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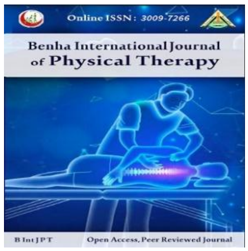


Original research

# Impact of Tensor Fascia Lata Stretch Prior to Squat on Vastus Medialis Obliqus Activity in Patellofemoral Pain Syndrome: Pretest- Posttest Single Group Study.

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## Abstract

**Background:** A prevailing cause of knee pain is the patellofemoral pain syndrome (PFPS) resulting from imbalance in the quadriceps components. Previous studies sought exercises that enhance vastus medialis obliquus (VMO) activation and the VMO to vastus lateralis (VL) ratio in PFPS patients. **Purpose:** This study tested if there is a difference in the muscle activity of the VMO and VL and VMO: VL ratio during standing and squat before and after tensor facia lata (TFL) stretch in PFPS patients. **Methods:** 37 PFPS patients participated in this study with age between 18 and 30 years. Participants 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 (r=0.08), VL activity (r=0.1), or VMO: VL ratio (r=0.21) while standing after the TFL stretch. A decrease in the VMO (r=0.52) and VL (r=0.47) activity occurred during the squat hold position, but the VMO: VL ratio (0.02) remained unchanged (p >0.05). **Conclusion:** The TFL stretch couldn't enhance the VMO:VL ratio in PFPS patients. Further studies are needed to compare the results between both genders and study the effects of incorporating TFL stretch with VMO activation exercises.

Keywords: iliotibial band, squat, static stretch, electromyography

## INTRODUCTION:

Patellofemoral pain syndrome (PFPS) is a common cause of pain around the kneecap youthful individuals [1]. The diagnosis is usually made by ruling out other knee conditions[2]. A hallmark symptom of PFPS is pain localized to the anterior area of the knee, which tends to intensify during activities that involve knee flexion, such as kneeling, sitting for extended periods, or during the usage of stairs[1,2]. Research has identified several risk factors that contribute to the development of patellofemoral

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pain syndrome (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 oblique (VMO) [4]. Weakness in the VMO hinders the patellofemoral joint stability resulting in abnormal pressure variations inside the patellofemoral joint and resulting in mal tracking 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 robustly examined the activity levels of both the VMO and VL during squats, analyzing the impact of hip adduction versus a standard squat without it. 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 enhances 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].

Thus, this study aims to examine how stretching the TFL muscle before squat exercises affect 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.

## METHODS

### *Study design*

An experimental 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 participants executed a written consent form after obtaining comprehensive information regarding the study's goal and process.

### *Participants*

This study comprised thirty-seven subjects 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 patellofemoral pain syndrome (PFPS), including patellofemoral compression, patellofemoral gliding, or resistive quadriceps setting [3].

Individuals who 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 were eliminated from the study. 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 participant [15].

***Procedure***

Each participant 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 supromedial 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 contaction (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, participants 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 participant was asked to try to extend the knee as much as possible for 5 seconds. Data was be recorded after two trials with 30 seconds rest in between [16].

Muscle activity of the VMO and VL as an average from three squat repetitions with 5 seconds interval. The squat was kept at 50° knee flexion and participants 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. In total there are 37 participants with knee pain, the mean ± SD of age, weight, height and BMI of the study participants are 23.08 ± 2.9 years, 67.05 ± 11.64 kg, 1.64 ± 0.6 m and 24 ± 2.79 kg/m² respectively. Wilcoxon Signed-Rank Test was utilized 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). 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.

## RESULTS

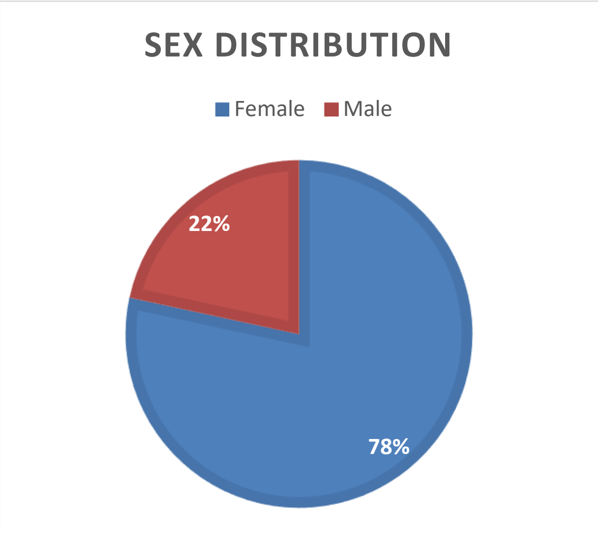
### *Subject characteristics*

In total there were 37 participants (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).

**Table 1: Subject demographics**

| | Age | Wight | Height | BMI |
|---|---|---|---|---|
| X±SD | 23.08±2.9 | 67.05±11.64 | 1.64±0.6 | 24±2.79 |

**Figure 1: Sex distribution.**




### *Muscle activity during standing:*

There was no substantial difference between the VMO activity before and after the stretching (p-value = 0.613, r=0.08). The comparison showed that there was also no substantial difference in the VL activity (p-value = 0.531, r=0.1). Moreover, there was no substantial difference in the VMO:VL ratio (p-value = 0.207, 0.2) table (2).

**Table 2: 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-significant.**

### *Muscle activity during squatting:*

For the VMO activity, a substantial decrease was observed before and after the stretching (p-value = 0.002, r=0.52). 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, r=0.47). On the other hand, the VMO:VL ratio showed no substantial difference before and after the stretching, with a (p-value = 0.898, r=0.02) table (3).

**Table 3: 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↓: significant decrease.** **NS: non-significant**

## 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

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VL, there was no substantial difference in the VMO:VL muscle ratio following the TFL stretch. This is due to that the stretch caused a reduction in the activity of both the VMO and the VL not the VL alone. If the TFL stretch decreased the VL activity alone while the VMO activity remained constant or even increased, then an improvement in the ratio would have been seen.

The results of this study agreed with Pethick et al.[18] who tested the knee extensors during submaximal knee extension isometric contraction before and immediately after static stretch. Participants were given 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 gastrocnemius 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 the triceps surae muscle elicited decreased muscle activity after triceps stretch [21]. Another study done on eight males working as delivery drivers had controversial results. The results elicited a decrease in muscle activity of the forearm extensors muscle group 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 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]. Their results were based on data from only healthy male participants, yet the current study results were obtained from 29 females and only 8 males all diagnosed with PFPS. Also in their experiment, the squat depth was kept at 80° knee flexion not 50° like the current study. The difference in the results between males and females, as well as different squat depth is to be further investigated.

## 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. Those findings indicate 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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