Effects of I-Walk Training on Gait Performances in Patients with Chronic Stroke

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Abstract

Objective: To determine the effects of I-Walk (Robotic-assisted gait device) training compared with over-ground walking training on motor impairments assessed by lower extremity scores, lower extremity angles during walking, and gait performances in patients with chronic stroke.

Methods: A single blinded randomized controlled trial was conducted. Twenty four chronic stroke patients were randomly assigned into two groups; experimental group (n=12) and control group (n=12). For gait performances, patients in an experimental group received I-Walk training, while those in a control group received over-ground walking training. The duration of training was 60 min per day, 3 days per week for 8 weeks. The outcome measures included motor impairments assessed by the Fugl-Meyer Assessment of Lower Extremity (FMA-LE) scores, lower extremity angles during walking (hips, knees, ankles), and gait performances (step length, cadence, walking speed, stride length, and step length symmetry ratio). All variables were measured before and after the training period.

Results: There was a statistically significant difference in motor impairments assessed by the FMA-LE scores, lower extremity angles during walking on hips and knees, as well as gait performances, including step length, cadence, and walking speed, between the experimental and the control groups ($p<0.05$). In particular, the statistically significant changes were demonstrated in motor impairments assessed by the FMA-LE scores, lower extremity angles during walking on hips, knees, and ankles, as well as gait performances, including step length, cadence, walking speed, stride length, and step length symmetry ratio, before and after the I-Walk training in the experimental group ($p<0.05$).

Conclusions: The I-Walking training could yield a statistically significant improvement of motor impairments assessed by FMA-LE scores, lower extremity angles during walking, and gait performances in chronic stroke patients. Nonetheless, further studies are recommended to elucidate and ratify the effective outcomes in patients with other stages of stroke, different ranges of lower extremity, and various spatiotemporal parameters.

Keywords: Gait training, Hemiplegia, Physical therapy, Robotic, Task-specific training

ผลของการฝึกด้วยเครื่องไอ-วอล์คต่อสมรรถนะของการเดินในผู้ป่วยโรคหลอดเลือดสมองระยะเรื้อรัง

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บทคัดย่อ

วัตถุประสงค์: เพื่อเปรียบเทียบผลของการฝึกด้วยเครื่องไอ-วอล์ค (หุ่นยนต์ฝึกเดิน) และการฝึกเดินบนพื้นราบต่อการทำงานของขา, มุมการเคลื่อนไหวของขาขณะเดิน และสมรรถนะของการเดินในผู้ป่วยโรคหลอดเลือดสมองระยะเรื้อรัง

วิธีดำเนินการวิจัย: เป็นการทดลองแบบสุ่มและมีกลุ่มควบคุม ผู้ป่วยโรคหลอดเลือดสมองระยะเรื้อรังจำนวน 24 คน ได้รับการสุ่มแบ่งกลุ่มเป็น 2 กลุ่มคือ กลุ่มทดลอง (n =12) และกลุ่มควบคุม (n=12) สำหรับการฝึกเดิน กลุ่มทดลองจะได้รับการฝึกด้วยเครื่องไอ-วอล์ค ในขณะที่กลุ่มควบคุมจะได้รับการฝึกเดินบนพื้นราบ ระยะเวลาในการฝึก 60 นาทีต่อวัน 3 วันต่อสัปดาห์ เป็นเวลา 8 สัปดาห์ โดยทำการวัดผลการทำงานของขาด้วยแบบประเมิน Fugl-Meyer Assessment of Lower extremity (FMA-LE), มุมการเคลื่อนไหวของขาขณะเดิน และสมรรถนะของการเดินใน โดยทำการวัดค่าตัวแปรเหล่านี้ก่อนการฝึกและหลังการฝึก

ผลการวิจัย: มีความแตกต่างอย่างมีนัยสำคัญทาสถิติของการทำงานของขา มุมการเคลื่อนไหวข้อสะโพก ข้อเข่า ระยะก้าวขา ความถี่ในการก้าวขา ความเร็วในการเดิน เมื่อเปรียบเทียบระหว่างกลุ่มทดลองและกลุ่มควบคุม ($p<0.05$) และพบว่าคะแนนของ FMA-LE และความสมมาตรของการก้าวขา มีการเปลี่ยนแปลงอย่างมีนัยสำคัญทางสถิติ เมื่อเปรียบเทียบก่อนและหลังการฝึกในกลุ่มทดลอง ($p<0.05$)

สรุป: การฝึกด้วยเครื่องไอ-วอล์ค สามารถเพิ่มการทำงานของขา, มุมการเคลื่อนไหวของขาขณะเดิน และสมรรถนะของการเดินในผู้ป่วยโรคหลอดเลือดสมองระยะเรื้อรังได้ อย่างไรก็ตามในอนาคตคณะผู้วิจัยแนะนำว่าควรมีการศึกษาในผู้ป่วยโรคหลอดเลือดสมองระยะอื่น, ระดับความรุนแรงของขาที่แตกต่างกัน รวมถึงศึกษาในตัวแปร spatiotemporal เพื่อให้เกิดความชัดเจนและช่วยยืนยันผลการศึกษาที่พบได้ดียิ่งขึ้น

คำสำคัญ: การฝึกเดิน, อัมพาตครึ่งซีก, กายภาพบำบัด, หุ่นยนต์, การฝึกแบบ Task-specific training

Introduction

Stroke is a major cause of various impairments in the patients, for example muscle weakness, sensory impairment, poor balance and spasticity [1]. These impairments affect the control of movement of one side of the body that limit ability to perform activities of daily living [2].

Walking is the one of the most common movement problem in patients with chronic stroke [3]. The capacity of walking in a community is required, for example : the ability of walking at speeds to crossing the street, stepping on and off a moving footpath, walking through the doors, walking around furniture, obstacle crossing [4]. Therefore, gait recovery is a major goal in physical therapy rehabilitation for patients with chronic stroke [5].

In the last decade, physical therapy has focused on using robotic-assisted gait device[6]. Goals of the robotic assisted gait a training are to control movement and to design training for rehabilitation exercise that will induce neural plasticity changes associated with task-specific training (active assisting, challenge-based, stimulating normal task) and improving motor recovery[7]. Hesse and colleagues in 2013 concluded that robotic assisted gait training resulted in restoring and improving gait in patients with subacute and chronic stroke. They found significant larger increments in walking speed, walking distance after using robotic assisted gait device than usual physical therapy treatment [8]. Moreover, robotic assisted gait training could improve walking ability in patients with stroke. However, the robotic assisted gait training device in Thailand are still limited due to the high price. Therefore these devices are available only in some medical centers or hospitals.

In Thailand, I-Walk is a new device that designed from the robotic assisted gait training, end-effector type for patients with stroke. I-Walk is less costly. The device is consisted of two systems, body weight support system and gait training system. I-Walk training is more repetitive gait pattern of complex gait cycles than overground walking training. However, Implementations of the I-Walk in stroke individuals to improve gait performance are limited due to the lack of research study. Therefore, the aim of this study was to investigate the effect of I-Walk training to improve motor impairments, lower extremity angles during walking and gait performances in patients with chronic stroke.

Methods

Design

The study design in this research was experimental single-blind randomized controlled trial comparing the effect of I-Walk gait training and overground walking training on gait performances in participants with chronic stroke.

Participants

The experimental protocol was set up at Physical therapy and Hydrotherapy center, Faculty of Allied Health Sciences, Thammasat University and at Bueng Yitho Medical and Rehabilitation Center, Pathumthani, Thailand. The protocol of this study was approved by the Ethics Review Sub-Committee for Research Involving Human Research Subjects of Thammasat University.

Inclusion criteria

1. The participants were inpatients who got stroke attack onset more than six months.
2. Age between 45 and 70 years.
3. Able to walk at least 10 m. with or without walking device.

Exclusion criteria

1. The patients were excluded if they had unstable vital signs.
2. Any symptoms and signs that may affect their participation such as neurogenic pain and pain scale on a visual analog scale more than 5 out of 10.
3. Other neurological or medical disorder that can attribute negative impact on ambulatory ability.

Sample size

The researcher set a confidence level at 95 % and the power of test at 80 %. The $Z_{\alpha/2}$ is 1.96 and the Z_{β} is 0.84. The σ^2 is 0.015 and Δ^2 is 0.01 was derived from the pilot study which was conducted in 20 participants (10 participants/group). With the additional number of 20% drop out, the number of participants in each group was 12 participants.

Description of the outcome measures

The assessor of the study was a physical therapist who had a clinical experience in stroke rehabilitation more than 3 years.

The Fugl-Meyer Assessment of Lower Extremity (FMA-LE)

The FMA-LE reflects a motor recovery in post-stroke. The FMA-LE consisted of lower extremity, co-ordination/speed, and motor function. The motor function scores used to measure lower extremity recovery in stroke patients. The FMA-LE reflects a motor recovery in post stroke. The original scale, consisted of six domains (lower extremity, co-ordination/speed, motor function, sensation, joint mobility and pain) and scoring is done on 3 ordinal scale ranges from 0 to 2. The lower extremity tested for the reflex activity (flexors and extensors), flexor synergy (hip flexion, knee flexion and dorsiflexion), extensor synergy (hip extension, adduction, knee extension, and plantar flexion), and lower extremity movement combining synergies in sitting and standing position. The scale of lower extremity has 14 items. The score range from 0 to 28. The co-ordination/speed of heel to opposite knee (tremor, dysmetria and speed). The scale of co-ordination/speed has 3 items. The score range from 0 to 6. The FMA-LE, motor function, used to measure lower extremity recovery in stroke patients. The scale has 17 items from the sum of lower extremity and co-ordination/speed. The total score range from 0 (no motor function) to 34 (good motor recovery). FMA-LE, sensation, the scale has 6 items, two for light touch and four for position sense. The patient is asked whether who feels that light touches on leg and the feet. The total score ranges from 0 to 12. FMA-LE, joint motion and pain, the scale has 20 items, ten for joint motion and ten for joint pain. The patient is asked whether who feels that passive joint motion and pain that pain during or at the end of movement on leg and the feet. The total score ranges from 0 to 20 of each.

Lower extremity angles during walking

Prior to the gait analytic test, participants were wearing the body's most compact and black clothing. Then, the markers were attached at anatomical references consisted of acromion process of the scapular, greater trochanter, knee joint line, lateral malleolus, and fifth metatarsal. Participants were assessed their lower extremity angles during walking and gait performance using the Kinovea Software Version 0.8[9]. Participants were recorded for their walking ability using a digital camera with a frame rate of 60 Hz.[10]. Prior to the test, the video recording system was positioned perpendicular to the walkway, at approximately 4 m. from the walkway to capture 4 m. section in the middle of the walkway. An angular of lower extremities was analyzed at heel strike, mid stance, toe-off, push off, and mid-swing of gait cycle[9]. Hip angle was measured at the intercept between the line from the acromion process to the greater trochanter and the line from the greater trochanter to the lateral knee joint line. Knee angle was measured at the intercept between the line from the greater trochanter to the lateral knee joint and from the lateral knee joint to the lateral malleolus. Ankle angle was measured at the intercept between the line from the lateral knee joint to lateral malleolus and from the lateral malleolus to the fifth metatarsal. Three completed gait cycles were selected and parameters of complete gait cycle of each participant were averaged. Participants were assessed their walking performance while walking with preferred and fastest walking speed for 3 trials per condition. Then the average data of each speed were collected. The parameters were analyzed from the frames that best represent each gait phase with visible markers[11].

Gait performances

The step length was measured from the length as the distance between the heels of one foot to the other[10,12]. The stride length was measured from the total distance of the step length of the left and right leg[10,12]. The cadence was determined by the number of steps in the 4 m. moving range in the middle of the walkway[10]. Then the results were converted to a number of steps in 60 s.[10]. Walking speed was measured based on a distance of 4 m.

in the middle of the walkway[9-10]. The step length symmetry ratio was measured from the distance of the legs compared to the distance between the stepping of the paretic side and the non-paretic side. The ratio score that is closer to 1 indicates a more symmetrical gait[13].

Experimental protocol

Participants with stroke who meet the inclusion and exclusion criteria were randomized into experimental group (walking training with I-walk) or control group (walking training with conventional physical therapy) by a random number generator. On the first day, participants were interviewed and assessed for their baseline demographics, stroke characteristics. On the following days, they were trained in the program of allocated group. Participants in both groups received the usual physical therapy program before walking training program. The usual physical therapy program consists of upper extremity training (*grasping* and releasing balls, pinching tongs, using a spray bottle, kneading putty, pinching coins, using a spoon, lifting a heavy can, and wiping a table with a towel) for 15 min. and sit-to-stand training for 15 min. Prior to and after completing the program (24 sessions), participants were assessed lower limbs impairments by the FMA-LE and gait performances by hip angle, knee angle, ankle angle, step length, cadence, walking speed, stride length and step length symmetry ratio.

I-Walk gait training program (experimental group)

I-Walk gait training device consists of two systems: body weight support system and gait training system. The body weight support system consists of harness that used to support and prevent falling during the training. The gait training device represents by two-foot plates connected to a doubled plate. I-Walk generates a human like walking pattern. The end-effectors are represented by two foot plates connected to a double plate. The rear ends of the foot plates move forward and backward. The backward movement of the footplates simulates the stance phase while the forward movement simulates the swing phase. Based on task-specific repetitive training. The device helps initiate the repetitive forward gait motion. Cadence of device was set according to participants' average self-determined walking cadence over three trials before training[14]. The walking cadence can be selected from 0-120 steps per min. Prior to training; participants had to wear the harness of the safety system. The participants were encouraged to hold onto the handrails when they feel unstable (Figure 1). When participants could sustain the greater load in the lower paretic limb without help from the physical therapist. The greater load (I-walk cadence) of 10% of baseline was applied when the participants were able to straight the affected leg and increase weight bearing during the single-leg stance phase and move the affected leg during the swing phase without any compensations, fatigue or increased spasticity [15]. The I-Walking training period was 30 min.

Figure 1: A safety harness on the I-Walk trainer

Over-ground walking training program (control group)

Participants with stroke were allowed to use their walking devices as needed. Over-ground walking program was consisted of forward walking training for 10 minutes, sideway walking training for 10 minutes and obstacle walking training (obstacle height = 8 cm, width = 8 cm) for 10 minutes on the 10 m. walkway with self-selected walking speed. When participants could sustain the greater load in the lower paretic limb without help from the physical therapist without any compensation, fatigue and increased spasticity, the speed and distance of training were increased of their self-determined. The overground walking training period was 30 min.

Statistical analysis

Descriptive statistics were applied to explain the characteristics of the participants and findings of the study and SPSS version 11.5 was used for statistical analysis. The Two Way Mixed ANOVA was used to analyze the differences within the group and compare the differences between groups. The significance level was set at $p < 0.05$.

Results

Characteristics of the participants

Thirteen participants had a left-sided hemiparesis and eleven participants had a right-sided hemiparesis with the average 4.49 years post stroke (range 0.50-30.00, SD = 6.18). The characteristics are shown in Table 1. All baseline characteristics of either group were not significantly different across the groups ($p>0.05$).

Table 1:
Baseline characteristics of the participants

Variables	Experimental group (n=12)	Control group (n =12)
Mean age (years) (SD)	59.83 (6.53)	61.83 (7.24)
Mean height (m) (SD)	1.64 (0.06)	1.62 (0.80)
Mean weight (kg) (SD)	65.58 (8.29)	70.08 (14.37)
Mean BMI (kg/m^2) (SD)	24.38 (3.62)	27.02 (34.37)
Gender (Male:Female)	7 : 5	8 : 4
Mean post-onset time of stroke (years) (SD)	3.59 (2.82)	5.37 (8.37)
Pathology (Infarction:Hemorrhagic)	11 : 1	10 : 2
Affected side (Right:Left)	8 : 4	3 : 9
Mean MMSE (scores) (SD)	21.83 (3.12)	22.08 (3.28)
Mean MAS of lower limb (scores) (SD)	0.41 (0.67)	0.50 (0.52)
Assistive device (non use:use)	4 : 8	3 : 9

Note: BMI = Body Mass Index, MMSE = Mini Mental State Examination Thai version 2002, MAS = Modified Ashworth Scale.

Effects of the interventions

The improvement of lower extremity, co-ordination, motor function scores were statistically significant within the both groups (p<0.05). When comparing between groups, lower extremity and motor function scores of experimental group was significantly greater than control group (p<0.05) as shown in Table 2. The range of motion of lower extremity had a trend of increment in both groups after gait training. When comparing between groups, hip flexion and knee flexion during mid-swing of gait cycle in the experimental group was significantly greater than control group (p<0.05) as shown in Table 3**.** Participants in the I-walk training group had walked in a range of 1,120-1,200 steps per session while those in the over-ground walking training group had walked a range of 259-570 steps per session. After training, gait performance (walking speed, step length, stride length cadence and step symmetry ratio) in preferred and maximal walking speed test of experimental group was significantly improved (p<0.05). When comparing between groups, the improvement of step length, cadence and walking speed in the experimental group was significantly greater than those in the control group (p < 0.05) as shown in Table 4.

Table 2: The Fugl-Myer assessment of lower extremities before and after the training period

FMA-LE	Experimental group (n=12)			Control group (n=12)			Mean difference		
	Pre-test	Post-test	P-value [a]	Pre-test	Post-test	P-value [a]	Experimental group	Control group	P-value [a]
Mean scores of item E. Lower extremity (SD)	14.25 (3.81)	23.16 (2.88)	<0.001***	15.41 (5.28)	18.50 (4.01)	0.002**	8.91 (4.03)	3.09 (2.61)	0.003**
Mean scores of item F. Co-ordination (SD)	2.25 (1.21)	4.08 (1.37)	0.001**	3.16 (1.26)	3.75 (1.28)	0.012*	1.83 (1.34)	0.59 (0.67)	0.547
Mean scores of total E-F. Motor function (SD)	16.50 (4.05)	27.25 (3.84)	<0.001***	18.58 (6.31)	22.25 (5.04)	0.001**	10.75 (4.52)	3.67 (2.93)	0.012*

Note: [a] P-value from the Two-Way Mixed ANOVA with repeated measures. *Indicates significant difference, P-value <0.05; ** P-value <0.01; *** P-value <0.001.

Table 3:

Lower extremity angles during walking before and after the training period

Variables		Experimental group (n=12)			Control group (n=12)			Mean difference		
		Pre-test	Post-test	P-value [a]	Pre-test	Post-test	P-value [a]	Experimental group	Control group	P- value [a]
Mean degree of hip extension, Push off (SD)	Preferred	-0.88 (1.13)	5.22 (1.95)	0.003**	-2.50 (0.30)	0.30 (0.08)	0.127	6.10 (5.48)	2.80 (5.83)	0.288
	Maximal	0.50 (1.25)	6.83 (3.42)	0.001**	-0.50 (0.13)	1.69 (1.40)	0.233	6.33 (5.35)	2.19 (13.45)	0.323
Mean degree of hip flexion, Mid swing (SD)	Preferred	15.16 (6.03)	24.91 (8.19)	<0.001***	14.75 (5.22)	18.30 (5.14)	0.026*	9.75 (6.91)	3.55 (4.80)	0.027*
	Maximal	17.05 (7.65)	29.91 (8.36)	0.001**	17.38 (6.92)	21.44 (5.97)	0.045*	12.86(10.17)	4.06 (6.20)	0.009**
Mean degree of knee extension, Mid stance(SD)	Preferred	0.22 (5.42)	1.33 (1.67)	0.556	1.97 (2.03)	1.44 (1.66)	0.336	1.11 (1.33)	0.53 (1.82)	0.872
	Maximal	0.91 (5.23)	1.52 (2.23)	0.753	2.00 (2.99)	1.25 (2.18)	0.096	0.61 (1.56)	0.75 (1.43)	0.761
Mean degree of knee flexion, Mid swing (SD)	Preferred	22.11 (7.36)	34.97 (4.74)	<0.001***	23.30 (10.95)	28.91 (8.12)	0.023*	12.86(7.47)	5.61 (7.36)	0.036*
	Maximal	23.61 (9.43)	36.27 (5.83)	0.001**	25.83 (11.74)	30.16 (9.09)	0.021*	12.66(9.60)	4.33 (5.56)	0.063
Mean degree of dorsiflexion, Heel stride(SD)	Preferred	-30.72 (11.78)	-28.13 (11.58)	0.130	-27.05 (15.23)	-26.27(15.30)	0.323	2.59 (5.47)	0.78 (2.60)	0.740
	Maximal	-31.80 (9.71)	-29.25 (10.89)	0.093	-27.58 (15.99)	-28.08(16.04)	0.305	2.55 (4.81)	0.50 (1.61)	0.837
Mean degree of plantar flexion, Toe off (SD)	Preferred	37.30 (14.59)	33.63 (15.20)	0.012*	37.77 (10.13)	34.55(11.25)	0.331	3.67 (4.19)	3.22 (10.97)	0.611
	Maximal	32.86 (14.44)	38.22 (14.95)	0.018*	38.33 (9.02)	39.30 (9.79)	0.398	5.36 (6.70)	0.97 (10.94)	0.610
Mean degree of dorsiflexion, Mid swing (SD)	Preferred	-34.30 (19.18)	-27.34 (11.11)	0.072	-35.22 (12.80)	-26.47(15.43)	0.193	6.96 (12.13)	8.75 (21.83)	0.877
	Maximal	-35.42 (19.16)	-25.31 (10.99)	0.016*	-35.11(12.34)	-25.89(14.86)	0.161	10.11(12.29)	9.22 (21.24)	0.914

Note: [a] P-value from the Two-Way Mixed ANOVA with repeated measures. *Indicates significant difference, P-value <0.05; ** P-value <0.01; *** P-value <0.001.

Table 4:
Gait performances before and after the training period

Variables		Experimental group (n=12)			Control group (n=12)			Mean difference		
		Pre-test	Post-test	P-value [a]	Pre-test	Post-test	P-value [a]	Experimental group	Control group	P-value [a]
Mean step length of paretic side (m) (SD)	Preferred	0.35 (0.10)	0.45 (0.11)	<0.001***	0.33 (0.09)	0.36 (0.08)	0.007**	0.10 (0.07)	0.03 (0.03)	0.047*
	Maximal	0.38 (0.12)	0.47 (0.10)	0.004**	0.34 (0.10)	0.37 (0.10)	0.005**	0.09 (0.08)	0.03 (0.03)	0.024*
Mean step length of non-paretic side (m) (SD)	Preferred	0.28 (0.09)	0.33 (0.11)	0.001**	0.28 (0.11)	0.29(0.15)	0.009**	0.05 (0.03)	0.01(0.03)	0.038*
	Maximal	0.33 (0.11)	0.35 (0.11)	0.007**	0.29 (0.12)	0.33(0.13)	0.005**	0.02 (0.05)	0.04 (0.06)	0.046*
Mean cadence (step/min) (SD)	Preferred	63.05 (18.97)	84.56 (16.78)	<0.001***	51.78 (27.55)	58.59 (29.81)	0.136	21.51 (13.73)	6.81 (14.65)	0.017*
	Maximal	71.10 (18.30)	92.47 (15.49)	<0.001***	62.47 (28.16)	68.80 (29.63)	0.328	21.37 (12.88)	6.33 (12.41)	0.007**
Mean walking speed (m/s) (SD)	Preferred	0.27 (0.11)	0.60 (0.17)	<0.001***	0.24 (0.21)	0.30 (0.02)	0.029*	0.33 (0.15)	0.06 (0.08)	0.001**
	Maximal	0.37 (0.20)	0.74 (0.18)	<0.001***	0.29 (0.21)	0.36 (0.23)	0.035*	0.37 (0.16)	0.07 (0.09)	0.001**
Mean stride length (m) (SD)	Preferred	0.62 (0.18)	0.79 (0.23)	0.009**	0.61 (0.18)	0.65 (0.19)	0.014*	0.17 (0.18)	0.04 (0.05)	0.127
	Maximal	0.71 (0.22)	0.83 (0.23)	0.013*	0.64 (0.22)	0.74 (0.21)	0.005**	0.12 (0.12)	0.10 (0.06)	0.210
Mean step symmetry ratio (ratio) (SD)	Preferred	1.43 (0.58)	1.33 (1.18)	0.692	1.35 (0.39)	1.32 (0.31)	0.980	0.10 (0.25)	0.03 (0.30)	0.160
	Maximal	1.25 (0.38)	1.05(1.31)	0.297	1.56 (0.94)	1.34 (0.45)	0.265	0.20 (0.30)	0.22 (0.40)	0.320

Note: [a] P-value from the Two-Way Mixed ANOVA with repeated measures. *Indicates significant difference, P-value <0.05; ** P-value <0.01; *** P-value <0.001.

Discussion

This study was the first determining the effects of I-Walk (Robotic-assisted gait device) training compared with overground walking training. In our study found that participants in I-Walk training group walked more than 1,000 steps per session compare with over-ground walking training group walked less than 1,000 steps per session which similarly found in previous study. Hesse and Werner in 2003 reported that up to 1,000 steps which could be performed in a 20-minute treadmill training session, compared with 50 to 100 steps during a 20-minute session of conventional physical therapy. Their study suggested that approximately 1,000 steps per session are required to improve gait performance in patients with stroke [16]. The patients with chronic stroke in I-Walk training group had a significant motor recovery which might be due to brain plasticity [17]. The advantage of walk more than 1,000 steps per session is the ability of walking at speeds to crossing the street in the country of the previous study but maybe not sustable in Thailand.

The I-Walk training could improve volitional movements in patients with chronic stroke. As presented in the results, the participants with stroke in the experimental group demonstrated a greater improvement in score of FMA-LE than those in control group. The characteristic of I-Walk training similar with BWSTT and robotic assisted gait training that were task-specific training or task-oriented training [5,18]. Task-specific training focused on improvement of performance in functional tasks through repetition, progressive and intensity. Previous studies suggested that the task-specific training in a natural gait circuit and extend period of time available in a training session can influence the brain to adaptive, create a new neural network and brain activation patterns that can facilitate the motor recovery process[19]. The walking pattern on the I-walk is similar to walking with elliptical trainers. The movement patterns and muscle demands of the elliptical training related with walking up and down stairs climbing. Previous study reported that walking on the stairs is a movement that requires greater lower-limb strength and balance than walking on the ground[20].

The improvement of volitional movements of the participants in the I walk training group might effect on ankle movement during walking. As presented in the result that the range of motion of ankle plantar flexion during toe-off was improved in participants who were trained with I-Walk device. Previous study reported that the ability to perform ankle plantar flexion of the paretic ankle was strongly related to maximum walking speed and a reduction in plantar flexion was a cause of limited walking speed [21]. I-Walk training system had slightly moveable footplate (upward and downward) that can assist ankle dorsiflexion and plantar flexion movement during walking training. The active assisted movement repeated over the time of I-Walk training maintained repetitive movement of plantar flexion and greater number of steps within a training session more than over-ground walking training. Forrester and colleagues in 2011 studied the effects of robotics assisted gait training for 60 min. per day, 3 days per week, 6 weeks on ankle motor control and gait function in chronic stroke. Their study showed improvement of paretic ankle motor control, along with faster and smoother movements. The gait performances also increased significantly [22]. These reflect performance of stepping on and off a footpath, and obstacle crossing.

Walking speed of the participants in the I-walk training group was improved after the training. Walking speed is an important parameter in gait performance that directly related to physical disorder. Gait performances are the indicators of mobility impairment and disability after stroke. This predicts mortality, morbidity, and risk of future stroke. A maximal walking speed is a measure of gait performance after stroke and strong predictor of community ambulatory competence[23]. Previous study found that improvement in walking speed related with increased stride length, step length, and cadence [23]. After 24 sessions of walking training, the experimental group had increased their walking speed by 0.33 m/s in preferred walking speed and

0.36 m/s in maximum walking speed. The minimal detectable change (MDC) of maximal walking speed for survivors of stroke has been reported to be 0.3 m/s [24]. Therefore, the improvement of walking speed in the experimental group was a true performance change that did not due to variability in performance or measurement error.

There are some limitations in this study. First, this study did not recruit patients in other stages of stroke such as acute or sub-acute stroke. Then, the study did not collect a retention period after the training with I-Walk has ceased. Finally, the current study did not evaluate the spatiotemporal parameters related with walking for example, symmetrical stance time of both legs. Therefore, *further studies* should evaluate the effect of I-Walk training in patients with various stages of post-stroke and with a range of lower extremity deficits. Follow-up period should be examined to assess effect of I-walk training. Moreover, it is interesting to assess other spatiotemporal parameters related with walking, for example symmetrical stance time of both legs.

Conclusion

The study investigated the effects of I-Walk training in patients with chronic stroke. After 8 week training, the participants demonstrated significant improvement in their motor impairments, lower extremity angles during walking and gait performances. The greater improvement have found in participants who were trained using the I-Walk. It is helpful for the capacity of walking in a community requirement.

Conflict of interest

None

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