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Effect of Hip Adductors Isometric Contraction on Knee Extensors Isokinetic Torque in Patellofemoral Pain Syndrome

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Abstract:

Objective: To investigate if the isometric contraction of the hip adductors has an effect on the knee extensor peak torque either at 60º/s and 180º/s in patients with unilateral patellofemoral pain syndrome.

Methods: For 30 males and females aged 18-35 years old, the peak torque of the knee extensor muscles was measured by using the isokinetic dynamometer at the speeds of 60º/s and 180º/s. The isometric peak torque of hip adduction was measured by using a handheld dynamometer. The visual analogue scale was used for pain level assessment.

Results: The correlation between hip adduction isometric peak torque and concentric knee extension peak torque at 60º/s was a weak negative non-significant correlation ($r = -0.04$, $p = 0.82$) and the correlation between hip adduction isometric peak torque and concentric knee extension peak torque at 180º/s was aweak positive non-significant correlation ($r = 0.08$, $p = 0.66$). There was a significant decrease in pain without hip adductors isometric contraction at 180º/s compared with that at 60º/s ($p = 0.001$).

Conclusions: There was no significant interaction between the effect of hip adductors isometric contraction and knee extensor peak torque at angular velocities of60º/s and 180º/s. There was no significant difference in pain between with and without hip adductors isometric contraction at 60º/s and 180º/s. There was a significant decrease in knee pain with and without hip adductors isometric contraction at 180º/s compared with that at 60º/s.

Keywords. Patellofemoral pain syndrome (PFPS), Vastus medialis obliquus (VMO), Isokinetic dynamometer, Handheld Dynamometer.

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1.Introduction:

Patellofemoral pain syndrome (PFPS) is defined as pain in the anterior side of the knee joint around the patella that is more prevalent in athletes (1). PFPS affects 56% of the active population (2) With a ratio of 2:1 for females and males respectively (3). Although there is a high prevalence of this syndrome, the exact cause is still unknown (4). Patients with PFPS have some factors like: dysfunction in patellar tracking; the quadriceps tightness, gastrocnemius, iliotibial band and hamstrings, quadriceps muscle weakness and hamstrings; joint laxity; patellar deviations either shifting or rotation; and abnormal quadriceps angle (5). The misalignment between the trunk and the lower limb decreases the contact surface between the femur and the patella that causes increased pressure on the retro patellar cartilage (6).

Mechanical changes because of PFPS as in the daily living activities and ascending and descending stairs can affect the strength of the quadriceps (7). The knee flexors and extensors torque in PFPS patients were evaluated by using the isokinetic dynamometer in contraction time and test speed. , The VMO activity increases as the torque around the knee increases, to stabilize the patella (8, 9). The VMO is least active in the extended position. The shutdown of the VMO activation in extension is a factor that is important in patellar subluxation. 5-6% of the maximal capacity of the VMO in the last 30 degrees while extending from a semi-flexed weight-bearing position. Maximal myoelectric activity and peak torque occurs in flexion rather than extension. Straight leg raises with adduction is applied to contract the VMO as the VMO is attached to the adductor magnus muscle (10). The effectiveness of exercise therapy in treating PFPS, particularly in terms of improving the VMO's functionality, has not been extensively studied. One exercise that is commonly used in PFPS rehabilitation is the double-leg semisquat with hip adduction. To enhance VMO activity, clinicians often suggest patients to hold a ball between their knees while performing squatting exercises. However, this traditional method of VMO strengthening for PFPS has been questioned due to the absence of concrete evidence (11).

The objectives of the study: The purpose of this research was to analyze how the isometric contraction of hip adduction impacts the maximum torque of knee extensors at 60º/s and 180º/s, using an isokinetic dynamometer device in patients suffering from unilateral PFPS. Additionally, the study aimed to investigate the effect of hip adductors isometric contraction on pain levels experienced during concentric knee extension at 60º/s and 180º/s in individuals with unilateral PFPS.

2.Patients and Methods:

2.1.: Design and Setting:

To evaluate the difference in peak torque of knee extensor muscles in patients with unilateral PFPS, a cross-sectional study design was employed using an isokinetic dynamometer device. The study measured peak torque at two different speeds (60º/s and 180º/s) with and without hip adduction isometric contraction. The study was approved by the Institutional Review Board of the Faculty of Physical Therapy at Cairo University under the code P.T.REC/012/003041, and the patients provided informed consent for publication. Additionally, the study was registered on clinicaltrials.gov (registration number NCT05083897).

2.2. Patients:

Thirty patients were recruited with diagnosis of unilateral PFPS (sample size was calculated by using G Power test method) and referred to the physical therapy clinic of the Cairo University. The inclusion criteria for PFPS patients were 1) Anterior or retro-patellar knee pain from at least two of the following Activities: (I) prolonged sitting (II) squatting (III) running (IV) stair climbing; (V) hopping/jumping (VI) kneeling; (12). 2) Insidious onset of symptoms. 3) They were diagnosed as a PFPS case by a physician 4) The patient's age ranged from 18-35 years (13). The patient was excluded if had: 1) traumatic patellar subluxation or dislocation. 2) A history of any of the following conditions: meniscal or other intra articular pathologic conditions; cruciate or collateral ligament involvement. 3) any lower limb bony or congenital deformities 4) Previous knee and hip joint surgeries. 5) osteoarthritis in the ankle, knee, or hip joints. 6) conditions that affect muscle strength such as diabetes mellitus or rheumatoid arthritis.7) pregnancy.

2.3. Instruments:

Patients were asked to rate their typical pain on a 10-cm visual analog scale (VAS), which has been proven to be a reliable, valid, and responsive method in assessing the outcome in individuals with unilateral PFPS (14).

The isokinetic dynamometer (Biodex System 3 PRO) is used for measuring dynamic muscle contraction at constant speed 60º/s and 180º/s. Prior to each day of testing, the dynamometer underwent calibration to ensure accurate measurements. The person who conducted the isokinetic evaluations was consistent throughout the process.

A hand-held dynamometer (HHD) is a strolling device that was used to objectively measure the strength of the muscles during manual muscle

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testing (MMT) (15). HHD is easier in use, inexpensive and don't require high training to applicate in a proficient way (16).

2.4. Procedures:

Patient's data collection sheet was filled including age, gender, weight, height, pain intensity and limb adductor moment arm. Patients rated their pain on a 10-cm VAS, with 0 meaning painless and 10 Extremely meaning pain (14). The peak torque of knee extensors was measured using an isokinetic dynamometer (Biodex System 3) and the hip isometric adduction was evaluated by the HHD (Lafayette). Patients started the assessment in a random order by choosing a card from 4 cards (1. Assessment of concentric knee extension from 90º to 0ºflexion at 60º/s without isometric hip adduction – 2. Assessment of concentric knee extension from 90º to 0ºflexion at 180º/s without isometric hip adduction – 3. Assessment of concentric knee extension from 90º to 0ºflexion at 60º/s with isometric hip adduction – 4. Assessment of concentric knee extension from 90º to 0º flexion at 180º/s with isometric hip adduction) then the dynamometers were calibrated before performing the test. The patient was familiarized first with the device before each trial by applying one submaximal concentric knee isokinetic extension contraction trial for testing the speed of the device and trying the resistance.

The sitting position was used to measure the peak torque of the concentric knee extensors, with the knees and hips flexed at 90ºwith 90º seat orientation and seat back tilt 70-85º and firstly without hip adduction then adding hip adduction. The dynamometer's rotational axis was positioned in line with the lateral epicondyle of the femur. The lever arm was fastened 5 cm above the lateral malleolus by using straps. because of Moving the pad proximally has been demonstrated to decrease anterior tibial translation (8). To secure the trunk and limb during the test, a total of four belts were utilized. Among these, two were placed diagonally over the trunk, one was wrapped around the pelvis, and the remaining one was fastened on the distal thigh.

A HHD was fixed at distal medial aspect of the thigh with external belt (17). HHD measured the hip adduction peak torque through all testing trials by asking patient to do maximum isometric hip adduction force against the handheld dynamometer.

In order to evaluate concentric torque, the participants were asked to perform three maximum contractions in the concentric mode. The movements were carried out at two different angular velocities, 60°/s and 180°/s, within a range of motion of 90° to 0° of knee flexion. A resting period of one minute was given between each trial. (18). Patient rated their pain during every trial of the assessment by 10-cm VAS to investigate the effect of isometric hip adduction on pain.

To ensure accuracy in the acquired torque data, the limb's weight was measured before each test in compliance with the dynamometer manual guidelines. The data acquisition software automatically adjusted the test results to account for the impact of gravity (8).

3. Statistical analysis:

Patients' characteristics were expressed as mean and standard deviation for numerical data and as frequency and percentage for categorical data. Two-way MANOVA with repeated measures was conducted to investigate the effect of isometric contraction of the hip adductors and angular velocity on knee extensors peak torque and pain. Post hoc Bonferroni multiple comparison was conducted for pairwise comparison. Pearson correlation coefficient was conducted to investigate the relationship between isometric hip adduction peak torque and concentric knee extension peak torque. The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social studies (SPSS) version 25 for windows.

4. Results:

Subjects' characteristics:

Thirty patients with unilateral PFPS participated in this study. The mean value ± SD of age, weight, height and BMI were 26.3 ± 4.69 years, 72.16 ± 11.11 kg, 169.28 ± 10.51 cm and 25.23 ± 3.61 kg/m² respectively. Females were 25 (83.3%) subjects and males were 5 (16.7%)subjects.

Effect of isometric contraction of the hip adductors and angular velocity on peak torque of the knee extensors:

There was no significant interaction effect of hip adductors isometric contraction and angular velocity ($F = 2.19$, $p = 0.14$, Partial Eta Squared = 0.07). There was a significant main effect of hip adductors isometric contraction ($F = 5.88$, $p = 0.02$, Partial Eta Squared = 0.16). There was a significant main effect of velocity ($F = 109.83$, $p = 0.001$, Partial Eta Squared = 0.79). There was a significant decrease in extensors peak torque at 60º/s with hip adductors isometric contraction compared without hip adductors isometric contraction ($p = 0.02$). There was no significant difference in extensors peak torque at 180º/s between with and without hip adductors isometric contraction (p = 0.19). There was a significant decrease in extensors peak torque with and without hip adductors isometric contraction at 180º/s compared with that at 60º/s ($p < 0.001$). (**Table 1**).

Table 1: Effect of hip adductors isometric contraction and angular velocity on knee extensors peak torque:

Knee extension peak torque (Nm)	With hip adductors isometric contraction	Without hip adductors isometric contraction		
	Mean ±SD	Mean ±SD	MD (95% CI)	p-value
60º/s	73.17 ± 41.56	81.37 ± 41.33	-8.2 (-15.21: -1.19)	0.02
180º/s	32.1 ± 24.03	35.08 ± 25.01	-2.98 (-7.59: 1.63)	0.19
MD (95% CI)	41.07 (31.42: 50.7)	46.29 (37.43: 55.14)		
p-value	0.001	0.001		

SD, Standard deviation; CI, Confidence interval; p- value, probability value.

Effect of hip adductors isometric contraction and angular velocity on knee pain:

There was no significant interaction effect of hip adductors isometric contraction and angular velocity (F = 1.63, p = 0.21, Partial Eta Squared = 0.05). There was no significant main effect of hip adductors isometric contraction (F = 0.11, p = 0.73, Partial Eta Squared = 0.004). There was a significant main effect of velocity (F = 25.37, p = 0.001, Partial Eta Squared = 0.46). There was no significant difference in pain at 60º/s and 180º/s between with and without hip adductors isometric contraction ($p > 0.05$). There was a significant decrease in knee pain with and without hip adductors isometric contraction at 180º/s compared with that at 60º/s ($p < 0.001$). (**Table 2**).

Relationship between isometric hip adduction peak torque and concentric knee extension peak torque:

The correlation between isometric hip adduction peak torque and concentric knee extension peak torque was weak negative non-significant correlation at 60º/s (r = -0.04, p = 0.82) and at 180º/s (r = 0.08, p = 0.66). (**Table 3**).

Table 2. Effect of hip adductors isometric contraction and angular velocity on knee pain:

Knee extension peak torque (Nm)	With hip adductors isometric contraction	Without hip adductors isometric contraction		
	Mean ±SD	Mean ±SD	MD (95% CI)	p-value
60º/s	4.06 ± 2.22	4.03 ± 2.2	0.03 (-0.64: 0.71)	0.92
180º/s	2.53 ± 2.43	2.76 ± 1.92	-0.23 (-0.81: 0.35)	0.42
MD (95% CI)	1.53 (0.91: 2.15)	1.26 (0.67: 1.86)		
p-value	0.001	0.001		

SD, Standard deviation; CI, Confidence interval; p- value, probability value.

Table 3. Correlation between isometric hip adduction peak torque and concentric knee extension peak torque:

	r value	p value
at 60º/s	-0.04	0.82
at 180º/s	0.08	0.66

r value: Pearson correlation coefficient; p- value, probability value

5. Discussion:

This study investigated the effect of the isometric contraction of the hip adductors on knee extensors peak torque at 60º/s and 180º/s by using isokinetic dynamometer and pain which is measured by VAS.

The results of this study showed that There was no significant difference in knee extensors peak torque while making the hip adduction isometric contraction at 60º/s and 180º/s. There was no significant difference in pain at 60º/s and 180º/s between with and without hip adductors isometric contraction. There was a significant decrease in knee pain with and without hip adductors isometric contraction at 180º/s compared with that at 60º/s.

PFPS is the most common lower limb overuse injury, high prevalence in physically active individuals (19). There isn't any other study to compare with the results of this study, but the current results are in accordance with the results of previous studies.

Several studies have assessed hip adduction in functional activities. Women who suffer from PFPS do not exhibit any variation in hip position when performing functional tasks such as running, stepping down, and landing from a jump. (20)

Bolgla et al (21) reported no variation in hip position while descending stairs. On the other hand, Wilson and Davis (22) found that females with displayed more hip adduction while running, hopping, and doing a single-leg squat. Dierks et al (23) found an increase in hip adduction in PFPS patients after a prolonged run, indicating that this could be due to fatigue.

In a study conducted by Baldon et al (24), the eccentric strength of a group of females with PFPS and a control group was compared by evaluating their abduction, adduction, external rotation, and internal rotation. The PFPS group showed a 28% lower peak torque in the abductors and a 14% lower peak torque in the adductors. Additionally, the PFPS group exhibited an 11% higher eccentric adduction: abduction torque ratio. Ping et.al. Found by the electromyography that activation of VMO with adduction gives more firing level than activation without adduction during bilateral semi-squat exercise (25). But which one of them, the closed kinetic chain exercises, or the open kinetic chain exercises for knee extension with or without hip adduction targets strengthening of the VMO (26).

Wen-Dien et.al. found that there is a high VMO activation during applying sling-based closed kinetic extension exercise and high VMO:VL (Vastus lateralis) ratio during sling adduction exercise and they recommended more studies combining these two exercises (27). Kelly et.al. said that there was no discriminatory VMO muscle activation and asked for more studies comparing the effects of double leg semi squat with hip adduction exercises for patients with and without PFPS (26). On other hand this study found that the hip adduction contraction didn't influence the knee extension peak torque and couldn't use the adduction as a position for strengthening the knee extensors.

Laprade et al (28) examined the activation of the VMO muscle during certain open kinetic chain exercises. Their findings indicated that performing hip adduction during knee extension, medial tibial rotation, and medial tibial rotation during knee extension did not have a significant impact on VMO activity. Earl et al (29) revealed that mini squats with isometric hip adduction could selectively target the VMO muscle.

Ott et al. (9) related pain because of PFPS to the decreased torque of knee extensors while Powers et al. (30) related the decrease in the torque to the changed mechanics to avoid pain.

Some studies made an association between the higher functional capacity and the higher torque of knee extensors and flexors (8).

Callaghan and Oldham (31) found that muscle atrophy is not the cause of decreased muscle torque in patients with PFPS as they didn't find a correlation between the cross section of the quadriceps muscle and the peak torque which suggests that changes in the mechanics are the cause in the decreased torque. Toumi et.al. (32) found that the decrease in VMO activation does not stimulate a decrease in the quadriceps muscle strength.

Conclusion:

There is no relation between hip adduction isometric contraction and knee extensors peak torque, and it can't be used as a treatment for patient with PFPS. But there is a decrease of patient's pain with and without hip adduction isometric contraction at 180º/s than 60º/s. So, it's preferable to use a medium velocity when treating PFPS patients in open kinetic chain exercises to minimize pain and gain good progression.

Recommendations:

Treatment program can be added and assess pre and post treatment.

Limitations:

The study was limited due to the absence of financial assistance.

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Disclosure statement:

The research did not involve any financial interest or benefits for the author.

Conflict of interest:

The authors have declared that they do not have any conflict of interest.

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