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Effect of VMO Strengthening on Patellar Shifting in Subjects with Patellofemoral Pain Syndrome: An Experimental Study

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Abstract:

The knee joint is one of the most important yet complex joints in the human body containing Tibio-Femoral and Patella-femoral joints. The Position of the patella is determined by following components- tilt, rotation and Q-angle. To regulate the patellar tracking VMO helps to stabilize the knee cap medially and prevents it from shifting laterally and tracking improperly at the patella-femoral joint and maintains a normal patellar shift. This study aimed to find out whether squat-add exercise effective in strengthening the VMO as well as correcting the lateral shifting of patella in subjects having PFPS and are biofeedback effective in this case. The objective of this randomized controlled trial was to evaluate the effect of "SQUAT ADD" exercises in patellofemoral pain syndrome in terms of lateral shifting of patella with and without biofeedback. Diagnosed chronic PFPS subjects (n= 25) were randomized to receive 5 week 3 days/wk treatment protocol of VMO strengthening with and without biofeedback (2 set 3 repetition). Lateral shifting of patella measured through radiograph by lateral displacement measurement

method (>1 mm abnormal). We assessed before and after treatment. Paired t-test and Independent sample tests determined group difference for outcome measure after treatment. At after treatment both groups showed statistically decrease in lateral shifting of patella. The present study concluded that SQUAT ADD exercise showed reduction in patellar lateral shifting of subjects with PFPS. The benefit of biofeedback although remains unclear.

Key words: Lateral displacement, Squat-add exercise, Anterior knee pain, Patellofemoral pain syndrome, VMO strengthening

Introduction:

Patellofemoral pain syndrome is common clinical entity used to describe a variety of pathologic conditions associated with the articulation between the under surface of the patella and the femoral condyles. [Janice K. Loudon.et.al. 2002].The pain is not constant, instead varying with the type and level of activity. PFPS often includes conditions such as chondromalacia patellae, runner's knee, patellofemoral arthralgia, patellalgia, anterior knee pain and patellar tendinitis.[S.T.Green.et al.2005].PFPS is characterized by diffuse pain over the anterior aspects of the knee and is aggravated by activities that increase patellofemoral joint compressive force, such as squatting and prolonged sitting and repetitive activities such as walking, running, measurement of patellar alignment is imperative in the examination of the patient with PFPS.[Tony Wilson.2007].PFPS can be caused by a variety of factors such as: quadriceps weakness, increased Q- angle, VMO weakness,faulty lower limb mechanics, overuse and lateral retinaculum tightness. The major complaints of patients with PFPS are diffuse knee pain, patellar crepitus, locking, knee joint stiffness, and decreased activity level [Janice K. Loudon.et.al. 2002]. The etiology is thought to be primarily due to the pathomechanics of the tracking of the patella within

the femoral condyles. Deviation of the patella laterally generates increased pressure behind the lateral patellar facet on the lateral femoral condyle is proposed as the main cause of pain. Thus, a lack of congruency of the patellar tracking can be caused through osseous or soft tissue structure. The knee 'Q' angle may be a predisposing factor as may be foot alignment looking for signs of excessive foot pronation causes increased internal tibial rotation and has been directly linked to PFPS.[http:// www.footbionics.html]

Vastus medialis is a primary medial dynamic stabilizer which stabilizes the patella medially and the distal obliquely angled fibers of the vastus medialis, keeps the patella in alignment in the femoral sulcus.

Therefore, if there is any patellar maltracking occur it may be attributed due to weakness of VMO.[S.T.Green.et al.2005] Therefore, strengthening of VMO might be lead to correction of patellar tracking.

One of the researcher found the effectiveness of bilateral squat with isometric hip adduction exercise in patellar tracking and VMO strengthening in healthy individuals.[Sian.E. Irish 2010]. Some researcher evaluated the intra- rater reliability of functional performance tests for subjects with PFPS and found good intra- rater reliability and were related to changes in pain.[Janice.K. London et. al.2002]. Clinical interventions targeting Vasti/ VMO muscle imbalance may improve patellar tracking only in maltracking subjects. Various protocols for VMO strengthening have been used including both open kinetic and close kinetic chain exercises.

A form of close kinetic chain exercise called, "Squat add" exercise revealed the maximum activation of VMO in normal healthy individuals, but no literature exists regarding effect of 'Squat add' exercise in subjects with PFPS.

No study to our knowledge has determined whether VMO strengthening actually leads to changes in patellar

alignment. Thus, the present study was to design to fulfil these objectives.

Methods and Materials:

An experimental study was conducted on total of 25 subjects who were enrolled from various hospitals and health centers in Odisha on the basis of inclusion and exclusion criteria for 5 week 3 days/week [Jessica Carlson et.al.2010] and they were divided into 2 groups after the consent was informed.To be considered for the study, patient had to be diagnosed PFPS. The diagnosis of PFP was based on the location of symptoms (Peripatellar and / or Retropatellar) and the reproduction of pain with activities commonly association with this condition, such as stair descent, squatting, kneeling, and prolonged sitting. Subjects were screened by physical examination to rule out, plica syndrome, chondromalaciae patellae as possible causes of current symptoms. Subjects were excluded from participation if they reported a history of any knee disorder other than PFPS, recurrent patella dislocation, any surgery involving the knee, clinical evidence of meniscal or ligaments lesion and patella tendon pathology, a history of knee trauma or intra articular injection therapy, any neurological disease, hip flexion of less than 45 degree, history of diabetes. Subjects were included if they were diagnosed chronic PFPS, they were in between age group 18yr to 35yr, both genders male and female were allowed for the study followed by normal Body mass index (BMI). All the 25 subjects were screened met the study inclusion criteria and randomly assigned to two groups with 13 subjects in Group A followed by Squat- add exercise with biofeedback and 12 subjects in Group B followed by Squat-add exercise without biofeedback. In general, the subjects enrolled in the study were relatively sedentary and participated in activities of daily living. Subjects were selected

and assigned by convenient sampling and randomized distribution method.

Method, purposes and risks associated with the study were explained to the subjects and signed consent forms were taken and pre intervention data were collected from the subjects. No other treatment or drugs were used during the study period. Outcome measures were checked. All relevant ethical safeguards were met in relation to subjects protection in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, revised 2002. The study was approved by the institutional research ethics committee. After the baseline parameters were taken, subjects received the intervention according to group allotted. Instruments used for the intervention was Sphygmomanometer, Universal Goniometer, Straps, Stop watch, Digital Video Camera**.**

Intervention

On the first day for all subjects in this group pre-intervention data for lateral shifting of patella were checked through radiograph [Tony Wilson.2007]. Subjects assigned to group A were received Squat - add exercise with biofeedback for 5 week 3days/wk [Jessica Carlson et.al.2010] intervention. Subjects were first administered by Squat - add exercise for 2 sets along with 3 repetition [J.E.Earl.et.al.2001] with 6 sec [J.E.Earl.et.al.2001] of cuff hold time in between 10 sec [Erik .Witvrouw et.al 2000] of rest in each repetition. Only in group A, Subjects were allowed to see the dial of the sphygmomanometer as a feedback. The intervention was provided for 5 week,3 days/ week. After 5 weeks post intervention data was collected. Each subjects in the exercise group followed a standardized exercise programme.

Subjects in this group were instructed to keep their feet hip distance apart and their knees over toes i.e; knee flex whilst performed a squat and with the back flat against a wall while at controlled speed to the optimal angle of 45^{o} degree as measured by a goniometer, which was held for 6 sec and ascending to the initial position.

This exercise were achieved by compression of sphygmomanometer cuff placed between the medial joint lines of the knee and squeezed it at maximum effort and held for 6 sec. The cuff was inflated to 80 mmHg. The adduction force was maintained throughout the entire exercise, and a moderately inflated cuff i.e. 80mmHg was chosen to maximize the comfort because there will be concern that a more rigid object could lead to discomfort, thus inhibiting muscle activity. In group B, subjects were first administered Squat- add exercise for 2 sets along with 3 repetition with 6 sec of cuff hold time in between 10 sec of rest in each repetition. Subjects in this group were not shown the dial of the sphygmomanometer as a feedback. The intervention was provided for 5 week 3 days/ week. After 5 weeks post intervention data were collected for lateral shifting of patella through radiograph. Subjects in this group followed the same procedure as subjects in group A.

Outcome Measures:

For participants assigned to the exercise group, outcome measures were obtained on 2 occasions: pre intervention measurement and post intervention measurement. The measurements were taken by lateral displacement measurement method.

Measurement of Lateral Shifting of Patella:

Measurement of lateral shifting of patella were taken by the distance from the medial edge of the patella to a line drawn

perpendicular to the posterior condylar line AB and passing through the most anterior point of the medial condyle [Tony Wilson.2007].

Statistical Analysis:

The data was analyzed by using SPSS version-16. Paired t-test, independent sample was used for analysis of data. Paired t-test was applied to compare the data within the groups. Independent sample test was used to compare the data between the groups. The statistical significance was set at 0.05 at 95% confidence and p value <0.05 was considered significant.

Results:

Demographic Data:

For group A and B, mean and standard deviation of age, height, weight and BMI are, for group A age (yr) 26.923$\pm$ 5.678, for height (cm) 163.46 $\pm$ 6.838, for weight (kg) 61.2311 $\pm$ 6.521, for BMI 22.955 $\pm$ 1.483, for group B age (yr) 26 $\pm$ 4.748, for height (cm) 162.422 $\pm$ 6.037, for weight (kg) 61.583 $\pm$ 6.302, for BMI 23.296 $\pm$ 1.395.

Lateral Shifting Of Patella (Within Group Analysis):

For group A and B, mean and standard deviation of Patellar lateral shifting at pre and post 5 weeks after treatment.

The pre and post score of Group A mean and standard deviation were 8.2885$\pm$ 2.520 and 9.125$\pm$1.707 with t -value 4.186 and p-value .001.

The pre and post score of Group B mean and standard deviation were 7.3269$\pm$2.100 and 7.75$\pm$1.630 with t – value 7.396 and p- value .000. For Patellar lateral shifting both groups showed statistically significant difference [Group A (p =.001), Group B (p = .000)].

Lateral Shifting of Patella between Group Analysis:

Independent sample test was done to compare the data of pre-post values of patella lateral shifting between the groups.

Table 3 shows the mean and SD of lateral patellar shifting score at pre and post 5 weeks after treatment. The scores of Group A and Group B on 1st day were 8.2885±2.520 and 7.3269±2.100 with t- value -.978 and p- value .339 respectively. The scores of Group A and Group B on after 5weeks were 9.125±1.707 and 7.75±1.630 with t- value -.559 and p- value .581 respectively. For Patellar lateral shifting between the groups was not statistically significance.

Discussion

The result of the present study reveals that there was a potential significant difference on decrease in lateral patellar shifting in subjects with chronic PFPS through "Squat- add" exercise in both groups.

According to K. Mrityunjaya et.al (2014) VMO strengthening may have greater effect as it has a direct relation to the patellar alignment and VMO muscle has been suggested to act as a dynamic medial stabilizer, which helps to realign the patella during the last 20^0 to 30^0 of knee extension. Also, the insufficiency of the VMO, including diminished VMO ctivity, may increase the lateral pull of the patella and reduce function at the knee joint.

Hence, it can be said VMO is the most important muscle to control the patellar alignment and its strengthening can very much contribute to the normalization of patellar position. They also found isometric quadriceps exercises to be less effective as it works on whole of the quadriceps muscle and not specifically on patellar stabilizers.[K.Mrityunjay et.al.2014].

Fang Lin et.al (2010) mentioned in his study that, anatomical studies have shown that the muscle fibers of the VMO are more obliquely oriented than the fibers of the VML,

and it has been shown that the tendon associated with the VMO inserts on the medial side rather than the superior edge of the patella. This oblique orientation and the medial location of the tendon insertion on the patella would produce medial patellar tilt and lateral rotation (inferior pole moving laterally in the frontal plane) with VMO contraction. In subjects with PFP contraction of the VMO produced medial patellar rotation.This may be due to weakness in the oblique muscle fibers of the VMO in subjects with PFP could also contribute to this finding.[Fang. Lin et.al.2010].

H. Minoonejad et.al. (2012) mentioned in his study that, imbalance between the vastus lateralis (VL) and vastus medialis oblique (VMO) muscles is closely related to patella maltracking and PFPS. Dysfunction in motor control are largely managed by retraining of vasti muscles, especially VMO. Therefore, combined exercises focused on selective strengthening of VMO leads to correction of patellar maltracking. Strengthening of the quadriceps by focusing on retraining of the VMO which stabilizes the patella in trochlea groove, is the most commonly used and highly accepted procedure in management of patellofemoral pain syndrome, known as "Gold Standard"[H.Minoonejad et.al.2012].

There are various studies which mention, VMO plays an important role in patellar stabilizing factor. The VMO muscle centralize the patella and place if in its normal optimal position, Susan A. Doucette et.al (2004) mentioned in her study that if the tension in the VMO is removed, the pressure zone shifts almost entirely to the lateral facet of the patella. Any variation in the lateral balance of the patella created by an alteration in the lines of action or in the magnitudes of the tensions in the VMO and Vastus medialis longus has been found to have a pronounced influence on the location and orientation of the pressure zone. Susan A. Doucette et al. also confirmed that centralization of the patella improved patellar tracking and patellar tilt which is possible with VMO

strengthening in lateral patellar compression syndrome.[Susan A. Doucette et.al.1992].

Jessica Carlson et.al (2010) mentioned in her study that hip adduction increases VMO amplitude. The origin of VMO from the adductor longus and magnus tendons has led clinicians to believe that an isometric contraction of the hip adductors may facilitate VMO activity when strengthening quadriceps. Strengthening of VMO should decrease the lateral pull on the patella and strong hip adductors give the VMO stable origin from which to contract. This is in agreement with the results of our study. Close kinetic chain exercise are significantly better than both the OKC exercise in terms of VMO: VL ratio.Close kinetic chain exercises are more functional than Open kineticchain exercises as the quadriceps do not work in isolation during daily activities hence close kinetic chain exercises have been indicated for knee rehabilitation. Squat-add exercise is superior in preferentially activating VMO.

Due to pain associated with PFPS, it may not be indicated to maximally activate the VMO without prior reconditioning of this muscle. [Jessica Carlson et.al.2010].

Sian.E. Irish et.al.(2010) reported that, double leg squat with isometric hip adduction (Squatt-add) exercise produce significantly greater VMO activation than open kinetic chain exercises. Open kinetic chain exercises were shown to preferentially activate Vastus lateralis instead of VMO and therefore may not be suitable for patients with PFPS.[Sian. E. Irish et.al.2010].

H. Minoonejad et.al. (2012) reported that open kinetic chain exercises are the traditional method of strengthening the quadriceps muscle, which has been used since past years, but close kinetic chain exercises are remarkably used during recent years. One of the reasons to use close kinetic chain exercises is that they are similar to activities of daily living i;e. they are functional. Low stress is imposed on patellofemoral joint in

closed as compared to open kinetic chain exercise.[H.Minoonejad et.al.2012].

According to Eun –Mi- Jang et al. (2013) VMO muscle activity increased in squat exercises with hip adduction compared to the conventional squat exercise. In his study he also mentioned that, the VMO muscle showed significantly greater electrical activity during a double leg semi squat exercise associated with the hip adduction that is Squat-add exercise. That squat add exercise with maximal adduction of the hip showed an increase in the myoelectrical activity of VMO.[Eun-Mi-Jang et.al.2013].

According to Kelly Rafael et.al (2005) close kinetic chain knee extension exercises in the functional range of motion should be emphasized to strengthen the knee joint muscles because of its lower stress on the patellofemoral joint.

45^0 degree knee flexion is a optimal angle for squatting because the peak compressive forces generally occur near maximum knee flexion, this angle would not cause any harm to PFPS patient, individuals with patellofemoral disorders should avoid performing the squat at high knee flexion angle due to pain aggravating factor.[Kelly Rafael et.al.2005]. H. Farahini et.al (2006) reported that VMO activity was significantly higher in closed chain exercise as compared to the open kinetic chain exercise regardless of angle [H. Farahini et.al.2006].

G.Y.F.Ng et.al (2006) in astudy reported that, VMO/ VL EMG ratio was significantly improved over time in the EMG biofeedback + exercise group but not in the other group. This result suggested that the addition of biofeedback to exercise could have a beneficial effect on VMO activation. EMG biofeedback and conventional physiotherapy helped in the functional recovery of quadriceps femoris muscle in 42 patients with uncomplicated menisectomy. It was found that the average difference between pre and post training EMG output for the biofeedback group was 10 times higher than that of the standard therapy group. Ingersoll and Knight (1991) reported

that EMG biofeedback training was superior to progressive resistive exercise for correcting patellar mal-alignment. The authors suggested that VMO muscle strengthening exercise with theassistance of EMG biofeedback as being essential in correcting patellar mal - alignment.[G.Y.F.Ng et.al. 2006].

EMG biofeedback although appears to be the more popular form of biofeedback is not available everywhere. Hence, in our study, we used a simpler form of pressure feedback which can be easily used in a clinical setting. The result of present study is in agreement with previously mentioned literature whereby biofeedback led to better improvement in function on experimental group as compared to the control group,although we did not find any concurrent difference in pain and VMO strength.

This leads us to believe that, biofeedback in this study had psychological benefits as well as physiological. The actual mechanism for the change however remains unclear.

Future research study:

Larger sample size.

Studies with longer duration are recommended with follow -up.

Comparison of the effect of VMO strengthening in subjects with and without PFPS.

Limitations of the study:

Sample size was small.

Duration of treatment protocol was short.

Conclusion

We can conclude that Squat- add exercise showed reduction in patellar lateral shifting of subjects with PFPS. The benefit of biofeedback although remains unclear.

Clinical Significance

SQUAT-ADD exercises may be recommended to subjects with PFPS since they have been proved effective in decreasing lateral patellar shifting.

Images, Tables and Graphs

Fig. 1 (A) Squat-Add Exercise With Biofeedback (B) Squat -Add Without Biofeedback

Fig.2 (A) 12 mm Lateral shifting of patella before treatment

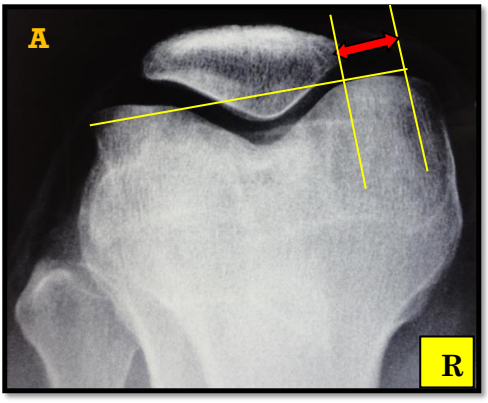

Fig.3 (B) 9.5 mm Lateral shifting of patella after treatment

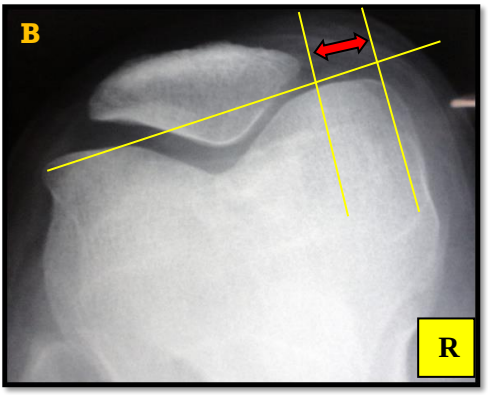

TABLE 1. Demographic Data

VARIABLES	MEAN		STANDARD DEVIATION	
	GROUP A	GROUP B	GROUP A	GROUP B
AGE(YRS)	26.923	26	5.678	4.748
HEIGHT(CM)	163.46	162.422	6.838	6.037
WEIGHT(KG)	61.2311	61.583	6.521	6.302
BMI	22.955	23.296	1.483	1.395

TABLE 2. Within Group Analysis For Patellar Shifting Score

	MEAN		STANDARD DEVIATION		t	p
	PRE	POST	PRE	POST		
GROUPA	8.2885	9.125	2.520	1.707	4.186	.001
GROUP B	7.3269	7.75	2.100	1.630	7.396	.000

TABLE 3. Between Group Analysis Of Patellar Shifting Score

	MEAN		STANDARD DEVIATION		t	p
	GROUPA	GROUP B	GROUPA	GROUP B		
PRE	8.2885	7.3269	2.520	2.100	-.978	.339
POST	9.125	7.75	1.707	1.630	-.559	.581

Fig.4 Comparison of Mean Pre & Post Patellar Shifting For Group A & B

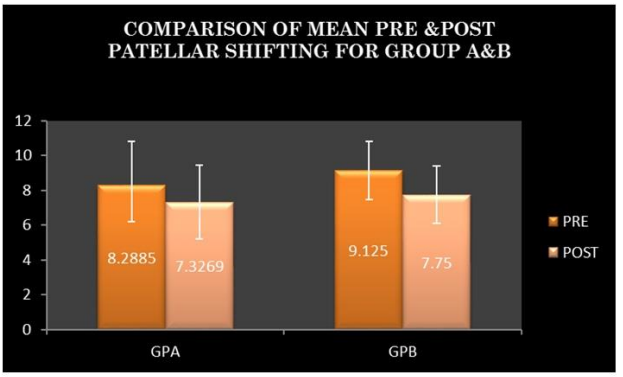

Fig.5 Comparison Of Mean Pre & Post patellar Shifting Between Group A & B

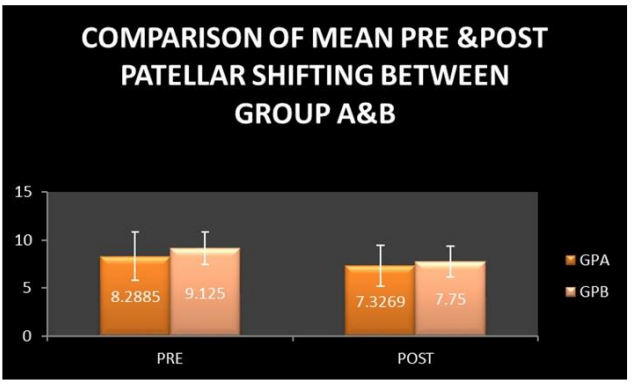

TABLE 4. Summary

What Literature Says…	What Our Study Adds…
According to available literature, Strengthening of VMO is an effective treatment for improving balance, and functional ability but there is no clear evidence regarding effect of VMO strengthening on patellar shifting in subjects with PFPS.	Our study reveals that, Strengthening of VMO leads to decrease in abnormal lateral patellar shifting in subjects with PFPS.

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REFERENCE

Carlson, Jessica, Lyndsay Hobbs et al. 2010. "Isolation of the Vastus medialis oblique muscle during semi-squat and straight leg raise exercises." *The Playmouth Student Journal of Health & Social Work* 2:40-53.

Doucette, Susan A., E. Marlowe et al. 1992. "The effect of exercise on patellar tracking in lateral patella compression syndrome." *The American Journal of Sports Medicine* 20 (4) 434-440.

Earl, J.E. et al. 2001. "Activation of the VMO and VL during dynamic mini-squat exercises with and without isometric hip adduction." *Journal of electromyography and Kinesiology* 11: 381-386.

Eun-Mi-Jang, Hyo-Jin-Heo et al. 2013. "Activation of VMO and VL in squat exercises for women with different hip adduction loads." *Journal of Physical Therapy Sciences* 25: 257-258.

Fang, Lin, Nicole A. Wilson et al. 2010. "In vivo patellar tracking induced by individuals quadriceps components in individuals with patellofemoral pain." *Journal of Biomechanics* 43:235-241.

Farahini, H., G. R. Shah Husseini et al. 2006. "Vastus medialis oblique and vastus lateralis activities ratio on selected degrees of range of motion in open and closed kinetic

chain during isometric contraction.*" Medical Journal of Islamic Republication of Iran*. 19: (4):Winter.1384

Green S.T. et al. 2005. "Clinical management: Patellofemoral syndrome." 9: 16-26

Irish, Sian E., Adam J. Millward et al. 2010. "The effect of closed kinetic chain exercises and open Journal of Bodywork and Movement Therapies kinetic chain exercise on the muscle activity of vastus medialis oblique and vastus lateralis." *Journal of strength and conditioning Research*. May 24 (5): 1256-1262.

Loudon, Janice K., Doug Wiesnert et al. 2002. "Intrarater reliability of functional performance tests for subjects with patellofemoral pain syndrome." *Journal of Athletic Training*. 37 (3):256-261.

Minoonejad, H., R. Rajabi et al. 2012. "Combined open and closed kinetic chain exercises for Patellofemoral pain syndrome: A randomized controlled trial." *World Journal Sports Sciences* 6 (3):278-285.

Mrityunjay, K., Deepak Chhabra et al. 2014. "Comparision between effect of isometric quadriceps exercise and vastus medialis oblique strengthening on quadriceps angle and patellar shift in normal individuals." *European Academic Research* II(4).

Ng, G.Y.F., A. Q. Zhang et al. 2008. "Biofeeback exercise improved the EMG activity ratio of the medial and Lateral vasti muscles in subject with patelloemoral pain syndrome." *Journal of Electromyography and Kinesiology* 18: 128-133

Rafael, Kelly, Ribeiro Coqueiro et al. 2005. "Analysis on activation of the VMO and VLL muscles during semisquat exercises with and without hip adduction in individuals with Patellofemoral pain syndrome." *Journal of Electromyography and kinesiology* 15:596-603

Taskiran, E., Z.Dinedurga et al. 1998. "Effect of the vastus medialis obiquus on the patellofemoral joint." *Journal of Knee Surg, Sports Traumatol, Arthrosc* 6:173-180.

Wilson, Tony. 2007. "The measurement of patellar alignment in patellofemoral pain syndrome: Are we confusing assumptions with evidence?" *Journal of orthopaedics and Sports physical therapy* 37 (6): 330.

Witvrouw, Erik, Roeland Lysens et al. 2000. "Open Versus Closed kinetic chain exercises for Patellofemoral pain" *American Journal of Sports Medicine* 28(5): 687-694.

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