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Efficacy of the Gait Training Using Footpad-Type Locomotion Interface in Chronic Post-Stroke Patients: A Pilot Study

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Abstract

Purpose: In recent years, robotics have been used for rehabilitation. We developed a footpad-type locomotion interface using robot technology, and we reported improvement on gait speed and muscle strength. The purpose of this study was to compare the effects of gait training using a footpad-type locomotion interface (GTLI) with those of body weight support treadmill training (BWSTT).

Methods: Eleven chronic post-stroke patients participated in this study. The subjects received GTLI and BWSTT respectively three times a week for a total of 12 times. The outcome measures were maximum gait speed, timed up and go test, and isometric muscle strengths of both hip and knee flexion and extension

Result: No differences were observed in the gait speed and timed up and go test among GTLI and BWSTT. In isometric muscle strengths, GTLI improved better than BWSTT.

Conclusion: These results suggest that GTLI and BWST have similar effects on improving the gait and balance abilities. In addition, GTLI is more effective in improving the isometric muscle strength of hip extension and knee flexion than using BWSTT.

Keywords: Footpad type locomotion interface; BWSTT; Chronic post-stroke

Introduction

In recent years, robotic devices such as LOKOMAT, Gait Trainer and, Hybrid Assistive Limb® have been used in rehabilitation. About them, a lot of intervention effects are reported [1-3]. A systematic review of electromechanical assisted gait training using robotic devices was effective at improving the gait ability after stroke [4]. Systematic review showed some problems. The problem included optimum training duration and frequency of electromechanical assisted gait training using robotic devices and the high cost of the robotic devices. Therefore, we developed a footpad-type, small size and low-price locomotion interface [5]. The footpad-type locomotion interface consists of two slider cranks for moving the footpads back and forth, two actuators for moving the footpads up and down, and computer for controlling their movements. The trajectories of footpads are based on healthy individual's gait trajectory. The trajectory can be scaled to any size and cycle in accord with the subject's physical ability and condition (Figure 1). As a result, patients were able to perform repetitive exercises and hip extension exercises by the footpad-type locomotion interface. The footpad-type locomotion interface is controlled by a computer program, the gait trajectories and gait speed can be easily changed. We previously reported improvements in walking speed with a footpad-type locomotion interface in chronic stroke patients [6,7]. However, we had not compared the other gait training.

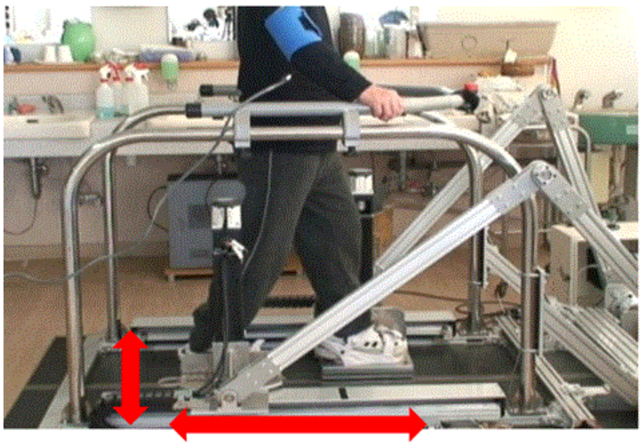

Figure 1: Footpad-type locomotion interface.

Body weight support treadmill training (BWSTT) is one of the most used gait training methods in recent years. BWSTT has been reported for intervention effects and efficacy. The purpose of this study was to examine the effectiveness of gait training using a footpad-type locomotion interface (GTLI) by comparing GTLI and BWSTT.

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Methods

Eleven ambulatory chronic post-stroke patients participated in this study (Table 1). Figure 2 shows the study protocol. Subjects were allocated by a computer-generated sequence into an odd number (group A) and even number (group B). In group A (n=7), the subjects underwent training using GTLI (three times a week for a total of 12 sessions) followed by that using BWST (three times a week for a total of 12 sessions), whereas in group B (n=4), the subjects underwent training using BWSTT followed by that using GTLI.

In GTLI, we used a footpad-type locomotion interface named GaitMaster developed by the Department of Intelligent Interaction Technologies, Graduate school of Systems and Information Engineering, University of Tsukuba. In BWSTT, we used a Biodex Unweighting System (Biodex Medical Systems, Shirley, NY, USA) and a Gait Training System (Biodex Medical Systems, Shirley, NY, USA).

The condition of gait training using GTLI and BWSTT was as follows: (a) gait training was 20 min once a day, (b) the gait speed set as fast as possible, (c) The subjects were able to grip the handrail. The gait speed, stride, and were controlled in accord with the subject's condition. During gait training, the subject's body movement and lower limb movement were assisted by a physical therapist as needed. In BWSTT, the amount of body-weight support was fixed at 20% in all BWSTT sessions.

n	11
Age	59.4 ± 10.8
Paretic side right/left	6/5
Post-stroke interval (months)	45.1 ± 35.1
BRS	2/6/3
Sensory Disturbance	
None	3
Mild	5
Moderate	3
Data are shown as number and mean ± SD, BRS: Brunnstrome Recovery Stage	

Table 1: Characteristics of participants.

The outcome measures were maximum gait speed, timed up and go test (TUG), and isometric muscle strengths of both hip and knee flexion and extension. For the assessment of gait speed, the subjects walked 10m on the ground at maximum speeds. We measured three times and used the fastest speed.

The TUG measures the time, in seconds, that it takes an individual to stand up from a chair, walk a distance of 3m, turn, walk back to the chair and sit down again.

We measured three times and used the fastest speed. For the assessment muscle strengths, we used hand-held dynamometer (μtas-MF01, Anima Corp, Tokyo) and measured the maximum isometric muscle strength of both hip and knee flexion and extension. We measured the hip flexion and knee flexion, extension with the subject in the sitting position and the hip extension in the supine position.

We measured the maximum isometric strength for 10-sec periods. We measured two times and used the maximum muscle strength.

These measures were evaluated at once a week (Measurement, M: M1-12, Figure 2). There was a non-training period of at least 8 weeks between each training session.

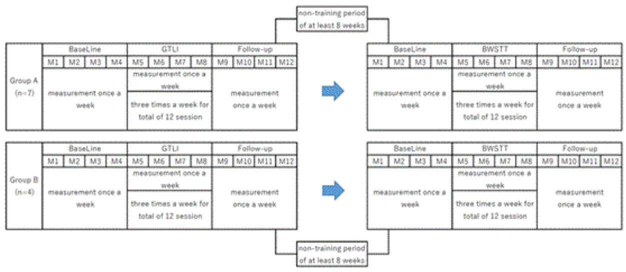

Figure 2: Study protocol: GTLI: Gait Training using locomotion interface, BWSTT: Body Weight support treadmill training, M1-12: measurement number 1-12.

For maximum gait speed, TUG and muscle strengths, we calculated the change from the pre-training. The Mann-Whitney test was used to compare the changes at post-training (M8) or 1-month after post-training (M12) of the GTLI and BWSTT and as well as the characteristics of groups A and B.

Statistical analyses were performed using SPSS version 19.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $P<0.05$.

This study was approved by the ethics committee of Tsukuba Memorial Hospital, and all participants or their legal representatives gave written informed consent to participate in the study.

Result

At the study onset, no differences between groups A and B were observed among the baseline clinical data, initial gait speed, initial TUG and initial isometric muscle strength (Table 2). Gait speed, and TUG of 11 subjects were analyzed. In two isometric muscle strengths could not be measured. Therefore, isometric muscle strengths of 9 subjects were analyzed.

Table 3 shows a comparison between GTLI and BWSTT in post-training, and 1-month after post-training. We found no significant difference between the GTLI and BWSTT in change in maximum gait speed at post-training (GTLI 0.13 ± 0.05 m/s versus BWSTT 0.18 ± 0.06 m/s, p=0.65), and 1-month after post-training (GTLI 0.16 ± 0.06 m/s versus BWSTT 0.12 ± 0.06 m/s, p=0.27).

Regarding change in TUG, we found no significant difference between the GTLI and BWSTT in change in TUG at post-training (GTLI -2.3 ± 0.8 seconds versus BWSTT -0.9 ± 0.6 seconds, p=0.30), and 1-month after post-training (GTLI -3.0 ± 0.9 versus BWSTT -0.9 ± 0.7, p=0.09).

As regards the isometric muscle strength, we found significant difference between the GTLI and BWSTT in paretic hip extension at post-training (GTLI 1.1 ± 0.5 kg versus BWSTT -0.5 ± 0.7 kg, p=0.01) and paretic knee flexion at 1-month after post-training (GTLI 2.3 ± 0.8 kg versus BWSTT -0.1 ± 0.7 kg, p=0.02).

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We found no significant difference between the GTLI and BWSTT in change in the other isometric muscle strength at post-training and 1-month after post-training.

		Group A	Group B	
n		7	4	
Age		57.9 ± 7.5	62.0 ± 16.3	n.s
Post-stroke interval (months)		57.0 ± 39.6	24.3 ± 6.7	n.s
BRS III/IV/V		1/5/1	1/1/2	
Maximum gait speed (m/s)		0.71 ± 0.23	0.99 ± 0.12	n.s
TUG (s)		20.6 ± 7.5	14.3 ± 2.4	n.s
Isometric muscle strength				
Paretic side (n)				
Hip	extension	6.6 ± 3.3 (7)	4.3 ± 15.2 (2)	n.s
	flexion	9.1 ± 3.3 (7)	7.1 ± 1.9 (2)	n.s
Knee	extension	17.3 ± 11.4 (7)	14.2 ± 4.0 (2)	n.s
	flexion	4.8 ± 4.0 (7)	1.2 ± 1.6 (2)	n.s
Non Paretic side (n)				
Hip	extension	13.4 ± 4.4 (7)	13.8 ± 9.3 (2)	n.s
	flexion	16.1 ± 5.0 (7)	27.8 ± 3.2 (2)	n.s
Knee	extension	28.5 ± 3.3 (7)	33.7 ± 3.1 (2)	n.s
	flexion	12.7 ± 3.3 (7)	16.8 ± 8.2 (2)	n.s
Data are shown as number and mean ± SD, BRS: Brunnstrom Recovery Stage, TUG: Timed up & Go test; n.s: not significant				

Table 2: Clinical data and initial assessment data for both group.

Discussion

In gait speed and TUG, there was no significant difference between GTLI and BWSTT. These results show that GTLI has similar efficacy as BWSTT, which is recommended in the stroke treatment guidelines [8] in gait speed, and TUG.

			Post training			1 month after post-training		
			GTLI	BW STT		GTLI	BW STT	
Maximum gait speed (m/s)			0.13 ± 0.05	0.18 ± 0.06	n.s	0.16 ± 0.06	0.12 ± 0.06	n.s
TUG (seconds)			-2.3 ± 0.8	-0.9 ± 0.6	n.s	-3.0 ± 0.9	-0.9 ± 0.7	n.s
muscle strength (kg)								
paretic	Hip	extension	1.1 ± 0.5	-0.5 ± 0.7	p < 0.05	2.1 ± 1.1	0.4 ± 0.6	n.s
		flexion	2.9 ± 1.9	0.0 ± 1.1	n.s	3.9 ± 2.4	2.1 ± 1.3	n.s
	Knee	extension	2.6 ± 1.8	2.6 ± 1.6	n.s	3.1 ± 1.3	3.1 ± 1.9	n.s
		flexion	0.7 ± 0.6	0.2 ± 1.1	n.s	2.3 ± 0.8	-0.1 ± 0.7	p<0.05
Non paretic	Hip	extension	2.9 ± 2.1	0.8 ± 0.6	n.s	2.0 ± 0.8	1.6 ± 0.9	n.s
		flexion	2.6 ± 1.5	1.1 ± 1.8	n.s	2.7 ± 2.0	3.3 ± 1.9	n.s
	Knee	extension	0.8 ± 2.7	1.8 ± 2.7	n.s	5.0 ± 2.4	2.9 ± 1.2	n.s
		flexion	1.5 ± 0.9	1.0 ± 1.1	n.s	1.0 ± 1.3	2.9 ± 0.8	n.s
Data are shown as number and mean ± SD, GTLI: Gait Training Using a Footpad-type Locomotion Interface, BW STT: Body Weight Supported Threadmill Training, TUG: Timed up & Go test, n.s: not significant								

Table 3: Comparison between GTLI and BWSTT in post-training and 1 month after post-training.

Regarding isometric muscle strengths, paretic hip extension and paretic knee flexion were significantly more improved by GTLI than BWSTT. There were few reports about the improvement of the muscle strength in robotic gait training. We reported that GTLI significant high muscle activity than treadmill walking in healthy subjects [9]. For this reason, GTLI may have higher muscle activity than BWSTT in stroke patients.

These results suggest that GTLI and BWST have similar effects on improving the gait and balance abilities. In addition, GTLI is more effective in improving the lower-limb isometric muscle strength than that using BWSTT. Moreover, many of gait training using BWSTT and robots are used in hospitals and clinics. GTLI has been developed as portable equipment [10], so it may be useful as a home exercise as well as hospitals and clinics.

References

1. Mayr A, Kofler M, Quirbach E, Matzak H, Fröhlich K, et al. (2007) Prospective, blinded, randomized crossover study of gait rehabilitation in stroke patients using the Lokomat gait orthosis. Neurorehabil Neural Repair 21: 307-314.
2. Tong RK, Ng MF, Li LS (2006) Effectiveness of gait training using an electromechanical gait trainer, with and without functional electric stimulation, in subacute stroke: a randomized controlled trial. Arch Phys Med Rehabil 87: 1298-1304.
3. Watanabe H, Tanaka N, Inuta T, Saitou H, Yanagi H (2014) Locomotion Improvement Using a Hybrid Assistive Limb in Recovery Phase Stroke Patients: A Randomized Controlled Pilot Study. Arch Phys Med Rehabil 95: 2006-2012.
4. Mehrholz J, Eisner B, Werner C, Kugler J, Pohl M (2013) Electromechanical-assisted training for walking after stroke. Cochrane Database Syst Rev 25: CD006185.
5. Hiroaki Y, Shintaro T, Naoki T, Hideyuki S, Hiroo I (2012) Interactive Gait Rehabilitation System with a Locomotion Interface for Training Patients to Climb Stairs. Presence: Teleoperators and Virtual Environments 21: 16-30.
6. Tanaka N, Kanamori T, Saitou H, Yano H, Okuno J, et al. (2012) Improvements of Muscle Strength and Gait Ability among Chronic Post-Stroke Patients by Gait Training with a Footpad-Type Locomotion Interface. J Nov Physiother S1: 002.

7. Tanaka NSaitou H, Takao T, Iizuka N, Okuno J, et al. (2012) Effects of gait rehabilitation with a footpad-type locomotion interface in patients with chronic post-stroke hemiparesis: a pilot study. Clin Rehabil 26:686-695.
8. The japan Stroke Society (2015) Japanese Guidelines for the Management of Stroke 2015. Tokyo: Kyowa Kikaku.
9. Tanaka N, Watanabe H (2015) Electromyographic analysis of lower extremity muscles in healthy volunteers walking on a footpad-type locomotion interface. Physiotherapy 101: e1487-e1488.
10. Yano H, Tanaka N, Kamibayashi K, Saitou H, Iwata H, et al. (2015) Development of a Portable Gait Rehabilitation System for Home-Visit Rehabilitation. The Scientific World Journal. 2015:849831.