Original article:

Does the position of knee angle alter the muscle fiber size?

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Abstract

Introduction: Vastus Medialis Oblique [VMO] muscle plays an important role in patellar tracking and knee stability. Since many ages there are controversies over strengthening of VMO muscle in different knee angle and thus there is need to find out at which knee angle the VMO muscle could be strengthened to the maximum and effectively. Previous study had been done about isometric contraction at different knee angle using EMG and MRI, but not using ultrasonography. Hence this study was undertaken to find out the effect of knee position on Vastus medialis obliques muscle fibre size using ultra-sonography .

Methodology: Institutional ethical committee clearance was obtained, 14 participants were selected in the age group of 18 to 25 years without any musculo-skeletal disorder affecting the lower limb and neuromuscular disorder. Informed consent was obtained and their anthropometric measurement was recorded. The ultra-sonoghraphy was performed using a MINRAY (DP 2200 model), using a B mode linear array ultrasound probe (7 to 12 MHZ) placed at the supero-medial aspect of the patella where the VMO is prominent. The patient was in high sitting position and was asked to perform knee extension at 45^0, 30^0 and $0^{\ 0}$ and hold the position at these angles and the muscle fibre size was measured at these position.

Statistical analysis to check difference at various angles was done using one way ANOVA test.

Result: There was no significance change in the muscle fibre size at different knee angle as the p value was found to be greater than 0.05.

Conclusion: There was no effect of knee angle on muscle fibre size of vastus medialis oblique muscle.

Keywords: VMO, ultra-sonography, knee angle

Introduction

The Vastus Medialis muscle is one of the important quadriceps muscles. It is a teardrop shaped muscle situated on the lower medial thigh. It originates from the linea aspera and medial supracondylar line of the femur and inserts into the quadriceps tendon and upper outer part of the patella.[1] Because of the different orientation of the upper and lower fibers of the vastus medialis muscle, the upper fibres which are long relatively in line with the the quadriceps ligament referred to as the Vastus Medialis Longus(VML), and the lower fibers more obliquely oriented are referred to as the Vastus Medialis Oblique (VMO).[2] The function of the VMO is to align the patella in last 10 -15 degrees of knee extension.[3] The VMO acts more as a stabiliser to lateral patellar pull, while the VML contributed more to knee extension with the other vastii .[4]On reviewing the previous literatures of ultra-sonographic based study done on brachialis muscle the pennation angle and fascicle length at different elbow joint position and it was found that the muscle architecture was significantly affected by the elbow joint position.[5] Similarly a USG based study was carried out on abdominals muscle i.e upper rectus abdominis , lower rectus abdominis ,,external oblique , internal oblique and the tranversus abdominis at 30^0 , 60^0 , 90^0 and 0^0 and it

www.ijbamr.com P ISSN: 2250-284X , E ISSN : 2250-2858

was found that there was significant difference in muscle fibre size of rectus abdominis muscle only.[6] USG was validated to be used to study muscle morphology by comparing it with MRI.[7] And in assymptomatic individuals by using USG it was found that there was increased fibre angle and decreased insertion ratio with increased Tegner score.[8] M.khoskoo carried out a study by using USG before and after 6 weeks of quadriceps strengthening programme and observed significant increase in fibre angle and insertion length.[9] Diagnostic and imaging techniques such as Magnetic resonance imaging , electromyography and Ultrasonography has been used seen ages in the field for studying morphology and pathology of the skeletal muscles. But among these ultrasongraphy is most cost effective and non invasive technique where the muscle morphology can be visualized during static as well as dynamic activities.

There are no such available studies where the change in muscle fibre size of VMO was studied at different knee joint angle using USG. Thus this pilot study was undertaken to study the effect knee joint angle on muscle fibre size of VMO using ultrasonography.

Material and method

Participants:

14 healthy subjects from Dr Vithalrao Vikhe Patil institute were enrolled in the study, which included 2 males and 12 females. Participants in the age group of 18 to 25 years and who were willing to participate were included in the study. Subjects with previous or present history of knee pain, lower limb fracture in the past one year, any other musculoskeletal or neuromuscular disorder affecting the quadriceps muscle were excluded from the study. The Quadriceps muscle strength was grade 5 for both the the limb for all the 14 samples .The lower limb dominance was found by using unipedal stance test. The present research was approved by the institutional ethical committie.

Study design and setting:

The examination was carried out in the radiology department of Dr Vithalrao Vikhe Patil Medical Hospital after complete explanation of the study to the participants. Informed consent was obtained from them. A well experienced Sonologist was included for the evaluation. USG was performed on both the VMO muscle using a MINRAY (DP 2200 model) ultrasound machine available in the institute .The VMO muscle was located using a B mode linear array ultrasound probe (7 to 12 MHZ).The ultrasound probe was placed in longitudinal plane such that the probe is parallel to the VMO muscle fibres. The probe was placed on the anterior aspect of lower thigh supero-medial to the patella where the VMO muscle is prominent. The knee angle was measured using an universal goniometer where the the fulcrum was placed at the lateral condyle of the femur, the static arm in line with the greater trochanter of femur and the movable arm in line with lateral malleolus. Both the arms of the goniometer were stabilized by using a strap. Subjects were in the high sitting position with 90^0 resting position and then were asked to perform knee extension from that position into 45^0, 30^0 and 0^0 for each leg and maintain that position for 5 seconds and the muscle fibre was measured at these four angles using the inbuilt calliper in ultrasound machine.

Measurement:

The muscle fibre size was measured bilaterally at angles of 90^0(resting position),45^0 ,30^0 and 0^0. The images were obtained by pressing the pause button on the machine, when the sonologist located the VMO muscle fibre which was parallel to the direction of the probe at each angle. The cursor was placed on the boundary of fascia which appears to be the hypoechoic layer and separates the muscle into the surface layer and the deep layer on screen and the femur bone below and thus the distance of the muscle thickness was measured. The measurement of the muscle fibre size of left VMO at 90^0,45^0, 30^0 and 0^0 of knee angle can be visualized in figure 1, 2, 3 and 4.

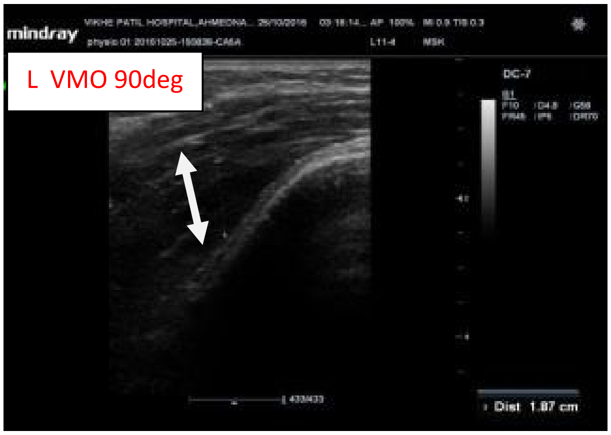


Figure 1: the muscle fibre size of Left VMO at 90^0

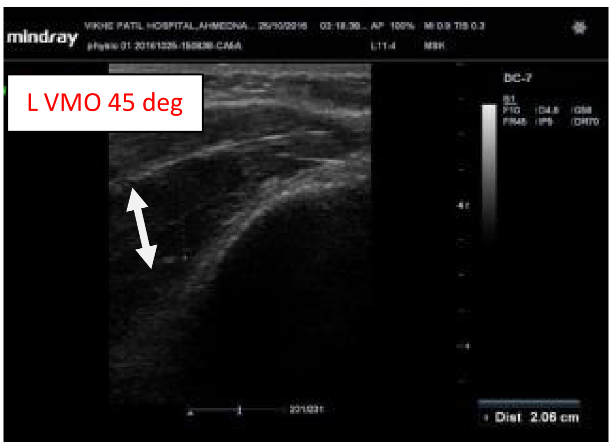


Figure 2: the muscle fibre size of Left VMO at 45^0

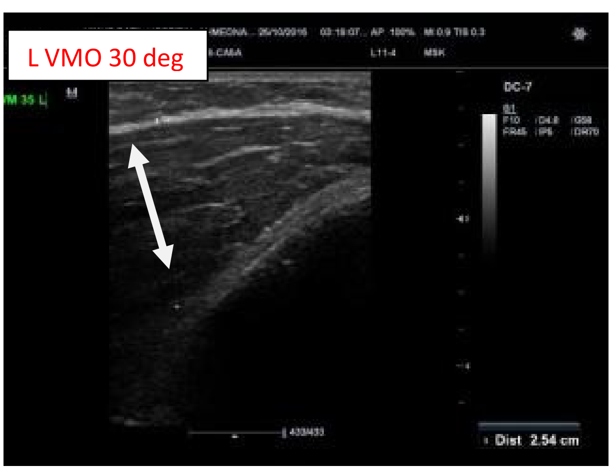


Figure 3: the muscle fibre size of Left VMO at 30^0

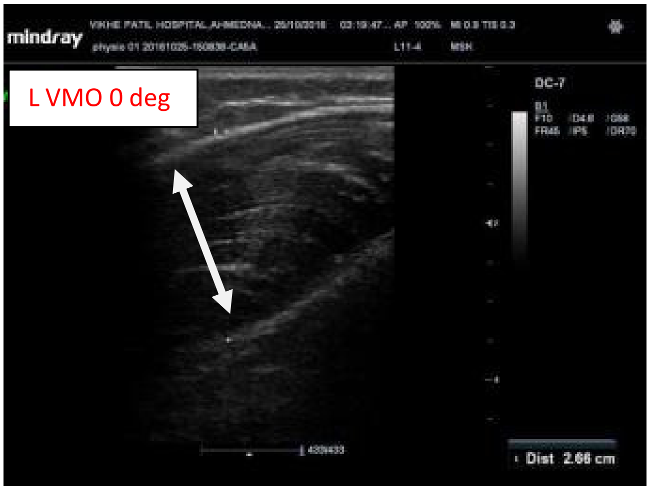


Figure 4: the muscle fibre size of Left VMO at 0^0

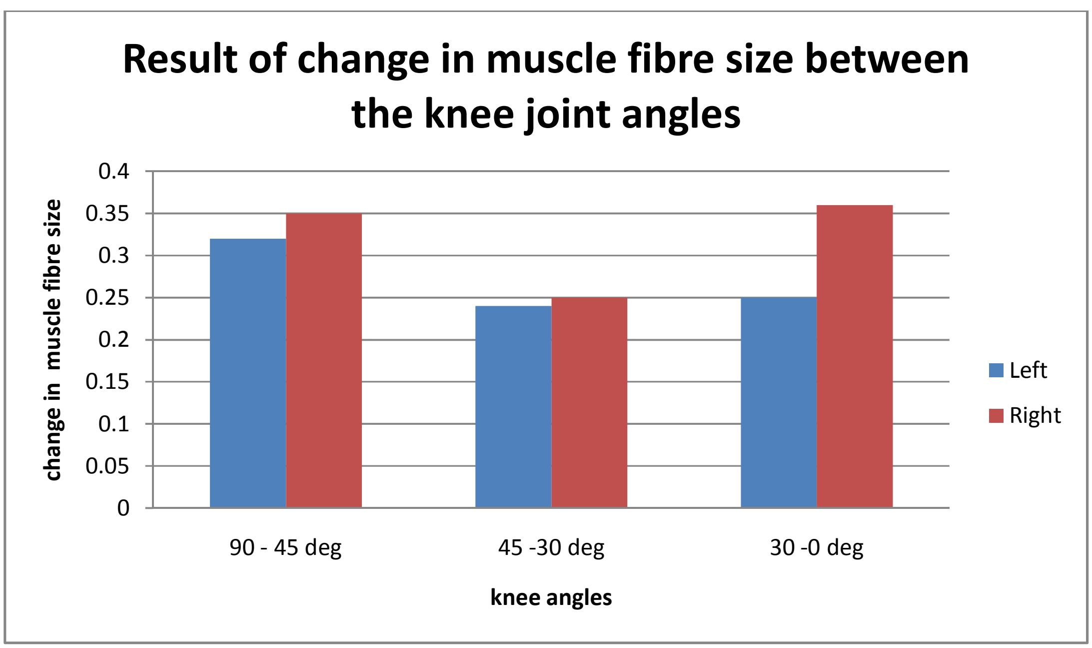
(L -left, VMO – Vastus medialis oblique, deg – degree)

Statistical analysis

The difference of the change in muscle fibre size from 90^0to45^0, 45^0 to30^0 ,30^0 to 0^0 for all the 14 samples for bilateral VMO was calculated by using one way ANOVA test

Results

Total 14 participant were included in the study , among which the Body mass index(BMI) 2 male participants had mean SD of 19.96 ±3.17,and 12 female BMI's mean SD was 21.13 ±2.54.The change of muscle fibre size at angles 90^0,45^0 ,30^0 and 0^0 and also the comparison at these angle between the left and right leg which was maximum at the angle between 30^0 to 0^0 (Graph 1)



Graph 1: Result of change in muscle fibre size between the knee joint angles.

Table 1: Comparison of muscle fibre size of left and right VMO at different knee angle

SIDE	90^0 TO 45^0	45^0 TO 30^0	$30\ ^0$TO 0^0	P VALUE	RESULT
Left	0.32±0.23	0.24 ± 0.15	0.25± 0.16	0.428 (> 0.05)	Non significant
Right	0.35 ±0.24	0.25± 0.23	0.36 ±0.34	0.476 (>0.05)	Non significant

On comparison of muscle fibre size for left VMO , from 90^0 to 45^0 ,45^0 to 30^0 , 30^0 to 0^0 using one way ANOVA, there was no significant ($p > 0.05$)change in muscle fibre size. On comparison of muscle fibre size for right VMO , from 90^0 to 45^0 ,45^0 to 30^0 , 30^0 to 0^0 using one way ANOVA, there was no significant ($p > 0.05$)change in muscle fibre size. (Table 1)

Table 2: Comparison of muscle fibre between left and right thigh VMO at different knee angle

SIDE	90^0 TO 45^0	45^0 TO 30^0	$30\ ^0$TO 0^0	P VALUE	RESULT
Left	0.32±0.23	0.24 ± 0.15	0.25± 0.16	0.5368	Not Significant
Right	0.35 ±0.24	0.25± 0.23	0.36 ±0.34		

On comparison of muscle fibre size between the VMO muscle of left and right thigh using one way ANOVA , there was no significant difference between them as p value is greater than 0.05 (Table 2)

Discussion:

Our study is the first study in which ultra-sonography is used to study the effect of knee angle on muscle fibre size .Through our pilot study we found out that the change in muscle fibre size wasn't significant. Though there is no significance we feel that the study is quite useful as the there wasn't any tool the muscle morphological change can be measured quantitatively while the muscle is at its action. This can be due to the participants didn't undergo any rehabilitative programme for the VMO before the study was done. And for the left it was found to be more between 90^0 to 45^0 and in the right it was to be found more in the from 30^0 to 0^0, this may be due to the differences in recruitment pattern between each individuals.

Though statistically not significant as compared to the left the change in muscle fibre size was more in the right , this is due to the participant in the study were right leg dominant. And the strength and the stability of the dominant leg is always more as compared to the non-dominant leg.[10]

Our result was similar to the studies done by Jeffery et al, Roshanak et al where there was no significant change in VMO/VL ratio at different knee angle.[11,12]

Through our literature review, some researchers hypothesized that selective strengthening of the VMO may be achieved isometrically at terminal extension (0 degrees).[13-19]Other available studies suggest the VMO may be strengthened isometrically at greater angles of knee flexion including 20, 60, and 90 degrees.[20-22] All research done to selectively strengthen VMO ,is beneficial due to the scarcity of the studies done in this area. Similar to our finding and much of the existing literature suggest that there is no single angle that may be universally prescribed to selectively strengthen the VMO.

Limitation

The sample size was very less, as this was only a pilot study. Further studies can be done where each a group of normal subject can be given a reha-bilitative programme at different knee angle. Then after the completion of that programme the ultrasound studies can be done on the same individual to check out the change in muscle fibre size.

Conclusion

This pilot study shows that there was no effect of different knee angles on VMO muscle fiber size when assessed with ultrasonography.

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