A Study on the Effect of Isometric Quadriceps Activation and Vastus Medialis Obliquus Strengthening in Decreasing Q-Angle among Young Females

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ABSTRACT

BACKGROUND

Females are more prone for lateral displacement of patella than males due to increased Q-angle (15–18°) in them compared to males (12–15°). In a normal state, lateral displacement is prevented by geometry of the joint and by the passive stabilizers. Even though contraction of the quadriceps tends to displace the patella laterally, vastus medialis oblique (VMO) acts medially and posteriorly as much as it acts proximally, and so its tension helps in resisting the Q angle effect. There are two procedures in common practice to reduce Q-angle and thereby to prevent lateral displacement of patella– either through vastus medialis oblique (VMO) strengthening or by isometric quadriceps activation (quadriceps muscle strengthening). We wanted to compare the effects of isometric quadriceps activation and VMO strengthening in reducing Q angle in a group of young females.

METHODS

A non-randomized, two group, pre-test, post-test assessment of Q-angle was done. Twenty healthy females of 18-20 age group were selected and randomly divided into two groups. Isometric quadriceps activation and VMO strengthening was done for 4 weeks. Q-angles were measured before and after the strengthening exercise using a long arm goniometer.

RESULTS

The mean q angle before treatment was 21. (minimum 20 and maximum 23). While after the treatment, q angles were significantly reduced in both the groups and mean q angle was 16.3.

CONCLUSIONS

Both the isometric quadriceps activation and VMO strengthening reduced Q-angle significantly and there was no significant difference between the two procedures. Results of this study help the physiotherapist in choosing the exercise for the management of patellofemoral pain and lateral displacement of patella.

KEY WORDS

Q Angle, Quadriceps Femoris, Vastus Medialis Obliquus, Patello-Femoral Pain.

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BACKGROUND

The "quadriceps" include the vastus medialis oblique (VMO), vastus intermedius, vastus lateralis and rectus femoris. Quadriceps Angle (Q-angle) is the angle formed between the intersection of the axis of quadriceps extensor mechanism and patellar tendon. Thus Q-angle is formed in the frontal plane by two line segments- from tibial tubercle to the middle of the patella and from the middle of the patella to the ASIS. The Q-angle in adult is typically 15 degrees. Weakness of quadriceps muscles may adversely affect the patellofemoral mechanism. Quadriceps strengthening is most commonly recommended as the quadriceps muscles play a significant role in patellar movement. Vastus medialis oblique muscle serves to extend the knee as well as function as a major medial stabilizer for the patella. During knee extension the VMO pulls the patella medially due to its orientation relative to the patella. Anatomically, a woman's knee is made with a naturally greater Q-angle between the femur and the tibia, predisposing it to greater stress due to the torsion applied between the femur and the tibia. The increased Q-angle causes the quadriceps to pull on the patella, which will encourage it to displace. The patella/patellar tendon ratio should be nearly equal. When the patellar tendon is excessively long, a high-riding patella exists and lateral displacement of the patella may occur easily. The increased Q- angle also causes the feet to be more pronated and flattened.[1]

It was observed that young and physically active females are more prone to patellar dislocation - especially with minimal trauma; when they twist the flexed knee with the foot fixed to the ground, for example, during sporting activities. Patella or knee cap instability is the most common recurrent symptom reported in literature. It may be associated with abnormal shape of the knee joint bones, weakness of the muscles around the hip or knees or tightness of soft tissues on the outside of the knee. Factors that contribute to an increased Q-angle in women include.[1-4] a wider pelvis, increased femoral ante version, increased knee valgus, external tibial torsion, increased ligamentous laxity, hyper pronation of the foot, patella alta, a tight lateral patellar retinaculum and a hypoplastic or weak vastus medialis oblique. The combination of increased femoral ante version, external tibial torsion, and hyper pronation of the foot is often termed the miserable malalignment syndrome and is seen more common in females. Treatment include strengthening the quadriceps and, in particular, the vastus medialis oblique can effectively reduce the Q-angle and prevents the lateral displacement of patella. A large quadriceps angle (Q-angle) is another frequently suggested contributing factor to Patello Femoral Pain Syndrome (PFPS). Patellofemoral Pain Syndrome, a clinical condition commonly found in athletes caused by weakening of Quadriceps muscles specifically VMO, increased Q-angle, overuse of the muscles and lateral retinaculum tightness.[5]

The Q-angle is influenced by a number of factors including the anatomy of the quadriceps and trochlear groove, the mechanics of the foot and the position of the tibial tubercle. The vastus medialis oblique muscles (VMO) of the quadriceps muscle group has been thought to be a major contributor to patella femoral joint pain. The VMO pulls the patella medially during knee extension and has been reported to fire later than the vastus lateralis (VL) in people with patellofemoral joint pain. This firing part may effect patellar tracking, causing the patella to track laterally because the VMO is not firing on time. Exercises that focus on VMO activity are emphasized to normalize the VMO:VL firing ratio to correct the patellar tracking pattern. Athletes with patellofemoral pain syndrome are frequently noted to have tight lateral knee retinaculum, tight hamstrings, patellar tracking abnormalities, a large Q-angle and vastus medialis oblique (VMO) muscle atrophy. Treatment emphasizes VMO strengthening and hamstring stretching. The accurate determination of the Q angle requires precise identification of the three bony landmarks used to measure it, even small differences in the placement of the center of Patella and Tibial tuberosity could alter the Q angle greatly.[6]

METHODS

Research design adopted for this study was non-randomized, two group, Pre-test, Post-test assessment of Q-angle. The study was done as per the ethical guidelines formulated by the institutional ethical committee of Sri Lakshmi Narayana Institute of Medical Sciences, Puducherry, India. Twenty healthy young women of age 18 – 20 yrs were selected for the study. Purpose of the study, procedure, potential benefits and possible risk if participate were explained to all the participants, prior to the study and a written consent has obtained. Duration of the Study was 4 Weeks, 5 days/week, two sets/day, each set contains 10 times holding for about 10 seconds, rest period 5-I0 seconds. Participants were divided in to two groups of 10 each, GroupA- was given Isometric Quadriceps Activation (IQA) and Group B was given VMO strengthening.

Isometric Quadriceps Activation (IQA) Procedure

Members of Group A were instructed to lie in supine position with extended knee. A rolled (or) folded towel was placed under the right knee. Next the participants were instructed to press the towel hold it for about 10 seconds and then relax. The procedure was repeated 10 times.

VMO Strengthening Procedure

Members of Group B were also instructed to lie in supine position with extended knee. Participants were instructed to rotate their right 1eg laterally. Followed to that they were told to raise the leg without bending the knee. Maintain the position for 10 seconds and then slowly lower the leg down. Relax and repeat the procedure for 10 times. Q-angle is measured using a Long-arm Goniometer (along with inch-tape & Scale-30 cm).

Statistical Analysis

In this study, difference in q angle before and after the treatment within the group is analyzed using unpaired' test and the difference between the groups were analyzed using unpaired 't' test with Welch's correction. Level of significance is 5%. Data was analysed with GraphPad® InStat 3 software.

RESULTS

In the present study effect of isometric quadriceps activation and vastus medialis obliquus strengthening were analysed in healthy young females. The mean q angle before treatment was 21. (minimum 20 and maximum 23). While after the treatment, q angles were significantly reduced in both the groups and mean q angle was 16.3.

	Group A – Isometric Quadriceps Activation		Group B – VMO Strengthening	
	IQA-Pre	IQA-Post	VMO-Pre	VMO-Post
	21	18	21	16
	21	16	20	16
	20	14	21	16
	23	18	22	18
	20	16	22	17
	22	15	21	15
	20	16	20	15
	23	18	20	16
	22	17	21	16
	21	16	22	18
Q – Angle (Mean ± SD)	21.3±1.16	16.4±1.35	21.3±0.81	16.3±1.059
	*** p<0.0001		*** p<0.0001	

Table 1. Effect of Isometric Quadriceps Activation and Vastus Medialis Oblique Strengthening on Q Angle of Females– Pre and Post-Test Comparison

IQA- Pre- Isometric Quadriceps Activation pre - test.
IQA- Post- Isometric Quadriceps Activation post – test.
VMO- Pre- Vastus Medialis Oblique strengthening pre-test.
VMO- Post- Vastus Medialis Oblique strengthening post – test.

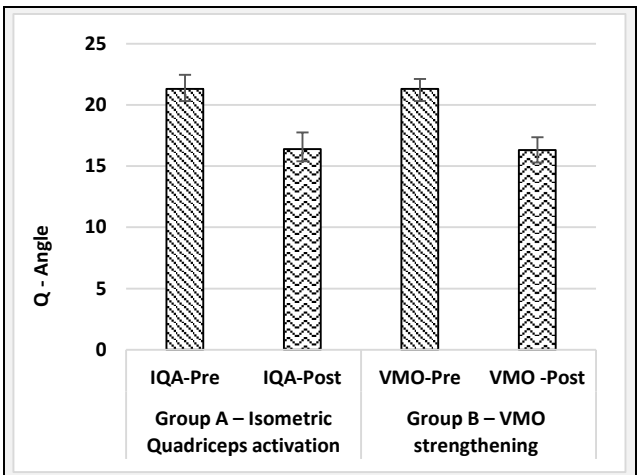

Figure 1. Effect of Isometric Quadriceps Activation and Vastus Medialis Oblique Strengthening on Q Angle of Females Pre- and Post-Test Comparison

IQA- Pre-Isometric Quadriceps Activation pre - test
IQA- Post-Isometric Quadriceps Activation post - test
VMO- Pre-Vastus Medialis Oblique strengthening pre-test
VMO- Post-Vastus Medialis Oblique strengthening post – test

DISCUSSION

Q-angle is used to indicate the force vector acting on the patella and patellofemoral joint. Results of this study indicate that both isometric quadriceps activation and vastus medialis oblique strengthening can reduce the Q angle significantly. The normal Q angle in the non-treated females of the present population was 21. Even though both the treatment procedures could reduce the Q angle to 16; significant statistical difference was not there between the procedures in reducing the Q angle (p value – 0.4). Changes on the Q-angle are associated with chondromalacia patella, lateral dislocation of the patella, erosion of the patellar cartilage and of the lateral condyle, femoral internal rotation, foot pronation and internal tibial torsion.[7] The Q angle shows an inverse relationship with quadriceps strength, as the smallest the angle the greater the force produced by the quadriceps, which assumes that individuals with an increased Q angle have weak quadriceps muscles and are more subject to diseases of the patellofemoral joint.[8]

Lathing house and Trimble[9] suggested that an excessive Q-angle may predispose women to greater lateral displacement of the patella during vigorous activities and sports, in which the quadriceps muscle is stressed. According to Hettinger.[10] strength gain at 5% per week with one six second contraction per day at 67% maximal effort. He later concluded that maximal contraction produce better results. Van Eijden et al.,[11] stated that isometric exercise produces a greater amount of tension in the muscle than do concentric contraction. As suggested by His Lop,[12] 2/3 maximal contraction maintained for 6 second and performed daily, which increases strength in healthy females. Kauffman.[13] used more intensive training regimes, 2 sets of 10 maximum isometric contraction to test healthy young and older women. He found the young women (mean age of 22.6 years) gained 95% strength and old women (mean age of 69.2 years) gained 72%. The difference in gain in strength between the two groups was not statistically significant.

Q-angle decreases with pronation of leg and increased internal rotation. The prolonged pronation of the foot requires compensation for the lack of external rotation of the tibia so the knee can extend properly. The femur internally rotates to make up for this lack of tibial external rotation and increases the force between the lateral patella and lateral femoral condyle.[14] As the tibia internally rotates with pronation, the femur internally rotates with greater exertion than the tibia, carrying the patella with it. This medial shift of the patella increases the Q- angle, causing excessive lateral pressure.[15] Hvid and Anderson[16] suggest that Q-angle may be most strongly associated with excessive hip internal rotation, which displaces the trochlear groove medially, leading to lateral malalignment of the patella. Lieb and Perry[17] stated that the distal fibers of VMO are angled approximately 55° from the longitudinal axis of the femur. This increased angle gives mechanical advantage allowing the VMO proficient in preventing lateral patellar subluxation.

Increased patellofemoral joint stress and altered patellar tracking may increase the risk for PFP. Increase in Q angle in conditions like genu valgum, femoral ante version, external tibial torsion and subtalar joint pronation are associated with increased static patellofemoral joint stress. Quadriceps muscle weakness or imbalance with relative vastus medialis (VMO) weakness or imbalance in neuromuscular control of the VMO and vastus lateralis (VL) may cause PFP. The VMO is the weakest portion of the quadriceps, the first to atrophy with disuse and the last to rehabilitate. VMO weakness results in lateral shifting and tracking of the patella during the last 30° of extension with resultant reduction in patellofemoral contact area and increased patellofemoral stress.[18] Sale[19] reported that strength training programme of the muscles involved, depends not only on the quality and quantity of the muscles but also depends upon the nervous system to activate the muscles appropriately.

Weakness of the VMO allows the patella to track too far laterally. The VMO is a major focus in the rehabilitation of patellofemoral pain; strengthening the VMO and improving the firing sequence with the VL are primarily concerns to correct the patellar tracking pattern. Also knee braces, specifically patellar braces, have been thought to help with this process. The patellofemoral knee brace places pressure on the lateral side of the patella to deter lateral movement. Treatment techniques frequently used include quadriceps exercises focusing on the VMO, patellar taping, electrical stimulation to guide quadriceps exercises, nonsteroidal anti-inflammatory agents, and patellofemoral knee braces.

A 2-cm lateral shift in the ASIS results in a 2 degree increase in Q-angle. Also a more medially placed patella and a shorter patellar tendon result in a larger Q-angle. Therefore, a large Q-angle is more indicative of a medialized patella than a lateralized ASIS. Applying this reasoning to the mal tracking population, It can be theorized a large Q-angle is indicative of a medially placed patella under static conditions. This medial placement is a result of passive constraints alone because muscle activity is not present when the Q-angle is measured. For the non-lateral mal trackers (all but two of whom had a Q-angle > 15 degree), these passive constraints are capable of counteracting the lateral pull of the extensors during active contraction and maintaining a medialized patella.[20]

CONCLUSIONS

Many treatment procedures are available for the reduction of q angle and prevention of patellar displacement. Isometric quadriceps activation and vastus medialis oblique strengthening is cost effective and easy to administer. It can be used easily in a clinical and nonclinical setup. In the present study both these procedure were effective in reducing Q angle significantly.

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