The Effect of Wearing a Soft Knee Brace and Balance Training on Paretic Side Foot Pressure and Knee Joint Muscle Strength in Stroke Patients

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〈Abstract〉

The purpose of this study was to investigate the effect of wearing a soft knee brace during balance training on paretic side foot pressure and knee joint muscle strength in stroke patients. The recruited 20 stroke patients were randomized into 10 experimental group and 10 control group. All subjects were subjected to balance training, and only the experimental group was trained in balance while wearing a soft knee brace. Experimental group and the control group before and after the intervention showed significant increases in foot pressure and knee joint muscle strength on the paralyzed side ($p<0.05$), experimental group showed a significant increase in foot pressure and knee joint muscle strength compared to the control group ($p<0.05$). This study confirmed that wearing a soft knee brace had a positive effect on paretic side foot pressure and knee joint muscle strength in stroke patients.

Keywords : Soft knee brace, Balance training, Foot pressure, Muscle strength, Stroke

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1. Introduction

In stroke patients, muscle weakness causes excessive extension of the knee joint [1]. Since the knee joint supports the body during weight-bearing and maintains balance by sensing body movements [2], abnormal deformation of the knee joint causes instability of the knee joint [3]. Instability of the knee joint reduces the ability to control posture and weakens the muscles of the lower extremities [4,5]. Knee joint muscle weakness in stroke patients shows instability, which leads to a decrease in proprioceptive sense, causing problems with balance [6,7]. Therefore, the stability of the knee joint can be an important factor in the balance ability in stroke patients. Currently, many assistive tools such as taping and orthosis are being used for balance training interventions in stroke patients [8,9].

Among them, knee orthosis is an assistive tool that improves knee function by providing stability to the knee [10]. In addition, knee brace improves proprioceptive sense by providing compressive force to the joint area and affects balance ability [11,12]. In addition, the knee brace reduces the weight bearing on the knee [13] and increases muscle activity [14]. For patients with knee joint instability, wearing a knee brace is effective in improving balance and muscle strength [11,14].

KAFO (Knee-ankle-foot orthosis) or customized orthosis is prescribed for stroke patients complaining of knee instability [15]. A rigid orthosis composed of such a strong support is complex and characterized by not enveloping the knee joint [16]. Wearing such knee orthosis may cause discomfort and reduce the ability to balance by limiting the movement of the knee joint [12]. On the other hand, the soft knee brace used in this study is made of an elastic material and is lightweight and adheres to the shape of the leg, providing a good fit. In addition, since it allows the movement of the knee joint freely, it has the advantage that it can be used together during exercise intervention. In patients with knee osteoarthritis, a soft knee brace could reduce pain, improve physical function [17], and reduce knee instability [18,19]. A taping method that wraps the knee joint in a form similar to a soft knee brace could improve the dynamic balance of stroke patients [20]. Therefore, a soft knee brace that allows functional movement is necessary for the rehabilitation of stroke patients.

Despite these advantages, studies confirming the effect of wearing a soft knee brace on stroke patients are insufficient. Therefore, the purpose of this study is to investigate the effect of wearing a soft knee brace that can be easily and conveniently worn even by stroke patients.

2. Methods

2.1 Subjects

In this study, balance training was conducted

on 20 stroke patients visiting a rehabilitation hospital. The subjects were randomly assigned to an experimental group and a control group by 10 people using a randomization program (www.randomization. com). The experimental group received balance training while wearing a soft knee brace, and the control group received balance training without any intervention. After a total of 4 weeks of intervention, paretic side foot pressure and knee joint muscle strength were measured. Subject selection criteria were limited to those who can independently gait, have no orthopedic knee disease, and have a thigh circumference within the soft knee brace size range. The general characteristics of the subjects are as follows (Table 1).

Table 1. General characteristics of the subjects

(M ± SD)

Classification	Experimental Group (n=10)	Control Group (n=10)	p
Gender (male/female)	8 / 2	7 / 3	0.606
Paretic side (left/right)	5 / 5	6 / 4	0.653
Age (year)	62.30 ± 8.68	62.00 ± 10.07	0.944
Height (cm)	167.40 ± 7.69	165.70 ± 9.50	0.665
Weight (kg)	67.90 ± 7.72	65.80 ± 12.72	0.661

*p<0.05

2.2 Outcome measures

2.2.1 Knee joint muscle strength

Knee joint muscle strength was measured using Micro FET2 (Hoggan Scientific, Salt Lake City UT, USA), which is a portable dynamometer strength measuring device.

Subjects were instructed to bend the hip and knee joint by 90° on a treatment mat, take off their shoes in a sitting position, and place their feet 4 to 5 cm away from the floor. In addition, to provide stability of the upper limb, the edge of the treatment mat was held by hand. The measurer set the measurement unit of the instrument to Newtons (N) value and then placed a pad suitable for the measurement site on the paretic side. To measure the strength of the knee joint flexion, the subject was instructed to “strongly flex knee joint” after placing a pad 1 to 2 cm above the paretic side posterior talotibial joint [21]. To measure the strength of the knee joint extension, the pad was placed 1-2 cm above the paretic side talotibial joint, and then “strongly extend the knee joint” was instructed. When measuring muscle strength, maximum voluntary contraction was performed for 5 seconds, and the maximum value (N) was recorded. The average value obtained by measuring a total of three times was used. A 30 second rest period was given between measurements.

2.2.2 Paretic side foot pressure

Biorescue (Biorescue RM INGENIERIE, France) was used to measure the paretic side foot pressure of the subjects. Subjects looked forward in a standing position with their feet hip-width apart on the measuring plate. The subject's paretic side foot pressure was measured while maintaining the standing position for 1 minute [22]. Foot pressure

represents 100% of the combined value of the left and right foot, and the closer the pressure of one foot is to 50%, the more symmetrical the foot pressure.

2.3 Interventions

2.3.1 Soft knee brace

Soft knee brace (NEENCA, USA) was selected to provide knee stability. These braces are comfortable to wear, allow functional movement and provide stability to the knee. The experimental group wore a soft knee brace on the paretic side knee joint in a comfortable sitting position. In order to give a feeling of adaptation after wearing, sufficient rest time was given and balance training was performed.

The size of the brace in this study was S size (37-43cm), M size (43-49.5cm), and L size (49.5-56cm). According to the size marking and measurement method provided by the manufacturer, the circumference of the thigh above the patella bone (10cm) was measured, and a brace that meets the measurement standard was worn.

2.3.2 Balance training

Balance training was performed using Aero-Step XL (TOGU, GERMANY). The subject takes a starting position with his feet shoulder-width apart on an unstable support surface and maintaining a standing position facing forward. Slightly flex the knee joint, hold it for 5-10 seconds, and then return to the starting position [23]. This movement was repeated 10 times per set, for a total of 5 sets. It was conducted for 30 minutes, including a 2 minute break between sets, 3 times a week for a total of 4 weeks. An assistant stood by to prevent falls during balance training.

2.4 Data and statistical analysis

This study was statistically analyzed using SPSS 21.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to find out the general characteristics of the subjects. Normality test was confirmed by shapiro-wilk. In order to confirm the difference between paretic side foot pressure and knee joint muscle strength before and after the intervention of the subjects, the wilcoxon sign-rank test was used. The kruskal-wallis test was used and a post-hoc test was performed to analyze the difference in the amount of change in the paretic side foot pressure and knee joint muscle strength before and after the intervention between the groups. The significance level of all variables was set to 0.05.

3. Results

3.1 Difference between paretic side foot pressure and knee joint muscle strength before and after intervention

The differences in paretic side foot pressure

Table 2. Difference in paretic side foot pressure and knee joint muscle strength pre and post intervention

(M ± SD)

Classification	Experimental group (n=10)			Control group (n=10)		
Foot pressure (%)						
	pre	post	p	pre	post	p
Paretic side foot pressure	40.03 ± 5.91	45.57 ± 3.29	0.005**	42.41 ± 6.73	44.92 ± 3.50	0.005**
Knee joint muscle strength (N)						
	pre	post	p	pre	post	p
Knee flexion	38.85 ± 11.39	40.91 ± 10.78	0.005**	33.18 ± 9.15	34.03 ± 8.93	0.009**
Knee extension	56.61 ± 10.78	57.92 ± 15.11	0.005**	46.88 ± 12.01	47.68 ± 11.95	0.005**

**p<0.01, *p<0.05
Experimental group: balance training wearing soft knee brace
Control group: balance training

and knee joint muscle strength before and after intervention are as follows (Table 2). The experimental group and control group significantly increased paretic side foot pressure and all knee joint muscle strength after intervention(p<0.01).

3.2 Difference between paretic side foot pressure and knee joint muscle strength before and after intervention

The results of analysis of changes in paretic side foot pressure and knee joint muscle strength before and after intervention between groups are as follows(Table 3). The amount of change in paretic side foot pressure and knee joint muscle strength was significantly different in the experimental group than in the control group(p<0.05).

4. Discussion

The purpose of this study was to investigate the effect of balance training wearing a soft

Table 3. Comparison of foot pressure and knee joint muscle strength pre and post the intervention among the groups

(M ± SD)

Classification	Experimental group (n=10)	Control group (n=10)	Z	p
Foot pressure (%)				
Paretic side foot pressure	5.54 ± 4.09	2.51 ± 3.55	-2.384	0.17*
Knee joint stength (N)				
Knee flexion	2.06 ± 1.01	0.85 ± 0.75	-2.763	0.006**
Knee extension	1.31 ± 0.48	0.80 ± 0.37	-2.206	0.027*

**p<0.01, *p<0.05
Experimental group: balance training wearing soft knee brace
Control group: balance training

knee brace on paretic side foot pressure and knee joint muscle strength in stroke patients.

A soft brace applied to the ankle improves balance and gait speed. However, it did not significantly increase the paretic single limb support ratio [24]. Therefore, it was found that there is a limit to the soft brace applied to the ankle for stroke patients to increase the weight-bearing to the paretic side. The paretic side foot pressure was significantly increased after the intervention in both the experimental and control groups. Balance training has the effect of reducing the movement speed of foot pressure [25], and training using a balance platform reduced weight-bearing imbalance in stroke patients [26]. In addition, balance training reduces muscle imbalance compared to strength training [27]. Therefore, balance training improves the imbalanced weight distribution by resolving muscle imbalance in stroke patients, which is consistent with the results of this study.

In this study, there was a significant difference in the amount of change in paretic side foot pressure between the experimental group and the control group. The reason is that wearing a soft knee brace during balance training reduces knee joint instability [19] and affects balance ability by promoting proprioceptive sense [11]. Because of this, the soft knee brace worn by the experimental group during balance training in this study provided stability to the knee joint, which is thought to have a greater effect on the weight bearing on the paretic side. However, in a previous study, a soft brace applied to the knee joint reduced balance ability [28]. This soft brace has rigid straps on the medial and lateral sides of the knee joint. It was reported that fixation by these rigid straps interfered with proprioception and decreased balance [28]. The soft brace used in this study did not have rigid straps and had high elasticity, so it is thought that the results were different from those of previous studies. Elastic taping applied to joints and muscles was effective in improving balance and gait in stroke patients [29]. Elastic taping has to be replaced periodically according to the length of the patient's joints and muscles, and there is a disadvantage that the skin may be damaged when the tape is removed. On the contrary, the soft brace applied in this study has the advantage of being easy to put on and take off.

Knee joint muscle strength was significantly increased after the intervention in both the experimental and control groups. Balance training was the same as the effect of strength training on knee joint muscle strength [27], and the platform balance training program for the elderly improved knee joint flexion muscle strength and knee joint extension muscle strength [30]. Therefore, it is considered that balance training had an effect on the knee joint flexors and extensors in this study as well.

There was a significant difference in the amount of change in knee joint muscle strength between the experimental group and

the control group. In a previous study, knee braces increased the strength of the quadriceps and hamstrings [31]. It is considered that the elasticity of the knee brace promotes voluntary contraction of the quadriceps femoris and hamstrings, thereby increasing the participation rate of the paretic side leg during balance training. The elasticity of the knee brace helps the muscles around the knee joint to contract while extending by passive tension during knee joint flexion during balance training. In addition, it is thought that the muscle strength increased because the compression force around the knee joint provided by the knee brace promoted muscle activation through proprioceptive sensory from mechanoreceptors.

As a limitation, we could not generalize to all stroke patients due to the small number of subjects. Due to the novel and exploratory aspects of neurophysiotherapy studies using soft knee braces, small sample sizes are common for neurophysiotherapy studies. When adding more subjects to generalize, many additional researchers are needed to control this, and care must be taken.

This study did not carefully consider the structure and characteristics of the knee joint for each subject, and did not provide objective data on how proprioception sense is facilitated through a soft knee brace. However, the soft knee brace used in this study is comfortable for stroke patients to put on and take off independently. Therefore, it was possible to easily wear a soft knee brace at the same time as balance training in clinical practice because activity was guaranteed. In the future, it is expected that various evaluation methods and dynamic balance training will be applied to stroke patients and used as basic data for an efficient brace wearing method.

5. Conclusions

The purpose of this study was to investigate the effect of wearing a soft knee brace on paretic side foot pressure and knee joint muscle strength during balance training in 20 stroke patients. The experimental group wearing the soft knee brace significantly increased paretic side foot pressure and knee joint muscle strength than the control group without the soft knee brace. Therefore, it can be seen that soft knee brace affects paretic side foot pressure and knee joint muscle strength during balance training in stroke patients.

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