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Comparative efficacy of treadmill training and combination of bicycle ergometer and over-ground walk on functional ambulation post-stroke - a pilot study

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Abstract

The recovery of ambulation is an important focus of rehabilitation for both stroke survivors and their rehabilitation team. This study was conducted to compare the therapeutic efficacy of treadmill training and combination of bicycle ergometer & over ground walk training on functional ambulation (FA) post stroke.

Fifteen stroke survivors participated in a 6-week, 2-group quasi-experimental study which was conducted at the Aminu Kano Teaching Hospital. Walking speed was used to rate FA of participants. Participants were randomly distributed into 2 groups: A (treadmill training) and B (bicycle ergometer and over ground walking training). The data was analysed with inferential statistics of Wilcoxon sign rank test and Mann-Whitney U test to determine within and between group differences in FA respectively.

The mean age and baseline FA of the participants in group A was 47.78 ± 8.17 years and 0.32±0.08 m/s while that of participants in group B was 46.9 ± 7.11 years and 0.34±0.15 m/s. There were a significant within group difference (pre versus post intervention) in the scores of FA in group A ($p=0.018$) and group B ($p=0.043$). There was however insignificant between group difference (treadmill versus bicycle ergometer and over ground walking) in FA at baseline ($p>0.05$) and post intervention periods ($p>0.05$).

This study concluded that both treadmill training and combination of bicycle ergometer and over ground walking are effective in the retraining FA post stroke, however, combination of 2 task-oriented exercises did yield better recovery of FA than using treadmill training alone.

Key words: stroke, treadmill, over-ground walk, bicycle ergometer, functional ambulation

Introduction

Motor impairment is one major of consequences of having stroke that leads to impairment of functional ambulation, difficulty going out of the house and doing leisure activities [1]. A number of stroke survivors suffer significant decline in their ability to ambulate [2] and up to 14.6% were unable to walk independently in the community without any supervision [3]. Improvement in walking ability is one of the highest priorities for people living with stroke [4]. Independence in ambulation was also seen as a highly desired goal among stroke survivors and that is why it is being used as a yardstick for measuring functional recovery by both patients and their relatives [5]. Loss of independent ambulation, especially outdoors, has been described as one of the most disabling consequence of having a stroke [1].

Studies have shown that task-oriented training increases ambulation capacity through improvement in spatio-temporal gait parameters, muscle strength, speed and gait endurance post stroke [6,7,8,9,10]. It has been opined that treadmill training may be an effective treatment for improving gait asymmetries post-stroke [11,12]. Treadmill training improves functional mobility, cardiovascular fitness [13], stride length, cadence, distance walked and gait velocity [14]. Over-ground walking training with partial body weight support also improves spatio-temporal gait parameters of stroke patients [15]. It increases walking speed, endurance, and balance [16]. A study found that combined treadmill and over-ground walking program was effective in improving functional ambulation after stroke [17].

Additionally, studies have also compared the effectiveness of treadmill training and over-ground walking exercise on functional ambulation recovery post stroke but up to date there is no consensus on which of the two treatment protocols is the most effective. For instance, it was reported that over-ground walking was more effective in improving gait endurance than treadmill training [16]. Over-ground walking also produced higher muscle activity and activated several muscles during gait cycle compared with robot-assisted treadmill walking [11]. A study found however that treadmill training was effective in improving functional ambulation and perception of walking than over-ground walking [18]. Other studies reported that the two treatment programs are likely to produce similar therapeutic effects on functional ambulation [19,20]. It is, therefore, not clear based on the available literature which of the two is the best form of training technique.

It is a common practice in most physiotherapy departments in Nigeria that gait retraining is usually done using combinations of different task-oriented training programs. But it is never known whether combining 2 different task-oriented exercises will yield better recovery of functional ambulation than practising only one. It was hypothesized that individuals that received combined task-oriented programs (bicycle ergometer and over-ground walking) would not be better than those who received only treadmill training in their functional ambulation recovery.

Methodology

A total of 15 consenting participants were recruited in this study using purposive sampling technique. Between group quasi-experimental research design was used for the study. The population involved stroke survivors attending outpatient physiotherapy clinic in Aminu Kano Teaching Hospital (AKTH). Eligible subjects fulfilled the following inclusion criteria: ability to walk a minimum of 10 meters with or without little physical assistance from a therapist or walking aid. Subjects were excluded if they had severe cognitive deficits. Inability to comprehend verbal instruction or to communicate (aphasia) and severe joint disorders (e.g. osteoarthritis) and comorbid obesity that restricts walking function.

Data collection procedure

Ethical approval was sought from ethical committees of AKTH. Following approval, consent of each subject was sought and obtained before participation. The subjects were screened for eligibility. Participants were randomised into group A (treadmill training) and group B (bicycle ergometer and over-ground walking) using simple random sampling. The participants were educated on the treatment protocols involved in the study. They were advised to wear comfortable clothing conducive to performing dynamic exercises. Blood pressure was measured before the exercise to ensure that participants are not having high blood pressures pre exercise.

Treadmill training group

The participants in group A walk on treadmill (Bonte Technology BV, Zwolle, Netherlands) at a comfortable treadmill speed. Each participant was treated twice weekly for 6 weeks. The treatment session lasted 6 minutes per session in weeks 1-2. The participants, were asked to walk for maximum of eight minutes in weeks 3-4. Finally they were asked to walk for 10 minutes in weeks 5-6. Participant who wished to have some rest were allowed to do so for maximum of 2 minutes after which they were asked to continue the training. But rest period was not a part of the total training time.

Combined Over-Ground Walking and Bicycle Ergometer Group

Participants in group B were asked to do over-ground walk to and from on a 20-meter pathway at a comfortable walking speed for 6 minutes every treatment

session conducted twice weekly for 6 weeks. Rest periods were allowed in between as might be required by a participant but the rest periods were not calculated as part of the total time for the over-ground training.

The participants in Group B also trained on bicycle ergometer (body guard ergocycle 955, Norway). The seat was adjusted to a comfortable height (with knee slightly bent at lowest pedal position). The weak lower limb was strapped to the bicycle ergometer pedal for comfort and to avoid sliding away of the participant's foot. The participants were then instructed to ride the bicycle ergometer at comfortable pedalling speed. The participants were treated twice weekly for 6 weeks. The participants were allowed to rest as the need arose. The resting period was not a part of the total training time.

Total time of training for group B

Week 1-2 = 12 minutes (6 minutes bicycling + 6 minutes over-ground walking).
Weeks 3-4 = 14 minutes (8 minutes bicycling + 6 minutes over-ground walking).
Weeks 5-6=16 minutes (10 minutes bicycling + 6 minutes over-ground walking).

Outcome assessment

Improvement of walking speed was used to rate functional ambulation performance among the participants. The baseline walking speed was assessed at the commencement of training. Participants were asked to walk at a comfortable walking speed to cover the 10-meter distance. The time taken to cover 10 meters was then recorded using a stopwatch. Walking speed was calculated as the distance covered per unit of time in meters per second. The post-intervention walking speed was measured the same way as the baseline measurement described above.

Data analysis procedure

Due to small sample size in both groups (8 and 7 respectively) non-parametric statistics were used. Also speed data for the combined bicycle ergometer and over-ground walking group was not normally distributed. Wilcoxon sign rank test was used to find within-group differences in walking speed. Between-group differences in walking speed, duration of stroke and age, were assessed with Mann-Whitney U test. Level of significance was set at 0.05. All calculations were conducted using SPSS version 16 on window software.

Results

Twenty three participants were initially recruited for this study, but only 15 participants completed the study. Group A consisted of 8 participants, 5 males (62.5%) and 3 females (37.5%). Group B consisted of seven participants, 4 males (57.1%) and 3 females (42.9%). Majority of the females in both groups were house wives and the average duration of stroke for both groups was 9 months as presented in table 1. Participants in the treadmill group had average speed of 0.32±0.08m/s and 0.37±0.10 m/s at baseline and post intervention, respectively. Participants in the combined over-ground walking and bicycle exercise group recorded average walking speed of 0.34±0.15 m/s and 0.40±0.23 m/s before and after intervention, respectively, as presented in table 2.

There was significant improvement in functional ambulation in the treadmill group ($p<0.05$) and in the combined over-ground walk and bicycle ergometer groups ($p<0.05$) with post intervention score being significantly greater than pre intervention score in both groups (table 3). Finally, there was no significant difference in functional ambulation across the 2 group both at baseline ($p>0.05$) and at post intervention periods ($p>0.05$) implying that combination of over-ground walk and bicycle ergometer is not better than the treadmill (table 4).

Table 1. Demographic characteristics of participants

VARIABLES	FREQUENCY
Age (years)	**Range (Mean ± SD)**
Group A	30-56 (45.40 ± 10.16)
Group B	25-55 (41.57 ± 11.21)
Duration of stroke (months)	
Group A	7-13 (9.38 ± 2.35)
Group B	5-18 (9.14 ± 4.49)
Occupation	**n (%)**
Group A	
Housewife)	3 (37.5)
Civil servant	2 (25.0)
Trader	2 (25.0)
Student	1 (12.5)
Group B	
Housewife	3 (37.5)
Civil servant	2 (25.0)
Trader	2 (25.0)

KEY: n=number of participants, SD=Standard Deviation, %=percent

Table 2. Functional ambulation (walking speed) of participants at pre- and post-intervention periods

Variables	Mean ± S.D. (m/s)	n	Kolmogorov-Smirnov P-value	Shapiro-Wilk P-value
Pre-treatment Treadmill training group	0.32±0.08	8	0.20*	0.92*
Post-treatment Treadmill training group	0.37±.10	8	0.20*	0.38*
Pre-treatment Combine over-ground walk and bicycle training group	0.34±0.15	7	0.01	0.02
Post-treatment Combine over-ground walk and bicycle training group	0.40±0.23	7	0.00	0.001

*normally distributed, N=frequency, S.D=Standard Deviation, m/s=meters per second

Table 3. Within group comparisons of pre and post-intervention scores of functional ambulation (walking speed) using wilcoxon sign rank test

Variable	Speed	Mean rank	Sum of ranks	Z	P-value
Treadmill group	Pre-intervention Post-intervention	4.00[a]	28.00[a]	-2.37	p=0.018*
Combine over-ground walk and bicycle training group	Pre-intervention Post-intervention	3.00[a]	15.00[a]	-2.02	p=0.043*

[a]=positive rank (post intervention score is greater that pre intervention score), *=significant

Table 4. Comparisons of pre- and post-intervention scores of functional ambulation (walking speed) across groups using Mann-Whitney U

Variables	Intervention	N	Mean Rank	U-Value	P-Value
Baseline	Treadmill group	8	8.25	26.00	0.82
	Combine over-ground walk and bicycle training group	7	7.71		
Post-intervention	Treadmill group	8	8.44	24.50	0.68
	Combine over-ground walk and bicycle training group	7	7.50		
Age	Treadmill group	8	8.56	23.50	0.60
	Combine over-ground walk and bicycle training group	7	7.36		
Duration of stroke	Treadmill group	8	8.75	22.00	0.482
	Combine over-ground walk and bicycle training group	7	7.14		

Discussion

The recovery of walking ability is an important focus of rehabilitation both for individual who have experienced a stroke and their rehabilitation team. This study investigated the effect of number of task-oriented exercises on functional ambulation recovery after stroke.

In this study treadmill training significantly improved functional ambulation recovery post stroke. This implies that treadmill training is a reliable rehabilitation protocol that can specifically improve functional mobility (walking speed). This result was in agreement with the findings of previous studies. A study reported that in chronic stroke patients, treadmill walking was associated with increase in walking speed and quality [21]. Another study reported that treadmill exercise improves functional mobility in patients with chronic stroke [13]. In-line with the findings of this study, treadmill training was found to improve walking speed and gait endurance [16]. It also leads to recovery of gait and balance in stroke patients [16,22].

In addition, this study found that combined task-oriented exercises (over-ground walking and bicycle ergometer) significantly improved functional ambulation (walking speed) post stroke. This implies that combination of two task-oriented trainings is beneficial for the improvement of walking ability of stroke patients. This finding was in-line with that of Tang et al. [24] in which addition of cycle ergometer training to conventional rehabilitation leads to improvement in aerobic and walking capacities post intervention. It was similarly reported that addition of cycle ergometer exercise to conventional exercise effectively increased balance and gait abilities of chronic stroke patients [23]. Furthermore, the possible similarity between the finding in this study and those of Tang et al. [24] and Kim et al. [23] is that most conventional physiotherapy exercises for stroke patients usually include over-ground walking training.

This study found that there is no significant difference in functional ambulation between treadmill group and combined task-oriented training group post intervention. The implication of this finding is that performing combination of two task-oriented exercises may not result in better recovery of walking function than performing only one. It further implies that treadmill training is comparable to combination of over-ground walking and bicycle ergometer training in the improvement of functional ambulation post-stroke. Hence combination of over-ground walk and bicycle ergometer training is not superior to treadmill training for the improvement of walking function post stroke. In-line with the outcome of this study, it has been reported in another study that there was no significant difference in gait and balance between treadmill group and bicycle ergometer group [22]. Also, it was observed that program of varied over-ground walking was not superior to body weight supported treadmill training for the improvement of gait speed [20].

Conclusion

Both treadmill training and combination of over-ground walk and bicycle ergometer training lead to significant improvement of functional ambulation post stroke. Practice of combined task-oriented programs (bicycle ergometer and over-ground walking) is not better than training on treadmill for functional ambulation recovery. Effectiveness of each task-oriented exercise should be considered and not the combination of exercises when planning functional ambulation training for stroke survivors.

References

1. Pound P., Gompertz P., Ebrahim S.: *A patient-centred study of the consequences of stroke.* Clin Rehabil. 1998:12(4):338-47.
2. Van de Port I., Kwakkel G., van Wijk I., Lindeman E.: *Susceptibility to deterioration of mobility long-term after stroke: a prospective cohort study.* Stroke. 2006:37(1):167-171.
3. Lord S.E., McPherson K., McNaughton H.K., Rochester L., Weatherall M.: *Community Ambulation After Stroke: How Important and Obtainable Is It and What Measures Appear Predictive?* Arch Phys Med Rehabil. 2004: 85: 234-239.
4. Eng J.J., and Tang P.F.: *Gait training strategies to optimize walking ability in people with stroke: A synthesis of the evidence.* Expert Rev Neurother. 2007: 7(10): 1417–1436.
5. *Hamzat T.K., Olaleye, O.A.: Stroke rehabilitation: when should ambulation commence.* J Nigeria Med Rehabil Therap. 2002: 7(20): 23-25.
6. *Smith G.S., Silver K.H.C., Goldberg A.P., Macko* R.F.: *Task-oriented exercise improves hamstring strength and spastic reflexes in chronic stroke patients*. Stroke. 1999: 30: 2112-2118.
7. English C.K., Hillier S.L., Stiller K.R., Warden-Flood A.: *Circuit class therapy versus individual physiotherapy sessions during inpatient stroke rehabilitation: a controlled trial.* Arch Phys Med Rehabil. 2007:88:955-963.
8. Van de Port I., Wood-Dauphinee S., Lindeman E., Kwakkel G.: *Effects of exercise training programs on walking competency after stroke: a systematic review.* Am J Phys Med Rehabil. 2007: 86: 935-951.
9. Wevers L., van de Port I., Vermue M., Mead G., Kwakkel G.: *Effects of task-oriented circuit class training on walking competency after stroke: a systematic review.* Stroke. 2009:40:2450-2459.
10. Badaru U.M., Alonge V., Adeniyi A.F., Ogwumike O.O.: *Relative Therapeutic Efficacy of the Treadmill and Step Bench in Gait Rehabilitation of Hemiparetic Stroke Patients*. Afr J Physiother Rehabil Sci. 2012: 4(1&2):45–50.
11. Coenen P., van Werven G., van Nunen M.P., Van Dieën J.H., Gerrits K.H., Janssen, T.W.: *Robot-assisted walking vs overground walking in stroke patients: an evaluation of muscle activity.* J Rehabil Med. 2012: 44(4):331-337.
12. Savin D.N., Morton S.M., Whitall J.: *Generalization of improved step length symmetry from treadmill to over ground walking in persons with stroke and hemiparesis.* Clin Neurophysiol. 2014: 125 (5): 1012–1020.
13. Macko R.D., Ivey F.M., Forrester L.W., Hanley D., Sorkin J.D., Katzel L.I., Silver H., Goldberg A.P.: *Treadmill rehabilitation improves ambulatory function and cardiovascular fitness in patients with chronic stroke*. Stroke. 2005: 36: 2206-2221.
14. Patterson S.L., Rodgers M.M., Macko R.F., Forrester L.W.: *Effect of treadmill exercise training on spatial and temporal gait parameters in subjects with chronic stroke: A preliminary report.* J Rehabil Res Dev. 2008: 48(2):221-228.

15. Sousa C.O., Barela J.A., Prado-Medeiros C.L., Salvini T.F., Barela A.M.F.: *Gait training with partial body weight support during overground walking for individuals with chronic stroke: a pilot study.* J Neuro Eng Rehabil. 2011: 8 (48):1-7.
16. Park I-M., Lee Y-S., Moon B-M., Sim S-M.: *A Comparison of the Effects of Over ground Gait Training and Treadmill Gait Training According to Stroke Patients' Gait Velocity*. J. , Phys. Ther. Sci. 2013: 25: 379–382.
17. Ada L., Dean C.M., Hall J.M., Bampton J., Crompton S.: *A treadmill and overground walking program improves walking in persons residing in the community after stroke: a placebo-controlled, randomized trial.* Arch Phys Med Rehabil. 2003:84:1486-1491.
18. Dean C.M., Ada L., Bampton J., Morris M.E., Katrak P.H., Potts S.: *Treadmill walking with body weight support in sub-acute non-ambulatory stroke improves walking capacity more than overground walking: a randomised trial.* J Physiother. 2010:56: 97-103.
19. Kuys S.S., Brauer S.G., Ada L., Russell T.G.: *Immediate effect of treadmill walking practice versus overground walking practice on overground walking pattern in ambulatory stroke patients: an experimental study.* Clin Rehabil. 2008: 22: 931–939.
20. DePaul V.G., Wishart L.R., Richardson J., Thabane L., Ma J., Lee T.D.: *Varied over ground walking training versus body-weight-supported treadmill training in adults within 1 year of stroke: a randomized controlled trial*. Neurorehabil Neural Repair. 2015: 29(4):329-40.
21. Silver K.H., Macko R.F., Forrester L.W., Goldberg A.P., Smith G.V.: *Effects of aerobic treadmill training on gait velocity, cadence, and gait symmetry in chronic hemiparetic stroke: a preliminary report*. Neurorehabil Neural Repair. 2000: 14:65-71.
22. Kim C.S., Bae S.S.: *The Comparison of Effect of Treadmill and Ergometer Training on Gait and Balance in Stroke*. J Korean Societ Physical Med. 2010: 5(3):435-443.
23. Kim S.J., Cho H.Y., Kim Y.L., Lee S.M.: *Effects of stationary cycling exercise on the balance and gait abilities of chronic stroke patients*. J. Phys. Ther. Sci. 2015: 27: 3529–3531.
24. Tang A., Sibley K.M., Thomas S.G., Bayley M.T., Richardson D., McIlroy W.E., Brooks D.: *Effects of an aerobic exercise program on aerobic capacity, spatiotemporal gait parameters, and functional capacity in subacute stroke*. Neurorehabil Neural Repair. 2009: 23(4):398-406.

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