Effect of cane-supported gait type in lower limb muscle activation of stroke patients

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지팡이 보행 유형이 뇌졸중 환자의 하지 근활성도에 미치는 영향

최은평, 양성주, 정아현, 나혜수, 김영옥, 오규빈, 조기훈(교신저자)
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요 약

This study aimed to investigate the changes of paretic side lower limb muscle activation according to the types of cane-supported gait using a weight-support feedback cane (WSFC). Eleven hemiparetic stroke patients were recruited from a local rehabilitation hospital. WSFC can measure the amount of force exerted on the cane during cane-supported walking in units of kg, through a force sensor installed inside the handle. This study measured lower limb muscle activation under four conditions: two-point and three-point gait with WSFC using mono and quadripod canes. In two-point gait, subjects were asked to move the WSFC and paretic side foot forward at the same time and then move the non-paretic side foot. In three-point gait, subjects were asked to first move the WSFC forward, then the paretic side foot and finally the non-paretic side foot. As a results, the paretic side lower limb muscle activation during stance phase was significantly higher in the two-point gait with WSFC than the three-point gait with WSFC in both of mono and quadripod canes ($P<0.05$). This result suggests that applying the three-point gait with high cane-dependence in the early stages of training for stability and subsequently applying two-point gait for enhancement of lower limb muscle activation could be effective.

1. INTRODUCTION

In stroke rehabilitation, walking assistive devices such as crutches, canes, and walkers are used to facilitate balance control ability and to provide stability during walking [1, 2]. In particular, canes help in maintaining the standing posture by assisting the extensor muscles of the hip and back and contribute to enhanced stability during movement [3].

However, there has been no specific clinical guideline for cane-supported gait in stroke patients to date. Moreover, in stroke gait training, despite many types of cane-support gait have been applied, research on canes is mostly focused on exploring the appropriate cane height [4, 5] and the effects by cane type [6, 7]. In addition, research on the comparison of paretic side lower limb muscle activation and the weight load on the cane (cane dependency) according to the methods of cane-supported gait remains insufficient.

Thus, this study aimed to investigate the changes of paretic side lower limb muscle activation according to the types of cane-supported gait using a weight-support feedback cane (WSFC) that had been designed to quantitatively measure the weight support load on the cane. In this study, the paretic lower limb muscle activation was measured during two types of cane-supported gait (two-point and three-point gaits) using mono and quadripod canes.

2. METHODS

2.1 Subjects

Eleven stroke patients were recruited from a local rehabilitation hospital after attaining a full understanding of the purpose and methods of the research and signing a consent form. The inclusion criteria were as follows: (1) hemiparesis from a single stroke that occurred at least 6

months prior to the time of recruitment, (2) adequate cognition levels to follow simple instructions and understand the content and purpose of the study (Korean version of the Mini-Mental State Examination score ≥24 points), (3) ability to walk with a cane (functional ambulation classification, 2 - 3), and (4) load of more than 7% body weight on the cane. The exclusion criteria were as follows: (1) musculoskeletal conditions that could potentially affect the ability to walk safely, (2) hemispatial neglect, and (3) severe heart disease or uncontrolled hypertension. A summary of the general characteristics of the 11 subjects who fulfilled the inclusion criteria is shown in Table 1.

[Table 1] General characteristics of the 11 subjects

Parameters	m±SD(n)
Paretic side (Left/Right)	3/8
Age (years)	50.45±11.18
Height (cm)	170.81±7.98
Weight (kg)	71.63±8.61
Brunnstrom stage (2/3/4)	5/5/1
MAS (1/1+/2)	2/4/5
Onset duration (months)	14.18±7.54
MMSE-K (scores)	29.45±0.82
MBI (scores)	60.72±13.92
FAC (2/3)	7/4

Values are expressed as Mean±SD.

MAS: Modified Ashworth Scale, MMSE-K: Mini Mental State Examination-Korean, MBI: Modified Barthel Index, FAC: Functional Ambulation Category

2.2 Procedure

This study applied a cross-sectional design to investigate changes in lower limb muscle activation according to types of cane-supported gait in chronic stroke patients. We explained the objective and experimental procedure of the study to all subjects, and they voluntarily signed informed consent forms.

WSFC can measure the amount of force exerted on the cane during cane-supported walking in units of kg, through a force sensor installed inside the handle (Fig 1). The measured cane load was displayed in real time on a monitor located at the top of the handle and laptop software connected via Bluetooth. Additionally, WSFC can be used in the form of either a mono cane or a quadripod cane by switching the leg part. Prior to the experiment, all subjects were asked to walk comfortably for 20-m using the WSFC.

[Fig. 1] A weight-support feedback cane (WSFC). WSFC can be used in a mono cane and in a quadripod cane by switching the cane's legs.

To investigate the changes of paretic side lower limb muscle activation according to the types of cane-supported gait, we performed measurements under four conditions: two-point and three-point gait with WSFC using mono and quadripod canes. All subjects were instructed to hold the WSFC at the height of the greater trochanter using the non-paretic side hand during measurement.

For measurements of two-point gait with WSFC, subjects were asked to move the WSFC and paretic side foot forward at the same time and then move the non-paretic side foot. For measurements of three-point gait with WSFC, subjects were asked to first move the WSFC forward, then the paretic side foot and finally the non-paretic side foot. Measurements of two- and three-point gait with WSFC were performed on both mono and quadripod canes. All measurements were taken within the 20-meter walk and the average load on the WSFC during the 20-meter walk was calculated using the laptop software. Paretic-side lower limb muscle activation (rectus femoris, biceps femoris, medial gastrocnemius, tibialis anterior, and gluteus medius) were measured through the wireless surface EMG while stance phase of WSFC supported gait. All measurements proceeded after explication and demonstration of cane-supported walking and sufficient rest was given in-between measurements. Additionally, one assistant was present beside the subject for safety during the experiment.

2.3 Statistical analysis

Data analysis was performed using SPSS (version 21.0; IBM Corp., Armonk, NY). Descriptive statistics were used to describe characteristics of the subjects. The Shapiro-Wilk test was used to confirm that all outcome variables were normally distributed. Paired t-test was used to compare lower limb muscle activation during two-point and three-point gait with WSFC. A significance level of 0.05 was used for all tests.

3. RESULTS

The paretic side lower limb muscle activation during stance phase was significantly higher in the two-point gait with WSFC than the three-point gait with WSFC in both of mono and quadripod canes ($P<0.05$, Table 2).

[Table 2] Changes of paretic side lower limb muscle activation in stance phase during two-point and three-point gaits with WSFC

Parameters (%RVC)		Two-point gait with WSFC	Three-point gait with WSFC	t (P) values
Mono cane supported gait	RF	187.72±87.73	158.98±77.28	2.321 (.043)
	BF	152.32±78.87	122.56±49.96	2.497 (.032)
	TA	539.87±312.38	409.76±241.86	2.310 (.044)
	GCM-M	141.24±98.30	111.13±65.29	2.474 (.033)
	GM	149.85±86.73	108.54±37.50	2.314 (.043)
Quadripod cane supported gait	RF	179.82±102.46	160.96±82.91	1.108 (.294)
	BF	142.74±66.09	123.60±39.45	1.446 (.179)
	TA	523.66±267.03	374.61±218.21	3.274 (.008)
	GCM-M	137.92±86.41	115.87±67.93	2.940 (.015)
	GM	116.81±44.64	100.49±38.65	2.567 (.028)

Values are expressed as Mean±SD.
WSFC: Weight Support Feedback Cane, RF: Rectus Femoris, BF: Biceps Femoris, TA: Tibialis Anterior, GCM-M: Gastrocnemius (Medial Part), GM: Gluteus Medius

4. DISCUSSION AND CONCLUSION

Previous study of cane-supported gait in hemiparetic stroke patients reported that the amount of weight-bearing on the paretic side lower limb decreases as cane dependency increases, whereas the amount of paretic side lower limb weight-bearing increases as cane dependence decreases [8]. Furthermore, the increase in the amount of paretic side lower limb weight-bearing due to decreased cane dependence directly contributes to the increase in paretic side lower limb muscle activation [9]. In particular, stable maintenance of single-leg stance during the gait cycle requires concurrent contractions of the lower limb muscles [10]. As a result of this study, the degree of weight support loaded on a cane was higher in three-point gait with WSFC than the two-point gait with WSFC in both of mono and quadripod canes. In contrast, paretic side lower limb muscle activation during stance phase was higher in two-point gait with WSFC than three-point gait with WSFC in both of mono and quadripod canes. This result suggests that for gait training in hemiplegia, the two-point gait may be more effective than the three-point gait in paretic side lower limb muscle activation during the stance phase of gait cycle. Furthermore, the three-point gait, which has higher cane-dependence, may be more effective than the two-point gait in terms of stability. Therefore, in a hemiparetic stroke gait training, the types of cane-supported gait should be considered carefully. In particular, applying the three-point gait with high cane-dependence in the early stages of training for stability and subsequently applying two-point gait for enhancement of lower limb muscle activation could be effective.

In the present study, we proposed a clinical protocol based on the differences between the two-point gait and the three-point gait during cane-supported gait training, although we have not explored other factors that can affect lower limb muscle activation during cane-supported walking, such as gait speed and onset duration, which should be considered in future research. Moreover, as the study included only chronic stroke patients with hemiparesis, it is difficult to generalize the results of this study

Funding

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT) (No. 2018R1C1B5084411).

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