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EFFECT OF TIBIALIS POSTERIOR STRENGTHENING ALONG WITH CONVENTIONAL THERAPY ON PAIN AND MEDIAL LONGITUDINAL ARCH OF FOOT AMONG PATELLOFEMORAL PAIN SYNDROME

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Abstract: **Background: Patellofemoral pain syndrome (PFPS) is more prevalent among other knee conditions and often associated with altered biomechanics, including excessive foot pronation. The tibialis posterior muscle plays a major role in maintaining the medial longitudinal arch of the foot. So strengthening this muscle and conventional therapy are widely used to reduce pain and improve the foot arch. But there are a limited number of studies available specifically on the effect of tibialis posterior strengthening along with the conventional therapy to reduce pain and improve medial longitudinal arch of foot arch among the patellofemoral pain syndrome population. This study aimed to evaluate the effect of tibialis posterior strengthening along with conventional therapy on pain and medial longitudinal arch of foot among patellofemoral pain syndrome.**

Methods: Pre and post experimental study that includes 30 patients. They were divided into two groups. Group A received tibialis posterior strengthening along with conventional therapy and Group B received conventional therapy alone. The treatment duration was 6 weeks. The outcome measures were Numerical Pain Rating Scale measures the pain and Navicular Drop Test measures the medial longitudinal arch of foot.

Result: Using unpaired't' comparison of post test values of Group A and Group B of Numerical Pain Rating Scale shows t value 5.48 and Navicular Drop Test shows t value 10.83 respectively.

Conclusion: This study concluded that there is a notable improvement in tibialis posterior strengthening along with conventional therapy on pain reduction and improve medial longitudinal arch of foot among patients with patellofemoral pain syndrome.

Keywords: **Patellofemoral pain syndrome, pain, medial longitudinal arch of foot, tibialis posterior strengthening, conventional therapy**.

I. INTRODUCTION

Patellofemoral pain syndrome (PFPS) is one of the most common causes of anterior knee pain. This condition is widely referred to as runner's knee, retropatellar pain syndrome (behind the kneecap), lateral facet compression syndrome, peripatellar pain (around the kneecap) or idiopathic anterior knee pain. It is a chronic condition, in that the pain is mostly occurs during the load which is put on to the extensors of the leg. That is when the patient climbing stairs, squatting, running, cycling or sitting with bent knees. [1, 2]It is difficult to place the one finger on a specific spot and be certain that the pain is there. Occasionally it has been referred as the "moviegoer's sign". Reports of the knee "giving away" are likely, although typically no instability is associated with this problem. [3] The prevalence rate for the general adult population was reported to be 22.7%; in which the rate of 29.2% for women and the rate of 15.5% for men. [4]

Numerous pathophysiological mechanisms contribute to patellofemoral pain. Patellofemoral discomfort has often been caused by an imbalance in the quadriceps muscles and tightness of the soft tissue surrounding the knee joint. Due to the vastus lateralis activity during knee extension, this imbalance may cause the patella to track laterally. It has been suggested that PFPS is predisposed by increased Q-angle, genu valgum, excessive foot pronation, and joint overuse. Many factors, including quadriceps weakness, abnormal hip biomechanics, inflexibility, lower limb malalignment, and altered neuromuscular control, have been identified in several studies as contributing to PFPS. [5] Patellar malalignment can be caused by a number of reasons. The patella may glide on the lateral ridge of the femoral groove and cause pain if the Q angle increases by more than 15°. The functional and mechanical effectiveness of the patellofemoral joint can be diminished by a tight rectus femoris muscle, which restricts patellar mobility. Tightness in the hamstring muscle group may enhance the reaction forces of the patellofemoral joint because of an increased knee flexion moment, whereas a tight iliotibial band may pull the patella laterally during knee flexion. Ankle dorsiflexion may be limited by tight gastrocnemius muscles. It causes the tibial internal rotation and subtalar joint pronation to increase, which leads to improper patellar tendon pullying and patellar malalignment. [6]

PFPS management should concentrate on putting in place a thorough rehabilitation program. PFPS may result from dynamic valgus, which involves adduction and hip medial rotation. An excessive amount of medial femoral rotation has been shown to increase the stress on the patellofemoral joint and decrease the patellofemoral contact area. [7] Weakness in external rotation and hip abduction are more common in patients with patellofemoral pain syndrome. Patients with PFPS had considerably lower hip abduction and external rotation strengths compared to healthy controls. In excessive internal rotation at the hip, the gluteus medius muscle may be dysfunctional. This increased hip internal rotation may increase the valgus force vector at the knee, which would aggravate PFPS. [8] The subtalar joint's pronation is one of the typical gait cycle actions. When it does not resupinate or during the incorrect stage of the gait cycle, it is considered abnormal. Because it has been suggested that greater foot pronation is coupled with increased tibial and femoral internal rotation, excessive foot pronation during walking is often associated with the development of patellofemoral pain syndrome (PFPS). It may elevate the Q angle and augment the lateral stresses on the patella.[9] PFPS management should concentrate on putting in place a thorough rehabilitation program. In order to successfully resume recreational or competitive activities, it is crucial to let the patient know that following the rehabilitation plan is necessary. In addition to treating the underlying cause, it involves physical therapy, bracing, patellar taping, foot orthoses, analgesics, and relative rest. Surgical options include proximal realignment, distal realignment, articular cartilage operations, and lateral retinaculum release. [10]

Exercise therapy is the critical component. Exercise treatment that combines the exercises that target the hips and knees should be part of management. The postero-lateral hip musculature should be the focus of hip specified exercise therapy. Knee-targeted exercise treatment may include weight-bearing exercise (resisted squats), or non-weight-bearing exercise (resisted knee extension), or both. Exercise therapies such patellar mobilization, patellar taping, patellofemoral knee orthoses, foot orthoses, and lower limb stretching are all thought to be beneficial when used in conjunction with other treatment modalities. [11]

In adults, the height of the foot arch has an impact on the knee joint mechanism. Therefore, it is advised that creating a successful plan for early intervention and treatment of acquired flat foot is quite important. [12]A key dynamic stabilizer of the medial longitudinal arch (MLA) is the tibialis posterior. In addition to causing the foot to invert and plantarflex, its contraction elevates the MLA, locking the mid-tarsal bones and stiffening the forefoot and hindfoot. [13] In addition to enhancing dynamic balance and reducing pressure on the plantar medial column, exercises which strengthen the tibialis posterior may additionally enhance foot functions, strengthen the foot muscles, diminish the excessive pronation, and assist those with anterior knee discomfort in improving their functional and emotional well-being. [14]

Conventional therapy involves stretching and strengthening the hip and knee muscles. Based on studies, it is more beneficial to strengthen the hip abductors and external rotators in addition to the knees when treating PFPS. This allows for muscle training while lowering discomfort and improving function and muscle strength. [15]

The quadriceps [vastus lateralis], hamstrings, iliotibial band, lateral retinaculum, and gastrocnemius muscle are some of the muscles that can be stretched to relax the tight tissues. It might increase range of motion and alleviate the symptoms of patellofemoral pain syndrome. [16] Several studies have evaluated the effects of conventional therapy on patellofemoral pain syndrome. But there is less number of experimental studies conducted between the tibialis posterior strengthening and conventional therapy. Therefore the purpose of this study was to investigate the tibialis posterior strengthening along with conventional therapy in patients with patellofemoral pain syndrome.

The Numeric pain rating scale (NPRS) is a unidimensional measure of pain intensity. It is a numerical version of visual analogue scale. It was developed by Downie in 1978. The 11- point numeric scale ranges from ‘0’ representing no pain to ‘10’ representing worst pain imaginable. The scale has been used to assess the intensity of pain. It can be administered graphically or verbally for self completion. The participant is asked to indicate the numeric value on the segmented scale that has best describes their pain intensity that they have experienced in the disease course [20]. The Navicular Drop Test (NDT) was first described by Brody in 1982 as a means of quantifying the amount of foot pronation in runners. The difference in the height of the navicular tuberosity between the seated and standing position was measured with the Vernier caliper. The interpretation for NDT is Supinated foot - <5mm, neutral foot – 5 to 9mm, Pronated foot - >10mm. It is useful in assessing the foot arch effectively [25].

II. METHODOLOGY

A pre- and post- test experimental study design was used to compare the effects of tibialis posterior strengthening along with conventional therapy on pain and medial longitudinal arch of foot among patellofemoral pain syndrome. This study was conducted from December 2024 to January 2025 at an Institution in South India. The study was endorsed by the ethics committee of our Institution. The study involved participants who provided written informed consent. Patients diagnosed with PFPS for over 3months of the following characteristics: unilateral PFPS, Pain during prolonged sitting/ standing/ stair climbing/ running/ kneeling/ hopping/ jumping, Flat foot (flexible type > 10mm), age range between 20 to 45 years of female gender were included in this study. Patients with osteoarthritis, rheumatoid arthritis, tumors, osteoporosis, recent knee surgeries or recent injuries - fracture around the knee, patellar dislocations, ligament sprain, meniscal tear, bursitis, IT tendinopathy, any congenital deformities, proprioceptive problems and sensory dysfunction, Knee pain referred from lumbar, hip region and under any recent medications (analgesics, steroids) were excluded from this study. 30 patients were selected based on convenient sampling method. Then they were randomly assigned to two groups such as an experimental group (group A, n = 15), and a control group (group B, n = 15). For group A, they received tibialis posterior strengthening along with conventional therapy such as strengthening exercises of hip and knee muscles, and stretching. For group B, they receive conventional therapy such as strengthening exercises of hip posterolateral muscles and knee muscles and stretching.

EXERCISE PROCEDURE

Exercise programme for both groups

Hip muscles strengthening

1) Hip abductor strengthening: The participants were in a side-lying position with the hip and knees extended and an elastic band tied proximal to the ankle joint. The participants performed hip abduction (up to approximately 30°) against the resistance.

2) Hip lateral rotator strengthening: The participants were in a side-lying position with the feet together, knee flexed to 90°. A strap was applied to stabilize the thigh to avoid sagittal and frontal plane hip motion. An elastic band was tied around the ankle and fastened to a rigid pole. The participants were instructed to keep their feet together and perform an external rotation of the hip to nearly 30° against the resistance of the elastic band.

3) Hip extensor strengthening: The participants were in a standing position by facing the couch or chair. An elastic band’s one end is tied over the ankle and other end over the couch. The participants were instructed to extend the knee against resistance.

Knee strengthening (VMO)

1) The patient is in standing position with the back supported. Patient was asked to do squat (30° - 45° knee flexion) with hip abduction. The patient was asked to do wall slide along with hold the muscle in contraction for 10 seconds in each exercise.

2) The patient is in sitting position. An elastic band’s one end is tied over the ankle and other end tied over the couch. Then instruct the patient to extend the knee against resistance.

Stretching exercises

1) Quadriceps stretch: Ask the patient to stand on the unaffected leg by using support of the backrest of chair with the unaffected hand. Then ask her to hold the front of the affected side ankle with affected hand and pull the foot up to the patient's gluteus. Patient is instructed to not to bend at waist and keep her back straight.

2) Hamstring stretch: Ask the patient to assume a sitting position with the unaffected leg off the couch and keep the affected leg straight in the couch. And ask her to tries to touch her toes with fingers. Instruct her to keep the back straight. 3) IT band stretch: The patient was asked to cross the affected leg behind the unaffected leg and then lean towards the unaffected leg side with the foot placed on the ground. This stretch was best performed with arms over the head by creating a "bow" from ankle to hand on the affected leg.

4) Gastrocnemius stretch: Ask the patient to stand by facing the wall and using her hands as support from this position. Then the unaffected leg is kept front and the affected leg is kept at the back. The affected leg should be hold at extension. And then slightly lean towards the wall until the stretch is felt in the affected leg.

Exercise programme for experimental group

Tibialis posterior strengthening

1) Single leg calf raise in sitting: The patient is in seated position in the chair. An elastic band is tied over the forefoot. Ask the patient to do calf raise, inversion and tibial outward rotation.

2) Calf raise in standing: The patient is in standing position. A tennis ball is placed between two medial malleoli and asks the patient to do calf raise.

✓ All the strengthening exercises are repeated for 10 repetitions and 3sets per day for 5days per week over total duration of 6 weeks and all the stretching exercises are performed with 10 seconds hold and 3repetitions per day for 5 days per week over total duration of 6 weeks**.**

FIGURE 1

[Hip abductor strengthening]

FIGURE 2

[Hip lateral rotator strengthening]

FIGURE 3

[Hip extensor strengthening]

FIGURE 4

[Knee extensor strengthening]

FIGURE 5

[Seated calf raise]

FIGURE 6

[Standing calf raise]

FIGURE 7

[Quadriceps stretch]

FIGURE 8

[Hamstrings stretch]

FIGURE 9

[IT band stretch]

FIGURE 10

[Gatrocnemius stretch]

FIGURE 11

[Non-weight bearing position-NDT]

FIGURE 12

[Weight bearing position-NDT]

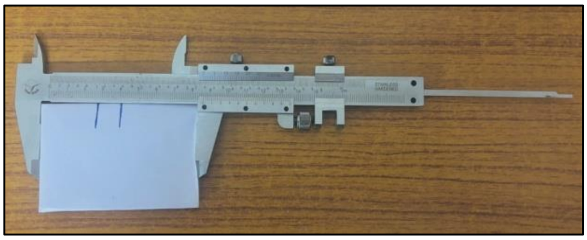


FIGURE N

[Vernier caliper measurement]

Before group allocation, patients were assessed for pain intensity and medial longitudinal arch using Numerical Pain Rating Scale (NPRS) and Navicular Drop data. Test (NDT) respectively. Once they had completed the 6-week intervention, patients were again assessed with NPRS and NDT. An independent t test was used at $p < 0.05$, to examine the pain intensity and medial longitudinal arch of foot. The Microsoft Excel software was employed to analyze research.

III. RESULTS

A total of 30 patellofemoral pain syndrome patients were included for the study. Table 1 demonstrates the demographic data of the study sample. Comparison of post-test scores of NPRS and NDT of both groups is shown in Tables 2 and 3 respectively and in Figures 14 and 15.

Table 1: Demographic Data

AGE	PARTICIPANTS	PERCENTAGE
20-22	8	26.6%
23-25	6	20%
26-30	7	23.3%
31-35	4	13.3%
36-45	5	16.6%

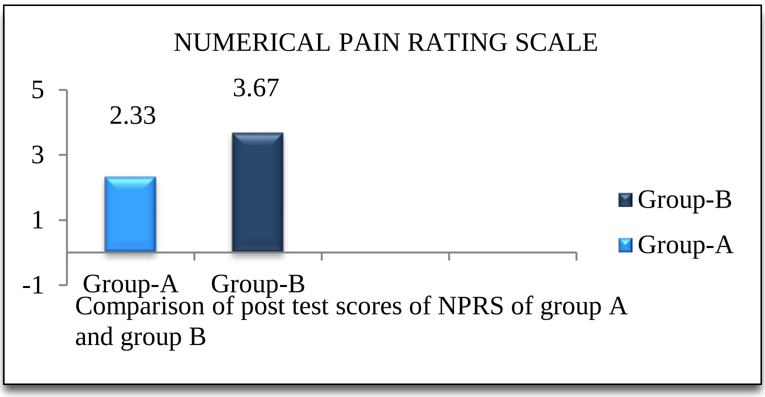
Table 2: Post test scores of NPRS [Group A and Group B]

S. No	Groups	No of patients	Mean	Mean difference	Standard deviation	Unpaired 'T' value
1	Group A	15	2.33	1.34	0.67	5.48
2	Group B	15	3.67			

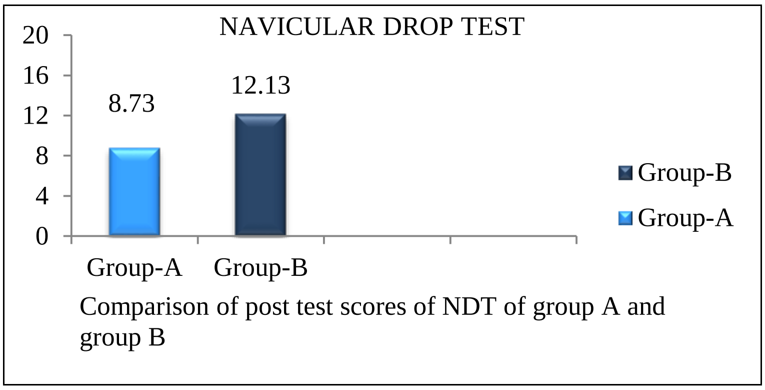
Table 3: Post test scores of NDT [Group A and Group B]

S. No	Groups	No of patients	Mean	Mean difference	Standard deviation	Unpaired 'T' value
1	Group A	15	8.73	3.4	0.738	10.83
2	Group B	15	12.13			

GRAPH 1: (POST TEST SCORES OF NPRS)



GRAPH 2: (POST TSEST SCORES OF NDT)



IV. DISCUSSION

In this study the pain and medial longitudinal arch of foot were assessed in both groups, i.e. Experimental group and Control group using the reliable outcome measures such as NPRS and NDT respectively. The scores of NPRS and NDT shows reduction in the experimental group [from pre-test scores of NPRS and NDT of group-A 6.33 and 13.33, to post-test scores of NPRS and NDT of group-A 2.33 and 8.73], which is statistically significant than the control group[from pre-test scores of NPRS of group-B 6.27 and 13.27, to post-test scores of NPRS and NDT of group-B 3.67 and 12.13] by using independent t test with the t-values 11.06 and 4.78 respectively. On supporting with our results, Sahin M et al. also observed that biomechanically, weakness of the posterolateral hip musculatures could lead to increased femoral adduction and medial rotation during dynamic weight bearing activities, which would increase the lateral patellofemoral joint vector and lead to patellar facet overload. This study considered that additional hip exercises decreased the patellofemoral stress load by inhibiting medial positioning of the patella relative to the tibial tubercle. Therefore the additional hip abductor and external rotator strengthening exercises might improve lower extremity biomechanics by decreased the patellofemoral compressive forces[14]. And according to Suryvanshi et al. all the antigravity muscles stabilize the hip and knee extension during the weight bearing phase of locomotion. Hip external rotators and abductors group of muscles help to maintain leg alignment and the isotonic contraction of adductors stabilizing the pelvis during movements. Weaknesses of these muscles enhance femoral rotation, genu valgus and it may predispose to patellofemoral joint compressive force can result in patellofemoral pain. So strengthening these posterolateral muscles were significantly decreased the pain and improve the function and prevent disability in patients with PFPS. [21]

According to the study conducted by Saeed Mikaili et al. there is more significant reduction in pain among vastus medialis oblique strengthening exercise compared to general quadriceps exercises by increased the ratio of vastus medialis oblique and vastus lateralis activity. In addition to alleviate the pain the VMO strengthening produces more force and also increased the muscle strength. [22] Traditionally the VMO strengthening was focused because its weakness might leads to lateral tracking of patella. Excessive hip motions, especially in the frontal and transverse planes, are thought to put additional strain on the patellofemoral joint. The weakening of the muscles surrounding the hip joint may be the cause of these excessive hip motions. So the hip strengthening would reduce the patellofemoral joint stress and help in the functional improvement. The VMO strengthening focused exercise was activated and strengthened the VMO muscle; thereby it improved the knee extension. Thus addition of hip strengthening exercises along with VMO strengthening resulted in alleviate the pain. According to Kavipriya et al. the subtalar joint's overpronation and excessive hindfoot eversion causes the tibia to twist excessively and alter the patellofemoral force's direction and decrease the patellofemoral joint's contact area, increasing the joint's strain while weight bearing, which causes pain in the patellofemoral joint. There may be a closed chain linkage between excessive foot pronation morphology and excessive tibial internal rotation. The primary stabilizer for MLA is the tibialis posterior. Tibialis posterior strengthening exercises will enhance foot dynamic balance, reduce strain on the plantar medial column, and enhance foot functions, strengthen foot muscles, reduce the excessive pronation and are aid in reshaping the foot. [13] There is a chance of tightness of the knee structures including vastus lateralis, hamstrings, IT band and gastrocnemius. Tightness of those lateral structures may cause a pull on the patella in the Progressing flexion to 60°, the contact pressure increases and moves from distal to proximal which leads to an elevated quadriceps angle, changes patella tracking, increases compressive stresses on the patellofemoral joint, and eventually causes knee pain. Tighter ligaments and tendons in the lower limbs may cause the patella to be distracted laterally and increase the creep effect over an extended period of time. [6]

However the conventional therapy also helps to reduce the pain in PFPS patients. But one of the risk factor of excessive pronation is overcome by strengthen the tibialis posterior muscle. In this study we found that the Group A shows significant improvement on the symptoms among PFPS patients when compared to the group B.

V. CONCLUSION

The study concluded that the 6weeks of tibialis posterior, vastus medialis, hip posterolateral muscles strengthening and vastus lateralis, hamstrings, IT band, gastrocnemius stretching programme were suggestively reduce the pain and improve the foot arch among the patellofemoral pain syndrome patients by reduce the risk factors such as muscle imbalance, excessive pronation, according to the results of the Numerical Pain Rating Scale and Navicular Drop Test. The statistical results showed that there was a significance difference between the pre test and post test values of Numerical Pain Rating Scale and Navicular Drop Test in group-A among the PFPS patients. According to the data analysis and interpretation, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted which states that, there is a significant improvement in the effect of tibialis posterior strengthening along with conventional therapy on pain and medial longitudinal arch of foot among the patellofemoral pain syndrome individuals.

VI. LIMITATIONS AND RECOMMENDATIONS

Limitations

- ✓ Small sample size.
- ✓ Only female population was included in this study.

Recommendations

- ✓ Larger population should be recommended.
- ✓ Further more study needed to correlate between PFPS and flat foot.
- ✓ Patellar position also needs to be deal more in future studies.
- ✓ Future study needed to focus on other parameters such as Q-angle evaluation, ROM, muscle strength.
- ✓ Long term follow-up should be needed for future studies.
- ✓ In addition to intervention, footwear modifications which include high arch shoes, insole modifications can also be added.

VII. ABBREVIATIONS

PFPS – Patellofemoral pain syndrome

NPRS – Numerical pain rating scale

NDT – Navicular drop test

MLA – Medial longitudinal arch of foot

VMO – Vastus medialis oblique

IT band – Iliotibial band

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