Impact of Tensor Fascia Latae Stretch Prior to Squat on Vastus Medialis Obliquus Activity in Patellofemoral Pain Syndrome

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ABSTRACT

Background: Patellofemoral pain syndrome (PFPS) is a prevalent causes of anterior knee pain among young adults resulting from imbalance in the quadriceps muscle components. Previous studies investigated exercises that enhance vastus medialis obliquus (VMO) activation and improve the VMO to vastus lateralis (VL) ratio in PFPS patients. **Purpose:** to test if there is a difference in VMO muscle activity and VMO: VL ratio during squats before and after tensor facia latae (TFL) stretch in PFPS patients. **Patients and methods:** Thirty-seven PFPS patients participated in this study with age between 18 and 30 years. Patients performed three squat repetitions while the muscle activity of the VMO and VL was measured using electromyography (EMG) in standing and squat hold positions. They then completed a static stretch of the TFL in a side-lying position, holding the stretch for one minute and repeating it five times with 10-second intervals. Afterward, VMO and VL activity was remeasured, and the VMO:VL ratio was calculated before and after the TFL stretch. **Results:** No statistical differences were found in the VMO, VL activity, or VMO: VL ratio while standing after the TFL stretch. A decrease in the VMO and VL activity occurred during the squat hold position, but the VMO: VL ratio remained unchanged ($p > 0.5$). **Conclusion:** there was no change in VMO and VL activity or the VMO:VL ratio after the TFL stretch in the standing phase. In the squat position, both VMO and VL activity substantially decreased, but the VMO:VL ratio stayed the same.

Keywords: patellofemoral pain syndrome, vastus medialis oblique tensor fascia latae, iliotibial band, squat, static stretch.

INTRODUCTION

Patellofemoral pain syndrome (PFPS) is a prevalent etiology of anterior knee pain in adolescents and young adults (1). The diagnosis is usually made by ruling out other knee conditions (2). The most distinguishing symptom of PFPS is pain in or around the anterior of the knee that worsens when the knee is flexed during weight-bearing activities, sitting for extended periods of time, or going downstairs (1,2). Research has identified several risk factors that contribute to the development of PFPS, such as anatomical abnormalities and overuse injuries (1,3). Hence, an imbalance among the components of the quadriceps muscle is a substantial contributing factor to the development of PFPS(3).

The two primary muscles responsible for stabilizing the patella during dynamic knee extension are the vastus lateralis (VL) and the vastus medialis obliquus (VMO) (4). Weakness in the VMO hinders the patellofemoral joint stability resulting in abnormal pressure variations within the patellofemoral joint leading to lateral maltracking of the patella (5). According to literature, the ratio between the VMO and the VL should maintain a balance close to 1:1. This ratio is essential for ensuring optimal stability and movement of the patella within the trochlear groove. However, research indicates that individuals with PFPS may exhibit a ratio as low as 0.54:1(5,6). The strengthening of the VMO is the cardinal aspect in the rehabilitaion of PFPS patients to enhance the ratio between the quadriceps components and regain joint's stability (5).

Investigating exercises that increase VMO muscle activation and enhance the ratio between VMO and VL has been a standardized target in previous literature. Squat as a form of closed kinetic chain exercise has a better activation of the VMO than open kinetic chain exercise (7). Mini squats that reach only 20° of knee flexion exhibit less VMO activity than deep squats that achieve 50° or more of knee flexion. This information is particularly relevant for patients with knee pain, as the latter can be a more demanding exercise. (8).

Moreover, a study compared the activity of both the VMO and VL during squat with and without hip adduction. The results showed that the VMO activity during squat with hip adduction was substantially higher than the activity during squat without hip adduction (9). Since the VMO have an origin from the tendon of the adductor magnus muscle, activation of the adductors muscle thereby enhance the activation of the VMO (10).

In addition to decreased VMO activity, PFPS patients also exhibit tightness in the tensor fascia lata (TFL) muscle and iliotibial band (ITB) (11); this tightness may lead to a lateral pull on the patella (12). A recent study used a novel lower limb range of motion test to test flexibility of kineic chain. The authors found that the symptomatic limb in individuals with PFPS had decreased knee flexion, hip adduction and total range of motion than the nonsymptomatic limb of the same individuals and the control group (13).

Furthermore, in recent study the investigators investigated the effect of TFL tightness on the muscle activity of VMO and the VMO:VL ratio on healthy male subjects. The authors compared the muscle activity of VMO and VL while performing squat before and after performing static stretch to TFL According to the study's results, the VMO muscle activity increased after performing SS to TFL muscle and subsequently the VMO:VL ratio improved (14).

Therefore, the objective of this study is to explore the impact of stretching the TFL muscle before squat exercise on the activity of the VMO and the VMO:VL ratio in patients diagnosed with PFPS. The goal is to identify targeted exercises that enhance the treatment of PFPS patients by restoring balance between the VMO and VL, all while minimizing stress on the joint.

MATERIALS AND METHODS

Study design

A cross-sectional study was conducted in the EMG lab in the Faculty of Physical Therapy at Al-Ahram Canadian University, Giza, Egypt. The research was conducted from August 2024 to January 2025 after ethical approval from the Institutional Review Board (IRB) of the Faculty of Physical Therapy, Cairo University (approved number: PT.REC/012/005630). All patients executed a written consent form subsequent to obtaining comprehensive information regarding the study's goal and process.

Participants

This study comprised thirty-seven patients referred by an orthopedic surgeon with a diagnosis of patellofemoral pain syndrome. The study participants comprised individuals of both genders, with a body mass index (BMI) ranging from 18.5 to 29.9, aged between 18 and 30 years. They experienced nontraumatic anterior knee pain during at least two activities (running, jumping, squatting, kneeling, stair ascent/descent, or prolonged sitting) and exhibited at least one positive clinical test for PFPS, including patellofemoral compression, patellofemoral gliding, or resistive quadriceps setting (3).

Patients were excluded from the study if they had concomitant knee pathology, a history of knee surgery, received physiotherapy treatment, or utilized non-steroidal anti-inflammatory drugs for knee pain within the three months preceding the procedure. Additional exclusion criteria included neurological or rheumatic disorders, pain intensity exceeding 5 on the visual analogue scale, hip and ankle pathology, a BMI greater than 30, or being a pregnant female patients (15).

Assessment Procedure

Each patient prepared the assessed limb by shaving the hair and cleaning the area with alcohol exchanges to eliminate any residues on the skin. The VMO and VL were equipped with Noraxon self-adhesive electrodes. The electrode was positioned 4 cm superior and 4 cm medial to the superomedial border of the patella for the VMO, while maintaining an angle of approximately 55 degrees to the long axis of the femur. The electrode of the VL was positioned 10 cm superior and 6-8 cm lateral to the superior lateral border of the patella, with a 15-degree angle to the vertical (7).

Before the procedure, a maximal voluntary isometric contraction (MVIC) was measured and used to normalize the muscle activity of the VMO and VL as a percentage of the MVIC. To measure the MVIC, patients were seated with 90 degrees knee flexion at the edge of the bed. A non-stretch material belt was placed above ankle malleoli to give resistance. Each patient was asked to try to extend the knee as much as possible for 5 seconds. Data was recorded after two trials with 30 seconds rest in between (16).

Muscle activity of the VMO and VL as an average from three squat reptations with 5 seconds interval. The squat was kept at 50° knee flexion and patients were asked to descend in 3 seconds, hold the squat position for 5 seconds and ascend back up in 3 seconds. Data was collected during the standing phase and the squat hold position and the VMO:VL ratio was calculated.

Participants were asked to perform static stretch for the TFL. For the stretch, each participant began in a side-lying position, with the limb being tested upmost. The lower limb (non-tested) was kept in hip and knee flexion to ensure stability. The tested limb was then taken into hip extension and adduction with knee extended (17). The exercise was held for 60 seconds and repeated 5 times with 10 seconds break intervals. The squat and the measurements during standing and squat hold position were repeated after static stretch of the TFL as done before the stretch.

The device used was the Ultium Noraxon EMG device. The raw data were sampled at frequency of 1,000 Hz, band-passed filtered within 20-500 Hz range and smoothed using root mean square at 50 ms (6,14).

Statistical analysis

The descriptive statistics (the mean and the standard deviation) was calculated for all subjects in the study to determine the homogeneity of the group. Paired t-test was utilised to compare between the VMO activity, VL activity and the VMO/VL ratio in the same subject before and after the stretching of tensor fascia late. The statistical significance value was set at 0.05 with a 95% confidence interval and a p-value <0.05 considered to be substantial using SPSS software version 20 (IBM, USA).

RESULTS

Subject charactrestics

In total there were 37 patients (29 females and 8 males) with anterior knee pain. The demographic variables included age, weight, height, BMI, and sex distribution as shown in table (1) and figure (1).

Table 1: Subject demographics

	Age	Wight	Length	BMI
X±SD	23.08±2.9	67.05±11.64	1.64±0.6	24±2.79

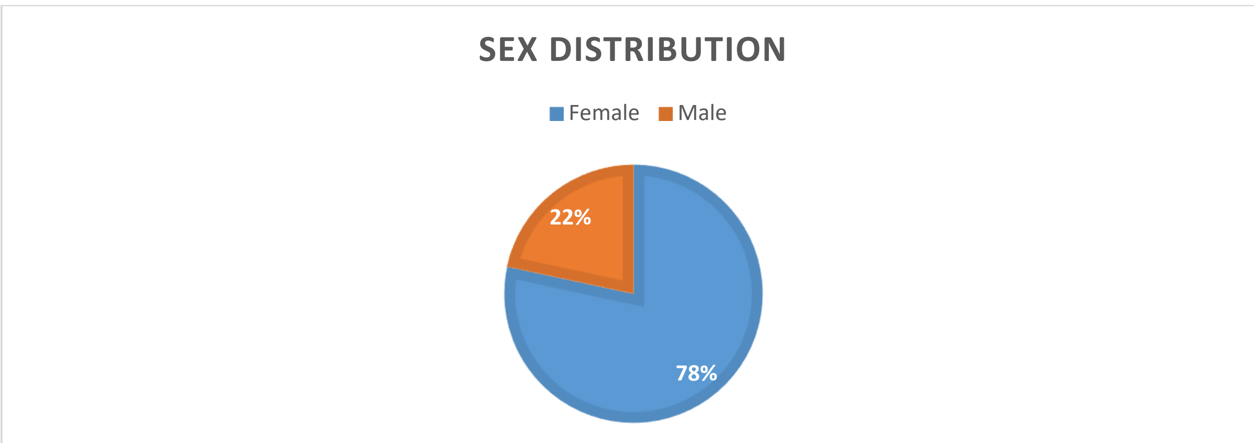

Figure 1: Sex distribution.

Data Analysis

The Shapiro-Wilk test for normality indicated that most of the independent variables were not normally distributed, except for VMO and VL activity after stretching in the standing position, as well as VMO and VL activity after stretching in the squatting position **(Table 2) (Table 3)**

Table 2: Normality test of variable during Standing

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
VMO activity before	.233	37	.000	.792	37	.000
VL activity before	.289	37	.000	.673	37	.000
VMO and VL activity before	.159	37	.019	.853	37	.000
VMO activity after	.202	37	.001	.704	37	.000
VL activity after	.305	37	.000	.650	37	.000
VMO and VL activity after	.121	37	.191	.963	37	.245

Table 3: Normality test of variable during Squatting

	Kolmogorov-Smirnova			Shapiro-Wilk		
SQ	**Statistic**	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
VMO activity before	.120	37	.194	.900	37	.003
VL activity before	.122	37	.177	.933	37	.028
VMO and VL activity before	.136	37	.080	.940	37	.045
VMO activity after	.123	37	.176	.963	37	.245
VL activity after	.085	37	.200*	.974	37	.515
VMO and VL activity after	.134	37	.090	.933	37	.028

Muscle activity during standing:

There was no substantial difference between the VMO activity before and after the stretching (p-value = 0.613). The comparison showed that there was also no substantial difference in the VL activity (p-value = 0.531). Moreover, there was no substantial difference in the VMO:VL ratio (p-value = 0.207) table (3).

Table 4: Volume of muscles with standing position before and after TFL stretch.

Variable	Time	Median	IQR	Z-value	P-value	Sig
VMO% activity	Before	6.94	9.88	- 0.50	0.613	NS
	After	6.13	12.83			
VL% activity	Before	13.90	13.27	- 0.62	0.531	NS
	After	12.10	15.13			
VMO:VL ratio	Before	0.48	0.36	-1.261	0.207	NS
	After	0.56	0.38			

NS: non-substantial.

Muscle activity during squatting

For the VMO activity, a substantial decrease was observed before and after the stretching (p-value = 0.002). Moreover, VL activity demonstrated a substantial decrease between its activity before and after the stretching in the squatting position, with a (p-value = 0.004).

On the other hand, the VMO:VL ratio showed no substantial difference before and after the stretching, with a (p-value = 0.898).

Table 5: Volume of muscles with squatting position before and after TFL stretch.

Variable	Time	Median	IQR	Z-value	P-value	Sig
VMO% activity	Before	52.80	38.50	- 3.16	0.002	S↓
	After	49.0	39.10			
VL% activity	Before	69.80	40.05	- 2.85	0.004	S↓
	After	61.10	45.75			
VMO:VL ratio	Before	0.85	0.40	-0.128	0.898	NS

S↓: substantial decrease. **NS:non-substantial.**

DISCUSSION

This study aimed to evaluate the impact of adding TFL muscle stretch prior to squat exercise on the VMO muscle activity in PFPS patients. The results indicated a substantial decrease in the muscle activity of both the VMO and the VL during squats conducted after the TFL stretch. However, despite the notable reduction in the activity of both the VMO and VL, there was no substantial difference in the VMO:VL muscle ratio following the TFL stretch.

The results of this study agreed with Pethick et al.(18) who tested the knee extensors during submaximal knee extention isometric contration before and immediately after SS. Patients were given either no stretch, 30, 60 or120 seconds stretch. According to the results, there was a substantial reduction in muscle activity after the 30, 60 and 120 seconds stretch. Moreover, Caldwell et al. (19) tested the knee extensors MVIC, drop jump height and contact time after four repetitions of 30 seconds hamstring SS. The results were also in agreement with the current study results and there was substantial deficit in the MVIC force as well as prolonged contact time in the stretch limb.

A previous study clearly demonstrated that there was a substantial reduction in EMG activity in the soleus and gastrocnemius muscles, while biceps femoris activity remained unchanged after one hamstring stretch and four calf stretches lasting 90 seconds (20). These results indicate that the longer the stretch of a muscle the more evident the reduction in muscle activity in it. Since they applied four calf muscle stretches there was substantial decrease in the soleus and gastrocenemius activity and on the contrary they applied only one hamstring stretch so no difference in the biceps femoris activity was present.

In addition to the previous studies, similar results were also found in studies done on upper limb muscles. A study done on the triceps surae muscle elicited decreased muscle activity after triceps stretch (21). Another study done on eight males working as delivery drivers had a controversal results. The results elicited a decrease in muscle activity of the forearm extensors muscle group after stretch, yet increased activity in the anterior deltoid and trapezius muscles after stretch (22).

The results of the current study might be due to stretch-induced force loss. This stretch-induced force loss is thought to be due to mechanical and neural mechanisms. The mechanical mechanism suggests that after stretch there is decrease

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in the muscle stiffness and alteration in the structure and length; therefore, affecting the force generating capacity due to the length-tension relationship. A substantial amount of evidence indicates that neural factors substantially contribute to the deficit, although the specific sites where neural drive is compromised remain unknown (23).

On the contrary, only one study tested TFL stretching on the VMO and showed results that contradict the current study, showing improved VMO and VMO:VL ratios in 19 healthy males. In their experiment, participants performed the TFL stretch from a supine position with the non-tested leg at 125° of hip flexion to maintain a flat back, while the tested leg was positioned in maximum adduction, maximum hip extension, and 90° of knee flexion and measuring squat depth at 80° knee flexion (14).

CONCLUSION

Stretching the TFL muscle resulted in no difference in the activity of both VMO and VL and their ratio during standing. However, there was a substantial decrease in the VMO and VL activity during squat hold position, but due to reduced activity in both muscles there was no substantial ratio. These findings indicated that the TFL stretch alone may not be effective for achieving desired muscle balance in rehabilitating patients with PFPS.

RECOMMENDATIONS

Future studies are recommended to compare the results between males and females, test the long term effects of TFL stretch on VMO activity and VMO:VL ratio and combining TFL stretch with VMO strengthening exercise in treatment of PFPS.

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Conflict of interest:

The authors declare no conflicts of interest.

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