

# EFFECTS OF STRENGTHENING OF LOWER LIMB MUSCLE GROUPS ON SOME GAIT PARAMETERS IN ADULT PATIENTS WITH STROKE

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## SUMMARY

*Gait re-education and mobility activities are important physiotherapy interventions for patients following stroke. The purpose of this study was to evaluate the effects of strengthening of affected lower limb muscle groups on some gait parameters in adult patients with stroke.*

*Twelve patients (6 men and 6 women) with stroke participated in the study. Each patient went through a six-week muscle strengthening regimen for the affected hip flexors, hip extensors, knee flexors and knee extensors on a UNEX SYSTEM III™ PC isokinetic machine.*

*An assessment of muscular strength was done pre-training and post-training. In addition, an assessment of the selected gait parameters (stride length, step length, natural gait speed, maximal gait speed and cadence) was also done pre-training and post-training. Paired t-tests were used to determine whether significant differences existed between the pre-training and post-training mean values of muscular strength and the gait parameters.*

*The mean age of the patients was  $61.25 \pm 7.84$  years, while their mean weight was  $63.08 \pm 5.93$ kg. The training regimen resulted in statistically significant improvement in the strength of the trained muscle groups and in all the selected gait*

*parameters, except cadence (at  $p < 0.05$ ). It was concluded that the strengthening of the lower limb muscles of the affected side improves some gait parameters over time in patients with stroke.*

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**Key words:** stroke, hemiplegia, gait parameters, muscle strengthening, rehabilitation

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## INTRODUCTION

Stroke is a major health problem in every part of the world. It is the most life threatening neurological condition of the elderly and the most common cause of adult disability.<sup>1</sup> The incidence of stroke increases dramatically with age; about 5% of persons over 65 years of age will suffer a stroke.<sup>2</sup> Men have a higher incidence of stroke than women. A large number of survivors of stroke are left with a variety of disabilities, including impairment of sensory, motor, mental, perceptual and language functions. The motor deficits are characterized by paralysis (hemiplegia) or weakness (hemiparesis) on the side of the body opposite the site of the lesion.<sup>3</sup>

Walking is possible for the majority of the patients following stroke, but it rarely returns to normal. Hence, gait re-education and mobility

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\* Concept and research design, writing and data analysis were provided by Mr Olawale while Mr Akinfeleye was in charge of data collection, data analysis and institutional liaisons.

training are important physiotherapy interventions for patients following stroke.<sup>4, 5</sup> Balance and gait deficits exhibited by patients with stroke inhibit the performance of normal functions and are contributory factors in the incidence of falls.<sup>6,7,8,9</sup> With malfunctioning postural reactions, the patients cannot effectively execute voluntary movements involving the extremities and they lack precise postural balance control.

Gait is defined as the manner or style of walking.<sup>10</sup> Gait is a complex activity and a large amount of time is expended by the physiotherapist on the description of gait patterns, identification of gait deviations and retraining of normal gait patterns in order to improve the ambulatory status of the patient. The description of an individual's gait pattern ordinarily includes the speed of locomotion and the number of steps completed per unit of time, as well as other characteristics of the gait.<sup>11</sup>

During a walking cycle, a given foot is either in contact with the ground (stance phase of gait cycle) or in the air (swing phase). The duration of the gait cycle for any one limb extends from the time the heel contacts the ground (called the heel strike) until the same heel contacts the ground again.<sup>12</sup>

Each of the two primary phases of the gait cycle can be subdivided into various stages called the sub-phases of gait. For example, the stance phase comprises heel strike, foot flat, heel off, and toe off sub-phases.<sup>12</sup> In pathological gait, some of these sub-phases, such as heel strike, may not occur. Much is still unknown about the control of voluntary movement. To move a limb, for example, the brain must plan a movement, arrange appropriate motion at many different joints at the same time, and adjust the motion by comparing plan with performance. The movements are planned in the cortex as well as in the basal ganglia and the internal portions of the cerebella hemisphere. The sensory inputs from muscles, tendons, joints and the skin relayed directly to the motor cortex, provide the feedback information which adjusts and smoothens the movements.<sup>13</sup>

Gait is usually altered following a stroke due to a number of factors, including impairment in sensation and perception and motor control. Common gait problems in hemiplegia arise as a result of unawareness of the affected (paretic) side, flexion contracture and scissoring at the hip, flexion contracture at the knee, unequal step length, and weak dorsiflexion at the ankle.<sup>14, 15</sup>

In order to set realistic goals and to develop and

implement a treatment plan directed towards improving or restoring the patient's gait, the physiotherapist must be able to assess the ambulatory status of the patient. The purpose of this study was to examine the effects of strengthening of the affected (paretic) lower limb muscle groups on some gait parameters in adult patients with stroke.

## MATERIALS AND METHODS

### Subjects

The subjects for this study comprised 12 stroke patients (6 men and 6 women) referred for rehabilitation at the Physiotherapy Department of the Lagos University Teaching Hospital during a period of six months (between 1<sup>st</sup> December 1999 and 31<sup>st</sup> May 2000). The sample selection criteria were: commencement of rehabilitation within 6 months of occurrence of first episode single stroke, absence of spasticity or musculoskeletal disorders such as osteoarthritis and rheumatoid arthritis, ability to ambulate without the use of walking aids, absence of auditory and/or visual impairment.

### METHOD

Demographic data on the patients were collected at the beginning of the study. Assessment of muscular strength and gait parameters was made pre-training and post-training. The muscular strength of the affected (paretic) hip flexors, hip extensors, knee flexors and knee extensors were assessed with the UNEX system III<sup>TM</sup> PC 2403 machine. The muscular strength of the knee extensors was measured with the patient sitting upright and the lever arm of the machine placed in front of the ankle just above the level of the malleoli. The patient was asked to extend the knee and the torque produced was measured and recorded in Newton metres. (Nm). The best torque produced out of the three trials was used for analysis. The muscular strength of the knee flexors was determined with the patient sitting upright and the level arm of the machine placed behind the Achilles tendon of the unaffected limb. The torque produced was recorded when the patient flexed the knee.

The muscular strength of the hip flexors was determined with the patient lying supine and the level arm of the machine placed to the limb just above the knee. The torque produced when the patient lifted up the leg was recorded. The muscular strength of the hip extensors was measured with the patient lying supine with the hips slightly flexed. The lever arm was placed behind the calf muscles and the patient was instructed to push down the lower limb.

The torque produced was then recorded.

The gait parameters were measured on a 6m walkway with a plain sheet of paper on its surface. Patients were instructed to step on an inkpad placed 2m away from the walkway, such that a uniform step would have been established before getting to the walkway. The footprints from the sole of the feet were produced on the paper as the patients walked from one end of the walkway to the other.

The step length (cm) was obtained by measuring the linear distance between two successive heel strikes (from affected limb to unaffected limb). Two measurements were made and the average distance was used for analysis. The stride length (cm) was obtained by measuring the linear distance from one heel strike of the affected limb to the next heel strike of the same limb. The natural gait speed (walking velocity) (m/s) was determined by dividing the length of the walkway by the time taken by the patient to walk at his natural pace from one end of the walkway to the other. The maximal gait speed (m/s) was obtained by dividing the length of the walkway by the time taken by the patient to walk at his maximal safe speed from one end of the walkway to the other. The cadence (step/minute) was determined by dividing the number of steps obtained on the walkway by the time taken to cover the walkway.

**TRAINING PROTOCOL**

Each patient went through a muscle strengthening regimen three times a week for six-weeks. Each session lasted about 30 minutes. Training for the muscle groups was carried out using the UNEX system III™ PC 2403 machine. The resistance load provided by the UNEX machine was increased several times with the same starting position. Each muscle group was trained in the same position used for the measurements as described above.

**DATA ANALYSIS**

The mean and standard deviation were computed for the pre-training and post-training measurements of muscular strength and gait parameters. Paired *t*-tests were used to determine whether significant differences existed between the pre-training and post-training mean values ( $P < 0.05$ ).

**RESULTS**

The demographic data of the patients are shown in table 1. The mean age was  $61.25 \pm 7.84$  years while the mean weight was  $63.08 \pm 5.93$  kg. Seven of the patients had left-sided hemiplegia while five had

right-sided hemiplegia. Table 2 shows the pre-training and post-training values for the muscular strength assessment. The muscular strength of the hip flexors increased from a mean of  $17.08 \pm 13.56$  Nm to  $28.75 \pm 21.65$  Nm (mean difference = 11.67 Nm). The hip extensors had a mean increase of 8.34 Nm (from  $22.08 \pm 6.20$  to  $30.42 \pm 5.82$ ). The muscular strength of the knee flexors increased from a mean of  $22.50 \pm 11.18$  to  $31.25 \pm 15.24$  Nm (mean difference = 8.75). The knee extensors had a mean increase of 9.58 Nm (from  $42.92 \pm 20.17$  to  $52.50 \pm 21.58$ ). All these increases were statistically significant ( $P < 0.05$ ).

**Table 1. Demographic Data of the Patients**

S/No.	Sex	Affected Side	Age	Weight (kg)
1	M	R	53	62
2	F	R	58	56
3	F	R	61	55
4	M	R	74	63
5	F	R	60	65
6	M	L	62	68
7	M	L	54	67
8	M	L	75	66
9	F	L	64	58
10	F	L	52	55
11	M	L	54	72
12	F	L	68	70
<b>MEAN</b>			61.25	63.08
<b>S.D.</b>			7.84	5.93

Table 3 shows the pre-training and post-training values for the kinematic gait parameters. The stride length increased from  $56.95 \pm 18.87$  cm to  $79.71 \pm 22.70$  cm; while the step length increased from  $27.93 \pm 8.10$  cm to  $42.59 \pm 9.45$  cm. The natural gait speed (walking velocity) increased from  $0.52 \pm 0.16$  m/s to  $0.81 \pm 0.23$  m/s; while the maximal gait speed increased from  $0.84 \pm 0.2$  m/s to  $1.22 \pm 0.39$  m/s; All these increases were statistically significant ( $P < 0.05$ ). The cadence increased from  $84 \pm 17.05$  steps/minute to  $95.83 \pm 13.51$  steps/minute. This increase was, however, not statistically significant ( $P < 0.05$ ).

**Table 2.** Muscular Strength Assessment (Nm)

S/No.	Hip Flexors		Hip Extensors		Knee Flexors		Knee Extensors	
	Pre-training	Post-training	Pre-training	Post-training	Pre-training	Post-training	Pre-training	Post-training
X	17.08	28.75	22.08	30.42	22.50	31.25	42.92	52.50
SD	±13.56	±21.65	±6.20	±5.82	±11.18	±15.24	±20.17	±21.58
Mean Diff.	11.67*		8.34*		8.75*		9.58*	

\* Significant

**Table 3.** Assessment of Gait Parameters

S/No.	Stride Length (cm)		Step Length (cm)		Natural Gait Speed (m/s)		Maximal Gait Speed (m/s)		Cadence (step/min)	
	Pre-training	Post-training	Pre-training	Post-training	Pre-training	Post-training	Pre-training	Post-training	Pre-training	Post-training
X	56.95	79.71	27.93	42.59	0.52	0.81	0.84	1.22	84.0	95.83
SD	±18.87	±22.70	±8.10	±9.45	±0.16	±0.23	±0.20	±0.39	±17.05	±13.51
Mean Diff.	22.76*		14.66*		0.29*		0.38*		11.83	

\* Significant

## DISCUSSION

During mobility, the two lower limbs play important but different functions. The leading limb mainly contributes to forward progression, whereas the trailing limb provides control and contributes to propulsion to a lesser extent. The trailing limb's power generation is generally secondary to control activities or possibly to control for the leading limb's propulsion.<sup>15</sup> In one particular study, the right lower limb was found to be responsible for propulsion, whereas the left lower limb was found to be responsible for support.<sup>16</sup> Gait analyses of subjects without lower limb impairment are done to characterize gait and to provide a framework for understanding musculoskeletal disorders in order to improve rehabilitation outcomes. Similarities or dissimilarities between the lower limbs of people without impairment might affect a clinician's interpretation of data obtained from people whose gait is affected by pathology. This fact is usually taken into account when evaluating gait and when considering approaches to rehabilitation and physiotherapy intervention.<sup>15</sup>

Patients who have had a stroke often have long-term difficulties with walking. Such patients are often referred for physiotherapy treatment.<sup>17</sup> In evaluating the physical impairment and functional limitations of patients, it is clinically useful to assess walking capacity and monitor the recovery of gait performance. For such patients, improvements in the

areas of mobility, balance and gait may have valuable benefits in terms of quality of life.<sup>14, 18</sup>

The results of this study show that the strengthening of the selected lower limb muscle groups of the affected side in patients with stroke causes significant improvements in step length, stride length, walking velocity and maximal gait speed. This improvement is attributable to the increase in muscular strength of the affected lower limbs as a result of the training regimen. The results accord with those of Nadeau et al. (1999), who reported that strengthening the weak lower limb muscles improved gait in patients with stroke.<sup>19</sup> However, in another study, Wade and colleagues<sup>20</sup> reported a transient and small (8%) increase in walking speed that did not improve patients' mobility disability. The external validity of our work is limited due to the small sample size used for this study.

## CONCLUSION/CLINICAL IMPLICATIONS

Many studies have confirmed the benefits of physiotherapy for patients with stroke, especially those with mobility problems. Improvement in mobility and gait is a reasonable expectation after physiotherapy intervention.<sup>18</sup> The findings of the present study are applicable to current clinical practices; and the significant improvements recorded could have resulted from the nature of the training and intensity of the treatment. Patients could also benefit from low intensity rehabilitation treatment,<sup>21</sup>

however, treatment should be commenced as early as possible. Further research into physiotherapy for patients with stroke should focus on specific components of therapy. The components that are effective (one of which was explored in the present study) can form an evidence base for treatment. It is important to identify for which cohort of patients and at what stage of the rehabilitation process a specific therapy is effective.<sup>22</sup> Physiotherapists should move away from rigid adherence to established schools of thought, most of which are based on diluted and ineffective forms of long-term therapy. The time is ripe for the implementation of evidence-based physiotherapy in clinical practice.

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