Isokinetic Knee Flexors/Extensors Muscle Strength Ratio of Affected and Unaffected Side in Stroke Patients

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ABSTRACT

The purpose of this study is to examine the conventional hamstring/ quadriceps H:Q strength ratios obtained during concentric and eccentric muscle contraction in maximal isokinetic knee flexion and extension movements. Thirty hemiparetic patients of both sexes were selected for this study. Their age ranged from 40 to 65 years , with a mean value of 52.6 (± 8.22) years, their height ranged from 149 to 180 cm, with a mean value of 162.6 (±6.95) cm and their weight ranged from 55 to 105 kg with a mean value of 78.1 (±14.57) kg. Knee flexors/extensors peak torque, total work and power ratios of affected and unaffected side at concentric and eccentric contractions were measured through isokinetic biodex system. Results showed non significant relationship of Knee flexors/extensors peak torque, total work and power ratios of affected and unaffected side at concentric and eccentric contractions. This study implies that eccentric and concentric action should be trained to gain balance between agonist and antagonist and to obtain full muscles strength and maximal functional abilities.
Key words: *Stroke, Isokinetic, Functional performance.*

INTRODUCTION

Although 60 percent of stroke survivors regain walking independence after 3 months, many have continuing problems with mobility due to impaired balance, motor weakness[1] and decreased walking velocities[2]. About 85 percent of these individuals failed to reach age-specific norms for gait speed even 3 months after the incident[3].

Because muscle weakness is one of the most prominent consequences of stroke[4,5,6]. An equally important area for future research is developing a greater understanding of the mechanisms underlying post-stroke weakness. Without this information, we are restricted in our efforts to design appropriate rehabilitation interventions to counteract compromised function associated with post-stroke weakness[7].

Traditionally, a strong bias has existed against quantifying strength in hemiplegic person, as a result, the majority of clinical research focused on outcome measures at the activity and participation levels[8]. To quantify this common impairment in person with post-stroke hemiparesis, reliable measures of muscle strength are necessary. The assessment of muscular strength is an important component in the evaluation of individuals with neurological condition[8]. With the increasing availability of sophisticated computer interfaced equipment, weakness may be quantified more precisely[9]. Among the various types of strength testing equipment isokinetic dynamometers was used in clinical and laboratory setting[10,11].

The ratios of maximal isokinetic hamstring muscle strength relative to maximal isokinetic quadriceps muscle strength (H:Q ratio) is a parameter commonly used to describe the muscle strength properties about the knee joint[7,12,13]. The H:Q ratio has conventionally been calculated as maximal knee flexion strength divided by maximal knee knee extension strength obtained at a given knee angular velocity and contraction mode (concentric and eccentric). The agonist-antagonist strength relationship for knee extension and flexion may be better described by a functional H:Q ratio of eccentric hamstring to concentric quadriceps muscle strength (H_{ecc} : Q_{con} representative of knee extension) or concentric hamstring to eccentric quadriceps muscle strength (H_{con} : Q_{ecc} representative of knee flexion).

In conceptual terms, the conventional H:Q ratio implies that concentric (or eccentric) contraction would take place for the knee extensors and flexors simultaneously. However, true knee joint movement only allow eccentric hamstring muscle contraction to be combined with concentric quadriceps muscle contraction (during extension) or vice versa (during flexion).

The purpose of the present study was to examine the conventional H:Q strength ratios obtained during concentric and eccentric muscle contraction in maximal isokinetic knee extension and flexion movements.

MATERIALS AND METHODS

Subjects

Thirty hemiparetic patients of both sexes were participated in the study. Their age ranged from 40 to 65 years, with a mean value of 52.6 (± 8.22) years. Their height ranged from 149 to 180 cm, with a mean value of 162.6 (±6.95) cm and their weight ranged from 55 to 105 kg with a mean value of 78.1 (±14.57) kg.

Procedure

Basic information was recorded about name, age, address, telephone number, in addition to the height and body weight which recorded by using height and weight scale. Before starting the test, the device was calibrated and the test protocol was set up to determine the basic input parameters including, the speed of movement, ROM and the mode of contractions either concentric-concentric or eccentric-eccentric mode.

Patients were asked to stop consumption of food, caffee, alcohol and medication and to avoid strenuous exercise during the last two hours prior to testing.

A) Set up and positioning

The dynamometer orientation was adjusted according to the manual instruction for knee flexion and extension testing so that the dynamometer head was rotated into 0 degree. Then to start the biodex system, the main power, the computer power and the dynamometer power was switched on and any other attachments to the dynamometer were removed and the start key in the control panel was switched on. A few seconds were allowed for the dynamometer shaft to rotate freely until the system displays a message that initializes the dynamometer. Then knee attachment was fixed on the dynamometer head.

Patient was positioned on chair with back supported at a 90° sitting angle. Large straps were applied horizontally across the pelvis and diagonally across the trunk to minimize body movement during testing. The Patient was asked to grasp the systems hand grips. The thigh was supported well and the leg was positioned at 90 degree of knee flexion without contacting the front edge of the chair by the posterior aspect of the leg. The lateral femoral condyle was aligned with the dynamometer's rotation axis and this was done by moving the dynamometer chair forward and backward to reach the accepted position. To check the alignment of the knee joint centre the leg was moved passively through full range of motion. If correctly aligned, the resistance pad should not tilt or slide along the leg. The cuff of the force transducer was placed on the distal part of the leg approximately two finger breadths proximal to the lateral malleoli.

Selection of testing position is essential for hemiparetic patients especially those with hypertension. Sitting position is more suitable for most of patients than supine which increase systemic pressure at the time in which the heavy resistance exercise can increase also systolic and diastolic blood pressure.

To start the test, the ROM was set up by determining the stop and start angle, the start angle was calculated by moving the lever arm, resistance pad and limb to an angle of ninety degree of knee flexion. The ROM was selected from 90 to full extension to include the knee range of motion where most functional activities occurs[14].

To overcome the effect of gravity the patient was asked to move his limb into full extension and the lever-arm was fixed by pressing on the button hold which in turn hold the limb, then the patient was asked to completely relax his limb to calculate the leg weight for gravity correction. Then the patient was asked to freely move his limb after the lever- arm had been unfixed.

B) Isokinetic testing

Isokinetic strength assessment was initiated at an angular velocity of 60°/sec. This particular velocity has been proven reliable in healthy subjects and was selected because most of stroke patients had difficulty generating faster movements.

The isokintic test was consisted of reciprocal concentric knee flexion and extension, 3 sub-maximal repetitions as a warm up was performed initially followed by 5 maximal repetitions when the patient indicated readiness. Patients were not provided visual feed back of their performance during testing and the verbal instruction was strictly standardized as the patient was asked to "push and pull as hard and as fast as possible" for 5 repetitions.

To test isokinetic eccentric knee flexors and extensors the contraction mode was converted into eccentric- eccentric mode. The test was started with hold the limb into zero position "full knee extension" to calculate the limb weight for gravity correction, then the device was un hold for free movements. 3 sub-maximal repetitions as a warm-up was performed followed by 5 maximal repetitions. The test was started with the knee at 90 degree flexion and the patient was asked to "contract your hamstring and let your limb move upward with the device" at this time the eccentric contraction of knee extensors was calculated, alternatively when the limb was moved upward the patient was asked to "contract your quadriceps and let your limb move downward with the device" at this time the eccentric contraction of knee flexors was calculated.

RESULTS

Knee flexors/extensors peak torque ratio, of affected and unaffected side at concentric and eccentric contraction.

As shown in table (1) and figure (1), isokinetic knee flexors/extensors ratios were calculated for the affected and unaffected limb during concentric and eccentric type of action at velocity (60^{o}/sec). The peak torque ratios were 0.43and 0.51 for affected and unaffected limb respectively during concentric type of action. And 1.2, 1.3 for affected and unaffected limb respectively during eccentric type of action, results showed non significant relation of flexors/extensors peak torque ratio (P=0.07) in the affected and unaffected side during concentric contraction and non significant also (P=0.7) in the affected and unaffected during eccentric type of action.

Table (1): Mean, standard deviation of knee flexors/extensors peak torque ratio for affected and unaffected limb during concentric and eccentric contraction.

	Concentric		Eccentric	
	affected	unaffected	affected	unaffected
Mean	0.43	0.51	1.2	1.3
SD	0.2	0.1	0.2	0.3
t-value	1.8		0.28	
P-value	0.07		0.7	

SD = standard deviation,* =significant difference

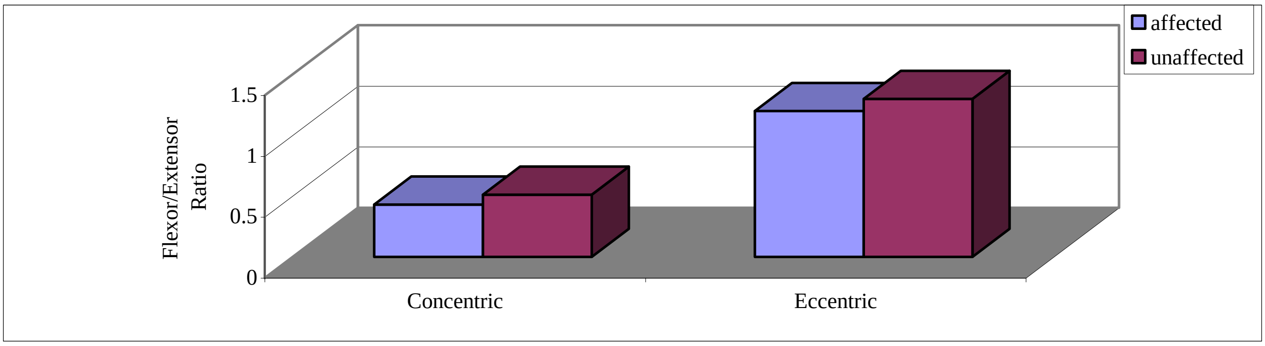

Fig. (1): Representations of mean and standard deviation for knee flexors/extensors peak torque ratio for affected and unaffected limb during concentric and eccentric contraction.

Knee flexors/extensors total work ratio of affected and unaffected side at concentric and eccentric contraction.

As shown in table (2) and figure (2). The total work ratio were 1.32 ± 0.81 and 2.35 ± 1.11 for affected and unaffected limb respectively during concentric type of action. And 1.67 ± 0.09 and 1.72 ± 0.98 for affected and unaffected limb respectively during eccentric type of action. There was non significant relation of flexors/extensors total work ratio of affected and unaffected limb during concentric contraction (P = 0.60) and non significant also during eccentric type of action (P = 0.9).

Table (2): Mean, standard deviation of knee flexors/extensors total work ratio for affected and unaffected limb during concentric and eccentric contraction.

	Concentric		Eccentric	
	affected	unaffected	affected	unaffected
Mean	1.32	2.35	1.67	1.72
SD	0.81	1.11	0.09	0.98
t-value	0.52		0.12	
P-value	0.60		0.90	

SD = standard deviation,*= significant difference

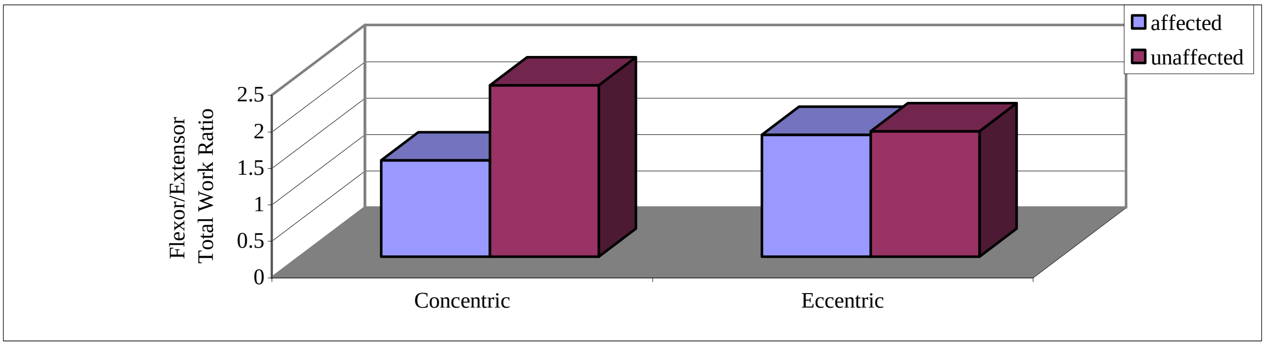

Fig. (2): Representations of mean and standard deviation for knee flexors/extensors total work ratio for affected and unaffected limb during concentric and eccentric contraction.

Knee flexors/extensors power ratio of affected and unaffected side at concentric and eccentric contraction.

As shown in table (3) and figure (3) power ratios were 0.55 ± 0.19 and 0.48 ± 0.17 for affected and unaffected limb respectively during concentric type of action, while during eccentric type of action the power ratios for affected and unaffected limb were 0.44 ± 0.18 and 0.49 ± 0.25 respectively. There was non significant relation of knee flexors/extensors average power ratio of affected and unaffected limb during concentric contraction (P = 0.7), also during eccentric contraction as (P = 0.5).

Table (3): Mean, standard deviation of knee flexors/extensors average power ratio for affected and unaffected limb during concentric and eccentric contraction.

	Concentric		Eccentric	
	affected	unaffected	affected	unaffected
Mean	0.55	0.48	0.44	0.49
SD	0.19	0.17	0.18	0.25
t-value	0.36		0.59	
P-value	0.07		0.5	

SD = standard deviation,*= significant difference

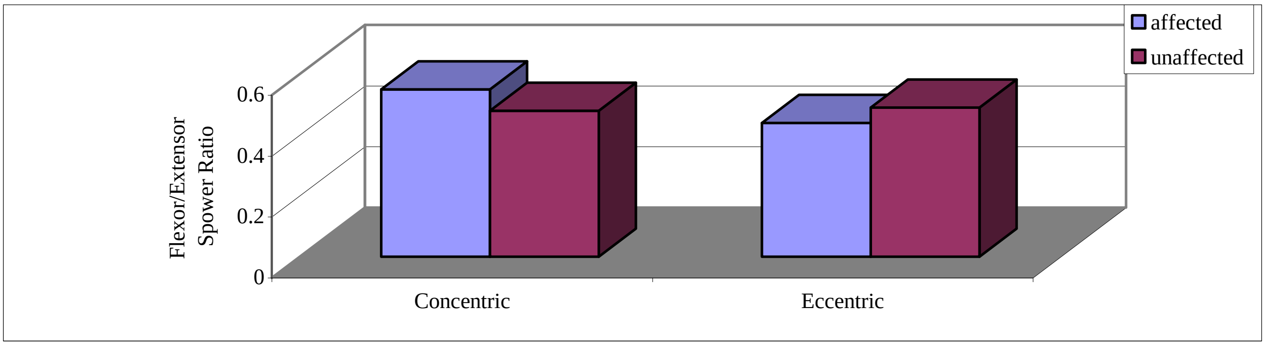

Fig. (3): Representations of mean and standard deviation for knee flexors/extensors average power ratio for affected and unaffected limb during concentric and eccentric contraction.

DISCUSSION

There is a gap in the literature concerning the relationships between isokinetic variables of knee flexors and extensors during concentric and eccentric type of action. Also limited data exists concerning the correlation between isokinetic testing of hemiparetic patients and functional performance tests.

In the present study, the isokinetic testing was used to evaluate (peak torque, total work, average power) of knee flexors and extensors of affected and unaffected limb during both concentric and eccentric type of action in stroke patients.

Muscle performance can be classified as normal or abnormal based on isokinetic testing results and data can be compared to data obtained from unaffected limb. This comparison can facilitate the development of strength and conditioning program to restore normal muscle balance, strength, and endurance in order to prevent injuries and enhance performance[15]. Isokinetic assessment using isolated knee extension and flexion is the most commonly used method to assess function of thigh musculature and the knee in the last few years[16].

Muscle strength of the affected extremities of hemiparetic patients is quantifiable and its measurement is reliable even in the presence of mild spasticity[17]. In the present study, although some patients presented with mild spasticity in the affected knee extensors, all patients were capable of exerting voluntary knee extension moment with the affected limb. Therefore, paretic muscle that preserves the ability to exert a considerable amount of muscle strength and has low levels of spasticity do not appear to have a significant effect on the consistency of torque production.

This opinion coincides with McLellan (1977)[18] and Martensson (1980)[19] who reported that stretch reflexes during voluntary movements could be suppressed by voluntary efforts in stroke patients with mild spasticity.

Test- retest reliability of peak torque was considered excellent in stroke patients, indicating that testing on one occasion could provide an acceptable measure of strength[20,21]. The reliability during concentric and eccentric muscle actions is in agreement with previous investigations using healthy subjects performing knee flexion and extension testing[20,22].

Results of the present study showed non significant relation of flexors/extensors peak torque ratio in the affected and unaffected side during concentric and eccentric type of action. This can be explained as concentric contraction of the anti-spastic knee flexors at fixed speed have been associated with the initiation of a stretch reflex in the spastic muscle, thus limiting the ability to produce maximal flexors torque values. Moreover, the nature of pyramidal tract lesion in stroke patients affect flexors of lower limb than extensors muscles.

Results showed also that, the flexors /extensors values of peak torque ratio of unaffected side were greater than affected side. Explanation of these results attributed to cerebral lesions in stroke patient which lead to a decreased number of motor units, disrupted recruitment order of motor units, and decreased motor unit firing rate during maximal contraction. This previous explanation was consistent with McComas (1973)[23], Grimby et al. (1973)[24], Rosenfalk et al. (1980)[25].

In agreement with the present study, Sunnerhagen et al. (1999)[26] found non significant difference between flexors of affected and unaffected side at 60°/ sec.

Previous studies revealed that, eccentric peak torque is greater than concentric peak torque in men,[27,28,29,30,31,32] women,[27,33] children,[34,35] and athletes[36], although the present study proved that there was non significant difference between mean peak torque ratio of flexor/extensor of the affected and unaffected side, this may be attributed to the increased in peak torque output during eccentric activity causing greater anterior tibial translation than concentric activity, the quadriceps muscles were sub-optimally recruited particularly during eccentric activity[36] and the firing patterns of eccentric and concentric activity differ[28] and might be altered to a greater degree during eccentric activity leading to a decrease in eccentric peak torque with respect to concentric peak torque.

Also biomechanical changes around the knee joint in stroke patient might affect eccentric activity to a greater degree than concentric activity. The finding that the peak torque ratio for both flexors and extensors was not significantly different between the affected and unaffected limb indicates that strength losses were not a result of altered joint motion dynamics, but rather from a deficiency in the muscles themselves or the neural control mechanism.

The decreased performance on the unaffected side is the result either of lack of training on that side, as the affected side influencing the other side, or of simple anatomic reasons. In the present study, we believe that the reason is neuro-anatomic, because approximately 10% of the descending motor pathway doesn't cross over to the other side.

This explanation is supported by the results of Sinkjaer and Magnusson (1994)[37] who found that the reflex stiffness of the ankle on the unaffected side was different from that of healthy control subjects. So, it is therefore recommended that, in the clinical setting, therapist should pay attention to the reduction of performance in the unaffected leg and should be kept in mind. So, training procedure should be functional and involve both extremities.

The total work values showed the same results as peak torque. The extensors value was greater than flexors value in both affected and unaffected side, with significant difference between both sides. Also the unaffected side values were greater than affected side as peak torque.

The extensors total work values during the eccentric contraction exactly as peak torque. The difference between the two variables during eccentric contraction showed that, the value of total work at unaffected side was less than affected side in contrast with peak torque. This can be explained by spasticity of the affected side which necessitates great effort for the limb to move.

The average power values were completely consistent with total work and peak torque values. The unaffected limb was greater than affected one and the extensors value was greater than flexors. During eccentric contraction, the average power value similar with the peak torque value in the way that the unaffected limb value was greater than the affected side in contrast with the total work value, the acerage power return to be different from both total work and peak torque, it showed that the extensors value was greater than flexors value.

The increased value of knee extensors than knee flexors is attributed to the presence of significant correlation between strength and muscle cross – sectional area[38], as the quadriceps muscles are the largest muscles of knee joint and have large cross sectional area.

The comparison between concentric and eccentric power values showed that, the flexors/extensors values were more affected during eccentric contraction than concentric one. The difference in the result during eccentric contraction in both affected and unaffected side for both flexors and extensors is attributed to the lack of information and practice of eccentric contraction as a type of muscle action.

Unfortunately most of therapist and clinician concentrate on concentric contraction during rehabilitation and neglect completely training of eccentric contraction. This study implies that eccentric and concentric action should be trained to gain balance between agonist and antagonist and to obtain full muscles strength and maximal functional abilities.

REFERENCES

1- Aagsiard, I., Siniuiisen, E.U. and Trollf, M.: Isokinetic hamstring/ quadriceps strength ratio: influence from joint an angular velocity, gravity correction and contraction mode. Acta Physiol Scand, 154: 421-427, 1995.
2- Bonci, C.: Assessment and evaluation of predisposing factors to anterior cruciate ligament injury. J Athl Train, 34(2): 155-164, 1999.
3- Callaghan, I., McCiii-lhy, J., Al-0m, I.R.A. and Oklliain, A.: The reprodticibilily of multi-joint isokinetic and isometric assessments in a healthy and patient popul.iliun. Clin Bioinech, 15(9): 678-683, 2000.
4- Carolynn, P., Jan, I. and Heather, E.B.: Weakness and strength training in persons with post-stroke hemiplegia: Rationale, method, and efficacy, Journal of Rehabilitation Research and Development, 41: 293-312, 2004.
5- Colliandcr, E.B., Tesch, P.A.: Bilateral eccentric and concentric torque of quadriceps and hamstring muscles in females and males Eurj AppI Physiol, 59: 227-232, 1989.
6- Ellenbecker, T., Roetert, P. and Riewald, S.: Isokinetic profile of wrist and forearm strength in elite female junior tennis players. Br JSports Med, 40(5): 411-414, 2006.
7- Enoka, R.M.: Eccentric contractions require unique activation strategies by the nervous system. J AppI Physiol, 81: 2339-2346, 1996.
8- Goldie, P.A., Matyas, T.A. and Evans, O.M.: Deficit and change in gait velocity during rehabilitation after stroke. Arch Phys Med Rehabil, 77: 1074-1082, 1996.
9- Grimby, L. and Hannerz, J.: Tonic and.phasic recruitment order of motor units in man under normal and pathological conditions. In: Des-medt JE, editor. New developments in electromyography and clinical neurophysiology. New York. Karger, 3: 225-233, 1973.
10- Janice, J.E., Kim, C.M. and Macintyre, D.L.: Reliability of lower extremity strength measures in persons with chronic stroke. Acch Phs Med Rehabil, 83: 322-328, 2002.
11- Kaimus, P.: Isokinetic evaluation of muscular performance: implications for muscle testing and rehabilitation. Int J Sports Med, 15(I): 11-18, 1994.
12- Katharina, S., Sunnerhagen, K.S., Svantesson, U., Lonn, L., Krotkiewski, M. and Grimby, G.: Upper motor neuron lesions: Their effect on muscle performance and appearance in stoke patients with minor motor impairment Arch Phys Med Rehabil, 80: 155-161, 1999.
13- Kellis, E. and Baltzopoulos, V.: Isokjnetic eccentric exercise. Sports Med, 19: 202-222, 1995.
14- Keskula, R., Duncan, B., Davis, L. and Finley, W.: Functional outcome measures For knee dysfunction assessment. J Athi Train, 31: 105-110, 1996.
15- Knutsson, E., Martensson, A.: Dynamic bmotor capacity in spastic paresis and its relation to prime motor dysfunction, spastic reflexes and antagonist co-contraction. Scand j Rehab Med, 12: 93-106, 1980.
16- Kramer, I.F.: Reliability of knee extensor and flexion torques during continuous concentric-eccentric cycles. Arch Phys Med Rehabil, 71: 460-464, 1990.

17- Lockhart, T.E, Woldstad, J.C. and Smith, J.L.: Effects of age- related gait changes on the biomechanics of slips and falls. Ergonomics, 46: 1136-1160, 2003.
18- Maiighan, I.I., Watson, S. and Weir, J.: Strength and cross sectional area of human skeletal muscle. Physiol, 338: 37-79, 1984.
19- Mayo, N.E., Wood-Dauphinee, S., Ahmed, S., Gordon, C., Higgins, J., Mcewen, S. and Salbach, N.: Disablement following stroke. Disabil Rehabil. 21: 258-268, 1999.
20- McConms, A.J.: Functional changes in motoneurones of hemiparetic muscles. J Neurol Neurosurg Psychiatry, 36: 183-193, 1973.
21- McLellan, D.L.: Co-contraction and stretch reflexes in spasticity during treatment with baclofen. J Neuro! Neui - osurg Psychiatry, 40: 30-38, 1977.
22- Motitadi, N.G., Kieter, G.N. and Fedlbtcd, K.: Concentric and eccenlric quadriceps torque in pre-adolescent males. Can J Sports Sci, 15: 240-243, 1990.
23- Newham, D.J. and Hsiao, S.F.: Knee muscle isometric strength, voluntary activation and antagonist co-contraction in the first six months after stroke. Disabil Rehabli, 23: 379-386, 2001.
24- Pohl, M., Mehrholz, J., Ritschel, C.R.: Speed-dependent treadmill training in ambulatory hemiparetic stroke patients: a randomized controlled trail. Stroke, 33: 553-558, 2002.
25- Pohl, P.S., Startzell, J.K., Duncan, P.W. and Wallace, D.: Reliability of lower extremity isokinetic strength testing in adults with stroke. Clin Rehabil, 14: 601-607, 2000.
26- Rosenl'alck, A. and Andniassen, S.: Impaired regulation of force and firing pattern of single motor units in patients with spasticity. J Neurol Neurosurg Psychiatry, 26: 1498-1509, 1994.
27- Seger, J.Y. and Thorstensson, A.: Muscle strength and myoelectric activity in pi-epuberlal and adult males and females. Eu-rop J AppI Physiol, 69: 81-87, 1994.
28- Sinkjaer, T. and M;ignussuii, I.: Passive, intrinsic and reflex-mediated Stifthess in the ankle extensors ofhemiparetic patients, Brain, 117: 355-363, 1994.
29- St Clair Gibson A: Neural and Unmoral control of muscle atrophy [dissertation]. University of Cape Town, Cape Town, South Africa, 1997.
30- Steiner, L.A., Harris, B.A. and Krebs, D.E.: Reliability of eccentric isokinetic knee flexion and extension measurements. Arch Phys Med Rehabil, 74: 1327-1335, 1993.
31- Tesch, P.A., Dudley, G.A. and Duvoisin, M.R.: Force and EMG signal patterns during repeated bouts of concentric or eccentric muscle actions. Acta Physiol. Scand, 138: 263-271, 1990.
32- Tredinnick, T.J. and Dinican, P.W.: Reliability of measurements of concentric and eccentric loading. Phys Ther, 68: 565-659, 1988.
33- Tripp, E.J. and Haris, S.R.: Test-retest reliability of isokinetic knee extension and flexion torque measurements in persons with spastic hemiparesis. Phys Ther, 71: 390-396, 1991.
34- Wede, D.T., Wood, V.A., Heller, A., Maggs, J. and Langton-Hewer, R.: Walking after stroke: measurement and recovery over the first 3 months. Scand j Rehab Med, 19: 25-30, 1987.
35- Wesling, S.H., Seger, J.Y.: Eccentric and concentric torque-velocity characteristics, torque output comparisons, and gravity effect torque corrections for the quadriceps and hamstring muscles in females. In 3 Sports Med, 10: 175-180, 1989.
36- Wu, Y., Li, R.C., Maffulli, N. and Chan, K.M.: Relationship between isokinetic concentric and eccentric contraction modes in the flexor and extensor muscle groups. J Orthop Sports Phys Ther, 26: 143-149, 1997.

الملخص العربي

نسبة قوة الانقباض الأيزوكينتيك للعضلات القابضة والباسطة لمفصل الركبة بين الجانب المصاب وغير المصاب بمرضى السكتة الدماغية

الهدف من هذه الدراسة هو اختبار نسبة الأداء بين قوة الانقباض الأيزوكينتيكى للعضلات القابضة و الباسطة لمفصل الركبة وذلك أثناء الانقباض المركزي وغير المركزي بين الجانب المصاب وغير المصاب بمرضى السكتة الدماغية . ثلاثون مريضا من الذكور والإناث مصابون بالضعف النصفي تم اختيارهم لهذه الدراسة وكان متوسط العمر 52.6±8.22 سنة ومتوسط الوزن 78.1±14.57 كجم ومتوسط الطول 162±6.95 سم . تم اختبار السلسلة الحركية من انقباض أيزوكينتيكى للعضلات القابضة والباسطة عند سرعة 60 سم/ث وتم إجراؤه باستخدام البيودكس 3 لاختبار نسبة الأداء بين قوة الانقباض الأيزوكينتيكى للعضلات القابضة والباسطة وذلك أثناء الانقباض المركزي وغير المركزي . ولقد أوضحت النتائج عدم وجود فروق ذات دلالة إحصائية في نسبة الأداء للمتغيرات الأيزوكينتيكية بين قوة الانقباض الأيزوكينتيكى للعضلات القابضة والباسطة وذلك أثناء الانقباض المركزي وغير المركزي . هذه الدراسة تبين ضرورة تدريب الانقباض المركزي و غير المركزي لتحقيق التوازن بين مجموعات العضلات المتضادة للحصول على أقصى قوة وقدرات وظيفية لها .