Short Communication

Comparison of Walking and Balance Control between Gait and Balance Training on Perturbation Treadmill and Overground in Individuals with Chronic Stroke

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ABSTRACT

Objectives: To study changes in walking and balance control after receiving two different gait and balance training programs in stroke patients.

Study design: Asssessor-blinded randomized controlled trial.

Setting: Sirindhorn National Medical Rehabilitation Institute, Thailand.

Subjects: Outpatients with chronic stroke with ability to walk without ambulatory aids for at least 10 meters.

Methods: Eligible participants were randomized to experimental group of training on perturbation treadmill and control group of training on overground. Each participant received the assigned training which lasted 30 minutes per session, 3 days per week, for 4 weeks. Before the trainings, both groups received a bench exercise program for 30 minutes. Primary outcome was Timed Up and Go (TUG) test and secondary outcomes was Berg Balance Scale. The outcomes were assessed before and after completion of 12 training sessions.

Results: Only 9 participants in each group completed the study. Both groups had a decrease in TUG time and an increased in BBS score but only the latter reached statistical significant level ($p < 0.05$). There were no significant changes in pre-post differerence of TUG (experiment 1.10 vs control 1.18, $p = 0.96$) and BBS score (experiment 1.44.vs control 2.89, $p = 0.17$) between the two groups.

Conclusions: Due to small sample size, it is inconclusive that 12 sessions of 30-minute gait and balance training on perturbation treadmill improved walking and balance control same as overground training did in individuals with chronic stroke. A further study with adequate sample size should be done.

Keywords*:* stroke, walking, postural balance, perturbation treadmill, gait training

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Introduction

Stroke is one of the leading public health problems, resulting in a significant number of deaths and disabilities.[1,2] In Thailand, the cumulative national loss of disability-adjusted life years (DALYs) due to stroke confirms that the consequences of stroke are one of the greatest burdens on patients and their families.[2] The Health Data Center (HDC) database from the Thai Ministry of Public Health indicates that there will be more than 250,000 new stroke cases over the age of 50 in 2021.[3] Stroke increases the risk of falls and serious injuries.[4] Stroke survivors living in community have higher risk of fractures than normal population[4] and higher risk of falls than healthy people of the same age.[5]

A systematic review in 2017 showed 3,105 participants from 56 studies, body weight-supported treadmill training (BWSTT) significantly contributes to improved gait speed and endurance in stroke patients who can walk independently[6] but not in those who depended on assistants for walking.[6] Different ways to improve efficacy of gait and balance training after stroke have been suggested, for examples, not using a handrail for support,[7] modifying walking speed during training,[8] altering visual input,[9] and provision of externally generated disturbances that mimic slipping and tripping.[10,11] The latter methods need high cost specialized gait training equipment.

As a specialized rehabilitation institute, we have a special Perturbation treadmill which has been claimed to improve postural balance during walking for those having impaired postural stability and risk of fall, for example, those with Parkinson's disease.[12] However, there has been no previous studies comparing between gait and balance training on Perturbation treadmill and overground in those with chronic stroke. If the gait and balance training on perturbation treadmill shows better outcome than overgound training, it may be worth to use this more expensive equipment in practice especially in those whose walking and balance control is not improved by overground training.

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Methods

Study design

This randomized controlled trial (RCT) was approved by the Human Research Ethics Committee of Sirindhorn National Medical Rehabilitation Institute, internal no. 3/2561.

Participants

Outpatients with chronic stroke who were referred to the Physical Therapy Unit, Sirindhorn National Medical Rehabilitation Institute were invited to participate in the study. After receiving informed consent, they were screened for eligibility. Inclusion criteria included demonstrable weakness of one leg, 6 months or longer after a first-ever stroke, age between 18-75 years, and ability to walk without ambulatory aids for at least 10 meters.

Exclusion criteria were having spasticity of the affected legs with modified Ashworth Scale > 2, impaired motor control due to neurological diseases other than stroke, severe balance deficit with static standing balance less than fair grade,[13] Thai-mental status examination (TMSE) score < 25, unilateral neglect, wounds on the feet and arthritis of lower extremities, joint replacement, body weight > 135 kg and receiving robot-assisted gait training.

Randomization

Eligible participants were randomly assigned to experimental and control groups using computer-assisted mixed block randomization.

Intervention

Before gait and balance training, all participants received a 30-minute bench exercise program which consisted of passive stretching exercises followed by resistance, active, or assisted hip, knee, and ankle range of motion exercises depending on existing muscle power, muscle tone and motor control. Static, not dynamic, sitting and standing balance exercises were included.

The experimental group received a 30-minute gait and balance training session on perturbation treadmill using BalanceTutor™ (Meditouch Company, Netanya, Israel) controlled by an experienced physical therapist (NS). All participants wore a harness for safety, not for partial body weight support as their body weight support was set to zero. They were then instructed to walk forward on the treadmill, not backward or sideway, at a self-selected and comfortable speed, without holding a side rail, initially without any interference. Later, perturbation generated by moving the treadmill in one of the four directions (forward, backward, left, and right) occurred at random intervals and directions with an average frequency of 6 stimulations per minute. The amplitude of the perturbation was adjusted in 0.5 centimeters increments between 0 and 15 centimeters. The speed of the treadmill and the amplitude of the disturbance were set to the highest possible level that the participants could continue without losing balance. There was no computer screen for visual feedback.

The control group received a 30-minute session of overground gait and balance training supervised by an experienced physical therapist (OS) without making physical contact unless one appeared to lose balance and needed hands-on correction. This overgound gait and balance training consisted of walking forward at a comfortable pace, intentionally walking with a narrower based than normal, sudden stopping and starting to walk when hearing verbal instructions from the supervising therapist, and finally walking in a zig-zag pattern. No other instructions on walking speed, stride length, or cadence were given. Walking backwards and sideways were not part of the training. And, they were not allowed to use a gait aid during training.

During the trainings, the participants in both groups were allowed to rest as often as necessary but all had to complete 30 minutes of walking, and attend the assigned training 3 times per week for 4 weeks, totally 12 training sessions, They also had to report the researchers if any accident such as a fall occurred.

Outcome measurements

Primary outcome was Timed Up and Go (TUG) test and secondary outcomes was Berg Balance Scale (BBS). Before and after completion of the 12-session training, a blinded physical therapist (MM) assessed all participants of both groups with TUGT and BBS.

The TUGT test is a tool to assess balance when walking by measuring the time to get up from a chair, walk a distance of 3 meters, turn around and come back to sit at a chair.[14] In this study, all participants were asked to walk with the fastest speed and we used a G-Walk (Meditouch Company, Netanya, Israel) equipped with a software to record the TUG time.[15] The test was repeated three times and the times recorded in seconds were averaged for further analysis.

BBS is a tool to assess basic balance required for everyday activities for the elderly and patients with neurological disorders.[16] The test includes 14 activities such as standing up from a seated position, standing still and reaching for objects, and stepping. Each activity is graded on a scale of 0 to 4 (5 levels), with a total score of 56 points, and score less than 45 indicates a greater risk of falling.[16]

Remark: This report is a part of the main project of Effectiveness of perturbation treadmill training and conventional gait training on balance control in stroke patients: a randomized controlled trial, and only some relevant data were reported and analaysed.

Sample size calculation

Our superiority hypothesis was the training on perturbation treadmill resulting in better walking and balance outcomes than the overgroup training did. Based on the mean and standard deviation of TUG times from the study of Jung et al.[17] and using n4Studies, the calculated sample size in each group was 26. When adding 25% drop out, the total expected number of participants were 66, 33 in each group.

Statistical methods

Demographic data were described using descriptive statistics. Kolmogorov-Smirnov test was used to test the data distribution. If the data was normally distributed, paired t-test was used to compare the mean values of TUG and BBS of pre- and post-training within group; and independent t-test to compare the pre-post difference between groups. A *p*-value < 0.05 was considered as significant difference by using SPSS.

Results

From November 2018 to December 2020, only 20 participants were eligible and randomized,[11] were assigned to the experimental group and 9 to the control group. Two in the experimental group could not complete the study and dropped out, one moved to another province and the other had a accidental fall at home with no fracture but needed 18 days of hospitalization. There was no drop out in the control group. The participants' demongraphic data as well as baseline results of the TUG test and BBS are shown in Table 1 and showed no statistically significant differences between groups.

Compared with the pre-training assessment (see Table 2), the post-training TUG time decreased in both groups but not reached statistically significant level whereas the post-training BBS score increased with statistically significant differences in both groups. However, there were no significant differences of the pre-post TUG time and BBS score between the two groups.

Discussion

Due to COVID-19 pandemic we had difficulty in recruiting outpatients to participate in the study. With small sample size, the results assumed as a preliminary report shows that the training on perturbation treadmill was not superior than the overground training as there were no statistically significant differences between groups.

Interestingly, statistically significant improvement in BBS balance score was found in both groups, but not in the TUG time. The improvement in the TUG time in both groups seems minimal and similar. Although randomization was done, the experimental group had older age but shorter duration of stroke than the control group. These factors may affect the TUG time. However, due to the limitation of samle size, relationship between the TUG time and these factors was not analysed.

Moreover, the mean BBS score increased 1.44 points in the experimental group and 2.89 points in the control group. The value of the control group seems comparable with results reported from other studies. For example, a systematic review showed that various kinds of gait training improved the BBS score of patients with chronic stroke by an average of 2.26 points.[18] However, the reference value of the smallest real difference (SRD) for BBS is 6.7 points,[19] and the minimal clinically important difference (MCID) for BBS is 5 points.[20] Therefore, when planning the next study, we have to consider whether more sessions of training will result in more points gained in BBS, and concern of difficulty in recruiting outpatient

Table 1. Comparison of participants' demographic and baseline assessment data between groups.

	Experimental group (N = 9)	Control group (N = 9)	*p*-value
Demographic data			
Gender: male/female[1]	7/2	7/2	1.00[a]
Age, years[2]	57.11 (10.09)	48.33 (14.31)	0.15[b]
Lesion: ischemic/hemorrhagic stroke[1]	7/2	7/2	1.00[a]
Affected side: left/right[1]	8/1	6/3	0.26[a]
Duration of illness, months[2]	7.78 (1.56)	12.11 (6.25)	0.06[b]
Baseline assessment			
TUG, seconds[2]	22.43 (6.81)	27.63 (13.19)	0.31[b]
BBS score[2]	49.55 (2.19)	47.33 (3.46)	0.90[b]

[1]Number, [2]mean (SD); [a]Pearson Chi-square for clustered data, [b]independent t-test

TUG, Timed Up and Go; BBS, Berg Balance Scale

Table 2. Comparison between pre- and post-training TUG time and BBS score within group and between groups.

Variable	Experiment (N = 9)		*p*-value[a]	Control (N = 9)		*p*-value[a]	Pre-post difference		*p*-value[b]
	Pre	Post		Pre	Post		Experiment	Control	
TUG, seconds	22.43 (6.81)	21.33 (7.44)	0.35	27.63 (13.19)	26.45 (12.74)	0.36	1.10 (3.31)	1.18 (3.64)	0.96
BBS Score	49.55 (2.19)	51.00 (2.40)	0.02*	47.33 (3.46)	50.22 (2.05)	0.01*	1.44 (1.51)	2.89 (2.62)	0.17

Mean (SD)

[a]Paired t-test,*statistically significant at $p < 0.05$; [b]independent t-test

TUG, Timed Up and Go; BBS, Berg Balance Scale participants and drop out rate which seemed to be barriers to complete the trail in the study.

This preliminary results demonstrating the lack of a statistical difference in the improvement of the TUG time and BBS score between the two groups. To prove this assumption, more sample size is needed. The data (mean and SD) from this study can be used to calculate the sample size of the future trails. Given the large cost differences between these two gait and balance training programs, future studies are needed to clarify not only the efficacy of the perturbation treadmill in gait rehabilitation of chronic stroke patients but also the cost-effectiveness of the therapy. In addition, fall rate should be included as an outcome parameter.

As the above-mentioned results show better outcome of BBS in the control group, the overground gait and balance training program as described in this study may provide sufficiently intensive and specific gait and balance training because it involves a mixture of sudden acceleration, deceleration (start and stop of gait), and change of direction (zigzag walking), which increases the need for dynamic balance correction (narrow-based walking). Next, perhaps the duration of training (30 minutes of total active training time) is another important factor. The use of telerehabilitation technologies for overground gait and balance training is conceivable. This has the potential to provide a very cost-effective solution for maintaining independence and preventing fall-related injuries in chronic stroke patients and should be a focus of future studies.

Conclusions

Due to llimited sample size, it is inconclusive that 12 sessions of 30-minutue gait and balance training on perturbation treadmill gives no better walking and balance than overground training. The results and limitations learned from this study can be used when planning the next proper trials to evaluate the effectiveness of both training programs.

Disclosure

The researchers (PS and TN) had received an education grant from the Meditouch Company to train how to properly use the equipment.

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References

1. Suwanwela N. Stroke epidemiology in Thailand. JOS. 2014;16:1-7.
2. Bundhamcharoen K, Odton P, Phulkerd S, Tangcharoensathien V. Burden of disease in Thailand: changes in health gap between 1999 and 2004. BMC Public Health. 2011;11:53. doi:10.1186/1471-2458-11-53.
3. HDC service.moph.go.th [Internet]. Nonthaburi: The prevalence of stroke. [cited 2021 Dec 30]. Available from: https://hdcservice.moph.go.th/hdc/reports/report.php?source=formated/ncd.php&cat_id=6a1fdf282fd28180eed7d1cfe0155e11&id=3092c3c3250ae67155f7e134680c4152.
4. Zheng JQ, Lai HJ, Zheng CM, Yen YC, Lu KC, Hu CJ, et al. Association of stroke subtypes with risk of hip fracture: a population-based study in Taiwan. Arch Osteoporos. 2017;12:104. doi:org/10.1007/s11657-017-0390-8.
5. Tsang CSL, Pang MYC. Association of subsequent falls with evidence of dual-task interference while walking in community-dwelling individuals after stroke. Clin Rehabil. 2020;34:971-80.
6. Mehrholz J, Thomas S, Elsner B. Treadmill training and body weight support for walking after stroke. Cochrane Database Syst Rev. 2017;8:Cd002840.
7. Graham SA, Roth EJ, Brown DA. Walking and balance outcomes for stroke survivors: a randomized clinical trial comparing body-weight-supported treadmill training with versus without challenging mobility skills. J Neuroeng Rehabil. 2018;15:92. doi:org/10.1186/s12984-018-0442-3.
8. Pohl M, Mehrholz J, Ritschel C, Rückriem S. Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: a randomized controlled trial. Stroke. 2002;33:553-8.
9. Ha SY, Sung YH. Effects of Fresnel prism glasses on balance and gait in stroke patients with hemiplegia: a randomized controlled trial pilot study. Technol Health Care. 2020;28:625-33.
10. Dusane S, Bhatt T. Effect of multisession progressive gait-slip training on fall-resisting skills of people with chronic stroke: examining motor adaptation in reactive stability. Brain Sci. 2021;11,894. doi:org/10.3390/brainsci11070894.
11. Nørgaard JE, Andersen S, Ryg J, Stevenson AJT, Andreasen J, Danielsen MB, et al. Effects of treadmill slip and trip perturbation-based balance training on falls in community-dwelling older adults (STABILITY): study protocol for a randomised controlled trial. BMJ Open. 2022;12:e052492. doi: 10.1136/bmjopen-2021-.
12. Protas EJ, Mitchell K, Williams A, Qureshy H, Caroline K, Lai EC. Gait and step training to reduce falls in Parkinson's disease. Neuro Rehabilitation. 2005;20:183-90.
13. O'Sullivan SB, Schmitz TJ, Fulk GD. Physical rehabilitation: 6th ed. Philadelphia: FA Davis. 2014.
14. Shumway-Cook A, Brauer S, Woollacott M. Predicting the probability for falls in community-dwelling older adults using the timed up & go test. Phys Ther. 2000;80:896-903.
15. Andrenacci I, Boccaccini R, Bolzoni A, Colavolpe G, Costantino C, Federico M, et al. A comparative evaluation of Inertial Sensors for gait and jump analysis. Sensors. 2021;21,5990. doi:org/10.3390/s21185990.
16. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health. 1992;83 Suppl 2:S7-11.
17. Jung J, Yu J, Kang H. Effects of virtual reality treadmill training on balance and balance self-efficacy in stroke patients with a history of falling. J Phys Ther Sci. 2012;24:1133-6.
18. Van Duijnhoven HJ, Heeren A, Peters MA, Veerbeek JM, Kwakkel G, Geurts AC, et al. Effects of exercise therapy on balance capacity in chronic stroke: systematic review and meta-analysis. Stroke. 2016;47:2603-10.
19. Liaw LJ, Hsieh CL, Lo SK, Chen HM, Lee S, Lin JH. The relative and absolute reliability of two balance performance measures in chronic stroke patients. Disabil Rehabil. 2008;30:656-61.
20. Tamura S, Miyata K, Kobayashi S, Takeda R, Iwamoto H. The minimal clinically important difference in Berg Balance Scale scores among patients with early subacute stroke: a multicenter, retrospective, observational study. Top Stroke Rehabil. 2022;29:423-9.