Evaluation of Hamstring and Quadriceps Endurance Insufficiency and Hamstring-Quadriceps Ratio in Cases of Patellofemoral Dysfunction

Yehia Nassef, D.P.T. and Bassem G. El Nahass, Sc. D., R.P.T.
Department of Traumatology and Orthopaedic Physical Therapy, Faculty of physical therapy, Cairo University.

ABSTRACT

Patellofemoral dysfunction is commonly associated by mechanical dysfunction of the patellofemoral joint as patellar mal tracking. The purpose of this study was to identify possible relation between patellofemoral mal tracking and endurance insufficiency of hamstring and quadriceps. In addition, the possible relationship between mal tracking and disturbed hamstring-quadriceps ratio. The study included 40 patients (23 females and 17 males) suffering from unilateral anterior knee pain with a mean age of age 34.28 years ±Sd(6.62). A matched age and sex control group of 40 normal volunteers (22 female and 18 male) was also included. The mean age of the control group was 35.3 years ±Sd (6.93). Participants in both groups were assessed by taking detailed history, manual muscle testing of hamstring and quadriceps, different special tests investigating patellofemoral joint affection and joint effusion. Radiological assessment of congruence angle was also performed twice, pre and post endurance activity on isokinetic machine, and isokinetic peak torques of hamstring and quadriceps, both eccentric and concentric, at 60 and 180 deg./sec. were measured, and hamstring-quadriceps ratio was calculated. The results showed significant difference in congruence angle deviation between the patients and control group, together with disturbance of hamstring-quadriceps ratio. The results of this study suggest the presence of a strong relationship of endurance insufficiency of hamstring and quadriceps, and disturbed hamstring-quadriceps ratio, with patellofemoral dysfunction.
Key words: *patellofemoral dysfunction, anterior knee pain, isokinetic testing, hamstring-quadriceps ratio, endurance insufficiency.*

INTRODUCTION

Patellofemoral pain syndrome is a widely used term commonly used to describe different causes of anterior knee pain. Several synonyms are used to describe the condition that includes, patellar mal alignment, patellofemmoral arthralgia, chondromalacia patellae, and runner's knee[11].

Patellofemoral dysfunction is most commonly caused by patellar mal alignment, which may be permanent as in congenital patellar dislocation. Other wise, and more common, it may result from patellar subluxation. Patellar mal tracking may also predispose to patellofemoral dysfunction[7].

Normal patellar tracking is controlled dynamically by two main parts of the quadriceps muscle, namely vastus medialis obliquus and vastus lateralis. If one of these components is weak or contractured for any reason, muscle imbalance cause patellar tracking abnormalities[5].

Intersection of two lines; one line from anterior superior iliac spine to midpoint of patella, and the other line from midpoint of patella to tibial tuberosity form the quadriceps angle (Q-angle).The greater the angle, the more likely that patellar mal tracking problems occur[10].

Rifai (1994)[10], applied the technique developed by Merchant et al., 1974,[9] to measure sulcus and congruence angles as indicators of patellar tracking. Dye and Boll, (1986)[4], defined Sulcus angle as the angle formed by the highest points on the lateral and medial femoral condyles and the lowest point of the intercondylar sulcus. While congruence angle was defined as the angle formed by two lines; the first is the bisector of the sulcus angle (considered as zero reference line) and the other projects from the apex of the sulcus angle to the lowest point in the articular ridge of patella.

Normal sulcus angle ranges from 126 to 150 degrees, average 135.82 (±4.33), no difference between males and females is recorded. Congruence angle, conventionally negative, has the range of –23 to + 16 degrees, average being –6.92 (±8.35). Negative values are by convention medial to zero reference line and positive lateral to the same line[10].

Isokinetic testing has gained popularity as a measuring technique of human strength and endurance, in different modes namely isometric, high and low velocity isotonics[3].

The ratio of hamstring-quadriceps muscles strength has also been suspected to relate to patellofemoral dysfunction. However, no general agreement has been achieved concerning optimum ratio for the knee[6].

Kannus, (1991)[8], studied hamstring-quadriceps ratio in normal individuals and stated that ratio in normal subjects ranges from 0.50- 0.75 but no one reported this ratio in injured knee joint.

The purpose of this work has been, therefore to identify the relation ship between patellar mal-tracking and hamstring-quadriceps muscles ratio. In addition, to identify whether endurance insufficiency of both muscles plays a role in patellofemoral pain following strenuous activity. In an attempt to achieve this purpose, radiological assessment of patellar tracking and isokinetic assessment of hamstring and quadriceps torques were done. Hamstring- quadriceps ratio was then calculated.

MATERIALS AND METHODS

Subjects

Forty volunteers subject (23 females and 17 males), with history of unilateral anterior knee pain were involved in this study. Their age ranged between 22 to 47 years and mean 34.28 years ± SD (6.62). All patients involved had no previous history of lower extremity abnormality. Their symptoms were more pronounced during squatting activities, running, stair climbing and descending, long marches, and kneeling position.

Symptoms were markedly improved in between these activities, and completely disappear during rest. They had no history of giving way or catching. Subjects were free from any previous affection of the knee joint. They were not routinely taking any kind of drugs for any reason.

Another forty healthy volunteers (22 females and 18 males) of an age ranging from 23 to 48 and mean 35.28 years ±SD (6.93), were included in the control group.

Both groups were non-athletes and all participants have no experience with isokinetic machine. All participants signed informed consent to participate.

Evaluation

This includes history taking, and different clinical tests including grinding test, inhibition test, patellar gliding test, passive patellar tilt test, apprehension sign, and testing for synovial plica syndrome.

Manual muscle testing was done for quadriceps and hamstring muscles. Participants in both the experimental and the control groups had grade 5 upon testing.

Radiographic techniques applying standard merchant technique were performed. Both sulcus and congruence angles were measured on x-ray films in degrees.

Endurance muscle testing of quadriceps and hamstring muscles, and hamstring-quadriceps ratio were performed using isokinetic machine, both concentrically and eccentrically. Two angular velocities were used 60 degree/sec and 180 degree/sec.

During isokinetic testing, participants were seated on dynamometer chair, which was fixed to 110 degrees. The lateral femoral condyle of the tested leg was aligned with the axis of rotation of the isokinetic dynamometer, and the ankle cuff placed proximal to the lateral malleolus.

Concentric and eccentric measurements were done, pushing against the machine and resisting it respectively, for both quadriceps and hamstrings.

The number of repetitions was not determined, but the patient maximum possible repetition to fatigue was allowed. The ratio between hamstring and quadriceps peak torques was calculated.

RESULTS

Eighty subjects were included in this study, 40 patients in the experimental group (22 females, 18 males), and 40 normal volunteers in the control group (23 females, 17 males).

Participants in both groups had no significant difference concerning their descriptive characteristics namely, age, weight, and height (table 1).

Table (1): Age, weight, and height means and standard deviations in experimental and control groups.

	Age (years)	Weight (kg)	Height (cm)
Experimental group	34.28 ± 6.62	71.6 ± 7.3	167.08 ± 5.51
Control group	35.28 ± 6.93	71.48 ± 7.06	166.3 ± 5.08

Isokinetic testing results showed the following

The concentric peak torques of knee flexors and extensors were calculated at velocity of 60 degrees/sec. For knee extensors means and S.D. of the peak torques for patients and control groups were 88.2 ± 17.21. and 111.58 ± 6.34 respectively. There was a significant difference in favor of the control group.

For knee flexors means and S.D. of the peak torques for patients and control group were 41.33 ± 10.49 and 68 ± 5.23 respectively. There was a significance difference between both groups in favor of control group.

The endurance ratios were 47.06 ± 8.65 and 61.05 ± 4.95 for experiment-al and control groups respectively. Again the mean value was significantly higher in control group (table 2 & fig 1).

Table (2): Means, standard deviations, t-values and level of significance for concentric peak torque (neu/m) of quadriceps and hamstring, and endurance ratio between them in experimental and control groups at 60 deg/sec.

	Extensors			Flexors			Fl/Ext. ratio		
Exp. group	88.20	17.21	15.65	41.33	10.49	19.80	47.06	8.65	7.32
Control group	111.85	6.34	.000	68.00	5.23	.000	61.05	4.95	.000

P<0.05.

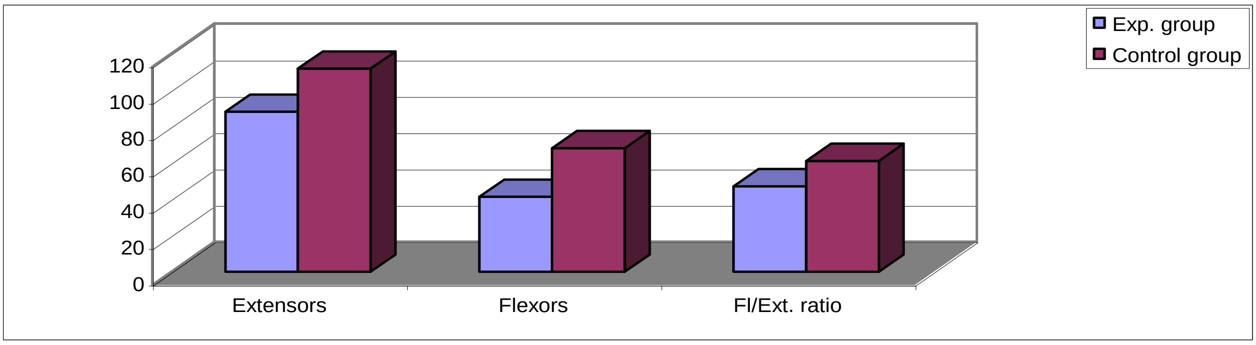

Fig. (1): Comparison between means experimental and control groups in concentric extensors, and flexors peak torque (neu/m) and endurance ratio at 60 deg/sec.

The eccentric peak torques of knee flexors and extensors were calculated at velocity of 60 degrees/sec. For knee extensors means and S.D. of the peak torques for patients and control groups were 113.25 ± 17.35, and 124.40 ± 6.50 respectively. There was a significant difference in favor of the control group. For knee flexors means and S.D. of the peak torques for patients and control group were 48.13 ± 10.26 and 76.68 ± 6.80 respectively. There was a significance difference between both groups in favor of control group. The endurance ratios were 42.49 ± 5.97 and 61.70 ± 5.31 for experimental and control groups respectively. Again the mean value was significantly higher in control group (table 3& fig 2).

Table (3): Means, standard deviations, t-values and level of significance for eccentric peak torque (neu/m) of quadriceps and hamstring, and endurance ratio between them in experimental and control groups at 60 deg/sec.

	Extensors			Flexors			Fl/Ext. ratio		
	Mean	SD	t. value/sig	Mean	SD	t. value/sig	Mean	SD	t. value/sig
Exp. group	113.25	17.35	8.89	48.13	10.26	12.60	42.49	5.97	18.65
Control group	124.40	6.50	.001	76.68	6.80	.000	61.70	5.31	.000

P<0.05.

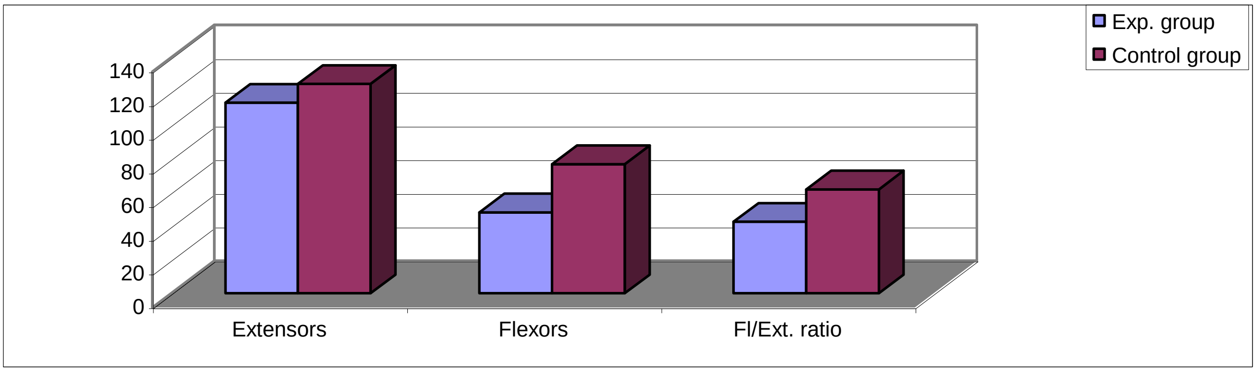

Fig. (2): Comparison between means experimental and control groups in eccentric extensors, and flexors peak torque (neu/m) and endurance ratio at 60 deg/sec.

The concentric flexor and extensor torques of quadriceps and hamstring muscles at 180 deg/sec, for extensors showed 110.5 ± 24.57 and 124.9 ± 7.43 for experimental and control groups respectively.

For flexors concentric peak torque for both muscle groups in experimental and control groups at 180 deg/sec were 54.4 ± 13.98 and 76.53 ± 5.61 respectively.

Concentric endurance ratio at 180 deg/sec for patients in experimental and control groups were 43.51 ± 5.58 and 61.51 ± 6.1 respectively (table 4 & fig. 3). The eccentric flexor and extensor torques of quadriceps and hamstring muscles at 180 deg/sec, for extensors showed 135.13 ± 21.37 and 140.8 ± 7.1 for experimental and control groups respectively.

For flexors concentric peak torque for both muscle groups in experimental and control groups at 180 deg/sec were 60.9 ± 9.2 and 84.33 ± 5.62 respectively. Concentric endurance ratio at 180 deg/sec for patients in experimental and control groups were 45.37 ± 4.98 and 63.32 ± 5.59 respectively (table 5& fig.4).

Table (4): Means, standard deviations, t-values and level of significance for concentric peak torque (neu/m) of quadriceps and hamstring, and endurance ratio between them in experimental and control groups at 180 deg/sec.

	Extensors			Flexors			Fl/Ext. ratio		
	Mean	SD	t. value/sig	Mean	SD	t. value/sig	Mean	SD	t. value/sig
Exp. group	110.50	24.57	7.94	54.40	13.98	14.39	43.51	5.58	9.55
Control group	124.90	7.43	.000	76.53	5.61	.000	61.51	6.10	.000

P<0.05

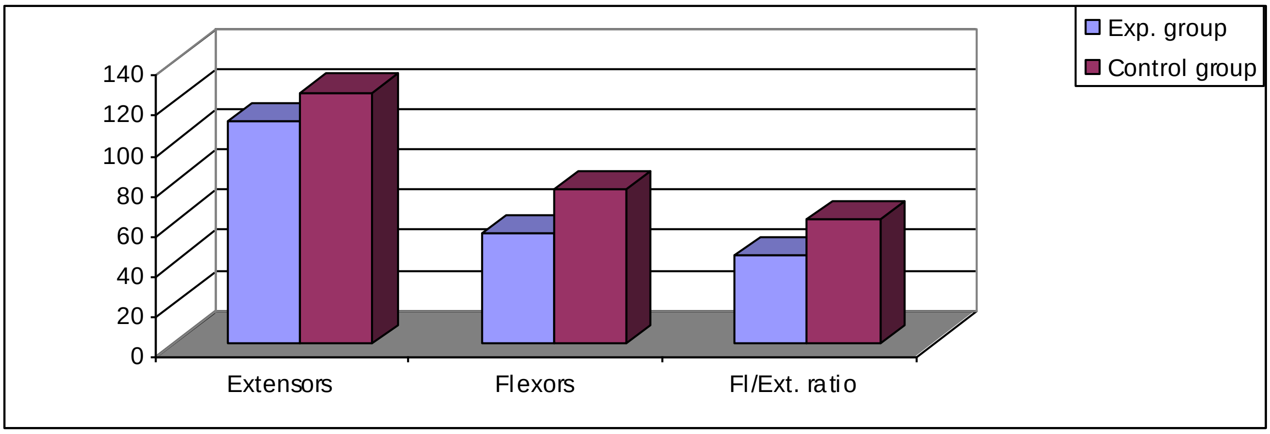

Fig. (3): Comparison between means experimental and control groups in concentric extensors, and flexors peak torque (neu/m) and endurance ratio at 180 deg/sec.

Table (5): Means, standard deviations, t-values and level of significance for eccentric peak torque (neu/m) of quadriceps and hamstring, and endurance ratio between them in experimental and control groups at 180 deg/sec.

	Extensors			Flexors			Fl/Ext. ratio		
	Mean	SD	t. value/sig	Mean	SD	t. value/sig	Mean	SD	t. value/sig
Exp. group	135.13	21.37	2.91	60.90	9.20	13.20	45.37	4.98	11.32
Control group	140.80	7.10	.03	84.33	5.62	.000	63.32	5.59	.000

P<0.05

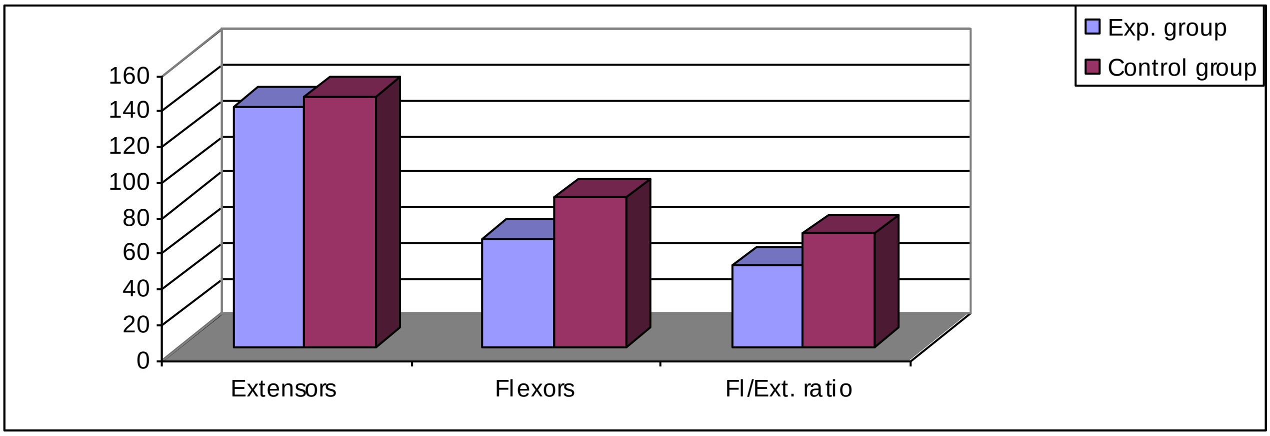

Fig. (4): Comparison between means experimental and control groups in eccentric extensors, and flexors peak torque (neu/m) and endurance ratio at 180 deg/sec.

Congruence angles were measured before and after endurance testing for both experimental and control groups. Experimental group showed a mean difference in congruence angle before and after testing of 9.45 ± 3.11. in control group it was 2.2 ± 3.46. Both values were found to indicate significant change in congruence angle in the two groups.

DISCUSSION

The results of the present study indicate a significant difference between the peak torque of quadriceps and hamstring, in both concentric and eccentric contractions. These results agreed with the results reported by Steiner et al. (1993)[12] and Worrel et al. (1991)[13] who expressed the same results in norms and patients.

Torque production was significantly greater for quadriceps and hamstrings during eccentric than concentric contraction at either 60 or 180 deg./sec. These results are in accordance with the results obtained by Cress et al., 1992[1].

Results of this study matched the results of Dvir, (1995)[3], who stated that torque deficits in eccentric testing was significant in patients suffering from anterior knee pain.

The presence of significant deviation of congruence angle in patients with anterior knee pain and muscle endurance insufficiency of quadriceps and hamstring found in this study agreed with results of Dandy, (1996)[2]. He correlated the clinical findings of the patients with radiological finding obtained by Merchant technique.

Normal results obtained by manual muscle testing, grade 5 for both groups, ensured that it is not muscle strength but, more likely, endurance insufficiency and abnormal hamstring-quadriceps ratio that predispose to patellofemoral dysfunction.

Conclusion

According to the results of this study it could be concluded that mechanical patellofemoral dysfunction will be the end result in subjects who have muscle endurance insufficiency and suffering from anterior knee pain. Also, It is important to focus on hamstring-quadriceps ratio to provide the basic information about the early detection of patellofemoral mal tracking and thus patellofemoral dysfunction. It is therefore recommended to emphasis endurance training as well as strengthening in the rehabilitation programs of patellofemoral dysfunction, and to set the normal hamstring-quadriceps ratio as a treatment goal for these conditions.

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الملخص العربي

تقييم عدم كفاية تحمل عضلات الفخذ الخلفية والعضلة ذات الأربع رؤوس ونسبة عضلات الفخذ الخلفية لذات الأربع رؤوس في حالات الاختلال الوظيفي لمفصل الرضفة مع أسفل عظمة الفخذ

تعتبر مشاكل مفصل الرضفة مع عظمة الفخذ من المشاكل الأكثر شيوعا في حالات العظام. وقد أرجع الكثيرون من الباحثين السبب وراء هذه المشاكل إلى أسباب عده تتعلق بميكانيكية المفصل. من أهم هذه الأسباب عدم تطابق الأسطح المفصلية بالدرجة المطلوبة. وقد رمت هذه الدراسة إلى دراسة بعض العوامل التي تؤدي إلى عدم التطابق وهي اختلال قوة تحمل عضلات الفخذ الأمامية و الخلفية واختلال نسبة قوة عضلات الفخذ الخلفية إلى الأمامية . وقد شارك في الدراسة 40 مريض (23 سيدة و 17 رجل) في مجموعة الدراسة . و 40 من الأصحاء في المجموعة الضابطة. وكان المشتركون في المجموعتين متماثلو الأعمار و من غير الرياضيين. وقد تم أخذ التاريخ المرضي وتقييم قوة عضلات الفخذ الأمامية و الخلفية يدويا و إجراء اختبارات مفصل الرضفة وأخذ صور الأشعة قبل و بعد الجهد بأسلوب (ميرشانت). كما تم قياس قوة عضلات الفخذ الأمامية و الخلفية بجهاز قياسات السرعة الثابتة عند 60 و 180 درجة في الثانية. وقد أثبتت النتائج وجد علاقة قوية بين عدم التطابق و اختلال قوة تحمل عضلات الفخذ الأمامية و الخلفية واختلال نسبة قوة عضلات الفخذ الخلفية إلى الأمامية. وقد خلصت الدراسة إلى ضرورة مراعاة استعادة قوة تحمل عضلات الفخذ الأمامية و الخلفية و نسبة قوة عضلات الفخذ الخلفية إلى الأمامية الطبيعية خلال برامج العلاج الطبيعي لهذه الحالات .