Relative Therapeutic Efficacy of the Treadmill and Step Bench in Gait Rehabilitation of Hemiparetic Stroke Patients

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Summary
The aim of this research is to compare the efficacy of treadmill and step bench exercises in hemiparetic gait rehabilitation. Previous studies have supported the use of treadmill and step bench exercises in gait rehabilitation.
Nineteen patients were recruited for an 8-week, 2-group quasi-experimental study which was conducted at the Aminu Kano Teaching Hospital. The patients were randomly distributed into 2 groups: A (step bench exercise) and B (treadmill). Groups A and B had 9 and 10 participants respectively. The mean age of the participants in group A was 47.78 $\pm$ 8.17 years, while that of participants in group B was 46.9 $\pm$ 7.11 years. Data collected on cadence, stride length, stride width, step length, stride velocity and foot angle before treatment at the 4th and 8th weeks of treatment were analysed using inferential statistics.
There was a significant difference ($p < 0.05$) in the pre-treatment and post-treatment scores in both groups. Comparison of the post-treatment mean scores of the 2 groups was made and the t-values for cadence, stride length, step length, stride width, stride velocity and foot angle were 1.18, -0.91,-0.86, 0.78,1.19 and 0.01, respectively, after analysis was carried out using the unpaired t test. The results showed no significant difference in the mean scores of the measured gait parameters for the groups ($p>0.05$).
It was concluded that hemiparetic stroke patients will benefit from both rehabilitation protocols, and that neither rehabilitation protocol is superior to the other.

KEY WORDS: Hemiparesis, gait, rehabilitation, treadmill, step-bench

INTRODUCTION

Stroke gait relative to normal value is characterized by low velocity, low cadence, short stride length, increased double support phases and asymmetric single limb loading (El-Bahrawy and El- Tamawy, 2004). In rehabilitation, a lot of time is spent on gait re-education and recovery of mobility (Gladman et al, 1993). The ability to walk is seen as a highly desired goal among stroke survivors, and it is used as a yardstick for measuring recovery by both patients and their relatives (Hamzat and Olaleye, 2002; Patterson et al, 2008). Macko et al (2005) reported that treadmill exercise improves both functional mobility and cardiovascular fitness in patients with chronic stroke. Treadmill exercise improves a 30-foot timed walk by 17%, 6-minute walk by 13%, unassisted walking velocity by 22%, stride length by 13% and cadence by 7% (Patterson et al, 2008). Treadmill training with partial body weight support (PBWS) may produce better walking and postural abilities than gait training on full weight (Pomeroy and Manning 2003; Barbeau and Visintin, 2003). Pohl et al (2002) showed that structured speed-dependent treadmill training after a stroke incidence resulted in better walking ability than limited progressive treadmill training and conventional gait training.

Step exercise was shown to increase gait performance in the elderly (Nishimoto et al, 1999). It can also be used to measure aerobic fitness in apparently healthy subjects (Akinyele, 2007). Step bench exercise trains stroke patients to initiate gait with the paretic lower limb. Weight bearing through or 'loading' of the paretic lower extremity and transfer of weight from one lower extremity to the other are important impairment-level goals of stroke rehabilitation (Mercer et al, 2009). Besides, Hesse et al (1997) found that when hemiparetic patients initiate gait with the affected leg, the movement pattern of the centre of pressure mass was comparable to that of the normal gait. Loading of the paretic lower extremity relates to the performance of many functional tasks including walking (Mercer et al, 2009). The objective of this research is to compare the efficacy of treadmill and step bench exercises in hemiparetic gait rehabilitation.

METHODOLOGY

The materials used for the study include a roll of white paper (3 metres long, ½ metre wide), 2 bottles of ink of different colours, masking tape, a stopwatch, a sphygmomanometer and a stethoscope, a treadmill (Healthcare, England) and a step bench (8 inches high, 14 inches long, 13 inches wide). Nineteen patients were recruited for an 8-week, 2-group quasi-experimental study which was conducted at the Aminu Kano Teaching Hospital, Nigeria. The patients were randomly distributed into 2 groups: A (step bench) and B (treadmill), with 9 and 10 participants, respectively. The patients were educated about the exercise and their blood pressures were measured before the commencement of every exercise session. The step bench exercise was done at 4 counts:

i. Up with one foot (the affected leg);
ii. Up with the second foot, body erect, legs straight on the bench;
iii. Down with the same foot placed on the bench first;
iv. Down with the other foot.

The treadmill group walked at a comfortable treadmill speed. All treatment sessions lasted between 4 and 10 minutes, with rest periods in between each session. There were three treatment sessions per week for eight weeks. The data collection procedure was adopted from Boenig (1977). Two moleskin tapes – one triangular and one square – saturated with ink were placed at the midline of the sole of each patient's shoes (front and heel). The moleskin tapes on each shoe were saturated with ink of different colours. The patient was then instructed to walk on the white paper that was taped to the floor. A stopwatch was used to record the time needed for the patient to walk across the entire length of the paper. The data collected on cadence, stride length, stride width, step length, stride velocity and foot angle before treatment, and at the 4^{th} week and 8^{th} weeks of treatment were analysed using inferential statistics.

Cadence

Cadence is the measurement of the number of steps taken per unit time. The value was calculated by dividing the total number of steps taken on the paper by the total time needed to walk across the length of the paper (measured in steps per minute).

Stride Length

The midpoint of the heel square was used as reference point for measurement. The stride length is the linear distance from the heel strike of one foot to the heel strike of the next successive step of the same foot (Distance AB measured in centimetres – figure 1).

Step Length

This is the measurement of the distance from the heel strike of one foot to the heel strike on the next successive step of the opposite foot, using the midpoint of the heel square as the reference point (Distance DC measured in centimetres – figure 1).

Step Width (Stride width)

Step width is the transverse linear distance between points on 2 successive feet. Heel-to-heel step width was calculated as the difference between distance G and H (figure 2), measured from the midpoint of 2 successive heel squares of the opposite feet to the edge of the paper. Toe-to-toe width was calculated in the same manner using the apices of the triangles as the reference point for measurement (E minus F). The average of the two measurements gives the stride width in centimetres.

Stride Velocity

Stride velocity is a measure of the distance covered per unit time.

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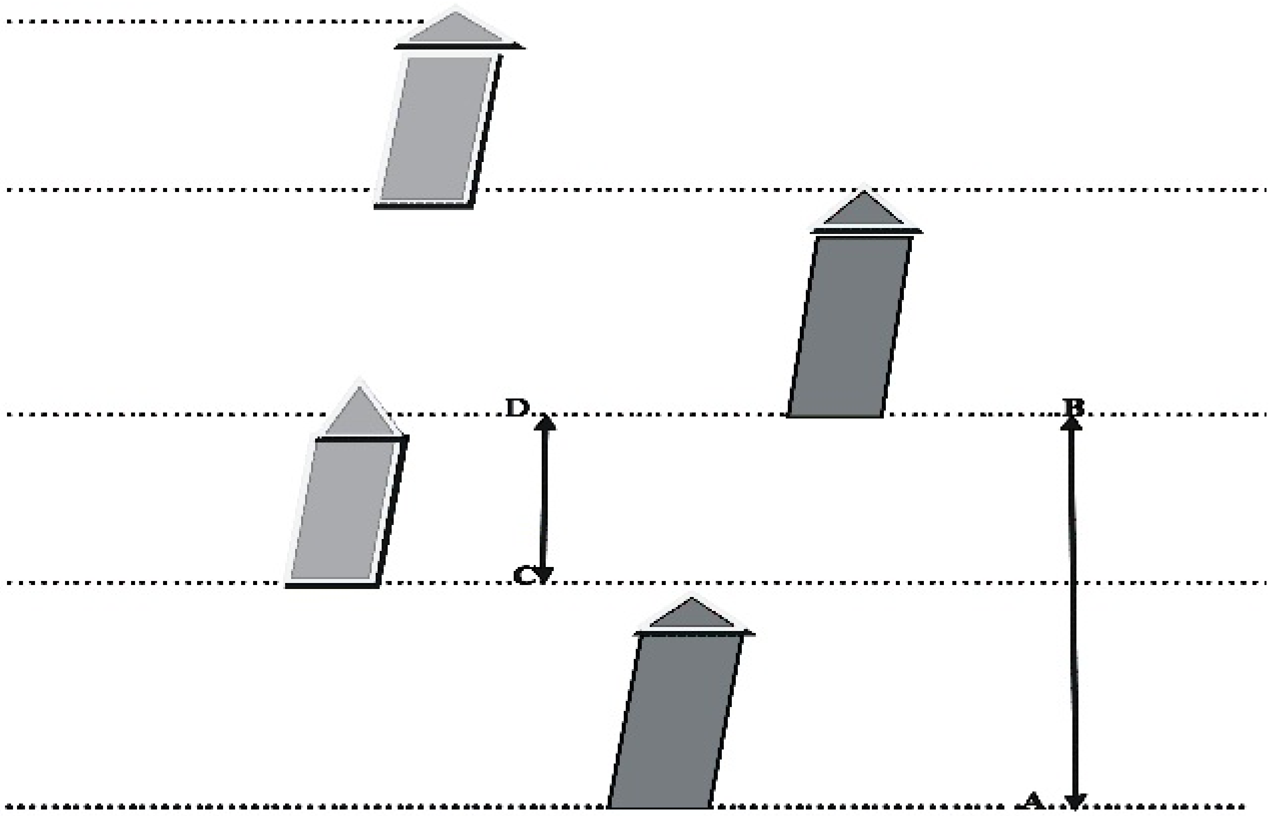

Figure 1. Measurement of stride length (distance AB) and step length (distance CD) from imprint on the paper (adopted from Boenig, 1977)

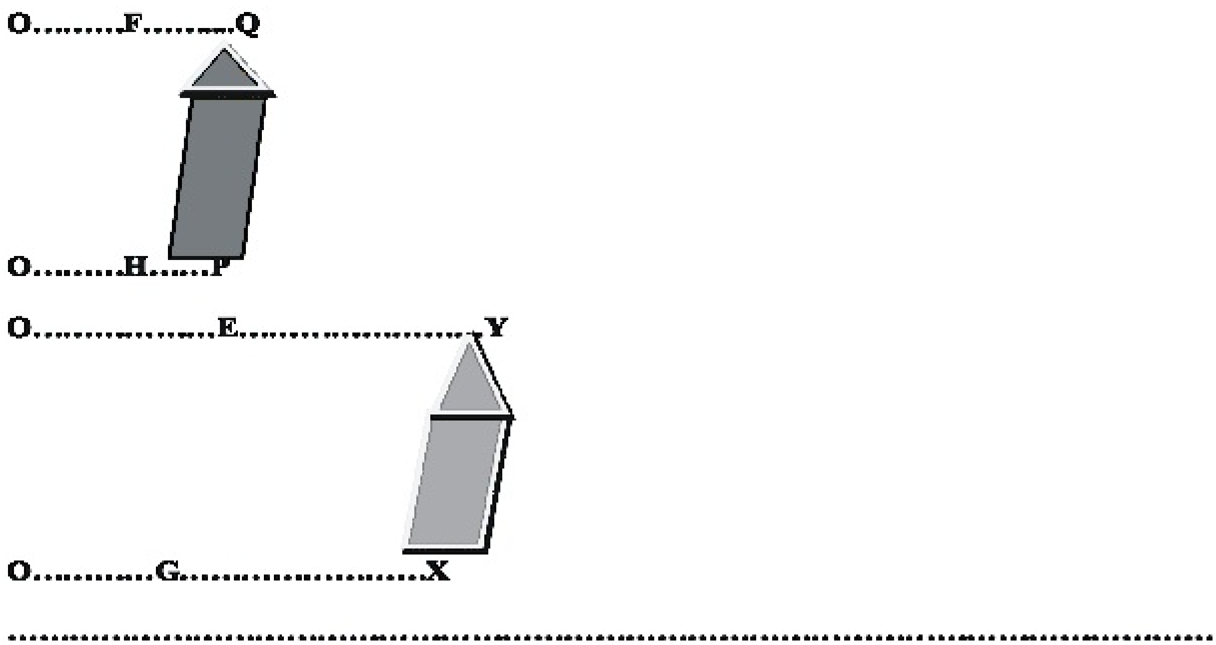

Figure 2. Measurement of stride width from the imprint on the paper strip (Boenig, 1977)

Foot Angle

Foot angle refers to the amount of toe-out, toe-in of each foot. For each step, a long axis was drawn through the apex of the toe triangle and the midpoint of the heel square. A line intersecting with the long axis was drawn perpendicular to the line of progression. A protractor placed on the perpendicular line, intersecting with the long foot axis was used to determine the angle of toe-out or toe-in (figure 3).

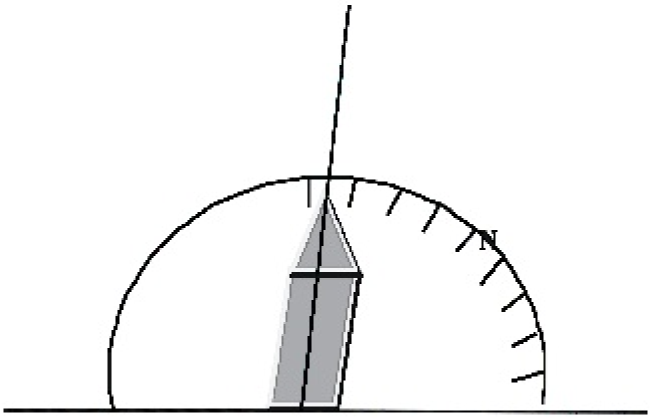

Figure 3. Measurement of foot angle from the imprint on the paper stip (Boenig, 1977)

RESULTS

The participants comprised 14 males (73.7%) and 5 females (26.32%). Group A (n = 9) had 7 males and 2 females and their ages ranged from 40 to 62 years, while 7 males and 3 females within the age range of 37 to 60 years formed group B (n = 10). The mean age of participants in group A was 47.78 ± 8.17 years, while that of group B was 46.9 ± 7.11 years Most of the participants were businessmen (52.6%) and housewives (26.32%). Civil servants and farmers constituted 10.53% each.

The difference between the pre-treatment and post-treatment values of gait parameters in groups A and B is presented in table 1. The results were analysed using the paired t-test and found to be significant for both groups ($P < 0.05$). The post-treatment mean scores for the two groups were compared. The results showed that the cadence mean score for group A (90.04 ± 8.67 steps/minute) and B (84.08 ± 13.02 steps/minute), the stride length score for group A (62.05 ± 20.18 cm) and B (69.64 ± 15.50 cm), the step length score for group A (31.66 ± 8.86 cm) and B (34.96 ± 7.8 cm), the stride width score for group A (13.01 ± 3.99cm) and B (11.70 ± 3.32 cm), the stride velocity score for group A (0.64 ± 0.06 m/s) and B (0.6 ± 0.09 m/s), and the foot angle score for group A (9.72 ± 3.62°) and B (9.63 ± 3.96°) were all not significant when analysed using the unpaired t test as presented in table 2.

Table 1. Comparison of the difference between pre-treatment and post-treatment mean values within groups

Group	Pre-treatment Mean ± S.D	Post-treatment Mean ± S.D	Calculated t
A (N= 9)			
Cadence	78.17 ± 14.57 steps/min.	90.04 ± 8.67 steps/min.	-3.33*
Stride width	15.26±5.04 cm	13.01±3.99 cm	3.93*
Step length	27.68±8.71 cm	31.66±8.86 cm	- 3.13*
Stride velocity	0.56± 0.1 m/s	0.64± 0.06 m/s	-3.337*
Foot angle	0.84± 4.29°	9.72± 3.62°	3.37*
Stride length	56.46± 18.3 cm	62.05± 20.18 cm	-2.92*
B (N= 10)			
Cadence	75.48 ± 13.99 steps/min.	84.08 ± 13.02 steps/min.	-5.1*
Stride width	13.56± 3.22 cm	11.70± 3.21 cm	3.65*
Step length	31.84± 9.1 cm	34.96± 7.8 cm	-3.67*
Stride velocity	0.54±0.1 m/s	0.6± 0.09 m/s	-5.09*
Foot angle	10.85± 4.17°	9.63± 3.96°	4.88*
Stride length	63.21± 18.07 cm	69.64± 15.50 cm	-4.89*

*significant. Group A; P = 0.05 df = 8. Table t= 2.31. Group B; P = 0.05 df = 9; table t= 2.26 df = Degree of freedom

Table2. Comparison of post-treatment means scores of gait parameters across the groups

Gait parameters	A Mean ± S.D (N= 9)	B Mean ± S.D (N=10)	Calculated t
Cadence	90.04 ± 8.67 steps/min.	84.08 ± 13.02 steps/min.	1.18
Stride length	62.05± 20.18 cm	69.64± 15.50 cm	-0.91
Step length	31.66±8.86 cm	34.96± 7.8 cm	-0.86
Stride width	13.01± +3.99 cm	11.70± 3.32 cm	0.78
Stride velocity	0.64± 0.06 m/s	0.6± 0.09 m/s	1. 19
Foot angle	9.72+ 3.62°	9.63± 3.96°	0.01

Table t = 2.11 P >0.05 df = 17. df = Degree of freedom S.D= Standard deviation, n= number of participants

DISCUSSION

The results of the comparison of the pre-treatment and post-treatment scores for each group showed significant improvement of the gait parameters using step bench and treadmill exercises. This implies that step bench and treadmill exercises are rehabilitation protocols that can significantly improve the gait pattern of hemiparetic stroke patients. These results were in agreement with the findings of previous studies. For example, improvements in cadence, stride length and stride velocity agreed with the findings of Patterson et al (2008) and Pohl et al (2002), who reported that structured speed-dependent treadmill training resulted in better walking ability than the controls. These results were also in line with the report of Macko et al (2005) that treadmill exercise improves functional mobility in patients with chronic stroke. The improvement in gait ability after step bench exercise and hemiparetic limb loading was in consonance with the findings of Nishimoto et al (1999). It also agreed with the findings of Mercer et al (2000) and Hesse et al (1997), who found that loading of the paretic lower extremity relates to the improved performance of many functional tasks including walking, which also improved weight, equal weight transference and symmetry of gait. The result of the comparison of the post-treatment mean scores for both groups showed no significant difference. This implies that there is no statistically significant difference in the efficacy of both modalities in the rehabilitation of the gait of hemiparetic stroke patients.

CONCLUSION

The findings of this study have shown that step bench exercises and treadmill retraining are beneficial in the rehabilitation of the gait of hemiparetic stroke patients. It was concluded that step bench exercises and treadmill retraining are both beneficial, and that neither is superior to the other. It was recommended that further research be carried out to determine how effective gait rehabilitation will be if these modalities are combined.

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