit-to-stand test (FTSST) was conducted while wearing and not wearing the underwear. The TIS and FTSST have acceptable inter-reliability and intra-reliability and concurrent validity for children with CP^{4–6}. The TIS includes three subscales, static sitting balance (7 points), dynamic sitting balance (10 points), and co-ordination (6 points), and the TIS score ranges from a minimum of 0 to a maximum of 23⁵). The FTSST measures the transition time between sitting and standing five consecutive times⁶). Because the participants with GMFCS levels III and IV found it difficult to stand without the support of their upper limbs, the FTSST was conducted using parallel bars. The FTSST was measured twice, and the minimum time required was used as the FTSST result.

TIS scores and FTSST results of the wearing and non-wearing groups were compared using Wilcoxon's signed-rank test. All analyses were performed using IBM SPSS Statistics for Windows (version 19.0); $p < 0.05$ was considered statistically significant.

RESULTS

Results of comparisons of each parameter between the wearing and non-wearing groups are presented in Table 2. While wearing the underwear-type HAO, the static sitting balance was lower, dynamic sitting balance was higher, and the FTSST results were significantly lower. The co-ordination score and total score of the TIS were not significantly different.

Table 2. Comparison of parameters associated with wearing and not wearing the underwear-type hip abduction orthosis

| | Wearing | Not wearing | r |
|-----------------|------------------|------------------|------|
| TIS (points) | | | |
| Static balance | 3.0 (2.0, 6.3)* | 6.5 (5.0, 7.0) | 0.78 |
| Dynamic balance | 4.5 (3.3, 6.0)* | 3.0 (1.3, 4.8) | 0.72 |
| Coordination | 1.0 (1.0, 1.0) | 1.0 (0, 1.0) | 0.50 |
| Total score | 10.5 (4.8, 12.8) | 10.0 (9.0, 10.8) | 0.19 |
| FTSST (times) | 9.1 (7.8, 10.1)* | 14.6 (9.2, 20.2) | 0.84 |

TIS: trunk impairment scale; FTSST: five times sit to stand test.

Data are presented as median (quartile one, quartile three).

*p<0.05, wearing vs. not wearing.

DISCUSSION

Children with GMFCS levels III and IV have poor abdominal muscle tone and insufficient dynamic balance compared with children with higher GMFCS levels⁷. Children with CP with GMFCS levels III and IV often present with scissor gait, which is characterized by the knees hitting each other, and perform STS activities with hip adduction and internal rotation. The developed tension varies with the length of the muscle and is lower for both short and stretched muscles⁸. When wearing the underwear-type HAO, the knees of the patient do not hit each other, resulting in improved TIS scores and FTSST test results because contraction of the hip abduction muscles becomes easier. If the sitting balance and STS motions of children with spastic CP with GMFCS levels III and IV improve when wearing underwear-type HAO, then their active movements will improve, thus reducing the need for assistance and manipulative procedures from physical therapists and caregivers.

The static sitting balance scale of the TIS was used to evaluate the ability to sit cross-legged for 10 seconds^{4, 5}. The lower static sitting balance associated with wearing the underwear-type HAO was attributed to the difficulty crossing the legs because of the internal part of the Cosa Active HAO. The dynamic sitting balance usually can be improved by improving the static sitting balance. It was considered that the static sitting balance scale of the TIS was unable to completely measure the effects of wearing the underwear-type HAO. The dynamic sitting balance scale of the TIS measured the ability to touch the bed with the elbow and return to the starting position on one side^{4, 5}. These movements involve not only contractions of the trunk muscles but also contractions of the hip muscles. Usually, the movements performed to touch the bed with the right elbow and return to the starting position require different muscle activities with respect to the right and left lower limbs; for example, stability and balance while sitting involves abduction of the left hip as the counterweight to the contraction of the right gluteus muscles. Children with spastic CP with paraplegia or quadriplegia have difficulty controlling selective voluntary movements⁹. Therefore, children with CP often have insufficient muscle abilities of the lower limbs, and adduction of the hips allows stabilization and balance while sitting. Because the dynamic sitting balance was higher in this study, children with CP may develop sufficient muscle abilities of the lower limbs. Moreover, the activities of the hip and lower trunk muscles of children with CP may be facilitated by wearing the underwear-type HAO.

This study had some limitations. The number of participants included in the study was small. In addition, the longitudinal relationship between the incidence of hip dislocation and joint contractures was not clear. Typical daily movements are some of the main causes of motor function changes and joint contracture among children with CP¹⁰. Therefore, further studies with a larger sample size that aim to determine the longitudinal motor function changes and the effects of joint contractures are needed to overcome these limitations. Furthermore, it is necessary to investigate changes in muscle activities of the hip and lower trunk muscles that result from wearing the underwear-type HAO.

In conclusion, because the dynamic sitting balance score of the TIS and the FTSST results were better when wearing orthosis underwear, it can be suggested that the underwear-type HAO is effective for promoting the sitting balance and STS activities of children with spastic CP.

Conflict of interest

The underwear-type hip abduction orthoses (Cosa Active) were provided by Otto Bock Japan K. K. at no cost.

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