ORIGINAL ARTICLE

Effectiveness of Partial Body-Weight Supported Treadmill Training-Audio Cues and Traditional Overground Walking in Improving Gait Speed and Cardiorespiratory Fitness After Stroke

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ABSTRACT

Objective: To compare the effectiveness of Partial Body-Weight Supported Treadmill Training-Audio Cues (PBWSTT-AC) and the traditional over ground walking in improving gait speed and cardiorespiratory fitness after stroke.

Methods: pretest-posttest control group design of patients with sub-acute and chronic ischemic stroke who came to Physical Medicine and Rehabilitation (PMR) Department of Dr. Soetomo and Airlangga University Hospital Surabaya. Patients with onset 3 weeks until 10 years, age between 21 until 70 years old, able to walk independently for 6 minutes, sufficient vision and hearing and can follow simple instructions were included in this study. There were 18 patients at beginning and 16 patients completed the study. Patients underwent walking exercise for 20 minute, 3 times a week for 12 sessions. PBWSTT-AC group received metronome auditory rhythmic stimulation, while control group received traditional walking exercise with customized speed according to patient's preference. Gait speed were assessed by 10 meter Walk Test and cardiopulmonary endurance counted from resting heart rate.

Results: There were improvements in gait speed and cardiorespiratory fitness within each subject group. Traditional group showed significantly larger increases in fast gait speed (p=0.023) but not in self-selected gait speed (p=0.002). PBWSTT-AC group showed significantly larger decreases (p=0.002) in resting heart rate (p=0.003).

Conclusion: PBWSTT-AC was not shown to be superior to traditional walking in improving gait speed, but superior in improving cardiorespiratory fitness. Further study are needed to evaluate the long-lasting effect of using PBWSTT-AC in improving cardiorespiratory fitness.

Keywords: *Partial Body-Weight Supported Treadmill Training-Audio Cues, gait speed, cardio respiratory fitness*

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INTRODUCTION

Cerebro Vascular Accident or stroke is the leading cause of long-term disability in the world that results not only in persistent neurological deficits, but also profound physical deconditioning that propagates disability and worsen cardiovascular risk. Approximately 54-

80% patient who survived can walk, but only 15% can walk outside the house.[1, 2] In 2011, 864 stroke patients (5.22% of all patients) visited Physical Medicine and Rehabilitation Outpatient Clinic Dr. Soetomo Hospital.

Most of post stroke patient will be deconditioning physiologically caused by disease and prolonged immobilization, including fatigue (70%), endurance limitation, poor toleration of exercise, orthostatic hypotension, lack of motivation and depression. Eventhough several prevention techniques, such as early mobilization, early and subsequent participation in rehabilitation and also implementation of balanced schedule between rest and activity, but majority of patients (almost complete recovery) report fatigue tendency and endurance limitation (VO_2 max 50-60% of the age- and sex- matched normative values in healthy person).[2-4]

Walking speed predicts the level of disability. At a walking speed of more than 0.8 m per second, full mobility in the community is likely; at a walking speed of less than 0.4 m per second, mobility is limited to the home; and at speeds of 0.4 to 0.8 m per second, mobility is limited to short walks in the community.[5]

Locomotor training, including the use of Partial Body-Weight Supported Treadmill Training-Audio Cues (PBWSTT-AC) is a rehabilitation intervention used to improve the ability to walk after stroke. The effectiveness and appropriate timing of this intervention have not been established.[1, 2, 5, 6]

This study was a pilot study in The Department of Physical Medicine and Rehabilitation Dr. Soetomo Hospital to evaluate the effectiveness of walking exercise using PBWSTT-AC and traditional over ground walking in improving gait speed and cardiorespiratory fitness patients with sub-acute and chronic stroke.

METHODS

Population

Patients with sub-acute and chronic ischemic stroke who referred to Department of Physical Medicine and Rehabilitation with onset 3 weeks until 10 years, age between 21 until 70 years old, can walk independently for 6 minutes with or without ambulation aids or orthosis, sufficient vision and hearing and can follow simple commands were included in this study. Those with uncontrolled hypertension, cardiorespiratory problems, apraxia, severe hemispatial neglect, aphasia, musculoskeletal disturbances, severe spasticity, tremor, ataxia, severe sensory disturbances were excluded from the trial.

Study Protocol and Interventions

Block randomization sampling were used to randomize patients into either the intervention or control group. The participants consisted of 16 patients who fulfilled the inclusion criteria and were enrolled into the trial. The first group were treated with PBWSTT-AC, while the second group acted as control.

Patients in the intervention group underwent walking exercises for 20 minutes 3 times a week for 12 sessions in PBWSTT (Biodex Gait Trainer 2 and Unweighing System) with metronome auditory rhythmic stimulation (125% of step cycle's rhythm) to optimize learning process. Control subjects received traditional over ground walking exercise with speed according to patient's preference.

Outcome Measures

The primary outcome measure was walking speed, performed by 10 meter Walk Test (10-mWT) and cardiopulmonary endurance, counted from resting heart rate. The 10-mWT is counted by dividing the time needed for walking 6 meters in distance, and repeated 3 times. Resting heart rate counted by palpation of radial artery's pulsation for 1 minute using the index and middle finger. All parameters were evaluated at the baseline and after 12 sessions of exercise.

Data Analysis

All analysis were conducted using SPSS version 13. Statistical calculation were performed using independent samples t-test for numerical data and Wilcoxon signed-ranked test for ordinal data, with $p < 0.05$ considered significant.

RESULTS

Baseline characteristics of subjects

There were 16 participants in total: 8 were randomised into intervention group and 8 into control group. There was no significant difference on baseline characteristics between the intervention and control group except the walking speed (SS and Fast), resting heart rate (Table 1). The mean age of subjects in the control group was older than that in the control group, but there was no significant different between them. Most of subjects in both group had a subacute stroke.

Table 1. Baseline Characteristic of the Intervention and Control Group

Karakteristik	PBWSTT-AC n = 8	Traditional n = 8	p value
Age (year)	51 (11.377)	55.88 (6.83)	0.316
Sex (female/male)	4/4 (50% / 50%)	2/6 (25%/75%)	0.608
Education (SD/SMP/SMA(K))	1/2/5 (12.5%/25%/62.5%)	2/2/4 (25%/25%/50%)	0.558
Body Mass Index (kg/m2)	23.290 (4.454)	25.421 (2.961)	0.279
Previous level of activity (mild/moderate)	4/4 (50% / 50%)	1/7 (12.5% / 87.5%)	0.282
Stroke onset (subacute/ chronic)	5/3 (62.5% / 37.5%)	5/3 (62.5% / 37.5%)	1.000
Walking speed SS (m/s)	0.5 (0.3)	0.9 (0.2)	0.009
Walking speed FAST (m/s)	0.7 (0.5)	1.3 (0.2)	0.014
Resting heart rate (bpm)	92.9 (10.4)	79.8 (4.9)	0.006

note:
value is mean (SD)
† p considered significant ($p<0.05$)

Walking Speed

There was a significant difference between the intervention (PBWSTT-AC) and the control (traditional) group for baseline of self-selected walking speed (p=0.009). Both groups gained a significant increase of self-selected walking speed after 12 sessions of treatment (p PBWSTT-AC=0.029; p traditional=0.002) (Table 2).

Table 2. Evaluation of Walking Speed SS of PBWSTT-AC and Control Group

	PBWSTT-AC n = 8	Traditional n = 8	p value
Baseline (m/s)	0.5 (0.3)	0.9 (0.2)	0.316
Evaluation after 12 session(m/s	0.7 (0.4)	1.1 (0.2)	0.608
Evaluation session 12 – baseline (m/s)	0.2 (0.2)	0.2 (0.1)	0.558
p value	0.029†	0.002†	0.279

note:
value is mean (SD)
† p considered significant ($p<0.05$)

Both groups had significant difference in baseline of fast walking speed (p=0.014). The traditional group showed a significant increase of fast walking speed greater than that in the PBWSTT-AC group after 12 sessions of treatment (p=0.023) (Table 3).

Table 3. Evaluation of Walking Speed Fast of PBWSTT-AC and Control Group

	PBWSTT-AC n = 8	Traditional n = 8	p value
Baseline (m/s)	0.7 (0.5)	1.3 (0.2)	0.014†
Evaluation after 12 session(m/s)	1.0 (0.5)	1.5 (0.3)	-
Evaluation session 12 – baseline (m/s)	0.3 (0.4)	0.2 (0.2)	0.595
p value	0.066	0.023†	

note:
value is mean (SD)
† p considered significant ($p<0.05$)

Cardiorespiratory Fitness
There was a significant difference between the PBWSTT-AC and the traditional group for baseline of resting heart rate as indicator of cardiorespiratory fitness (p=0.006). After 12 sessions of exercise, both groups showed a decrease of resting heart rate, but the intervention group (p=0.002) scored significantly greater decreases of resting heart rate than that in the control group (p=0.003). After 12 sessions, there was significant difference between both groups (p=0.014) (Table 4).

Table 4. Evaluation of Resting Heart Rate of the PBWSTT-AC and Control Group

	PBWSTT-AC n = 8	Traditional n = 8	p value
Baseline (bpm)	92.9 (10.4)	79.8 (4.9)	0.006†
Evaluation after 12 session(bpm)	79.7 (11.8)	75.1 (5.2)	-
Evaluation session 12 - baseline(bpm)	-13.1 (8.0)	-4.6 (3.0)	0.014†
p value	0.002†	0.003†	

note:
value is mean (SD)
† p considered significant ($p<0.05$)

Withdrawals
On the second session, 1 participant in the intervention group withdrew because of no complaint on walking subjectively. After 8 sessions, 1 participant in the control group cannot continue due to left distal radius fracture.

DISCUSSION

The PBWSTT-AC exercise protocol
Many protocols are used in walking rehabilitation, especially the PBWSTT but there is no precise concensus between the experts about the optimal technique and prescriptions (frequency, intensity and duration).[2, 5-7]

The protocol of PBWSTT-AC was selected in Rehabilitation Department of Airlangga University (due to Biodex Gait Trainer 2 facility). The adopted frequency and duration guidelines are based on cardiovascular endurance exercise protocol for about 20 to 60 minutes with an intensity achieving target heart rate (60% of maximal heart rate).[8, 9] Before and after exercise, patients have to do warming up and cooling down for 15 minutes. If any complaints of chest pain, pallor, over sweating, palpitation, dyspnea or headache presence, patients can take a break for about of 5-10 minutes. Audio-cues are added to PBWSTT exercise using metronome with frequency of 125% from the baseline based from auditory entrainment phenomenon to increase the excitability of spinal motor neuron.[10, 11]

Final evaluation of resting heart rate, self-selected and fast walking speed are calculated using resting heart rate and 10-mWT after 12 sessions of exercise, as shown on previous study where improvement occurred after 3 weeks of rehabilitation.[2, 6, 12]

The Traditional Exercise Protocol

The traditional, control group executes traditional walking exercise with individualized speed according to patient's preference without audio-cues. Other protocols are similar to PBWSTT-AC group.

Main Findings on PBWSTT-AC and Traditional Groups

Significant differences are produced between the intervention and control groups on the baseline value of self-selected and fast walking speed. Walking speed is an important function marker in stroke patients.[13,14] Self-selected walking speed in traditional group was faster (0.4m/s) in correlation with different level of motoric impairment and history of previous stroke. These finding might be caused by the wide range of characteristics and severity of stroke. Individual with severe hemiparesis cannot increase the strength of ankle plantar flexion and hip flexion to speeding-up their self-selected walking speed.[15]

Both the intervention and control group gained significant increase on self-selected walking speed after 12 sessions of exercise (p=0.029 and p=0.002) but no difference between groups (p=0.926). This finding is parallel to other studies showed that treadmill training with PBWSTT and progressive exercise at home show the same results for parameters on walking speed, motoric improvement, balance, functional status and quality of life.[16-19] Furthermore, based on a study by Duncan et al., they need 50 to 200 hours of PBWSTT exercise to achieve good results.[5]

The traditional group is the only group with significant increase on fast walking speed after 12 sessions of exercise (p=0.023). It might be due to the severity of impairment. Two subjects with severe impairment in the PBWSTT-AC group utilize ankle foot orthosis and cane to overcome their weakness. These would influence their capability to increase their walking speed. Improvement in walking speed can be reached 2 weeks after the initial treatment and additional benefits will be gained a week later.[6]

The baseline value of resting heart rate between the two groups is significantly different (p=0.006). PBWSTT-AC group shows higher value with the probability of worse cardiovascular conditions. Both groups obtain significant decrease of resting heart rate after 12 sessions of exercise (p=0.002 and p=0.003). The PBWSTT-AC group shows significant difference in which the decrease resting heart rate acts as a marker of cardiorespiratory fitness (p=0.014). This might be due to the progressivity of exercise from the first until last sessions (125% from initial step length) results in improvement of VO_2max and walking economy.

There are interactions among several factors such as exercise intensity, autonomic modulation of heart and cardiovascular fitness that will influence changes in resting heart rate.[20] Risk of mortality increases by 16% every 10-22 heart beats per minute.[21]

In this study, age is the only factor that influences self-selected walking speed. It is the predictor of therapy results because of its correlation to physical and mental status of patients and neuroplasticity changes. Moreover, interventions (PBWSTT-AC), level of physical activity and stroke onset are factors that affect the resting heart rate.

Limitation of this study

There are limitations found in this study. The baseline characteristics of self-selected and fast walking speed and resting heart rate are not homogenous between the intervention and control group. Locations, severity of stroke, effects of ankle foot orthosis and ambulation aids, and audio-cues are not analyzed in this study. Another limitation is the long-lasting effects of walking rehabilitation has not been evaluated further after some period of time.

CONCLUSION

Walking rehabilitation using PBWSTT-AC and traditional over ground walking method show similar efficacy in improving self-selected walking speed. Evidence has shown the efficacy of these exercises for post stroke patients.

PBWSTT-AC does not appear to be superior to traditional over ground walking in improving gait speed, but superior in improving cardiorespiratory fitness. Based on this study, post stroke patients with deconditioning problems who are already able to ambulate independently with or without ambulation aid and or othosis are the good candidates for PBWSTT-AC in improving cardiorespiratory fitness.

Further trials with better methodology are needed to evaluate the long-lasting effect of walking rehabilitation using PBWSTT-AC in improving cardiorespiratory fitness, factors influencing the efficacy of exercise, effect of adding PBWSTT in combination with traditional over ground walking method, and exact dose of exercise (frequency, intensity, duration and type) in improving fast walking speed.

REFERENCES

1. Harvey RL, Roth EJ, Yu D. Rehabilitation in Stroke Syndromes. In: Braddom RL, editor. Physical Medicine and Rehabilitation Braddom. 3rd ed; 2010. p. 1180-206.
2. Ivey FM, Hafer-Macko CE, Macko RF. Exercise Rehabilitation After Stroke. The Journal of the American Society for Experimental NeuroTherapeutics. 2006;3:439–50.
3. Macko R, Ivey FM, .Forrester LW, Hanley D, Sorkin JD, I.Katzel L, et al. Treadmill Exercise Rehabilitation Improves Ambulatory Function and Cardiovascular Fitness in Patients With Chronic Stroke : A Randomized Controlled Trial. Stroke. 2005;36:2206-11.
4. Baert I, Daly D, Dejaeger E, Vanroy C, Vanlandewijck Y, Feys H. Evolution of Cardiorespiratory Fitness After Stroke: A 1-Year Follow-Up Study. Influence of Prestroke Patients' Characteristics and Stroke Related Factors. Arch Phys Med Rehabil. 2012;93(4):669-76.
5. Duncan P, Sullivan KJ, Behrman AL, Azen SP, Wu SS, Nadeau SE, et al. Body-Weight-Supported Treadmill Rehabilitation after Stroke. The New England Journal of Medicine. 2011;364:2026-36.
6. Peurala SH, Tarkka IM, Pitkänen K, Sivenius J. The Effectiveness of Body Weight–Supported Gait Training and Floor Walking in Patients With Chronic Stroke. Arch Phys Med Rehabil. 2005;86:1557-64.
7. Hesse S, Werner C, Paul T, Bardeleben A, Chaler J. Influence of Walking Speed on Lower Limb Muscle Activity and Energy Consumption During Treadmill Walking of Hemiparetic Patients. Arch Phys Med Rehabil. 2001;82:1547-50.
8. Mahler DA. Prinsip Umum Peresepan Latihan. In: Mahler DA, editor. ACSM Panduan Uji Latihan Jasmani dan Peresepannya. 5th ed. Jakarta: EGC; 1995. p. 54-140.
9. Moldover JR, Stein J, Krug PG. In: G.Gonzales E, editor. Cardiopulmonary Physiology. 3rd ed. Boston: Butterworth Heinemann; 2001.
10. Kwak EE. Effect of Rhythmic Auditory Stimulation on Gait Performance in Children with Spastic Cerebral Palsy. Journal of Music Therapy. 2007;44(3):98-216.
11. Thaut M, Abiru M. Rhytmic Auditory Stimulation in Rehabilitation of Movement Disorders. Music Perception. 2009;27(4):283-69.
12. Lee SH, Lee KJ, Song CH. Effects of Rhytmic Auditory Stimulation (RAS) on Gait Ability and Symmetry after Stroke J Phys Ther Sci 2012;24(4):311-4.
13. Perry J, Garrett M, Gronley JK, Mulroy SJ. Classification of Walking Handicap in the Stroke Population. Stroke. 1995;26:982-9.
14. Studenski S, Perera S, Patel K, Rosano C, Faulkner K, Inzitari M, et al. Gait Speed and Survival in Older Adults. JAMA. 2011;305(1):50-8.

15. Beaman, Peterson, Neptune, Kautz. Differences in self-selected and fastest-comfortable walking in post-stroke hemiparetic persons. Gait and Posture. 2010;31:311-6.
16. Ada L, Dean CM, Morris ME, Simpson JM, Katrak P. Randomized Trial of Treadmill Walking With Body Weight Support to Establish Walking in Subacute Stroke : The MOBILISE Trial. Stroke : Journal of American Heart Association. 2010;41:1237-42.
17. Hoyer, Jahnsen, JK S, LI S. Body weight supported treadmill training versus traditional training in patients dependent on walking assistance after stroke: a randomized controlled trial. Diabil Rehabil. 2012;34(3):210-9.
18. Duncan P, Sullivan KJ, Behrman AL, Azen SP, Wu SS, Nadeau SE, et al. Protocol for the Locomotor Experience Applied Post-stroke (LEAPS) trial: a randomized controlled trial. BMC Neurology. 2007;7:39.
19. Franceschini M, Carda S, Agosti M, Antenucci R, Malgrati D, Cisari C. Walking After Stroke: What Does Treadmill Training With Body Weight Support Add to Overground Gait Training in Patients Early After Stroke? : A Single-Blind, Randomized, Controlled Trial. Stroke. 2009;40:3079-85.
20. Boone T. Post-Exercise Heart Rate Recovery: an Index of Cardiovascular Fitness. Journal of Exercise Physiology online. 2009 February 2009;12(1):19-22.
21. Jensen MT, Suadicani P, Hein HO, Gyntelberg F. Elevated resting heart rate, physical fitness and all-cause mortality: a 16-year follow-up in the Copenhagen Male Study. Heart (British Cardiac Society). 2013;99(12):882-7.