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Effect of Posterior Leaf Spring on Standing Balance in Patients With Hemiplegia

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국문요약

PLS 착용이 편마비 환자의 동적 균형에 미치는 영향

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이 연구는 성인 편마비 환자를 대상으로 PLS (Posterior Leaf Spring) 착용이 기립 균형에 미치는 영향을 알아보는 것이었다. 신발만 착용하였을 때의 기립조건과 신발과 PLS를 동시에 착용한 기립조건의 평균평형지수가 맨발로 서 있을 때의 기립조건에 비하여 높았다. 그러나 신발만 착용한 기립조건과 신발과 PLS를 함께 착용한 기립조건하에서의 평균평형지수의 차이는 없었다. 따라서 편마비 환자의 기립균형과 관련하여 PLS만을 착용한 효과와 신발만을 착용한 효과를 비교하는 연구가 필요하다.

핵심단어: 균형; 편마비 환자; Posterior Leaf Spring.

Introduction

Balance can be explained either “state” or “function”. Balance as a state is defined as a body in the equilibrium or zero sum of force (Johansson and Magnusson, 1991). Balance as a function is defined as a function that continuous muscle activity and joint motion are required to maintain the center of mass within the base of support (Iverson et al, 1990). Balance is affected by somatosensory dysfunction, visual field deficit, muscle weakness, joint contracture, spasticity, and abnormal posture. Functional limitation and fall occurs as an affected balance (Saladin, 1996). Physical therapist should evaluate and treat these factors that can affect balance.

Hemiplegic patients from stroke, traumatic brain injury, and cerebral palsy demonstrate problems such as asymmetrical posture, abnormal postural control, asymmetrical weight bearing, sitting or standing dysfunctions, disability to restore a balance when balance is lost, disability to maintain balance when performing a functional task (Carr and Shepherd, 1980; Lee et al, 1988; Saladin, 1996). Decrement of voluntary sway while standing, inappropriate muscle selection to produce correct reaction, decrement of reaction force in hemiparetic side, increased latency to postural reaction in hemiparetic side cause balance dyscontrol in patients with brain damage (Dettmann et al, 1987).

Researches on balance of patients with brain damage have been carried out recently with an influence of systems theory that various systems involve to achieve a functional tasks. Horak (1991) suggested that balance is affected by an interaction of musculoskeletal system, motor coordination, perception to direction, sensory organization, predictive central set, environmental adaptation, perception, and motivation. Therefore, physical therapist should determine the cause of balance dyscontrol and solve the problems to improve balance function.

Orthotic devices have been applied to enhance balance function and gait performance of hemiparetic patients (Brandstater et al., 1987; Diamond and Ottenbacher, 1990; Lehmann, 1983). Twitchell (1951) suggested that ankle joint deformity from spasticity and contracture not only prevent weight bearing but also reduce duration of weight bearing into hemiplegic lower extremity. Kim and Yi (1997) indicated that wearing ankle-foot-orthoses (AFO) would improve balance. Lee and Kwon (1997) reported that ankle range of motion influenced equilibrium after the study of equilibrium performance ability of normal adolescent. These findings suggested that abnormal ankle joint dysfunction of hemiplegic persons can delay recovery process in rehabilitation period.

Ankle-foot-orthoses support, protect, and correct ankle joint (Light and Kamenets, 1966). Sarno and Lehneis (1971) prescribed AFO for the patients with unstable knee, moderate spasticity in lower extremity, and no voluntary ankle joint movements. Diamond and Ottenbacher (1990) prescribed dynamic AFO to improve alignment of ankle and foot and to increase weight distribution for effective weight transfer.

It is expected from the findings of previous studies that hemiplegic persons wearing PLS will improve balance and ambulation capability by correcting joint deformity from contracture and spasticity and enhancing weight bearing. Though previous studies were performed to investigate the effect of PLS on gait characteristics of hemiplegic persons (Corcoran et al, 1970; Diamond and Ottenbacher, 1990; Kim et al, 1996; Lehmann et al, 1987), studies that investigate the effect of PLS on balance was not performed yet. The purpose of

Table 1. General characteristics of the subjects (N=15)

Characteristics		Mean±SD	Frequency
Sex	Male		10
	Female		5
Age (yrs)		53.8±13.8	
Body Wt. (kg)		60.9±6.3	

Table 2. Medical characteristics of the subjects (N=15)

Characteristics	Mean±SD	Frequency
Diagnosis		
Hemorrhage		10
Infarction		5
Paraplegic side		
Right		8
Left		7
Elapsed time from onset (week)	153.5±513.2	

this research, therefore, was to assess the standing balance performance of hemiplegic person wearing PLS by a computerized dynamic posturography device.

Methods

Subjects

Subjects consisted of 15 patients who were receiving physical therapy as inpatients or out patients at Seoul Samsung Medical Center affiliated with Sungkyunkwan University Medical School (Table 1). Inclusion criteria for subjects are as follows: 1) hemiplegic patients who were diagnosed with cerebrovascular accident, traumatic brain injury, or cerebral palsy, 2) hemiplegic patients who were prescribed to wear a PLS by a medical doctor, 3) hemiplegic patient who can understand and follow investigators' instructions, 4) hemiplegic patients who were able to stand for 10 minutes without assistance, 5) hemiplegic patients without orthopedic diseases in lower extremities, and 6) hemiplegic patients who agreed to participated on the study. Medical characteristics of subjects were presented (Table 2).

Instruments and procedures

EquiTest 5.02[1] consisted of safety belt for patient's stability, force plate (23 ㎝ × 46 ㎝), visual surrounding, monitor which was place parallel with visual surrounding, and software (EquiTest Program and Sensory Organization Test). Two force

1. NeuroCom International Inc. USA

plates were positioned together so that subject can stand along the longitudinal line drawn at each force plate. Two pressure sensors were embedded anterior-posterioly at each force plate. Subjects were asked to stand without changing feet position with upper extremities relaxed.

Assessment was performed in six conditions: (1) eyes-open condition; (2) eyes-closed condition; (3) eyes-open, fixed force plate, and swaying visual surround proportional to subject's anterior-posterior sway; (4) eyes-open and swaying surround proportional to subject's anterior-posterior sway; (5) eye-closed and moving surround proportional to subject's anterior-posterior sway; and (6) eyes-open and force plate and visual surround swaying proportional to subject's anterior-posterior sway. Assessment was performed for 20 seconds three times with 10 seconds of resting period per each condition. The equilibrium score was determined by each condition and expressed as a percentage from 0% to 100%, 100% equilibrium score indicated subject's maintaining balance without any sway, and 0% equilibrium score indicated a subject's falling because of instability. The composite equilibrium score was calculated by mean of six equilibrium scores.

Experiment procedures

1) The weight bearing distribution in standing was measured using EquiTest program in bare-foot standing, standing in shoes, and standing in shoes with PLS conditions. A subject was not allowed to have any visual input from computer monitor by placing computer monitor away from a subject's visual field. A subject was asked to stand on force plate in relaxed position. The body weight of a subject was measured. The measurement order was randomly selected by a subject to control the order effect.

2) The balance in standing was measured using EquiTest sensory organization test (SOT) program in bare-foot standing, standing in shoes, and standing in shoes with PLS conditions.

Data analysis

Kolmogorov-Smirnov test was used to determine that collected data were normally distributed. Repeated measures ANOVA was used to compare composite equilibrium scores of three conditions: bare-foot standing, standing in shoes, and standing in shoes with PLS. Bonferroni correction test was used as a multiple comparison test. SAS was used and significance level was 0.05.

Results

Kolmogorov-Smirnov test indicated that collected data were normally distributed. Composite equilibrium scores were calculated (Table 3).

Table 3. Average equilibrium index by standing conditions (Unit: %)

Conditions	Mean±SD
Barefoot	65.20±9.22
With shoe	68.40±7.44
With shoe and PLS*	68.73±8.85

*PLS: Posterior Leaf Spring

Table 4. Repeated one-way ANOVA results by standing conditions

	Sum of Sqares	DF	Mean Square	F	p
Condition	114.2	2	57.1	4.4	.02
Error	364.5	28	13.0		

There was a statistically significant difference among composite equilibrium scores (Table 4).

Bonferroni correction test indicated that composite equilibrium scores of standing-in-shoes condition were higher than those in bare-foot-standing condition; composite equilibrium score of standing-in-shoes with PLS condition was higher than those of bare-foot standing condition. There was no significant difference between composite equilibrium scores of standing-in-shoes condition and scores of standing-in-shoes with PLS condition.

Discussion

PLS has been prescribed to improve standing balance and ambulation in clinical settings. However, there are disadvantages of wearing PLS as an orthotic device such as decreased adaptability and not providing functional recovery at ankle joint musculature by limiting joint movement. There are only a few studies that showed the effect of PLS. This research was performed to investigate the effect of PLS on standing balance of hemiplegic persons.

Balance can be classified into static balance and dynamic balance. Static balance refers to the ability to stand without perturbation on stabilized base, and dynamic balance refers to the ability to maintain equilibrium with external perturbation or with self-generated movement. Therefore, balance assessment tool can be classified into static, dynamic, or functional balance assessment tool (Ragnarsdottir, 1996).

The role of orthosis is to provide the affected lower extremity with equal weight bearing and to affect standing balance positively by compensating for lost function, supporting and protecting the joint, and producing normal movement with stabilization (Lehmann et al, 1983; Perry, 1974). Condie and Condie (1995) advocated that PLS was used to improve balance and proprioceptive feedback by encouraging weight bearing on lower extremity. They also indicated that the use of PLS would prevent joint contracture and inhibit primitive reflex patterns.

Kim et al (1997) studied the effect of PLS on lower extremity weight bearing in patients with hemiplegia and reported that weight bearing on affected extremity without PLS (42.7%) was more than that with PLS (40.1%). It was suggested when the PLS was applied, decreased somato-sensory feedback from plantar surface and proprioceptive feedback from muscles and joint around ankle influenced negatively on standing balance. However, it was controversial that 1.6% difference in weight bearing is meaningful clinically. In present study, composite equilibrium scores of standing-in-shoes condition were higher than those in bare-foot-standing condition. However, composite equilibrium scores of standing-in-shoes with PLS condition was not higher than those of standing-in-shoes condition. There was a possibility that the effect of PLS was overshadowed by wearing shoes in standing-in-shoes with PLS condition. There was another possibility that ankle strategy can not be efficiently used when PLS was applied to ankle joint; this possibility can not be testified in present study because standing balance was not measured with PLS condition.

Future study is required to investigate the effect of PLS by comparing standing with PLS only condition and standing-in-shoes condition. However, gait training in standing-in-shoes with PLS condition is more appropriate than that in standing with PLS only condition in clinical setting. Therefore, it is suggested that balance in standing-in-shoes with PLS condition provides clinicians with critical and meaningful information. Under the Korean customs, shoes are usually taken off indoors. Further research is needed to benefit hemiplegic patient when they are wearing PLS without shoes indoors.

Findings of this study should be generalized cautiously because only the patients group who satisfied the inclusion criteria at Samsung Medical Center participated in the study. It cannot be concluded that applying PLS improves the standing balance in patients with hemiplegia because standing balance was not measured with PLS condition. However, it is concluded that in standing-in-shoes with PLS condition improved standing balance in patients with hemiplegia.

Conclusion

The purpose of this research was to investigate the immediate effect of PLS on the standing balance in hemiplegic patients. The results indicated that composite equilibrium scores of standing-in-shoes condition and standing-in-shoes with PLS condition were higher than that in bare-foot-standing condition. However, there was no significant difference between composite equilibrium score of standing-in-shoes condition and standing-in-shoes with PLS condition. Future study is needed to compare standing with PLS only condition and standing-in-shoes condition in relation to standing balance in patients with hemiplegia.

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