

A Study to Compare the Activation of Vastus Medialis Oblique by EMG for three Different Exercises in Patient with Osteoarthritis of Knee Joint: An Observational Study

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Abstract

Background and Objectives: Osteoarthritis (OA) also called as Osteoarthrosis or degenerative joint disease, it is the most common form of common disorder of synovial joint. OA represents a major cause of morbidity and disability and as well as it having a significant economic burden on patients and health care resources. Dysfunction of the quadriceps muscle, specially vastus medialis (VM), has been hypothesized as cause of OA knee. Various studies evaluating the EMG activity for VMO in straight leg raise, knee extension and weight bearing exercises like single leg stance to strengthen the quadriceps muscle in patient with OA knee but results are different. So, aim of the study is to compare the activation of VMO by EMG for three different exercises in patients with osteoarthritis of knee joint.

Methods: The study was conducted on 100 patients with OA knee with mean age of 49.36±5.58 (SD years). EMG activity of VMO was compared during MVIC with 10 RM in three different positions: 1) straight leg raise (SLR), 2) terminal knee extension with medial rotation of hip, 3) Single leg stance at 30 degrees knee flexion.

Results : ANOVA and Tukey Kramer Multiple Comparison Test were used for statistical analysis. The result revealed that there is a significant increase in VMO muscle activity when testing position 1 compared with testing position 2 and 3 but there was no significant difference was found between testing position 2 and 3.

Conclusion: The result showed that terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion significantly activate the VMO than straight leg raise (SLR). The comparison of these therapeutic exercises have been advanced to strengthen the quadriceps muscles and hence can be used as early rehabilitation program in patient with OA knee.

Keywords: OA knee, VMO, sEMG, SLR, Knee extension, One leg standing.

Introduction

Osteoarthritis (OA) also called as a Osteoarthrosis or degenerative joint disease, it is the most common form of chronic disorder of synovial joints.¹ OA is

more common after 40 years in women than men but the prevalence increases dramatically with age. 45% of women over the age of 65 have symptoms while radiological evidence is found in 70% of those over 65.²

Pain is anteromedial in medial compartment of tibiofemoral joint OA. Other clinical features include crepitus on moving the joint, irregular and enlarged looking joint due to formation of peripheral osteophytes, wasting of quadriceps muscles, stiffness may be present

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initially due to pain and muscle spasm and later due to capsular contracture.³

In osteoarthritis patients, quadriceps muscle weakness may contribute to the substantial functional deficits that occur with disease progression.³ Knee osteoarthritis usually affects the medial tibiofemoral joint compartment probably because of the increased load on this compartment during normal walking.⁴ The physiotherapist plays an important role in the health care process of the patients with knee OA.⁵ Quadriceps strengthening has traditionally been an important component of exercise programs for knee Osteoarthritis.⁶

One study mentioned that early atrophy of the VMO is an indicator of general quadriceps weakness.⁷ Because there is evidence supporting the importance of the VMO, it is essential to design a rehabilitation program that best achieves the goal of regaining and improving the strength of the VMO.⁸

Exercises described in the literature to activate the VMO are knee extensions, straight leg raise, quad sets, leg press, wall squats, mini squats, step ups, lunges, balance and reach exercises.⁹

Patients can perform a SLR in a protected and safe manner early in the rehabilitation process of osteoarthritis of knee joint.¹⁰ The VMO functions to control patella alignment by pulling the patella medially during extension and under normal knee function acts as a dynamic medial stabilizer of the patella once the knee reaches terminal extension⁷ and the final arc of 30 degrees of extension is suggested for strengthening the quadriceps.¹¹ Several literatures have reported that the only exercise resulted in a higher VM:VL ratio was knee extension with medial rotation of hip (KEMR) compared to lateral rotation of hip (KELR).¹² Weight bearing exercises like single leg stance are important because these exercises are similar to many functional movement and required to perform many ADLs; however, patients initially lack adequate quadriceps activation to safely perform weight bearing exercise.¹⁰ These exercise requires greater quadriceps activity with greater knee flexion and beneficial for exercises progression in patient with knee OA.¹³

Debra Kushion et al.,(2012) performed a study and concluded that exercises including short arc quad knee extensions are more effective for both the VMO and VL activation than those incorporating straight leg raises.¹⁴

EMG is an appropriate tool for assessing the relative intensity of muscle activity produced during exercises in various positions.¹⁵ Quadriceps dysfunction in the patients with OA knee has been assessed by diminished EMG activity of the VMO caused by inhibition due to pain, effusion and atrophies.¹⁶ Multiple research studies were being conducted using the EMG equipment to compare the different quadriceps strengthening exercises for rehabilitation but no studies have concluded one exercise or a group of exercises that isolate the VMO. So, the present study is undertaken with intention to compare the effect of three different exercises on EMG activity of VMO.

Methodology

Source of data: Various physiotherapy OPD setup of Rajkot city

Sample design: Purposive Sampling

Sample size: 100 subjects

Study design: Cross sectional observational study

Criteria for selection:

Inclusion Criteria:

1. Age of 40-60 year.
2. Gender : male and female patients with unilateral OA knee
3. Patient who diagnosed clinically as OA knee with criteria given by **Altman R. et al**³³ i.e. knee pain and osteophytes on x-ray or knee pain plus patients age 40 years or older having morning stiffness lasting 30 mins or less and crepitus on motion.
4. Kellgren-Lawrence radiographic grade I, II and III.
5. Unilateral medial compartment tibiofemoral OA without involvement of any other compartment of

knee joint.

Exclusion Criteria:

1. Required an assistive device for ambulation.
2. History of ≥ 2 falls in the past year.
3. Having history of musculoskeletal injury (meniscal or ligamentous injury or fracture) of lower limb.
4. Having history of total knee arthroplasty.
5. Having neurologic disorders that affected lower-extremity

Materials to be used:

1. RMS EMG PK M-II Software.
2. Bipolar adhesive surface electrode
3. Cotton
4. Spirit
5. Electrode gel

7. Pen
8. Paper
9. Treatment table
10. Pillow
11. Bolster
12. Goniometer
13. Consent form

MEASUREMENT PROCEDURE

Written consent was taken from the subjects, who fulfilled the inclusion and exclusion criteria. 10 RM was found for knee extensors on the affected side in the respective test position by using the de lorme's shoe prior to the testing procedure for each patients. After the placement of the electrodes, subjects were asked to perform 3 repetitions of the three sets of exercises on the affected side. The EMG signals were acquired and analyzed using the RMS EMG PK M-II software.

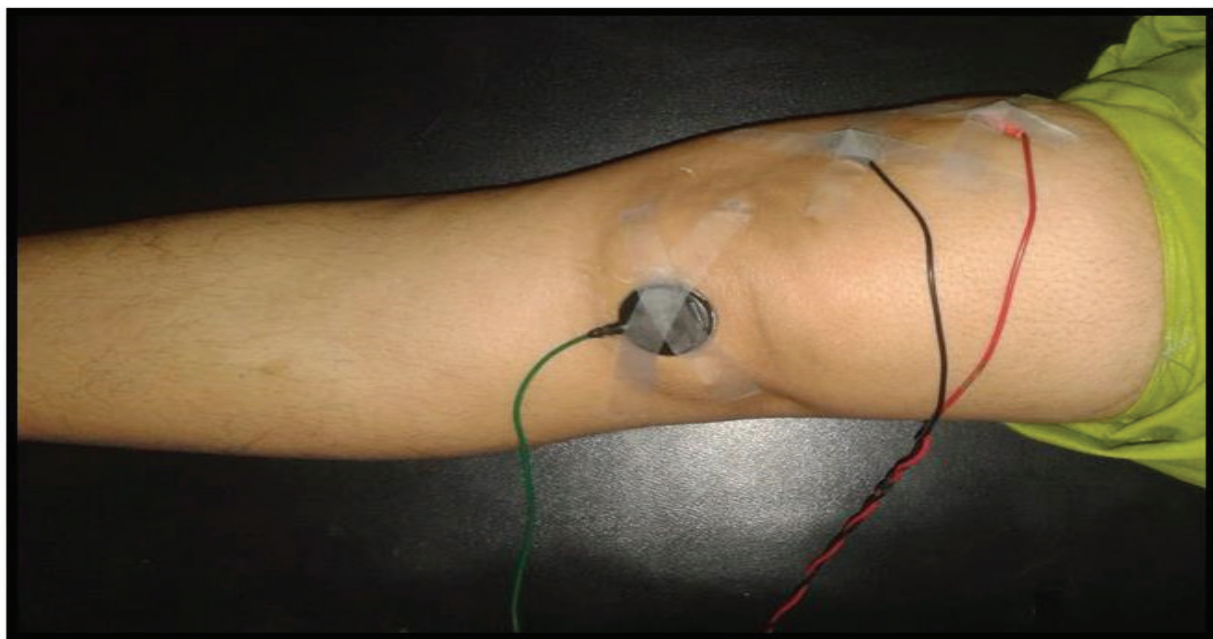


Figure 1: Electrode placement of VMO

Results

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. ANOVA analysis was done for evaluating sEMG activity of VMO in all the three testing positions and Tukey Kramer Multiple Comparison Test was used to compare the between conditions differences of sEMG activity of VMO .



Figure 2: MVIC measurement of VMO for straight leg raise



Figure 3: MVIC measurement of VMO for terminal knee extension with medial rotation of hip



Figure 4: MVIC measurement of VMO for single leg stance at 30 degrees knee flexion

Table 1: Mean + SD values of %MVIC for VMO muscle

	MEAN ± SD		
	Straight leg raise	Terminal knee extension with medial rotation of hip	Single leg stance at 30 degrees knee flexion
VMO	14.88±7.85	24.57±15.059	22.29±12.24

Interpretation: The above table shows VMO maximal activity is found in terminal knee extension with medial rotation of hip and minimal activity is found in straight leg raise position.

Table 2: Multiple comparisons for mean difference of VMO activity in three testing positions in patients with OA knee.

		Mean difference	Std. error	Sig.
Straight leg raise	Terminal knee extension with medial rotation of hip	-9.690	1.710	.000
	Single leg stance at 30 degrees knee flexion	-7.410	1.710	.000
Terminal knee extension with medial rotation of hip	Straight leg raise	9.690	1.710	.000
	Single leg stance at 30 degrees knee flexion	2.280	1.710	.378
Single leg stance at 30 degrees knee flexion	Straight leg raise	7.410	1.710	.000
	Terminal knee extension with medial rotation of hip	-2.280	1.710	.378

*The mean difference is significant at the .05 level.

Interpretation: The above table shows the comparison between three testing positions. the result shows significant difference when comparison of straight leg raise with terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion. but no significant difference in activity between terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion.

Table 3: ANOVA analysis with post hoc test for VMO between SLR compared with Terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion for the study

		Sum of Squares	df	Mean Square	F	Sig.
Terminal knee extension with medial rotation of hip	Between Groups	17221.477	28	615.053	8.348	.000
	Within Groups	5231.033	71	73.677		
	Total	22452.510	99			
Single leg stance at 30 degrees knee flexion	Between Groups	9861.292	28	352.189	5.014	.000
	Within Groups	4987.298	71	70.244		
	Total	14848.590	99			

Interpretation : In above table F value shows significant difference in terminal knee extension with medial rotation of hip ($F= 8.348, p<.005$), single leg stance at 30 degrees knee flexion($F=5.014, p<.005$)

Table 4: ANOVA analysis with post hoc test for VMO between Terminal knee extensions with medial rotation of hip compared with SLR and Single leg stance at 30 degrees knee flexion for the study

		Sum of Squares	df	Mean Square	F	Sig.
SLR	Between Groups	5096.961	36	141.582	8.765	.000
	Within Groups	1017.599	63	16.152		
	Total	6114.560	99			
Single leg stance at 30 degrees knee flexion	Between Groups	9847.778	36	273.549	3.446	.000
	Within Groups	5000.812	63	79.378		
	Total	14848.590	99			

Interpretation: In above table F value shows significant difference in straight leg raise

($F= 8.765, p<.005$), single leg stance at 30 degrees knee flexion($F=3.446, p<.005$)

Table 5: ANOVA analysis with post hoc test for VMO between Single leg stance at 30 degrees knee flexion compared with SLR and Terminal knee extension with medial rotation of hip for the study

		Sum of Squares	df	Mean Square	F	Sig.
SLR	Between Groups	4823.945	34	141.881	7.146	.000
	Within Groups	1290.615	65	19.856		
	Total	6114.560	99			
Terminal knee extension with medial rotation of hip	Between Groups	16296.748	34	479.316	5.061	.000
	Within Groups	6155.762	65	94.704		
	Total	22452.510	99			

Interpretation: In above table F value shows significant difference in straight leg raise

($F= 7.146, p<.005$), terminal knee extension with medial rotation of hip ($F=5.061, p<.005$)

Discussion

The results of the present study supports the experimental hypothesis which shows significant increase in VMO muscle activity during all 3 testing positions ($p < 0.05$) when comparison was made between MVIC straight leg raise and MVIC terminal knee extension with medial rotation of hip and when comparison was made between MVIC straight leg raise and MVIC single leg stance at 30 degrees knee flexion whereas no significant difference ($p > 0.05$) was found in MVIC terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion.

This result showed that there was a significant increase in the muscle activity of VMO during terminal knee extension with medial rotation of hip. It was assumed that since the lower most fibers of the VMO are attached to the anteromedial aspect of the tibia via the medial extensor aponeurosis, it may act to resist lateral rotation of the tibia. Thus, VMO can be preferentially recruited with active medial rotation of the tibia and it was explained by the study of **Ludi Laprade, et al.,(1998)**¹⁷

The other significant difference found in the muscle activity of VMO during MVIC terminal knee extension with medial rotation of hip when compared to MVIC straight leg raise. **Stephen M. et al.,(1994)** showed that the vastus medialis oblique and vastus lateralis demonstrated significantly more activity during the 15-0° arc of the short arc knee extension exercise and Short-arc knee extension with hamstring co-contraction exercise than during any portion of the SLR, squat, or Isometric knee co -contraction exercise(ICO) exercises.¹⁸ This Study demonstrated that there was a significant increase in the VMO muscle activity during Single leg stance at 30 degrees knee flexion. Weight bearing exercises required varying levels of VM activation.. In the single leg stance with 30 degree knee flexion, represented a more demanding task. In this case, knee flexion increased the applied torque due to gravity resulting in greater VM activation.¹⁰ Isometric quadriceps contraction in combination with a SLR resulted in significantly greater VM activity than an isolated SLR .¹⁰ Study done by **Debra cushion et al,(2012)** support

the result of the present study and he explained that the short arc quad exercises(SAQ) provide additional VMO activity and thus have a greater impact on strengthening the VMO than do SLRs.¹⁴

The SAQ exercise involves dynamic knee extension involving concentric and eccentric activation of the quadriceps muscles, leading to greater recruitment of the VMO and VL.SLR requires the VMO and VL to stabilize the knee in extension, which closely resembles an isometric contraction during flexion and extension of the hip. This type of contraction may require less force from the VMO and VL, and therefore result in a lower activation. Another possible explanation is that as the knee nears extension, the moment arm of the quadriceps decreases and therefore more muscle tension is needed to perform the movement and further increase EMG activation of VMO.¹⁴

From the results of this study it can be concluded that VMO shows greater EMG activity due to the anatomy and kinesiology of the muscle during terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion as compared to straight leg raise. Ultimately, it might be feasible to determine which exercise is able to enhance preferential activation of the VMO for patients with knee OA.

Conclusion

- Exercises including terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion were equally effective for activation of VMO in patients with osteoarthritis of knee joint.
- Terminal knee extension with medial rotation of hip and single leg stance at 30 degrees knee flexion are more facilitative than those incorporating straight leg raises for activating the VMO and VL muscles in osteoarthritic patients.

Hence these exercises are effective in improving Quadriceps strength and functional status is better option in osteoarthritis of knee joint patients.

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Ethical Clearance: Taken from Institutional Ethical Committee of Shree K.K. Sheth Physiotherapy College, Rajkot.

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