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Original Research Article

A STUDY TO ASSESS ELECTROMYOGRAPHIC ACTIVITY OF VASTUS MEDIALIS OBLIQUE AND VASTUS LATERALIS DURING SEMISQUAT WITH DIFFERENT HIP POSITIONS IN NORMAL HEALTHY INDIVIDUALS

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ABSTRACT

Background: The knee complex is the most often injured joints in human body. Performing functional tasks like getting up from the bench, unipedal jumping and rising on the heels may favour patella lateralization and predispose towards developing patellofemoral disorders. It has been hypothesized that an imbalance between the vastus medialis oblique (VMO) and the vastus lateralis (VL) muscles, may be an etiological factor in the development of patellofemoral pain syndrome. The squat is one of the most frequently used Exercises to strengthen VMO for strengthening and conditioning in many sports routines designed to enhance athletic performance.

Purpose Of Study: To determine the VMO muscles activity and VMO/VL ratio with 30 degree of squat in different hip position.

Methods: 250 normal healthy individual, with age ranging from 18-25 years, who fulfilled the inclusion and exclusion criteria, were recruited in the study. MVIC was recorded for vastus medialis obliqus and vastus lateralis form both knees with 30 degree squat position. Three position of hip (Neutral hip position, 45º medial rotation of hip and 30º lateral rotation of hip) were performed in both lower limb and activity of all these muscles was recorded via EMG.

Results: Data analysis was done by repeated measure ANOVA with tukey corrections for pair-wise comparison of muscle activity with all positions of hip for each muscle. The results showed a muscle activity for VMO minimal activity is found in lateral rotation of hip and maximum activity is found in medial rotation of hip. And for VL minimal activity is found in neutral rotation of hip and maximum activity is found in medial rotation of hip. So the ratio of VMO/VL is found minimum in lateral rotation and maximum in medial rotation. ($p>0.05$).

Conclusion: It can be concluded from this study that in semisquat position medial rotation of hip gives better activation for Vastus medialis obliqus muscle and increase ratio of VMO/VL. So, it can be used in knee rehabilitation program.

KEY WORDS: VMO, VL, VMO/VL ratio, EMG activity, Squatting.

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INTRODUCTION

There are four extensors of the knee collectively known as quadriceps femoris muscles. The vastus intermedius, vastus lateralis (VL) and vastus medialis obliqus muscles (VMO) originate on the femur and merge with the rectus

femoris muscle into a common tendon known as quadriceps tendon [1].

To maintain the normal patellofemoral alignment, it is vital to achieve a balanced activity between the vastus medialis (VMO) and vastus lateralis (VL). The electrical activation of the VMO and VL are often expressed as a ratio value, (VMO/VL). Significantly increased VMO/VL values indicate preferential VMO activation [2].

Patellofemoral pain syndrome (PFPS) is one of the most common problems among physically active individuals between the ages of 15 and 30. The prevalence of PFPS in females and males was 15.3%and 12.3% respectively [3].

Patients with patellofemoral pain syndrome (PFPS) often develop excessive lateral tracking of the patella that could be caused by a weakness of the VMO because this muscle mainly provides medial stabilization for the patella [3,4]. The pull of vastus lateralis muscle is normally 35^0 lateral to long axis of femur, whereas the pull of the proximal portion of the vastus medialis muscles is approximately 40^0 [5]. A muscular imbalance between the VMO and the VL, and improper timing of activation between the two muscles are perceived to result in abnormal patellar tracking and to be the two most common causes of PFPS [6,7].

Patellofemoral joint deterioration, which is characterized by subjective reports of anterior knee pain and objective evidence of patellar degeneration, is a common condition and spans a spectrum of athletic and nonathletic individuals [8,9].

Healthy individuals demonstrated different activation intensities between the VMO and VL muscles, as observed in the activities of getting up from the bench, unipedal jumping and rising on the heels.

Performing these functional tasks may favour patella lateralization and predispose these subjects towards developing patellofemoral disorders [8].

Many studies determine the facilitation of VMO in various hip positions like hip adduction/ abduction and with different foot positions like pronation/ supination. But there is lack of the study done on effect of rotational position of hip that affect the VMO Facilitation.

The purpose of the study is to test whether different combinations of hip rotation and knee flexion could affect the relative activation of the VMO and VL during weight-bearing activity in normal healthy individuals and to identify a desirable combination of hip and knee positioning for VMO facilitation in patients.

Experimental hypothesis: There is a significant difference in the EMG activity of VMO and VL during static quadriceps contraction in semisquat position with different positions of hip.

Null Hypothesis: There is no significant difference in the EMG activity of VMO and VL during static quadriceps contraction in semisquat position with different positions of hip.

MATERIALS AND METHODS

Study design and participants: Cross sectional observational study was conducted with random sampling on 250 normal healthy individuals of Rajkot city.

Materials used were: RMS EMG PK M-II, Surface electrodes, Electrode gel , Goniometer, Cotton, Spirit , Pen, Paper, Consent form

Inclusion Criteria: Age group: 18 - 25 years, Gender: Male and female (Normal healthy individual).

Exclusion Criteria: Subjects with traumatic injury to knee, Subjects with knee deformity, Subjects with any neurological condition, Subjects with any musculoskeletal condition of lower limb, Uncooperative Subjects.

Procedure: The proposed title and procedure was being approved by ethical committee members. 250 participants (females and males), aged 18 to 25 years old were recruited as per the inclusion and exclusion criteria. The entire procedure of testing was explained and an informed consent was obtained from each participant.

Prior to measurement all the sites of electrode placements were abraded with sand paper and cleaned with alcohol to minimize the skin impedance. Surface electrodes with a 10mm diameter were used to assess the EMG activity. Surface electrodes applied with electrode gel were positioned on the target muscle and firmly secured with adhesive tape [10].

Subjects were then asked to perform static quad-

riceps contraction at maximal voluntary isometric contraction (MVIC) at 30º knee flexion with Neutral hip position, 30º lateral rotation of hip, 45º medial rotation of hip, Three trials for each position were performed to allow participants to become comfortable with the testing procedure. The entire testing procedures were done on the same day in a single sitting. Opposite knee was also tested with the same procedure.

Statistical analysis: All Statistical analysis was done by software SPSS 14.0 version. Means and Standard Deviation (SD) were calculated as a measure of central tendency and measure of dispersion respectively. The effect of the different hip position on muscle activity was examined using a repeated measure Analysis of Variance (ANOVA) with tukey corrections for pair-wise comparisons.

Fig. 1: Graph for age and gender distribution.

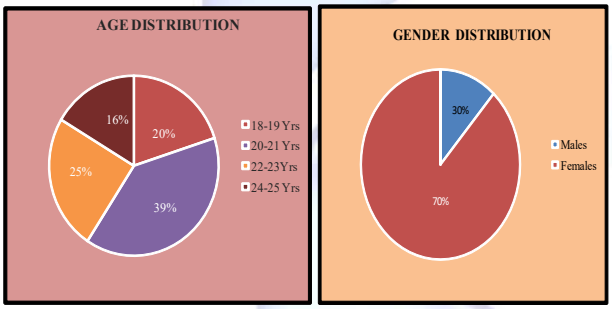


Table 1: ANOVA analysis with post hoc test for VMO/VL between NP with MR, LR for the study (sig.<0.5).

		Sum of Squares	F	Sig.
Lateral Rotation	Between Groups	56.665	20.982	0
	Within Groups	5		
	Total	61.665		
Medial Rotation	Between Groups	92.567	22.929	0
	Within Groups	7.474		
	Total	100.042		

Table 2: ANOVA analysis with post hoc test for VMO/VL between MR with NR, LR for the study (sig.<0.5).

		Sum of Squares	F	Sig.
Neutral Rotation	Between Groups	50.705	19.22	0
	Within Groups	4.884		
	Total	55.589		
Lateral Rotation	Between Groups	54.867	14.944	0
	Within Groups	6.798		
	Total	61.665		

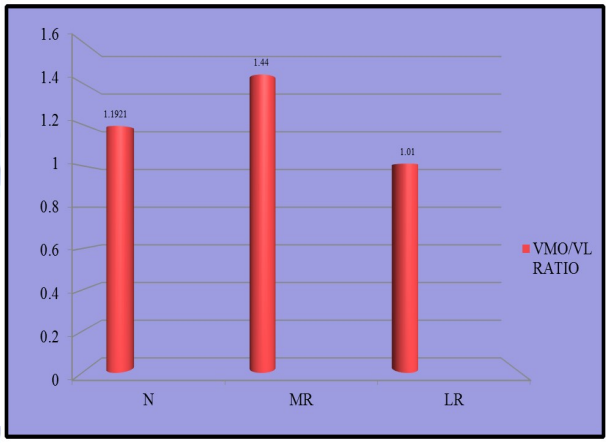
Table 3: ANOVA analysis with post hoc test for VMO/VL between LR with NR, MR for the study (sig.<0.5).

		Sum of Squares	F	Sig.
Neutral Rotation	Between Groups	53.699	18.176	0
	Within Groups	1.89		
	Total	55.589		
Medial Rotation	Between Groups	94.327	32.693	0
	Within Groups	5.715		
	Total	100.042		

Table 4: Comparison of vmo/vl ratio in different position.

	Neutral rotation of hip	Medial rotation of hip	Lateral rotation of hip
VMO	261.61 ± 95.06	323.55 ± 102.95	216.55 ± 91.36
VL	226.74 ± 80.49	238.05 ± 88.10	227.16 ± 88.72
VMO/VL	1.1921 ± 0.33	1.44 ± 0.44	1.01 ± 0.35

Fig. 2: Graph for comparison of vmo/vl ratio in different position.



DISCUSSION

Many factors are commonly cited as being primary contributors to the development of Patellofemoral Joint Disease. The most commonly cited factors are atrophy or dysplasia of the VMO or an imbalance in the strength ratios between the VMO and the VL. Thereby creating the need for rehabilitation and reintegration of patients to their daily activities. For this reason, various protocols are proposed for rehabilitation professionals [8,9].

The results of the present study support the experimental hypothesis which shows the significant difference between EMG activity of VMO and VL during static quadriceps contraction in semisquat position with different positions of hip.

One way ANOVA with tukey corrections is used for pair wise comparison of activity of both muscles during all the variants of hip position

in squat position. The results indicate that a significant increase is found in muscle activity in vastus medialis obliqus and vastus lateralis muscle with hip medial rotation lateral ($p<0.05$). Same results are found for the ratio of VMO/VL in 30 degree squat.

The squat is becoming increasingly popular in clinical settings as a means to strengthen lower-body muscles and connective tissue after joint-related injury. Squats can be performed at a variety of depths, generally measured by the degree of flexion at the knee. Strength coaches often categorize squats into 3 basic groupings: partial squats (30 to 40 degree knee angle), half squats (70 to 100 degree knee angle), and deep squats (greater than 100 degree knee angle).

The highest recorded peak tibiofemoral compression forces were obtained in a study of power lifters lifting 2.5 times bodyweight. Maximum values reached approximately 8,000 N at 130 degree of knee flexion and were consistent with maximal forces at the quadriceps tendon [11]. These forces slowly declined to at 30 degree of knee flexion up to 3,500 N, whereas Patellar tendon force was slowly decreased to approximately 2,000N. It is important to note that the ultimate tensile strength of the patellar tendon approximates 10,000 to 15,000 N and thus is more than capable of handling this forces [12]. The quadriceps tendon is significantly thicker than the patellar tendon; its strength is probably even greater, making the likelihood of exceeding the stress threshold even less.

Maximum anterior shear forces during the squat tend to occur within the first 60 degree of knee flexion [12,13]. The ACL provides approximately 86% of the restraining force against anterior shear, a product of its role in counteracting anterior translation of the tibia as well as resisting internal and external rotation in early knee flexion [14, 15]. Peak ACL forces generally occur between 15 degree and 30 degree of flexion, decreasing significantly at 60 degree [11]. Posterior shear begins to manifest at approximately 30 degree of flexion, PCL torque rose significantly with every flexion angle beyond 30 degree to a peak of 73.2 N at 90 degree. So, the 30 degree of squat is safer in relation to prevent injury as ACL, PCL, Quadriceps tendon and patellar tendon works to minimize shear force and compression force.

One study evaluated the effect of combined tibial and femoral rotation on the VMO/VL activity ratio reported no significant difference in the VMO/VL activity ratio in subjects with patellofemoral pain syndrome. Whilst Bos and Blosser assessed the VMO and VL EMG activity with combined tibial/ femoral external rotation and ankle dorsiflexion and results shows increased VMO/VL activity ratio at combined tibial and femoral internal rotation, in comparison to tibial and femoral external rotation whilst performing a step-up, step-down or semi-squat exercise [7]. Previous studies have reported that the associated medial tibial rotation during semisquatting with the hip medially rotated facilitated VMO contraction [13,14]. Another possible reason is that during medial rotation, the hips also adduct naturally, and adduction of the hip has been shown to facilitate the VMO in a weight-bearing condition. So, in present study medial rotation of hip combine with internal rotation of tibia this gives support to experimental hypothesis.

However, Gregersen, Hull, and Hakansson (2006) reported that during a cycling task when the foot was positioned in pronation, the VMO/VL activity ratio was significantly greater in comparison to neutral or supinated foot positions ($p<0.0001$) [11]. So, in this study during medial rotation of hip, foot remains in pronation and this leads to increase VMO/ VL ratio.

Many knee-rehabilitation programs focus primarily on strengthening the vastus medialis obliqus (VMO). This tends to be the focus because patients with any type of internal knee derangement have been shown to develop atrophy of the VMO and lose the last few degrees of full extension. Early atrophy of the VMO is an indicator of general quadriceps weakness and not just weakness in the particular muscle. One study concludes that the vastus medialis is the "key to the knee" because it is almost entirely responsible for stabilization and protection. Proper VMO functioning is also extremely important for patients with patellofemoral dysfunction, as well as any patient with knee pathology. There is evidence supporting the importance of the VMO and because the knee is the most commonly injured joint in sport-

related activities, it is essential to design a rehabilitation program that best achieves the goal of regaining and im-proving the strength of the VMO [14].

From the results of this study it can be concluded that VMO was most facilitated as compared with the VL during 30 degrees of semisquat with the hip medially rotated. And it is reasonable to believe that an increase in the EMG ratio of VMO/VL increases the medial stabilizing force on the patella and this will reduce the loading on the lateral facet of the patella.

Limitations: There was surface EMG used measure muscle activity and was assumed that recorded EMG signal indicated activity of each muscle but it can be caused by cross talk of adjacent muscle. Dominancy was not consider

Further Recommendations: Tibial rotation also should be taken into consideration. Study can be done with different foot position. Study also can be done to compare open kinetic chain exercise with close kinetic chain exercise. Study can be done in population with different knee pathology. Kinesiological EMG can be use to verify activity of muscle during squatting with the neutral position, medial rotation and lateral rotation.

CONCLUSION

It is concluded from this study that 30 semisquat position with medial rotation of hip gives better activation for Vastus medialis obliqus muscle and increase ratio of VMO/VL. So, it can be used in knee rehabilitation program.

ABBREVIATIONS

VMO - vastus medialis obliqus
VL – vastus lateralis
EMG - electromyography

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Conflicts of interest: **None**

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