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Original Research

Balancing the imbalance of stroke survivors with backward slope walking on differential treadmill gradients

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Abstract. The purpose of this study was to balance the imbalance of stroke survivors by using backward slope walking on differential treadmill gradients to challenge the cardiovascular and neuro-muscular systems and by synthesizing an analysis of lower limb biomechanics during this task. Thus, a total of thirty (30) stroke survivors randomly drawn participated in this study. Balance and co-ordination were tested in relation to backward slope walking on differential treadmill gradients (0°, 5° and 10°).Analysis of covariance was used to test the hypotheses at 0.01 level of significance. The F-values of 68.80 and 33.32 for balance and coordination were respectively found to be statistically significant at 0.01. Turkey HSD was used to determine the source of the significant difference among the groups. It was discovered that there was a significant difference at 10° gradient compared to 5° and 0° (10°>5°>0°) in the balance and co-ordination of the participants. It was therefore recommended that backward slope walking should be used as an additional component in intervention/rehabilitation programme to provide cardiovascular fitness, balance control/proprioception by increasing the amount of blood pump at each stroke and the efficiency of the heart of stroke survivors.

Keywords. Backward slope walking, stroke survivors, differential treadmill gradients.

Introduction

The burden of mortality, morbidity and disability attributable to chronic diseases is currently greatest and is continually growing in the developing economies like Nigeria. It is on this premise that the World Health Organization (2005) projected that by 2020, chronic diseases will account for three-quarters of all death worldwide, and that 71% of death due to Ischemic Heart Disease (IHD), 75% of deaths due to stroke, and 70% of deaths due to diabetes will occur in developing economies. Consequently, the incidence of stroke as the third leading cause of death in the world and 75% of death due to stroke in developing economies are striking changes in rates that calls for serious concern. Therefore, stroke is loss of brain function due to a disturbance in the blood supply to the brain. This disturbance is due to either lack of blood flow as a result of blockage of blood vessel (Ischemia) or caused by bleeding of blood vessels of the brain either directly into the brain or into the surrounding brain tissue (Haemorrhagic) (Sims & Muyderman, 2009). As a result, the affected area of the brain cannot function normally, which might result in an inability to move one or more limbs in one side of the body, and many survivors are left with disabilities (imbalance).

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As a result of the imbalance, regular cardio respiratory exercise could promotes fitness and provides additional health and wellness benefits that extend well beyond reducing risks for disease (Corbin et al., 2004). It is on this basis that walking is fundamental to life and living, and it is also a natural part of life. It involves shoulders and pelvis rotation in opposite directions while the trunk motion contributes significantly to this movement function (McArdle et al., 2000). They stressed that during walking, there is a whole body movement involving the coordination of arms and legs, and the upper and lower extremities, which contribute to the linear and angular momentum. Consequently, there is also subject variability during walking, while the ground reaction and movement of centre of gravity caused by body weight and its distribution during motion have implications of walking (Hoyt et al., 1994).

However, walking on sloped surfaces is a challenge in our daily environment that places unique demands on the cardiorespiratory system. Based on this, Bates et al. (1986) submitted that backward slope walking in an activity in which one always maintain contact with the ground or equipment as a means to acquire or maintain cardiovascular fitness and create or improve muscle balance while minimizing force related trauma to the lower extremities. On the treadmill however, Agwubike & Agbonlahor (2005) submitted that backward slope walking is a means of training athletes and non-athletes for agility and quick reaction to adjust or change position. They emphasized that in stepping back or backpedaling to catch a ball, strike a ball, or retrieve implements or dodge an incoming implement, people gain more stability which is a pre-requisite to mobility. Cirpriani (1995) asserted that backward slope walking is used clinically for rehabilitation of the knee, joint for patients with patellofemoral pain, anterior cruciate ligament injuries and osteoarthritis.

Furthermore, Hesse, Werner, Bardeleben and Barbeau (2001) observed that backward slope walking is used for ambulation training for paraplegic patients, for neurological impaired patients, for non-ambulatory patients with cerebral palsy, for hemiparetic patients, for walking after stroke and for spinal cord injured patients and also have the potential to improve the daily living activities and motor performance. Hesse et al. (1991) maintained that backward slope walking on treadmill could serve as a training means that can provide cardiovascular fitness in ambulatory hemiparetic patients after stroke by increasing the amount of blood pumps at each stroke and the efficiency of the heart.

There is therefore, ample evidence that the cardiovascular system is functionally implicated during backward slope walking. To this end, cardiovascular and neuromuscular systems can be exercised extensively by incorporating backward slope walking as a means of static postural control on alternating legs as well as a means for determining sports training modalities and daily routine activities. Thus, Agwubike & Agbonlahor (2007) asserted that backward slope walking among the exercise method is used to adjust positions such as the stepping back to hand a ball, catch or strike a ball, prevent injury arising from an imbalance in the muscles. Hence, the gradient of incline of backward slope walking on the treadmill can be established as the units of rise or vertical displacement per horizontal unit to acquire or maintain cardiovascular fitness and create or improve muscle balance.

Thus, the overall goal of this study was to balance the imbalance of stroke survivors by using 12-weeks backward slope walking on differential treadmill gradients (0°, 5° and 10°) training programme to challenge the cardiovascular and neuromuscular systems and by synthesizing an analysis of lower limb biomechanics during this task.

Figure 1. Backward slope walking on differential treadmill gradients.

Hypotheses: 1) There would be no significant difference in the balance of stroke survivors after a 12-week backward slope walking on differential treadmill gradient (0°, 50° and 10°) training programme. 2) There would be no significant difference in the coordination of stroke survivors after a 12-week backward slope walking on differential treadmill gradient (0°, 50° and 10°) training programme.

Methods

Subjects

The experiment was conducted based on thirty (30) hemi paretic stroke survivors receiving treatment at the physiotherapy out-patient department of University of Benin Teaching Hospital. Systematic random sampling technique was used to select the 30 hemi paretic survivors (15 heamorrhagic and 15 ischeamic) for the experiment.

Procedures

The research instrument used in this study was an adaptation of Flynn et al. (1995) training protocols already validated for the training and assessment of upper and lower imbalance and coordination

Balance Training Procedure

The training procedure aimed to improve the static and dynamic balance of the subjects. One leg stance and a parallel bar were used. Survivors were made to stand on one leg within the parallel bar until balance was lost. They stood on their affected leg with or without holding on to the parallel bar until they were tired or about to fall. It was then timed till balance was lost.

Coordination Training Procedure

The coordination training aimed to improve survivors' level of coordination. Survivors' finger and his/her nose tip were used as equipment. Survivors were made to touch the tip of his/her nose with the index finger. An examiner instructed them to touch the tip of their nose with the tip of their index finger. Repeat this as fast as possible.

Scoring: The performance was scored as follow. 1) Scored 2, when survivor was unable to touch his/her face. 2) Scored 4, when survivor was able to touch his/her face. 3) Scored 6, when survivor was able to touch his/her nose but not the tip. 4) Scored 8, when survivor was able to touch his/her nose. 5) Scored 10, when survivor was able to touch his/her nose with eyes closed.

The balance and coordination pre-test data of the survivors were taken, thereafter, the survivors performed 12-week backward slope walking on the treadmill. The treadmill speed was set at 5.0 km and the gradient of the treadmill were at level 0^0, upward 5^0, and 10^0 respectively, as the experimental conditions progressed. Each survivor performed movements three (3) times, according to each gradient to reduce experimental error. Three movements were conducted in each gradient for 20 minutes, 3 times per week for 12 weeks each.

Thereafter, the post-test data was taken following balance coordination training procedures. The mean value of each result was recorded and used for data analysis.

Statistical analysis

Regarding the statistical treatment, Analysis of Co-variance (ANCOVA) was to test the hypotheses. It was chosen because, it provides statistical control for extraneous variables and removes pre-existing difference, Tukey's honesty significant difference post-hoc-test was used to identify the source of the significance among the groups. The alpha level was set at 0.01.

Results

The results of the present study are presented in table 1-5.

The physical characteristics of the subjects (survivors) are indicated in table 1. All the subjects for the study had the mean age of 44.2 ± 7.3; mean height of 173.7 ± 36.6; mean weight of 85.5 ± 16.7; mean stroke type (Ischaemic 15 ± 2.7; haemorrhagic 15 ± 2.7) of 30 ± 5.4; mean sex (male 21 ± 1.6; female 9 ± 3.8) of 30 ± 5.4; and mean leg length (Femur 47.5 ± 13.5, Tibia/Fibula 46.7 ± 7.9) of 94.2 ± 21.4 respectively.

Hypothesis One: There would be no significant difference in the balance of stroke survivors after a 12-week backward walking on differential treadmill gradients (0^0, 5^0,10^0) training programme.

Analysis of co-variance (ANCOVA) was used to determine the significance of the difference in the balance of the stroke survivors between the three treadmill gradients of backward slope walking. The F-value of 68.80 was found to be statistically significant at 0.01 level of significance with 2 and 57 degrees of freedom. The hypothesis that there would be significant difference in balance of the stroke survivors after a 12-week backward slope walking on differential treadmill gradients was rejected. The implication is that there was significant difference in the balance of stroke survivors after a 12-week backward slope walking on differential treadmill gradient ($P < 0.01$). This necessitated probing into a post-hoc analysis to identify the source of the significance.

Table 1

Physical characteristics of the subjects (Mean ± SD; n = 30).

Age (yrs)		44.2 ± 7.3
Heights (cm)		173.7 ± 26.6
Weight (kg)		85.5 ± 16.7
Type of stroke	Ischemic	15 ± 2.7
	Haemorrhagic	15 ± 2.7
Sex	Male	21 ± 1.6
	Female	9 ± 3.8
Leg length	Femur (cm)	47.5 ± 13.5
	Tibia/Fibula (cm)	46.7 ± 7.9

In table 3, Tukey's honesty significant difference test was used to determine the difference in the balance between the three treadmill gradients. The pair wise of all the mean difference were found to be statistically significant at 0.01 level of significance. Thus, all the pair wise means showed variation. It therefore implies that the treatment had impact on the subjects' balance on the treadmill, since pairing the 10^0 groups with either the 0^0 or 5^0 groups elicited negative significant difference (-6.294* and–198.318*). The source of the significance was therefore the 10^0 gradient treadmill walking.

Table 2

Analysis of co-variance (ANCOVA) showing difference in the balance of stroke survivors between the three gradients of backward slope walking (0^0, 5^0,10^0).

Source	Type III Sum of Squares	df	Mean Square	F	p
Corrected model	.39[a]	5	.008	3832.947	000
Intercept	.929	1	.929	452168.2	.000
Test	.039	1	039	18890.332	.000
Treatment	.000	2	.000	68.601	000
Test Treatment	.000	2	.000	68.80*	.000
Error	.000	57	2.05		
Total	.969	60			
Corrected Total	.040	59			

* p < .05

Table 3

Tukey's Honesty significant difference test shows difference in the balance of stroke survivors between the three treadmill gradients (0°, 5°, 10°).

Dependent Variable	(I) Treatment (J) Treatment	Means Difference (I-J)	p	Inference
Balance	0° vs 5°	122.240*	.000	
	0° vs 10°	76.294*	.000	
	5° vs 0°	122.024*	.000	$10^0>5^0>0^0$
	5° vs 10°	198.318*	.000	
	10° vs 0°	-76.294*	.000	
	10° vs 5°	-198.318*	.000	

* p < .05

Table 4

Analysis of co-variance (ANCOVA) showing difference in the coordination of stroke survivors between the three gradients of backward slope walking (0^0, 5^0 and 10^0).

Source	Type III Sum of Squares	df	Mean Square	F	p
Corrected model	56943.300a	5	11388.660	1935.750	000
Intercept	1335630.000	1	1335630.000	227019.3	.000
Test	56073.633	1	56073.633	9530.929	.000
Treatment	477.600	2	238.800	40.589	000
Test Treatment	392.067	2	196.033	33.320*	.000
Error	670.700	57	5.883		
Total	1393244.000	60			
Corrected Total	57614.000	59			

* p < .05

In table 4, computed F-value is greater than the significant F-value (33.32 > .000) at 0.01 level of significance with 2 and 57 degrees of freedom. The null hypothesis that there would be no significant difference in the coordination of stroke survivors after a 12-week backward slope walking on differential treadmill gradients was rejected. Thus, this shows that there was significant difference in the coordination of stroke survivors after a 12-week backward slope walking on differential treadmill gradients (P<0.01). Therefore, there was a follow-up verification to identify the possible source of the significance.

Table 5

Tukey's Honesty significant difference test showing difference in the coordination of stroke survivors between the three treadmill gradients (0^0, 5^0 and 10^0).

Dependent Variable	(I) Treatment (J) Treatment	Means Difference (I-J)	p	Inference
Coordination	0^0 vs 5^0	- 3.900*	.000	
	0^0 vs 10^0	.600	.000	
	5^0 vs 0^0	3.900*	.000	10°>5°>0°
	5^0 vs 10^0	4.500*	.000	
	10^0 vs 0^0	.600	.000	
	10^0 vs 5^0	-4.500*	.000	

* p < .05

In table 5, Tukey's honesty significant difference test was used to determine the difference in variation in the coordination of the stroke survivors between the three treadmill gradients of backward slope walking. Since matching 0^0 with 5^0 yielded a significantly negative value (-3.900*) whereas matching 5^0 with 0^0 elicited a significantly positive value (3.900*), the 0^0 gradient walking has less training effect on the stroke survivors' coordination. Moreover, the matches of 0^0 with 10^0 (.600) just are matching the 10^0 with 0^0 (.600). The implication is that both the 0^0 and 10^0 groups parted to gain much on their coordination. However, the matching of 5^0 with 10^0 group yielded a positive significant value (4.500*) and the 10^0 with 5^0 group elicited a negatively significant value (-4.500*). This shows that the source of the significance is the 10^0 gradient group. Therefore, the treatment (backward slope walking on 10^0 gradient had substantial training effect on the subjects' coordination.

Discussion

The results of the present study provided the information required for deciding workload or fitness promotion, injury prevention, rehabilitation therapy, training modalities and daily routine activities. Thus, mastery of this exercise could be helpful in providing cardiovascular function; providing musclo-skeletal foundation; facilitating neuromuscular function in order to facilitate balance and proprioception.

The results of the study revealed that the two (2) hypotheses formulated and tested were rejected. Hence, the progression in gradients of the treadmill in backward slope walking had impact on the balance and coordination of the stroke survivors. Therefore, the results seen justified as it is in support of Agbonlahor & Agwubike (2007); Hesse et al. (2001); Hesse et al. (1999); Cirpriani (1995); Agwubike & Agbonhalor (2005) submissions that the intensify/ progression in backward slope walking resulted in the limited range of motion at the knee joint, augmented stretch of the hamstrings muscle group during the stride and the potential of proprioception/balance control training during activity. For these reasons, backward slope walking is an additional component in intervention / rehabilitation programme as well as an augmentation to overall fitness programme.

Conclusion

The results of the study revealed that the hypotheses relating to balance and coordination of the stroke survivors in relation to backward slope walking on differential treadmill gradients were significant, depicting that the impact of backward slope walking of the three treadmill gradients on the stroke survivors differed. Thus, the Tukey's honesty significant difference test was used to identify the source of the significant difference between the three treadmill gradients. It is therefore concluded that backward slope walking on differential treadmill gradients should be used as an alternate pattern of movement to enhance proper body balance, coordination and cardiac activities regulation.

Recommendations

Based on the results of this study, the following recommendations were made:

1. Backward slope walking on differential treadmill gradients should be used as an additional component in intervention/ rehabilitation programme to provide cardiovascular fitness.
2. Backward slope walking on differential treadmill gradients should be used for balance control/proprioception by increasing the amount of blood pumped at each stroke and the efficiency of the heart of stroke survivors
3. Sports goods developers/designers should develop treadmill that has both forward and backward automation to enhance backward movement training programme.

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