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Effect of Six Weeks Cycle Ergometry on Selected Gait Parameters of Stroke Survivors

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ABSTRACT

Purpose: Restoration of gait in stroke survivors is a major goal in rehabilitation. Recently, treadmill training has been introduced as a measure to improve the post stroke gait pattern, but there is still limited data on the use of the cycle ergometer. The primary aim was to compare selected gait parameters of hemiplegics subjects who received cycle ergometry and those who had traditional physiotherapy. **Method**: A total of twenty-four (24) subjects were alternately allocated to 2 groups, but only 20 completed the experimental procedure. The two groups received baseline traditional physiotherapy while the experimental group used a cycle ergometer as an addition. Participants pedaled at a predetermined cadence of 50 rpm until the participant indicated that he or she could not pedal any longer, and this training was repeated 3 times per week for 6 weeks. To measure outcomes, the participants were instructed to walk on a 3-meter walkway with sprinkled powder to show the footprints. The prints were then utilized to measure the selected parameters (step length, stride length and step width). The period of time from one heel contact of one foot to the following occurrence of the same event with the same foot is taken as gait cycle, while cadence was determined as number of steps per minute. The Wisconsin gait scale was used to measure any changes in the affected limb. Descriptive statistics and Analysis of variance (ANOVA) were used to analyze the data. **Results:** The initial cadence of the experimental group was 42.17steps/minute while the final was 64.00steps/min. Also, the initial cadence of the control group was 40.50steps/min while the final was 52.25steps/min. Similarly, the gait cycle improved from 20.83 seconds to 31.67 seconds for the experimental group while that of the control group improved from 20.00 to 25.75 seconds. This showed that there was significant improvement in cadence ($p < 0.00$) and gait cycle ($p < 0.00$) when cycle ergometry was combined with conventional therapy compared to those who had only conventional therapy. Also, the Wisconsin Gait Scale score improved significantly for the experimental group ($p < 0.02$). **Conclusion**: This study concluded that selected parameters of the gait of people post-stroke were improved when cycle ergometry was combined with conventional therapy. Further research is indicated.

INTRODUCTION

Gait abnormality is a common feature amongst stroke survivors. Survivors who eventually regain some form of walking ability may vary greatly in walking speed, spatio-temporal characteristics, and kinematic gait patterns. Attempts have been made in some studies to classify gaits.[1] For example, abnormal gait may be due to difficulty in moving the body over an unstable limb.[2] Sadeghi et al reported that common gait problems in hemiplegics are due to unawareness of the paretic side, flexion contracture, scissoring at the hip, flexion contracture at the knee, unequal step length, and weak ankle dorsiflexion. [3] Patients who have stroke often have long-term difficulties with walking.[4] Almost half of the individuals with a diagnosis of stroke have impairments in gait.[5] Gait deficits include both decreased walking velocity and endurance.[6] These may be severe enough to completely limit functional gait activities.

Ambulation is a significant part of functional recovery following stroke.[2] Walking is possible for a majority of patients following stroke, but it rarely returns to normal.[4] Gait re-education and mobility training are important physiotherapy interventions for patients following stroke. Restoration of gait is a major goal in neurological rehabilitation.[7]

Gait velocity or walking distance can be used to quantify functional recovery.[8,9] Performance-based gait tests are feasible to conduct at early recovery periods post-stroke, and this permits better discrimination among the patients compared to qualitative measures.[10] Olawale and Akinfeleye reported that strengthening of selected lower limb muscle groups on the affected side caused significant improvement in step length, stride length, and maximal gait speed.[4] Mevellec et al reported that recent studies have focused on the correlation between strength and gait parameters in hemiplegia, confirming the interest for strength training in patients with central nervous system lesions.[11]

Traditional physical therapy for people who are not ambulating after stroke has focused on the use of adaptive equipment, pre-ambulation strengthening programs, and standing exercises.[11,12] The use of therapy such as passive movement, PNF, mat exercises, and use of orthoses has variable levels of evidence in restoring normal stride, gait, or mobility to many stroke survivors. There is stronger evidence in favour of task-oriented exercise training to restore balance and gait.[13] The spectrum of therapy for the retraining of gait was recently widened by treadmill training with partial body-weight support, but the effectiveness appears to be inconclusive.[8] The role of cycle ergometry in restoring good gait among stroke survivor is still inconclusive. The resistance offered by cycle ergometry training may increase muscle strength and the reciprocal motion may contribute to a smooth gait pattern.

The primary aim of this study was to compare the gait parameters such as step length, stride length, step width, cadence, gait cycle, and gait velocity of hemiplegics subjects who received cycle ergometry with traditional physiotherapy and those who had traditional physiotherapy only.

METHODOLOGY

Subjects

A total of 24 subjects with hemiplegia consented to participate in the study. They are stroke survivors receiving out-patient care at the physiotherapy department of Obafemi Awolowo University Teaching Hospital complex, Ile-Ife, Osun state, Nigeria. The inclusion criteria were subjects with cerebrovascular accident, motor power > 2 at the affected lower limb at the time of recruitment, no previous history of musculoskeletal problem such as fracture and arthritis of the lower extremities. Participants whose period of stroke onset was more than 3 months were excluded from the study.

Procedure

The Research and Ethics Committee of Obafemi Awolowo University Teaching Hospital, Ile-Ife, Osun state, Nigeria, approved the ethical clearance for the study and all participants consented to participate. Prior to the study, the study sample size was estimated to be 18 participants, however, a larger number of 24 participants were recruited but only 20 completed the study. The initial 24 subjects were alternately allocated into 2 groups in the order of arrival. The first group (experimental group) comprised of 12 subjects while the control group also had 12 participants but only 8 participants completed the procedure.

The subject heights and weights were measured with the stadiometer and weighing scale respectively. The age, gender, and the affected side (paretic) were recorded. Also, the blood pressure of each subject was measured prior to the exercise. The two groups received the baseline therapy in the form of the proprioceptive neuromuscular facilitation (PNF), 10 repetitive passive movement (PM), passive stretching (PS), mat exercises (rolling and bridging exercise) as well as functional exercise (sitting, standing, and walking re-education), and postural awareness using biofeedback, 3 times per week for 6 weeks. Each session in a day lasted for 50 minutes. In addition to the baseline treatment programs, the experimental group pedaled the cycle ergometer at a predetermined cadence of 50 rpm until the participant indicated that he or she could not pedal any longer.[14] The frequency of training was 3 times per week.

The participants were instructed to walk on a 3-meter walkway with sprinkled powder to show the footprints. The prints were then utilized to measure the selected parameters (step length, stride length, and step width).[15, 16] The gait velocity was computed by dividing the 3 meters with time taken (seconds) to complete the walkway, while cadence was determined as number of steps taken per minute. Gait cycle was taken as the period of time from one heel contact of one foot to the following occurrence of the same event with the same foot. The Wisconsin Gait Scale was used to score changes in the affected limb, and is a useful tool to rate qualitative gait alterations of post-stroke hemiplegic subjects and to assess changes over time during rehabilitation training.[17] The minimum score on the scale is 13 while 42 is the maximum (the higher the score, the more seriously affected the

gait). The Wisconsin Gait Scale had been tested and found to be highly reliable as an outcome measurement tool (r = 0.93, p <001).[18] The main researcher took all parameters and he was blinded to the group allocation.

The initial values obtained before the first treatment session for the 2 groups (pre-training and pre control) and final values obtained after the last treatment session at week 6 for all parameters (post training and post control) were used for data analysis.

Data Analysis

Descriptive statistics were used to determine the mean, range, and standard deviation of the variables. Independent student t-test was used to compare the physical characteristic of the two groups. Analysis of variance (ANOVA) was also used to compare the pre-training, pre-control, and post-training and post control gait parameters. Post-Hoc analysis was used to determine which mean value was higher than the other.

RESULTS

The result showed that all the 12 participants in experimental group completed the study while only 8 completed it in group 2. There are 8 females and 4 males in the experimental group while there are 6 females and 2 males in the control group. Also, 60% of all the participants have right sided hemiplegia while others have left hemiplegia. The anthropometric parameters and blood pressure of the experimental and control group was presented in Table 1. The result of the student t-test comparing the anthropometric and cardiovascular parameters (systolic and diastolic pressure) of the two groups showed no statistically significant differences, indicating that they were comparable.

The ANOVA result of the study showed that there were significant differences between the training and the control group in cadence (F = 51.62; P<0.05); stride length (F = 3.12; P<0.05) and step width (F = 12.58; P<0.05), (Table 2). The ANOVA result showed that there was no significant difference in the step length or gait velocity (Table 2).

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The result of the post -hoc (Least Significant Difference) of the study showed that the cadence and step width of stroke survivors in the experimental group were higher than that of the control group (P<0.05). However, there were no significant differences in the gait velocity, step length and stride length (Table 3 and 4). Furthermore, the post-hoc (LSD) result showed that there were significant improvements in the Wisconsin Gait Scale scores (p<0.05) for the experimental group only when the pre-training and post-training scores were compared within each group. However, there was no significant difference in the final scores across the 2 groups.

TABLE 1: RESULT OF THE T-TEST COMPARING THE PHYSICAL CHARACTERISTICS

VARIABLES	GROUPS	N	MEAN	SD	t-VALUE	SIG
Age (yrs)	Training	12	50.00	5.93		
	Control	8	56.75	6.18	-1.73	0.12
Height (m)	Training	12	1.68	0.06		
	Control	8	1.67	0.43	0.35	0.73
Weight (kg)	Training	12	63.58	5.91		
	Control	8	61.95	2.68	0.51	0.62

TABLE 2: RESULT OF ANOVA COMPARING GAIT PARAMETER

VARIABLES	Experimental	Mean	Control	Mean	F	SIG
Gait Velocity m/s	Initial	0.21	Initial	0.25		
	Final	0.27	Final	0.29	2.74	0.08
Cadence (Steps/min)	Initial	42.17	Initial	40.50		
	Final	64.00	Final	52.25	51.62	0.00
Stride Length (m)	Initial	0.61	Initial	0.71		
	Final	0.76	Final	0.77	3.12	3.12
Step width (m)	Initial	0.14	Initial	0.12		
	Final	0.21	Final	0.17	12.58	0.00
Step Length (m)	Initial	0.30	Initial	0.34		
	Final	0.39	Final	0.38	2.74	0.08
Gait cycle	Initial	20.83	Initial	20.00		
	Final	31.67	Final	25.75	51.56	0.00
Wisconsin gait scale	Initial	27.56	Initial	22.35		
	Final	22.75	Final	22.81	4.67	0.02

TABLE 3: RESULTS OF THE POST HOC (Least Significant Difference) COMPARING GAIT PARAMETERS

VARIABLES	Mean difference between variables		P-level
Gait Velocity (m/s)	Post Training	Pre Training	0.04
	Post Control	Pre Control	0.30
	Post Training	Post Control	0.53
Cadence (Step/min)	Post Training	Pre Training	0.00
	Post Control	Pre Control	0.00
	Post Training	Post Control	0.00
Stride Length (m	Post Training	Pre Training	0.02
	Post Control	Pre Control	0.38
	Post Training	Post Control	0.92
Step Width (m)	Post Training	Pre Training	0.00
	Post Control	Pre Control	0.02
	Post Training	Post Control	0.02
Step Length (m)	Post Training	Pre Training	0.02
	Post Control	Pre Control	0.33
	Post Training	Post Control	0.84
Gate Cycle	Post Training	Pre Training	0.00
	Post Control	Pre Control	0.00
	Post Training	Post Control	0.00
Wisconsin Gait Scale	Pre Training	Post Training	0.01
	Pre Control	Pre Control	0.04
	Post Training	Post Control	0.37

DISCUSSION

Many studies have confirmed the benefit of physiotherapy for patients with stroke, especially those with mobility restrictions. This study found that subjects who pedaled a cycle ergometer with traditional physiotherapy (training group) showed more significant improvement in the cadence and gait cycle compared to those subjects that only did traditional physiotherapy (control group). Janssen et al observed that a short cycling training program on a semi-recumbent cycle ergometer can markedly improve cycling performance, aerobic capacity, and functional performance of chronic stroke survivors.[19] However, Kautz et al observed that despite extensive pedaling by stroke survivors there was no evidence of improved locomotion coordination postintervention.[20] Also, the study found that the participants in the experimental group ambulated with a wider base. This may be attributed to the likely increase in hip abductor groups, which might be strengthened due to the position assumed on the ergometer for a period of 6 weeks. However, the wide base will give more stability and this may translate to the increase cadence observed among the participants in the experimental group who cycled ergometer.

Gait training can effectively improve walking competency and functional mobility but may not lead to significant gains in activities of daily living after stroke.[21] Patients who receive electromechanical-assisted gait training in combination with physiotherapy after stroke are more likely to achieve independent walking than patients receiving gait training without these devices.[22] Fajiwara et al reported that muscle activity of the quadriceps femoris and tibialis anterior increased significantly during pedaling compared with voluntary knee extension effort, but the muscle activity of the knee flexors did not change.[23] Pedaling could facilitate phasic and coordinated muscle activities even in patients with severe hemiparesis, and it is potentially an effective mode of muscle re-education.[23] Improvement in mobility and gait is a reasonable expectation after physiotherapy intervention.[24] Mixing of components from different "approaches" is more effective than no treatment control in attaining functional independence following stroke, because there is insufficient evidence to conclude that any particular physiotherapeutic "approach" is more effective in promoting recovery of activity levels than any other approach.[25]

The significant improvement in the Wisconsin Gait Scale showed the effectiveness of the rehabilitation training. The Wisconsin Gait Scale is a useful tool to rate qualitative gait alterations of post-stroke hemiplegic subjects, and it is effective to monitor changes over time during rehabilitation training most especially when a targeted and standardized characterization of hemiplegic gait is required for tailoring rehabilitation and monitoring results.[17]

This study was suggestive that conventional rehabilitation is equally important in restoring normal gait because values obtained for both post training and post control showed improvement excluding the Wisconsin score for the control group. This was in

support of Wade and Freidman who reported that stroke survivors showed improvement in their gait patterns following rehabilitation therapy. [26, 27] Factors such as side of affectation, type of stroke, and presence or absence of spasticity were not put into consideration in this study. The small sample size may also affect the interpretation of this study.

CONCLUSION

This study concluded that cadence, gait cycle and Wisconsin gait scale scores were improved when cycle ergometry was combined with conventional therapy.

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