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The Immediate Effects of the Toe Spreader on the Gait of Children With Spastic Diplegic Cerebral Palsy

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국문요약

발가락 벌림 보조기가 양하지 뇌성마비 아동의 보행에 미치는 영향

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본 연구는 발가락 벌림 보조기(toe spreader)가 긴장성 발가락 굽힘 반사(Tonic Toe Flexion Reflex: TTFR)가 있는 양하지 뇌성마비 아동의 보행에 미치는 영향을 알아보고자 하였다. 12명의 TTFR이 있는 양하지 뇌성마비 아동을 대상으로 같은 날에 맨발과 발가락 벌림 보조기를 착용한 상태에서 보행분석을 실시하였다. 시간·거리 보행변수로 활보장(step length), 보장(step length), 보폭(step width), 발가락 외전각도(toe out angle), 활보시간(stride), 입각기(stance phase), 유각기(swing phase), 분속수(cadence), 보행속도(speed)를 측정하였다. 발가락 벌림 보조기 착용 시 시간·거리 보행변수는 통

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계적으로는 유의한 차이가 없었다(p>.05). 양하지 뇌성마비 아동에서 TTFR을 억제하기 위한 발가락 벌림 보조기의 즉시적인 효과는 유의하지 않다고 볼 수 있으며, 추후연구로 장기간 일상생활에서의 지속적인 착용을 통한 연구가 필요하다고 본다.

핵심단어: 긴장성 발가락 굽힘; 뇌성마비; 발가락 벌림 보조기; 보행 분석.

Introduction

Spasticity is a major cause of gait disturbance in cerebral palsy. Another important clinical symptom that diminishes gait ability is tonic toe flexion reflex (TTFR), which may result from the lack of primitive reflex control in the central nervous system (Cohen et al, 1967; Manfredi et al, 1975)(Figure 1).

Tonic flexion of the toes is an abnormal reflex which can occur as a result of a cerebrovascular accident or brain injury (Brain, 1950; Cohen and Iannone, 1967). For most primitive reflexes, retention of the reflex beyond the period when it should no longer be elicited suggests a pathologic process within the central nervous system (Zafeiriou, 2000). Tonic toe flexion is considered abnormal after the age of 2 years and indicated damage to the contralateral frontal lobe or tract descending from the frontal lobe, such as the corticospinal tract (Landou and Clare, 1966). In this study, the term "tonic toe flexion reflex" will be used to describe a hollowing out of the sole and an exaggerated curvature of the foot due to the toe flexion and adduction with associated foot inversion, usually due to a cutaneous or proprioceptive stimulus (Manfredi et al, 1975). During the stance phase of gait, both cutaneous and proprioceptive stimuli applied to the plantar surface of the foot could elicit the TTFR (Manfredi et al, 1975).

Several types of tone-reducing, ankle-foot orthoses have been reported (Ford et al, 1986). Because tonic toe flexion affects gait, toe spreader are sometimes used by physical therapists to inhibit tonic toe flexion during stance and gait. Evidence of a positive effect of the toe spreader is needed to justify the continued use of the device.

The effect of TTFR on gait is often treated by use of a toe spreader, a custom-fabricated orthotic device usually made from moleskin and closed cell foam (Fisher and Utley, Unpublished notes, 1998). The spreader is used to inhibit an excess of TTFR and pain (Fisher B and Utley, Unpublished notes, 1998). Abduction of the toes by a toe spreader made of foam rubber appears to inhibit toe clawing and extensor spasticity (ie. Increased resistance to flexion of the proximal interphalangeal joints) of the foot and often inhibits extensor spasticity of the entire lower extremity in patients with hemiplegia (Bobath B, 1978). Although clinical reports indicate the pos-

itive effects with the use of the toe spreader, data supporting the use of the device have not been reported in the spastic diplegic cerebral palsy.

The purpose of this study was to verify the immediate effects of a toe spreader in improving gait in the children with spastic diplegic cerebral palsy with TTFR.

Methods

Subjects

Twelve children diagnosed with spastic diplegic cerebral palsy (CP) volunteered for this study. To qualify for the study, the children had to be able to walk independently with no assistive devices for more than 5 m; exhibit TTFR, have no previous use of a toe spreader; be able to follow commands and be medically stable. Patients with fixed foot contracture were excluded. We obtained institutional ethics committee's approval for the study. The characteristics of subjects who participated in this study are shown in Table 1.

Procedures

Subjects were evaluated for TTFR by an author who was blinded to the gait analysis data. The evaluation was made while subjects stood barefoot for 1 minute and then walked barefoot a distance of 5 m. TTFR was diagnosed if tonic plantar flexion, flexion of the toes with hollowing of the sole, or occasional foot inversion were found at any time during the observation (Figure 1). The subject with TTFR then sat for 20 minutes while the toe spreader was fabricated and fitted. The toe spreader was held in the foot by tape on the dorsum of the foot.

To investigate the effectiveness of the toe spreader, the toe spreader was used

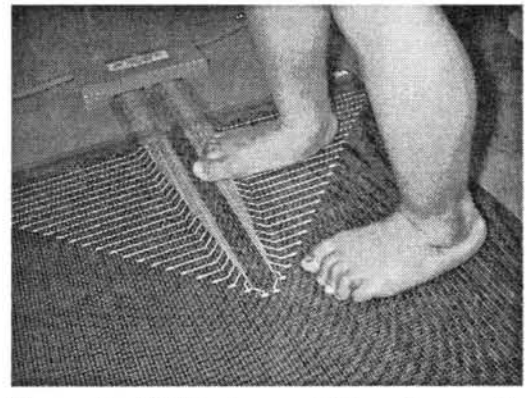

Figure 1. TTFR in a child with spastic diplegic cerebral palsy

Table 1. Descriptive characteristics of the subjects

Variables	Subjects
Mean age ± SD (y)	6.4±1.9
Male/female	7/5
Spasticity of plantar flexor (MAS) 0/1/1+/2/3/4	0/5/4/3/0/0

barefoot. The gait analysis consisted of a pre-test (barefoot) and a post-test (with toe spreader) at an interval of 30 minutes. For 30 minutes, subjects were allowed to play while standing or walking slowly freely while the toe spreader was adjusted to each subject's feet.

Gait was analyzed by MG1000 system[2] (Figure 2). To eliminate acceleration and deceleration periods, subjects started and ended their laps 1 m before and beyond the walkway. The test was repeated 3 times, and the data of the fastest walk was recorded. The Temporal-distance measurements were performed to determine stride, stance phase, swing phase, speed, cadence, stride length, step length, step width, and toe out angle. Gait analysis was performed before and after the toe spreader was attached.

The investigator contacted the subject and/or the subject's physical therapist after the data collection session for their comments regarding the effects of the toe spreader on the TTFR and gait after continued use of the toe spreader.

Statistical analysis

The wilcoxon signed rank test was used to assess the differences of between walking barefoot and with a toe spreader. Data were analyzed by using SPSS 11.0 and the significance level was set at $p<.05$.

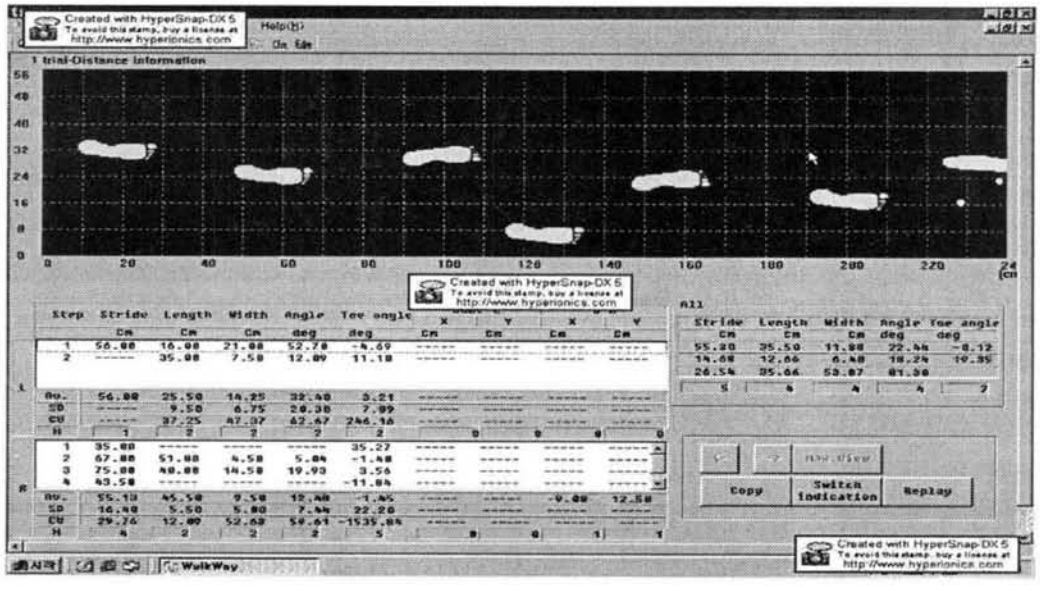

Figure 2. MG1000 system

2) Anina Inc. Japan.

Results

Mean and SEM for T-D gait variables between walking barefoot and with a toe spreader are presented in figure 3. The use of a toe spreader during gait, as compared with walking barefoot, didn't produce a statistically significant increase in all temporal-distance gait variables (stride p=.07, stance phase p=.9, swing phase p=.07, speed p=.44, cadence p=1.00, stride length p=.30, step length p=.91, step width p=.16, toe out angel p=.13)(Figure 3). Although it was not statistically significant, the temporal-distance (T-D) gait variable improved at a small rate.

Discussion

The walking pattern of a children with spastic diplegic cerebral palsy is often abnormal and inefficient. Increased tone in the lower extremity and pelvis is a factor in this abnormal gait pattern (Binder and Eng, 1989). Foot ankle orthoses are com-

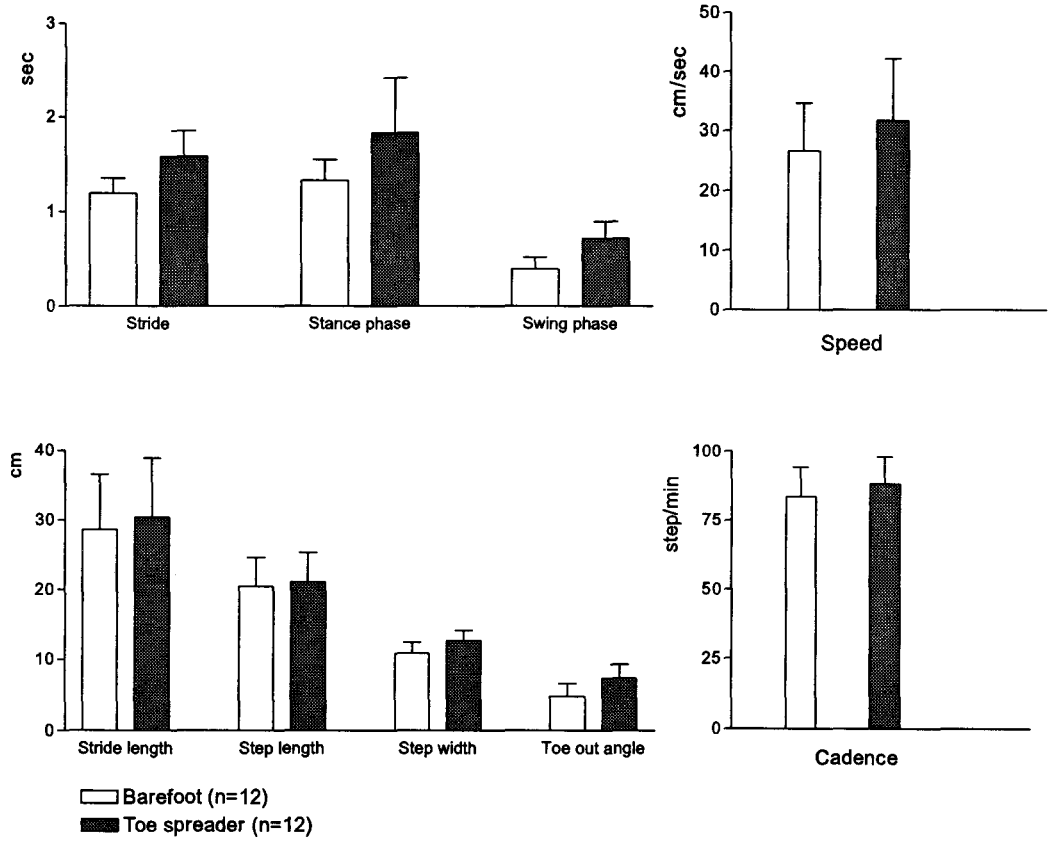

Figure 3. Comparison of the barefoot and with toe spreader in the T-D gait variables. Error bars represent mean ± SEM

monly used to prevent deformity, to support normal joint alignment and mechanism and to facilitate function (Knutson and Clark, 1991). Although TTFR is considered among the tonic reflexes, the pathogenesis of this symptom in patients with cerebral palsy has not been clarified. It appears similar to the toe-grasping reflex in newborns. However, TTFR is apparent when a patient stands on his/her feet and take a steps forward, while toe grasp reflex is elicited by stimulating the sole.

Increased curvature of the foot due to the TTFR may prevent normal plantar surface contact with ground and weight transfer from the lateral border of the foot, across the metatarsal head, to the ball of the great toe during stance (Kapandji, 1970; Landau and Clare 1966). The TTFR may also prevent normal dorsiflexion of the toes and foot at the beginning of swing phase. Altered weight bearing and weight shift changes the temporal distance (T-D) characteristics of gait, commonly resulting in decreased stance time in the affected side, decreased contralateral step length, decreased stride length and decreased cadence and velocity. De Saca et al (1994) analyzed the gait of hemiplegic patients with TTFR by using a toe spreader. Velocity and cadence increased significantly with the toe spreader, and De Saca attributed that to the altered foot mechanism. In terms of tone reducing AFO, the structure of our toe spreader is similar to that of the inhibition bar, the toe spreader appears to push the metatarsophalangeal joints into a neutral and slightly extended position, thus preventing the interphalangeal joints from taking extreme flexion (Iwata et al, 2003). The toe spreader may provide additional mechanical support and stability to the foot during stance phase as was evidenced by the results from this study. The increased stability may, in turn, allow greater excursion of the non-weight-bearing limb. In addition, there was no significant correlation between the severity of spasticity and increase in the walking speed in a CP child with TTFR.

In this study, the gait analysis showed that the attachment of the toe spreader was not statistically significant in T-D gait variables. Because we studied the immediate effects of the attachment of the toe spreader, we could predict that its effects increased at a small rate that was not statistically significant. When we compare the barefoot gait with the immediate effects of the attachment of the toe spreader, the walking speed increased by 9.1% and cadence increased 18%, as a result of the increment of stride length (4.2%) and step length (11.1%).

Our study has several limitations. The efficacy of the toe spreader must be proved by its extended use in the daily life of each patient. Although this study showed immediate effects, it didn't produce statistically significant increases in the T-D information. In addition, future research is needed to investigate the

changes in actual translation and the amount of force across the plantar surface during the stance phase of the gait with the use of the toe spreader and the muscle activity of lower extremity.

Conclusion

A Toe spreader didn't have the immediate effects on the gait of children with spastic diplegic cereral palsy with TTFR.

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