Journal of Medical Sciences

ISSN 1682-4474

science alert

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Research Paper

J. Med. Sci., 6 (3): 327-331
May-June, 2006

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued six times per year on paper and in electronic format.

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The Relationship Between Lower-extremity Muscle Strength and Functional Performance in Hemiparetic Patients

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The purpose of this study was to investigate the relationship between involved lower extremity muscle strength and two functional tasks: gait ability and balance and motor skills in chronic stage of a stroke. In 2004, an analytical study was conducted in Tehran province, Iran. Participants were thirty-four hemiparetic patients secondary to stroke aging 52.41±6.19 years and 37±26.37 months since stroke. The isometric strength of seven muscle groups was measured with a hand-held dynamometer. Gait ability and balance and motor skills were evaluated using Functional Ambulation Category (FAC) and Timed get up and go tests, respectively. All muscle groups' strength, except for hip extensors (r = 0.16), were correlated significantly with the timed get up and go scores (r = 0.37-0.45). None of these muscle groups' strength, except for hip abductors (r = 0.34), were correlated with functional ambulation category test scores (r = -0.02-0.2). The results showed that all muscles' strength, except for hip extensors, were valid predictors of balance and motor skills and strength of hip abductors were valid predictors of gait ability. Our results are in support of using the involved lower extremity muscle strength measurements for evaluation of balance and motor skills and treatment of people in the chronic stage of a stroke.

Key words: Muscle strength, gait, mobility skills, hemiparesis

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INTRODUCTION

The main goal in treating the patients following a stroke is to improve their gait ability, balance and motor skills (Kim and Eng, 2003). Strength deficits, decreased velocity and disturbed control of movements affect 60 to 78% of persons suffering from stroke and often result in decreased functional performance. Possible factors contributing to muscle weakness include decreased number and firing rates of motor units, inappropriate recruitment and timing of their activation, atrophy of type II muscle fibers and fatigue (Di Fabio and Badke, 1991; Collin and Wade, 1990).

It has been reported in the literature that the patterns of motion of the affected lower extremity had a stronger association with the severity of muscle weakness (De Quervain *et al*., 1996). Kim and Eng (2003) showed that the isokinetic torques of the paretic ankle plantar flexors, hip flexors and knee flexors had moderate to high correlations with gait speeds. Relationships between isometric forces and tasks such as gait, stair-climbing ability and transfer capacity have been identified (Bohannon and Walsh, 1991; Bohannon, 1986, 1991). Bohannon (1991) showed that isometric torque of paretic hip extensors, knee flexors, ankle dorsiflexors and plantar flexors were moderately correlated with gait speed (r = 0.46-0.6), whereas hip flexors, hip abductors and knee extensors were not correlated. The isometric torque of paretic knee extensors was moderately correlated with gait speed and isokinetic torque of these muscles was strongly correlated with gait speed (Bahannon and Walsh, 1991; Bahannon and Andrews, 1990). Olney *et al.* (1991) reported that the paretic hip flexors and the ankle plantarflexors' power has been strong predictor of gait speed in individuals after stroke. Because, isometric forces reflect only forces at one point in the range of motion, force measurements that evaluate forces throughout range of motion have been considered. Nakamura *et al.* (1985) demonstrated that isokinetic torque of the paretic knee extensors were strongly correlated with gait speed than isometric measurements. Nadeau *et al.* (1999) found the hip flexor torque to be highly correlated with gait speed, whereas ankle plantar flexor torque was partially associated with gait speed. Correlation between isokinetic torque of the paretic knee flexors and gait speed was also reported (Lindmark and Hamrin, 1995).

Although the studies support the relationship between muscle force and some aspects of functional abilities, there is a lack of study relating muscle force and other aspects of function such as gait ability and balance and motor skills. On the other hand, assessment and therapeutic approaches are more concentrated on the acute stage of disease and positive signs of upper motor neuron lesion than chronic stage and negative signs of the lesion. Presence of balance and motor skill problems and gait impairments in more than 60% of the patients show that these approaches have not been successful (O'Sullivan, 1994). Thus determination of relationship between muscle strength and these impairments and appropriate treatment method of these impairments are necessary. The aim of this study was two folded; first, to quantify the relationship between isometric strength of paretic lower limb muscles and two functional tasks, i.e., gait ability and balance and motor skills and second, to determine whether the isometric strength of the paretic lower limb muscles could predict gait ability and balance and motor skills in hemiparesis one year after stroke.

MATERIALS AND METHODS

This cross sectional analytical study was performed in Kahrizak Charity Foundation in 2004. Thirty four hemiparetic patients secondary to stroke participated in this study through simple non-probability sampling and through an approach to the consultant neurologist. All patients were screened to ensure that their time since onset of stroke was at least 12 months. Present study has been approved first by ethic's committee and then by the research council of Tarbiat Modarres University. The purpose of the study and testing protocol to be used were explained to the subjects and an informed and written consent document was obtained from all participants.

Patients were selected according to the following inclusion criteria: (1) at least one year post stroke, (2) age between 40 to 60 years, (3) hemiparesis secondary to stroke, (4) ability to stand at least 30 seconds with eyes open and separate feet and (5) able to understand instructions and follow simple directions. Patients with second stroke, bilateral involvements, lower limb arthritis, cerebellum and basal ganglia diseases, significant visual field deficit, severe perceptual aphasia, surgery of CNS and other neuromuscular and musculoskeletal diseases of the lower limb were excluded.

Data were collected through interview, inspection and examination. After obtaining a written consent form and the history of the disease and characteristics of patients the visual field was tested by confrontation test. Isometric strength (kg) of seven muscle groups was measured using hand-held dynamometer. Functional activities, including gait ability and balance and motor skills were measured using FAC (Functional Ambulation

Category) and Timed get up and go tests (ordinal), respectively. Every test was performed once by researcher for showing correct movement and once by each patient for learning the movement and three times for scoring. Isometric strength of hip flexors, knee flexors and extensors and ankle dorsiflexors was measured in sitting position and hip, knee and ankle joints in right angle, hip extensors in side lying position, hip abductors in supine, and plantarflexors in prone position and knee and ankle joints in 90°. During the isometric testing the dynamometer was attached to distal end of the moving bone (Hislop and Motgomery, 1995). Gait ability was recorded using the Functional Ambulation Category (FAC). The test includes six levels of support needed for gait but does not indicate whether an aid was used. Level 0 describes a patient who cannot walk or requires help of two or more people. At level 1, a patient needs continuous support from one person who helps with carrying weight and with balance and at level 2 a patient is dependent on continuous or intermittent support from one person to help with balance or coordination. At level 3 the patient needs only verbal supervision, at level 4 help is required on stairs and uneven surfaces and level 5 describes a patient who can walk independently anywhere. This test has been shown to be a valid and reliable indicator of gait ability (Hesse *et al.*, 1995). For the "Timed get up and go" test, subjects were seated in a chair with armrests and then instructed to stand and walk as quickly and as safely as possible for a distance of 3 meters. Subjects then turned around, returned to the chair and sat down. The time from the point at which their spine left the back of the chair until they returned to that same position was recorded using a stopwatch. The test includes four levels of assessment of balance and motor skills. Performance was scored according to the following scale; freely mobile (<10 sec); mostly independent (<20 sec); variable mobility (20 to 29 sec); impaired mobility (>30 sec). The average time of the 3 test trials was calculated. Neurologically intact adults who are independent in balance and mobility skills are able to perform the test in less than 10 sec. Adults who take more than 30 sec to complete the test were dependent in most activities of daily living and mobility skills. High intra rater (ICC = 0.99) and inter-rater (ICC = 0.99) reliability for evaluation of balance and motor skills have been demonstrated using this measure (Walker *et al.*, 2000).

Data were analyzed using SPSS9. Spearman's Correlations and linear regression were used to investigate the relationship and to predicate the results. Simple scatter plots and Spearman's Correlations (r) were used to confirm the linear relationship between individual muscle groups' strength and FAC and Timed up and go test results and to determine the strength of this relationship, respectively. The strength of correlations was described using Munro's correlational descriptors (very high = 0.9-1, high = 0.7-0.89, moderate = 0.5-0.69, low = 0.26-0.49). Association between muscles strength and two functional tasks were calculated using regression analysis. The level of significance was set at $p<0.05$.

RESULTS

The mean age of 34 subjects was 52.41±6.19 years and their time post stroke was 37±26.37 months. The 15 female and 19 male, 13 right and 21 left hemiparesis participated in this study. The mean FAC results in 34 participants was 3.47±0.99 that is 69.2% normal FAC. The median of test was 4. The mean Timed get up and go test results in 34 participants were 1.7±0.87 that is 42.5% normal Timed get up and go scores. The median of test was 1 (Table 1).

Results showed that paretic abductor muscles' strength was significantly correlated to gait abilities (FAC). This correlation was not significant in other muscle groups. Results showed that strength of all paretic muscles, except for hip extensors, were significantly correlated to balance and motor skills (Timed get up and go test). The highest correlation was found with ankle dorsiflexors (Table 1).

Results of regression analysis showed that only paretic abductor muscles' strength ($p = 0.049$) can predict gait ability in these subjects and t of other muscles were not significant ($p = 0.26$-0.9). The results showed t of all muscles, except hip extensors ($p = 0.37$), were significant ($p = 0.008$-0.03). Thus, the strength of most of the muscles is good predictor of balance and motor skills of hemiparetic patients.

Table 1: Descriptive statistics and results of Spearman's Correlation test between seven muscle groups strength (kg) and FAC and Timed up and go test results (ordinal).

		FAC		Get up and go		
	Mean ± SD	R	p-Value*	R	p-Value*	N
Hip flexor	4.7±2.59	-0.02	0.9	0.42	0.014	34
Hip extensor	6.7±3.19	0.16	0.36	0.16	0.37	34
Hip abductor	4.5±2.54	0.34	0.049	0.39	0.02	34
Knee flexor	3.1±3.47	0.16	0.38	0.4	0.02	34
Knee extensor	5.5±3.94	0.2	0.26	0.37	0.03	34
Ankle dorsiflexor	1.2±1.76	0.19	0.29	0.45	0.008	34
Ankle plantar flexor	1.5±2.25	0.09	0.61	0.41	0.02	34

*p<0.05

DISCUSSION

We examined the relationship between paretic lower limb muscle strength and the tasks of gait ability and balance and motor skills and we explored some of the variables that may predict the performance of these tasks. The findings showed that none of these muscle groups' isometric strength was correlated with gait ability of hemiparetic patients' in the chronic stage of disease except for hip abductors which indicated a low correlation. Low correlation, although significant, was demonstrated between isometric strength of all muscle groups and balance and motor skills, except for hip extensors. The results showed, on the other hand, that all muscles' strength, except for hip extensors, was valid predictors of balance and motor skills and strength of hip abductors was valid predictors of gait ability. While we expected the gait ability in hemiparetic patients to be dependent on the strength of several muscle groups, the results confirmed this relationship only with paretic hip abductors' strength. Bohannon (1990) reported the relationship between speed and isometric torque of lower extremity extensors and showed that in stroke subjects this torque and subsequent velocity is decreased. De Quervain (1996) found that weakness of the hip and knee flexors and ankle dorsiflexors are responsible for alteration of velocity and abnormal patterns of motion. He did not indicate the relationship between gait ability and muscles' strength. There are many studies about the relationship between speed and the isokinetic torque of paretic hip flexors and ankle plantarflexors (Kim and Eng, 2003, Nadeau *et al*., 1999), paretic knee extensors (Nakamura *et al*., 1985), paretic knee flexors (Lindmark and Hamrin, 1995) and paretic hip and ankle muscles (Karimi, 1996). However, there are few studies in which the relationship between isometric muscle strength and gait ability has been considered. In this study, we found that isometric strength of abductors is necessary for gait. There were two major limitations to our study. First, impaired performance of the muscles may vary depending on the circumstances of their activation. More specifically, the muscles may function more effectively during weight bearing than isolated testing and more effectively during eccentric than concentric contractions. Second, because other muscles contribute to gait, diminished gait ability among patients with stroke cannot be attributed entirely to a single muscle group such as the hip abductors. Our expectations regarding the relationship between isometric muscle strength and balance and motor skills were fulfilled partially (consider low, although significant correlation). Our findings revealed that isometric strength of all muscle groups, except for the knee extensors, were correlated with balance and motor skills (Timed get up and go test). Other studies suggest that time of the "up and go" test decreased as a result of strength training (Weiss *et al*., 2000). Another study has shown that exercises other than strengthening exercises can also result in a decrease in "up and go" test time (Geiger *et al*., 2001). There is no agreement on the therapeutic approaches in hemiparetic patients. Some of the methods of stroke rehabilitation have focused on the reduction of abnormal reflex activity and abnormal movement. It has been suggested that hypertonicity of antagonist is the main cause of motor dyscontrol and have proposed that normalization of muscle tone should be a priority of treatment (Bohannon, 1986). Other studies emphasized on the effects of strength training in the improvement of motor function, velocity and gait patterns (Teixeira-Salmela *et al*., 2001). We believe, on the basis of our findings, that motor deficits and spasticity are two separate signs of upper motor neuron lesion. Results of present study (low correlation between isometric muscle strength and two functional tasks) showed that other factor except to muscle strength affect theses tasks. Thus, there are strong relationship between the above-mentioned signs of upper motor neuron lesion (motor weakness and spasticity) and the two functional tasks. Therefore evaluation of these two impairments is important for determination of the type of intervention.

CONCLUSIONS

This study has two implications for clinical practice. First, the measurement of the strength of paretic lower limb muscles is beneficial for the assessment of the balance and motor skills in chronic hemiparesis and prediction of the performance of these tasks. Paretic hip abductors' strength is also a good factor for assessment of the gait ability and a valid predictor of gait ability. Second, the independent variables are appropriate targets for therapeutic interventions.

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