International Journal of Physiotherapy and Research,
Int J Physiother Res 2017, Vol 5(2):1976-86. ISSN 2321-1822
DOI: https://dx.doi.org/10.16965/ijpr.2017.120

Original Research Article

ISOKINETIC STRENGTH TRAINING IN PATIENTS WITH STROKE: EFFECTS ON MUSCLE STRENGTH, GAIT AND FUNCTIONAL MOBILITY

Nevein Mohammed Gharib *[1], Rabab Ali Mohamed [2].

[*1] Assistant Professor, Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

[2] Lecturer, Department of Basic Sciences, Faculty of Physical Therapy, Cairo University, Giza, Egypt.

ABSTRACT

Background: Muscle weakness in the lower limbs has adverse effects on walking performance and functional mobility in patients with stroke. Therefore, interventions aiming to improve muscle strength post stroke are considered crucial part of stroke rehabilitation.

Objective: To determine the effectiveness of isokinetic strength training for knee and ankle muscles of the affected side on muscle strength, gait and functional mobility in chronic stroke.

Materials and Methods: Thirty patients with stroke of both sexes (46-62 years) shared in this study. They were randomly assigned into two equal groups; experimental and control groups. Patients in the experimental group received a traditional physical therapy program in addition to isokinetic training for knee and ankle muscles in the affected side. Those in the control group received only the traditional physical therapy. Treatment was provided three times per week for eight successive weeks. The participants received pre and post-treatment assessments for the peak torque of the trained muscles, gait parameters and functional mobility as measured by the Timed Up and Go (TUG) test.

Results: Patients in both groups showed significant improvement post treatment in peak torque of knee and ankle muscles, gait parameters and TUG test ($p<0.05$). Additionally, after the intervention, between-group comparison revealed significant difference for peak torque of both knee and ankle muscles ($p<0.05$), walk speed ($t=2.44$, $p=0.02$), gait cycle time ($t=-3.43$, $p=0.002$), single limb support ($t=3.58$, $p=0.001$) and TUG test ($t=-3.45$, $p=0.002$) in favor of the experimental group.

Conclusion: Isokinetic strength training of the affected lower limb muscles in conjunction with proper physical therapy exercise program is effective in improving muscle strength, walking performance and functional mobility in patients with stroke.

KEY WORDS: Stroke, Isokinetic, Muscle strength, Gait, Functional mobility.

Address for correspondence: Dr. Nevein Mohammed Gharib, PhD, PT, Assistant Professor, Department of Physical Therapy for Neuromuscular Disorders and its Surgery, Faculty of Physical Therapy, Cairo University, Giza, Egypt. **E-Mail:** neveinmohammed@gmail.com

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Quick Response code	International Journal of Physiotherapy and Research ISSN 2321- 1822 www.ijmhr.org/ijpr.html	
DOI: 10.16965/ijpr.2017.120	Received: 18-02-2017 Peer Review: 19-02-2017 Revised: None	Accepted: 16-03-2017 Published (O): 11-04-2017 Published (P): 11-04-2017

INTRODUCTION

Stroke is considered as one of the most common leading causes of long-term disability that comes about because of brain cell damage which results in either an interruption of the blood supply to the brain or cerebral hemorrhage [1]. Impaired motor control is one of the main clinical manifestations of stroke. It is charact-

-erized by muscle weakness, spasticity and abnormal movement patterns. These impairments restrict the performance of many functional activities. Often, despite rigorous rehabilitation in the first few months after stroke, patients remain with marked disability and become in danger for further functional decline secondary to the aging process or comorbidity [2,3].

Muscle weakness is considered as a limiting factor in the rehabilitation of stroke survivors which often leads to an impaired walking pattern with altered gait characteristics [4]. Specifically, hemiplegic gait is typically associated with reduced gait speed [5,6], cadence [6,7], stride length [7,8] and an increased stance phase duration [8] and left-right asymmetry during walking [9] when compared with normal, age-matched persons. Muscle weakness not only leads to gait impairments but can also affect balance and postural transfers (i.e., changing position from sitting to standing and vice versa), further impeding the patients' functional mobility and independence [10]. It is therefore a central goal of stroke rehabilitation to improve the patient's independence and functional capacity by improving his or her mobility [11].

For many years, muscle strength testing and training in patients with spastic muscles have been questionable issues [12]. It was reported that diminished muscle strength was not because of weakness but rather to the restriction of the spastic antagonists. Additionally, muscle strengthening was not advocated as it was thought to increase spasticity and promote abnormal muscle activation patterns [13]. The evidence that strengthening exercises increases muscle tone is weak [14,15] and other researches, nonetheless, have demonstrated that muscle strength training is not related with increments in spasticity [3,16]. Moreover, stroke rehabilitation recommendations recently include strength training [17,18].

Functional task training concerning the practice of context-specific tasks has the benefit of directly practicing a problematic functional activity (e.g., gait), rather than concentrating on the impairments (e.g., strength) adversely affecting its execution [19]. Noteworthy improvement in many daily living activities have been reported after different functional trainings. In any case, functional training alone not just permits less control of intensity of effort created; however its effect on gait is as restricted as the one of strength training [20].

One practical way to promote a match between strength-training parameters and a functional task, as well as allow a better control for the intensity of effort, is to use isokinetic devices. These dynamometers can accommodate the individual's strength throughout the range of motion and allow weakened muscles to be trained using various speeds and types of contraction [21]. Furthermore, isokinetic training is believed to have great advantage over other rehabilitation methods. The larger effect of isokinetic training could be attributed to its ability to achieve maximal torque throughout the whole range of motion and this is not achieved during manual training [22].

To our best knowledge, no studies have yet investigated the impact of isokinetic strength training on gait parameters in patients with stroke. Only one study [23] has evaluated the impact of isokinetic program on gait speed and some biomechanical parameters. However, their treatment program was general (strength and aerobic exercises) and not intended to correspond to the specific prerequisites of gait. Furthermore, the gait parameters were analyzed only descriptively, thus limiting interpretation of the results. Also, there are controversial results regarding the effect of isokinetic strength training on functional mobility post stroke [3,24]. Therefore, the purpose of this study was to determine the effectiveness of isokinetic strength training for knee and ankle muscles of the affected side on muscle strength, gait parameters and functional mobility in patients with chronic stroke.

MATERIALS AND METHODS

Subjects: Thirty stroke patients of both sexes (16 males and 14 females) participated in this study. Their ages ranged from 46-62 years old. They were recruited from the neurological outpatient clinic of the Faculty of Physical Therapy, Cairo University, Egypt. The patients were diagnosed as having stroke confirmed by computed tomography or magnetic resonance imaging. The patients were eligible for inclusion if they had a history of single stroke due to hemorrhage or infarction with duration of illness ranged from 6-18 months and mild degree of spasticity of the affected lower limb (Modified Ashworth Scale < 2) [25]. Additionally, they were included if they had the ability to walk independently without assistance of orthosis or other external aids at least 10 meters for three times. The patients were excluded if they had unstable medical condition, other neurological or orthopedic diseases that may affect muscle strength, gait or functional mobility such as recurrent stroke, parkinsonism or severe osteoarthritis. Also, they were excluded if they had deafness, blindness, deep sensory loss or cognitive impairment (unable to follow simple verbal instructions during assessment or treatment). Prior to participation, each patient signed an informed consent form. The study was approved by Faculty of Physical Therapy - Cairo University ethical committee.

The subjects were randomly allocated into two equal groups; experimental and control groups with 15 patients in each using a computer-generated random number list. Participants in the experimental group received a designed conventional physical therapy program in addition to isokinetic strength training of knee flexors/extensors and ankle dorsiflexors/plantar flexors of the affected side. Participants in the control group received only the conventional physical therapy program given to the experimental group.

INSTRUMENTATION

Qualisys Motion Capture System: It was used in this study to assess gait parameters including walking speed, gait cycle time and single limb support on the affected side (as a percent of gait cycle). The system consisted of six ProReflex infrared high speed cameras to perform multi camera measurements and have a capture capability of 120 frames/sec. The basic principle of the system was to expose reflective markers to infrared light and to detect the light reflected by the markers. The used software programs were Q trac and Q tools (provided by Qualisys Company).

Eighteen skin markers were stuck to the skin over specific bony landmarks by double face adhesive plaster. The markers were placed bilaterally as follows: two on the acromion processes, two on the anterior superior iliac spines, two on the superior borders of the patellae, two on the lateral aspects of the knee joint lines (mid-point), two on the tibial tuberosities, two on the lateral malleoli, two over the heads of the fifth metatarsal bones and two markers were placed over the two heels (posterior of calcaneus). Also, one marker was placed on the spinous process of the 12th thoracic vertebra and another one on the sacrum. All markers were placed on all patients by the same examiner for placement consistency [26].

Biodex Isokinetic Dynamometer: The Biodex system 3 pro isokinetic dynamometer (Biodex Medical Inc., Shirley, New York, USA) was used for assessment as well as training of knee flexors/extensors and ankle dorsiflexors/plantar flexors of the affected side. It has been widely used in evaluation as well as training in adults with different musculoskeletal and neuromuscular disorders [27]. It is connected with a personal computer provided with a specific software that collects, displays, stores the data and controls the movements of the dynamometer. The machine is provided with many attachments and isolation straps to secure the trunk, shoulder, knee and ankle joints. It has three angular velocities classified into low speed (30-60^0/sec), moderate speeds (60-90^0/sec) and fast speeds (90-120^0/sec). The system provides the final results in the form of testing data chart and graph recordings of torque, speed, time, motion, work, power and different ratios. Because peak isokinetic torque can be reliably used for assessing muscle strength of the lower limbs in patients with stroke [28,29], so it was used in this study to assess the peak torque of the selected muscles as an indicator for their strength. Reliability and validity of torque measurement of the Biodex system was previously established [30].

The Timed Up and Go Test (TUG): This test is a widely used performance test for the evaluation of functional mobility or basic mobility skills after stroke [31,32]. The TUG is easy to administer compared with other performance measures and provides information on the abilities that facilitate living safely at home. The test requires participants to stand up from a chair, walk three meters, turn around, return to the chair, and sit down again. The time required to complete the test is recorded in seconds using a stopwatch [33].

PROCEDURES

For evaluation: Gait assessment was done in this study by the use of Qualisys Motion Capture System. The camera system was calibrated, before any 3D capture was performed, to enable the cameras to pick up the positions of the markers in the trajectory field of the walkway. The position of cameras and their spatial orientation remain unchanged during the study. Any relocation of the cameras required re-calibration [34]. Each patient was instructed to walk on the walkway bare feet and at what he/she considered to be a natural or comfortable walking speed (self-selected speed) [35]. Several walks along the walkway were allowed prior to recording of data, so that acclimatization to the walkway and the recording system could occur. The data were collected from three walking trials and the average was taken.

For isokinetic muscle strength assessment of knee flexors/extensors and ankle dorsiflexors/plantar flexors of the affected side, Biodex system 3 pro isokinetic dynamometer was used. Before starting each assessment (or training) session, the system was calibrated according to the manufacturer specifications. To ensure familiarity with the procedures and reduce the learning effect, each patient was allowed to attend a practice session 2-4 days before the actual assessment day. Four to six active concentric repetitions at angular velocity 30°/sec were allowed for knee extension/flexion and ankle dorsiflexion/plantar flexion [28].

Because patients with stroke have difficulty generating maximal exertion throughout the entire range of movement at high velocity [36], slow and moderate angular velocities of 30°/s and 90°/s were chosen to evaluate the strength of the selected muscles. For testing muscle peak torque, each patient was instructed to "push or pull as hard as possible" throughout the available range of motion for 4-6 repetitions till consistency of the results was gained across three repetitions. After each repetition of movement, all patients were allowed to rest for two seconds [28].

The standardized position for knee assessment was sitting with the backrest reclined 5° from vertical. Stabilization was applied by straps over chest, waist and the thigh to prevent any substitution. Transverse line passing through the femoral condyles was accepted as the axis for the knee joint and the dynamometer was adjusted with this axis. The pad surrounding the leg was fixed to the leg just above the lateral malleolus [37]. The range of motion was set as knee flexion and extension (0° - 90° / 90° - 0°). For ankle testing, each patient was positioned as in the knee testing. The knee joint was positioned in 20°-30° knee flexion. The adjustable lever arm was attached to the dorsum of foot at level of metatarsal heads. The dynamometer was adjusted with the lateral malleolus. The range of motion was set as ankle dorsiflexion and planter flexion (20° - 0°- 45°) [38].

Each patient was instructed to conduct three maximal reciprocal contractions at each angular velocity (30°/s and 90°/s) and the mean of the three trials was recorded. A rest period of two minutes was given between each test velocity. The progression was performed from slow to fast velocity [3]. All tests were conducted by the same examiner. The examiner provided instructions for all assessment procedures; however no verbal feedback was given during testing [39].

For assessment of functional mobility, TUG test was used. The test was performed and averaged over three trials for each subject. Each patient was instructed to stand up from a chair, walk 3 meters, turn around, return to the chair, and sit down again. The time required to complete the test was recorded in seconds using a stopwatch [33].

For treatment: All patients in both groups underwent a 60-minute conventional physical therapy exercise program (three sessions per week) for successive eight weeks. The conventional physiotherapy session began with stretching exercises to regain flexibility of tight muscles in the affected side based on the principles of Bobath concepts [13]. Specific strengthening exercises were also planned for trunk and weakened arm and leg muscles in the aûected side. Moreover, the patients received postural control and balance training (static and dynamic) from different positions such as sitting, kneeling, quadruped and standing positions. Weight shifting exercises were also applied to improve weight bearing and sensory awareness of the affected side. Activities for daily living (e.g. changing positions from sitting to standing) were also included in the physical therapy session. Additionally, all patients received gait training exercises with graduated difficulties and the patients were guided and assisted to perform each exercise correctly.

After the conventional physical therapy session, patients in the experimental group received additional isokinetic strength training for knee flexors/extensors and ankle dorsiflexors/plantar flexors of the affected limb by using the Biodex isokinetic dynamometer, three sessions a week over a period of eight weeks. The isokinetic strengthening protocol consisted of three sets of 5 repetitions of maximal concentric isokinetic knee flexion/extension followed by ankle dorsiflexion/plantar flexion. The training was conducted in the same position and angular velocities (30°/s and 90°/s) and through the same range of motion as the assessment with 10 seconds rest period [38]. Verbal instructions were used to motivate and direct the patients such as “Push as hard and as fast as possible against the lever arm’’ [22].

Statistical analysis: All statistical measures were performed through the statistical package for social sciences (SPSS) version 23 for windows. Results are expressed as mean ± standard deviation (SD). Unpaired t-test was conducted for comparison of the mean values of age, weight, and height between both groups. Mann–Whitney signed-rank test was used to compare the baseline assessment of the degree of spasticity between the two groups. Paired t-test was conducted for comparison of pre and post treatment mean values of all measured variables within each group. The comparison between both groups was calculated using unpaired t-test. The level of significance for all statistical tests was set at $p < 0.05$.

RESULTS AND TABLES

Analysis of baseline values between the two groups revealed non-significant differences as regarding to age (*p*=0.81), weight (*p*=0.48), height (*p*=0.27), duration of illness (*p*=0.62) and the degree of spasticity (*p*=0.47). The demographic and clinical characteristics of patients in both two groups are listed in Table 1.

Table 1: Demographic and clinical data of patients in both groups.

	Experimental group (n=15)	Control group (n=15)	*t*-value [c] /Z-value [d]	*p*-value
Age (years) [a]	54.4 ± 5.51	53.73 ± 4.68	0.36 [c]	0.72
Height (cm) [a]	166.20 ± 6.64	169.33± 8.42	-1.13 [c]	0.27
Weight (kg) [a]	70.87 ± 7.84	72.93 ± 7.99	-0.72 [c]	0.48
Duration (month)	9.6 ± 3.43	10.07 ± 2.89	-0.4 [c]	0.69
Gender [b]				
Male	7 (46.66)	9 (60%)		
Female	8 (53.33)	6 (40)		
Modified Ashowrth Scale [a]	1.23 ± 0.26	1.3 ± 0.25	-0.72 [d]	0.47
Affected side [b]				
Right	7 (46.66)	6 (40)		
Left	8 (53.33)	9 (60)		

Values are mean ± SD[a] or mean ± frequency (%)[b].
Method of statistical analysis is in the form of unpaired sample *t*-test[c].
Method of statistical analysis is in the form of U Mann-Whitney signed-rank [d].

There were statistically non-significant differences in the mean values of pre- treatment data of all variables being tested (peak torque, gait parameters and TUG test) between the two groups (p>0.05). As regarding to peak torque, it was assessed in this study to evaluate the muscle strength for the trained muscles (knee flexors/extensors and ankle dorsiflexors/plantar flexors). Comparison of the pre and post-treatment values of peak torque revealed a significant improvement in muscle strength in both groups (p<0.05) (Tables 2&3). On the other hand, there was higher improvement in muscle strength in the isokinetic group compared to the control group post treatment (p<0.05) (Table 5).

When comparing the baseline and post-treatment values of gait parameters (including walking speed, gait cycle time and SLS on the affected side) and TUG test within each group, the results revealed a significant improvement in all parameters in both groups (p<0.05) (Table 4). The analysis of these parameters post treatment between both groups revealed significant differences in walking speed (*p*=0.02), gait cycle time (*p*=0.002), SLS on the affected side (p=0.001) and TUG test (p=0.002) (Table 4).

Table 2: Descriptive statistics and within group comparison of knee peak torque values (Nm) in both groups.

Test/Group	Pre	Post	t-value	p-value
- Knee flexion 30˚/sec				
Experimental group	20.86 ± 4.57	28.6 ± 5.69	-10.92	0.0001*
Control group	19.01 ± 4.49	22.15 ± 4.43	-15.65	
- Knee flexion 90˚/sec				
Experimental group	15.65 ± 3.19	23.01 ± 4.38	-13.41	0.0001*
Control group	14.78 ± 4.35	18.18 ± 4.59	-14.63	
- Knee extension 30˚/sec				
Experimental group	28.62 ± 4.48	35.83 ± 6.14	-10.87	0.0001*
control group	26.82 ± 4.76	29.84 ± 4.76	-8.28	
- Knee extension 90˚/sec				
Experimental group	22.89 ± 4.03	29.33 ± 4.92	-11.3	0.0001*
Control group	21.62 ± 3.79	24.93 ± 3.81	-8.82	

Values are mean ± SD, Nm: Newton meter, Pre: Pre-treatment evaluation, Post: Post-treatment evaluation, * Significant at $p < 0.05$.

Table 3: Descriptive statistics and within group comparison of ankle peak torque values (Nm) in both groups.

Test/Group	Pre	Post	t-value	p-value
- Ankle dorsiflexion 30˚/sec				
Experimental group	10.25 ± 3.51	16.11 ± 4.78	-13.48	0.0001*
Control group	9.71 ± 3.69	12.15 ± 4.03	-15.89	
- Ankle dorsiflexion 90˚/sec				
Experimental group	7.11 ± 3.01	13.08 ± 4.03	-17.68	0.0001*
Control group	6.93 ± 3.28	9.04 ± 3.45	-20.54	
- Ankle plantar flexion 30˚/sec				
Experimental group	14.74 ± 4.50	22.14 ± 4.97	-25.56	0.0001*
Control group	14.31 ± 4.67	16.71 ± 5.04	-16.46	
- Ankle plantar flexion 90˚/sec				
Experimental group	11.29 ± 3.57	18.32 ± 4.55	-18.2	0.0001*
Control group	10.91 ± 3.64	13.38 ± 3.86	-18.56	

Values are mean ± SD, Nm: Newton meter, Pre: Pre-treatment evaluation, Post: Post-treatment evaluation. * Significant at $p < 0.05$.

Table 4: Descriptive statistics and within group comparison of gait parameters and TUG test in both groups.

Test/Group	Pre	Post	t-value	p-value
Walk speed (m/sec)				
Experimental group	0.43 ± 0.09	0.67 ± 0.11	-13.89	0.0001*
Control group	0.41 ± 0.11	0.58 ±0.09	-8.65	
Gait cycle time (sec)				
Experimental group	1.81 ± 0.18	1.31 ± 0.19	11.45	0.0001*
Control group	1.85 ± 0.22	1.55 ± 0.19	14.22	
SLS (% gait cycle)				
Experimental group	25.66 ± 3.71	31.53 ± 2.19	-7.58	0.0001*
Control group	24.4 ± 2.53	28.27 ± 2.76	-5.92	
TUG test (sec)				
Experimental group	35.73 ± 5.48	24.45 ± 3.91	11.69	0.0001*
Control group	34.47 ± 4.7	29.73 ± 4.53	9.42	

Values are mean ± SD, Pre: Pre-treatment evaluation, Post: Post-treatment evaluation, SLS: Single limb support, TUG: Timed up and go test, * Significant at $p < 0.05$.

Table 5: Statistical analysis of knee and ankle peak torque, gait parameters and TUG test between groups.

	Pre treatment		Post treatment	
	t-value	p-value	t-value	p-value
Knee flexion 30˚/sec	1.12	0.27	3.46	0.002*
Knee flexion 90˚/sec	0.62	0.54	2.94	0.006*
Knee extension 30˚/sec	1.07	0.29	2.98	0.006*
Knee extension 90˚/sec	0.89	0.38	2.74	0.01*
Ankle dorsiflexion 30˚/sec	0.41	0.69	2.45	0.02*
Ankle dorsiflexion 90˚/sec	0.16	0.87	2.94	0.006*
Ankle plantar flexion 30˚/sec	0.26	0.79	2.96	0.006*
Ankle plantar flexion 90˚/sec	0.28	0.77	3.21	0.003*
Walk speed (m/sec)	0.54	0.59	2.44	0.02*
Gait cycle time (sec)	-0.55	0.59	-3.43	0.002*
SLS (% gait cycle)	1.09	0.28	3.58	0.001*
TUG test (sec)	0.68	0.503	-3.45	0.002*

Values are mean ± SD, SLS: Single limb support, TUG: Timed up and go test, Pre: Pre-treatment evaluation, Post: Post-treatment evaluation, *Significant at $p < 0.05$.

DISCUSSION

Muscle weakness has been considered as a common dysfunction after stroke [10]. Conceivable reasons for this weakness incorporate diminished number of motor units, disturbed recruitment order of motor units, diminished firing rate of motor units and muscle atrophy after disuse [3,28]. Muscle weakness of the affected lower limb has adverse effects on walking performance and functional mobility in patients with stroke. Therefore, interventions aiming to improve muscle strength post stroke are considered crucial part in stroke rehabilitation [40].

The purpose of this study was to evaluate the effectiveness of isokinetic strength training for knee and ankle muscles of the affected side on muscle strength, gait parameters and functional mobility in patients with chronic stroke. The main findings of the current study were that patients who received isokinetic strength training combined with conventional physical therapy program (experimental group) showed significant improvement in the peak torque values of the knee flexors/extensors and ankle dorsiflexors/plantar flexors compared with those who received conventional training alone (control group). Additionally, there was significant improvement in gait parameters (including walk speed, gait cycle time and SLS on the affected side) and functional mobility (TUG test) in both groups in favor of the experimental group.

The significant increase in peak torque values (as an indicator for muscle strength) of the selected muscles in both groups might be attributed to the effect of the designed physical therapy program which was applied to the patients in both groups. This program incorporated conventional exercises (based on Bobath concepts) [13] followed by gait training exercise program. The exercises were directed to control unnecessary muscle activity, stretch and improve flexibility of tight muscles in the affected side, enhance normal movement pattern, improve voluntary control on the affected side, strengthen weak muscles and train postural control and balance from different positions. This justification comes in agreement with the findings of Lennon [7] who proved the efficacy of training based on Bobath concepts on walking abilities of stroke patients. Also, this comes in accordance with Sharp and Brouwer [3] who mentioned that stretching and flexibility exercises included in the physical therapy program given to patients with spasticity can produce a reduction in reflex or an enhancement of muscle compliance generating more effective muscle torque.

The higher improvement in the peak torque values in the experimental group than the control group might be attributed to the cumulative effect of the physical therapy exercise program together with the isokinetic strength training. Adding the isokinetic strength training to the rehabilitation program provides the best way for improving muscle strength aiming to increase the motor performance of the affected lower limb. This comes in agreement with Emrani et al [41] who reported that strength training can be applied in different modes which work differently through the range of motion. During traditional isotonic strength training, the weakest mechanical points of the range of motion are subjected to greatest load, while the rest of the angles work at less than maximal capacity. On the contrary, during isokinetic strength training, the resistance developed is in proportion to the amount of force exerted and a maximal effort can be experienced as the maximal load is applied at all points throughout the range of motion. Also, isokinetic training is considered as a safe method for evaluation and strength training with minimal risk of injury [21,27].

The improvement in the peak torque values of the selected muscles after isokinetic training might be attributed to the improvement in both motor unit recruitment and frequency of firing after training [42]. Added to this, the enhancement of motor learning through the establishment of coordinated neuromotor patterns between the agonist and antagonist muscles after practice of the movement could contribute to this improvement [43]. This comes in agreement with the findings of other studies [3,12,38,44] which suggest that muscle strength can be improved significantly after isokinetic strength training in patients with stroke. Additionally, it was proved that resistance training in healthy older adults can limit age-related decrease in muscle strength [45].

The results revealed marked enhancement in walking performance as proved by the significant improvement in gait parameters post treatment in both groups with a higher improvement in the isokinetic group compared with the control group. This might be attributed to the increase in the peak torque values of selected muscles in the paretic side in the isokinetic group higher than the control group. This justification comes in agreement with the findings of other studies [3,23,38,44]. Furthermore, Kim and Eng [46] concluded that isokinetic muscle torque of various lower limb muscles in the paretic side are positively correlated with walk speed of stroke patients mainly the torques of ankle plantar flexors, knee flexors and hip flexors in the affected side. Also, Gordon et al [17] reported that strength training has beneficial effects in patients with stroke. They found strong associations between paretic knee-extension torque and loco-motion ability and between both hip flexor and ankle plantar flexor strength of the paretic limb and walking speed after stroke.

In the past, there was some concern that strength training is not appropriate to be used in patients with spasticity [47] as such training was thought to facilitate the spastic pattern and consequently impede coordina-tion and emphasize abnormal patterns of muscle activation [13]. However, other studies [3,16] reported that strength gains in patients presented with spasticity have been accompanied with improved walking performance without increased spasticity.

In some studies [48-50], there were no clear relationship between strength training and walking performance. Additionally, Kim et al [12] proved that muscle strength of the affected lower limb and gait speed have been increased significantly in both the isokinetic and control groups. However, the strength gained from isokinetic training to the muscles of the lower limb was not sufficient to make a difference in walking function in the isokinetic group relative to the control group. This contradiction of results might be attributed to the difference of the isokinetic strength training protocol.

The significant improvement in walking performance post intervention in the experimental group might also be attributed to the additional effect of the conventional physical therapy program given to the patients in this group. This program focused on facilitating weight bearing on the affected side and challenging both static and dynamic balance (especially during walking). This helped the patient to achieve a better postural control during walking. Consequently, this allowed more control over the muscles of the affected lower limb during both concentric and eccentric activity needed during walking. This assisted the patient to increase walk speed and time of support on the affected side and subsequently decrease gait cycle time. This explanation comes in accordance with Kamm et al [51] who reported that the development of postural control during locomotion, facilitates the patients with upper motor neuron lesion to use the appropriate systems and sub-systems to promote the most efficient progress towards stability and control. Additionally, it was reported that walk speed and daily ambulatory activities are correlated with balance measures and postural control in chronic stroke patients [52,53].

As regarding to functional mobility which was assessed by TUG test, the results of the present study showed a significant improvement in TUG test in both groups with higher improvement in the experimental group than the control group. This might be attributed to the increase in strength of lower limb muscles post intervention in both groups. This is consistent with the findings of previous studies [24,38] which proved that the increase in lower extremity strength is significantly associated with gains in functional performance like TUG test. On the contrary, according to Sharp and Brouwer [3], isokinetic strength training program of the hemiparetic knee muscles resulted in significant improvement in muscle strength and walking speed and non-significant change in TUG test. In our study, TUG test has been improved significantly in the experimental group because of the combined effect of isokinetic strength training in addition to the application of conventional physical therapy program which incorporated training for gait, balance and functional activities like changing positions from sitting to standing.

There are some limitations to the present research. The small number of patients might limit the generalizability of the results to stroke population and impede the power to determine the differences between the two groups. All duration of illness for the patients participated in this study were from 6 to 18 months post stroke. Future studies are recommended to target different durations post stroke. The lack of follow-up for the patients in both the experimental and control groups might be considered another limitation of the study. The total amount of training time that the two groups got was additionally different. This is on the grounds that all participants received the same duration of conventional physical therapy while the participants in the experimental group received extra time for isokinetic strength training. This might account for the significant differences between the two groups. In this study, isokinetic strength training was applied unilaterally on the affected side only. Future studies are advocated to compare between unilateral and bilateral isokinetic strength training in patients with stroke. Furthermore, future studies are needed to assess the benefits of isokinetic strength training for lower limb muscles on other functional activities such as stair climbing, sit to stand and balance measures.

CONCLUSION

In light of the results of the present study, it can be concluded that isokinetic strength training of the affected lower limb muscles in conjunction with proper physical therapy exercise program is effective in improving muscle strength, walking performance and functional mobility in patients with chronic stroke. Therefore, this study implies that isokinetic strength training should be a part of the rehabilitation strategies used with stroke survivors.

ACKNOWLEDGEMENTS

We would like to acknowledge all patients who participated in this study for their cooperation and participation. Great thanks to all physical therapists at the outpatient clinic of the Faculty of Physical Therapy, Cairo University for their continuous help and collaboration in the enrolment of patients and information gathering in this study.

Conflicts of interest: None

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How to cite this article:

Nevein Mohammed Gharib, Rabab Ali Mohamed. ISOKINETIC STRENGTH TRAINING IN PATIENTS WITH STROKE: EFFECTS ON MUSCLE STRENGTH, GAIT AND FUNCTIONAL MOBILITY. Int J Physiother Res 2017;5(2):1976-1986. **DOI:** 10.16965/ijpr.2017.120