Efficacy of Lower Limb Muscle Strengthening Strategies in the Physiotherapeutic Management of Patello-Femoral Pain Syndrome. A Literature Review

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***Abstract*—Background: Patellofemoral Pain Syndrome (PFPS) is a common musculoskeletal condition and a primary cause of anterior knee pain, especially in young and active groups and females[2,3] and has a multifactorial etiology that includes hip muscle weaknesses, quadriceps–vastus medialis imbalances, rear-foot malalignment, and abnormal biomechanics.[1,4] Although, historically, quadriceps strengthening was considered an effective treatment.[18] the emerging ideas of hip, core, and functional strengthening are increasingly seen as effective interventions.[21]**

Objective:The following research will compare the effectiveness of various physiotherapy interventions, namely: quadriceps strengthening, hip muscle strengthening, core training and proprioceptive exercises, in pain and functional reduction in patients with PFPS.[1,3,13]

Methodology:Keywords: Patellofemural pain syndrome, physiotherapy, quadriceps strengthening, hip muscle, core stability, proprioception, anterior knee pain, rehabilitation were used to conduct an electronic search in GOOGLE SCHOLAR, PUBMED and SCIENCE DIRECT. Research that is relevant and concerned about Efficacy of Lower Limb Muscle Strengthening Strategies in Physiotherapeutic Management of Patellofemoral Pain Syndrome.

Conclusion Combination of physiotherapy on proximal and distal muscles is more effective in the management of PFPS compared to single-joint approaches. The best results are shown by multimodal, individualized treatment plans, especially those containing hip strengthening. Additional studies are necessary to normalise procedures, and to investigate the effectiveness in the long term among different populations.

***Index Terms*—Patellofemoralpain syndrome, quadriceps strengthening, hip muscles, proprioception , anterior knee pain,**

I. INTRODUCTION

The medical condition patellofemoral pain (PFP) produces anterior knee pain which originates from the patellofemoral joint area through patella and mediolateral retinaculum fibrous tissue connections. The development of this condition results from irregular patellar movement patterns which lead to excessive patellofemoral joint stress due to two factors which include insufficient control of proximal neuromuscular function and existing hip muscle deficiencies. The hip muscles, including the abductors and lateral rotators, play a critical role in maintaining stability for both the knee and pelvic region during walking. The weak hip abductors result in excessive femur adduction which creates increased forces that affect the knee joint through the development of Knee Valgum. The weak muscles responsible for hip lateral rotation create a situation where the femur can rotate internally without restriction which leads to increased contact pressure on the lateral patella facet and lateral femur condyle. The development of PFP occurs because individuals have poor hip muscles which primarily include their abductors and lateral rotators.

Weakness of the hip lateral rotators leads to unrestricted internal rotation of the femur on the tibia, which causes knee joint misalignment that results in biomechanical imbalance between hip extensors and lateral rotators, which creates additional patellofemoral pain and knee dysfunction.[1]

Functional patellofemoral pain syndrome (PFPS) represented the most common diagnosis which exists as a synonym for nonspecific PFP and it had a total prevalence of 6.4%. The other less frequent diagnoses were Sinding-Larsen-Johansson disease

(4.8%), Osgood-Schlatter disease (2.5%), and plica syndrome (2.3%). The findings show that PFP affects patients with patellofemoral joint (PFJ) structural damage and patients without PFJ structural damage. The structural damage which can at times be related to PFP consists of chondral damage, osteochondral damage, osteoarthritis (OA), overuse damage of the extensor apparatus (tendonitis and insertional tendinosis) and patellar instability.

The recent systematic review studied how PFP is linked with PFJ imaging factors which include bisect offset and congruence angle and patellar tilt. The study showed that PFP developed because patients had higher MRI bisect offsets and patellar tilt and they experienced rising congruence angles during both loaded and unloaded conditions. All these imaging parameters are patella maltracking indices. The scientific evidence establishes that PFP develops because of patella maltracking. The researchers found that PFPS patients showed more lateral patella movement and patella rotation plus greater lateral patella tilt compared to the patella movement of healthy subjects. The finding that the worst forms of patellar maltracking occur during upright position or weight-bearing (squat) positions implies that muscular activity is the most important factor that defines the patellar position on PFP patients. Multiple studies investigate how external hip rotator dysfunction impacts hip muscle function by controlling femur rotation. The research findings show that dynamic valgus deviation does not occur in the knee joint but instead happens through internal femur rotation which results from hip external rotator and abductor muscle weakness. The research studies from this paper found muscle imbalances yet researchers believe that altered hip muscle activity causes PFP patients to experience dynamic valgus malalignment. The best intervention programs involved exercises on hip external rotator and abductor muscles and knee extensor muscles. Exercises which target the knee and hip muscles have been shown to produce beneficial results.

The condition known as PFP occurs when the patella experiences incorrect tracking because of both functional patellar alignment problems and dynamic valgus movement patterns. The combination of decreased hip muscle strength and existing foot deformities can lead to a situation that results in functional valgus. [2]

The question regarding whether patella maltracking causes PFPS development has remained unresolved. The recent studies show that patella maltracking functions as a primary PFPS development mechanism. The study identified that patients with PFPS exhibited greater lateral patellar spin and maltracking through increased lateral translation and lateral tilt.

The latest studies revealed that the malalignment of the knee joints occurs through internal femur rotation which results from hip external rotator and abductor muscle (M. gluteus medius and minimus) strength deficiencies. Dynamic valgus can also influence the length of iliotibial tract and researchers discovered that the tract affects how the patella moves. Kaplans fibres connect the iliotibial tract to the patella explain the anatomical connection between these two structures.

The study found positive results after participants completed active stretching exercises together with squats and ergometer and active quadriceps exercises which included active leg raises and leg press. The exercise programme included four exercises which targeted the hip abductor muscles as part of its strength training component.[3]

CAUSES:

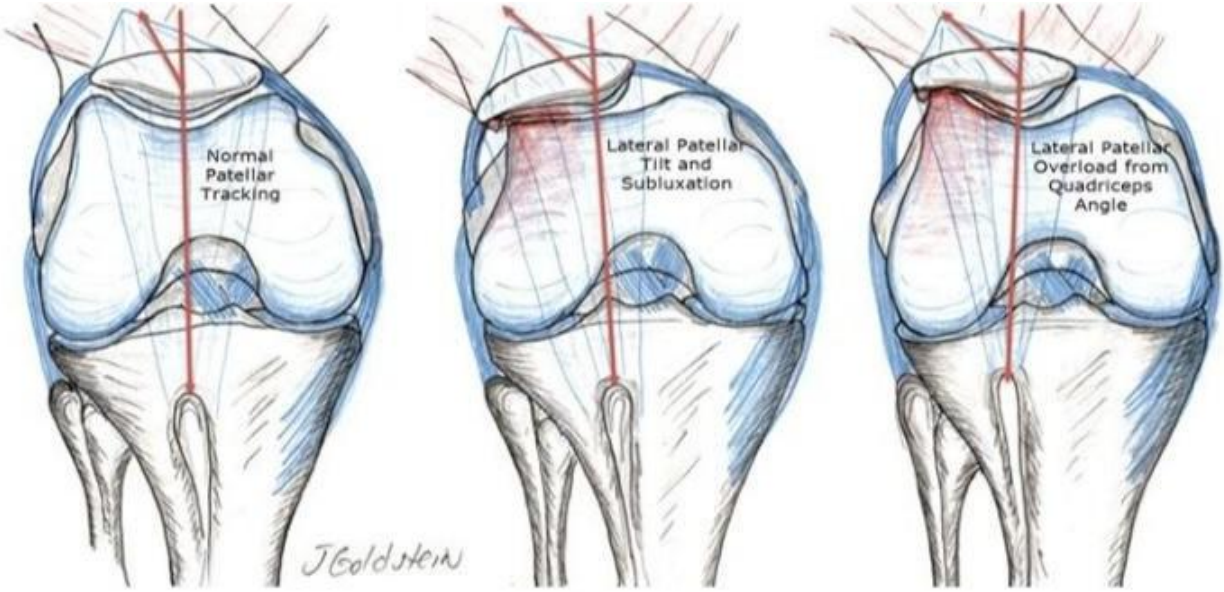
- Muscle Imbalances: Weakness or imbalance in the quadriceps, hamstrings, or hip muscles can affect patellar alignment.
- Abnormal Q-Angle: An increased quadriceps angle can lead to improper tracking of the patella.
- Structural abnormalities: Issue such as shallow trochlear groove or patella Alta.
- Ligamentous Laxity: Loose ligaments can result in increased patellar instability.
- Injury or Trauma: Previous knee injuries or surgeries can alter patellar mechanics.
- Overuse: Repetitive stress on the knee joint from activities like running or jumping.[4]

CLINICAL FEATURES:

- Pain: Anterior knee pain, especially with activities like squatting, jumping, or climbing stairs
- Patellar instability: Feeling of the patella slipping or shifting out of place.
- Crepitus: Grinding or grating sensation when

moving the knee.

- Swelling: Mild to moderate swelling of the knee.
- Weakness: Weakness of quadriceps muscle particularly the vastus medialis obliquus (VMO).
- Abnormal tracking: Patella does not follow its usual course, but can soon move sideways (outward).
- Apprehension sign: Patient is worried or scared when examiner forces the patella to the side.
- Patellar tilt: Patella tilts abnormally, often laterally. [5]



EPIDEMIOLOGY:

Patellofemoral Pain Syndrome (PFPS) is a very common musculoskeletal disorder especially the anterior section of the knee. It is prevalent in different age brackets but it is particularly high among teenagers, sportspersons, and females.

- Prevalence in General Population**:** The prevalence rate of PFPS is estimated to be approximately 22.7 per 1 year. It is a common cause of anterior knee pain and it is also one of the most common diagnoses in sports medicine clinics.
- Adolescents: PFPS is the most prevalent cause of non-traumatic knee pain in adolescents, with an incidence of 6767 percent in school-aged children and girls and children who engage in sports have a higher incidence. The disease can last many years with 40 percent of adolescents reporting the presence of symptoms despite five years. [14]
- Gender Predisposition**:** PFPS is predominantly female; there are reports of up to 2:1 to 4:1 ratios for feminine and masculine populations in athletics, respectively.[9,4]
- Athletes and Military Recruits: Physically active groups are more prone to PFPS. Among amateur bikers, it is approximately 35 percent, and in soldiers recruited to the army recently it is approximately 13.5 percent. PFPS is especially prevalent among runners with 4 to 21 percent of overuse injuries among novice runners.[2,10]
- Chronic Nature: PFPS commonly is a chronic one. Between 70 and 90 percent of the patients have recurring or chronic symptoms in the long run. It has a major impact on the daily activities, sports and social interactions in adolescents.[1,8,5]

The knee functions as a complex joint which contains separate tibio-femoral joints and patellofemoral joints. The patella itself exists as an inverted triangle shape which connects to the quadriceps tendon thus becoming the largest sesamoid bone found in the human body. The patellar tendon connects to the distal end of the tibial tubercle at its lower point. The patella enters the trochlear groove of the anterior femur that bears lateral and medial patellar articular surfaces. [6]

Adolescents develop overuse PF pain which medical

professionals define as their main diagnostic criteria. The population of patellofemoral pain syndrome is widespread because both adolescents and adults experience this condition which creates major challenges for people and their communities. The development of patellofemoral pain syndrome (PFPS) occurs through a complex interaction of anatomical factors and biomechanical factors and psychological factors and social factors and behavioral factors. [7]

The results of the moving weight bearing image examination showed that increased femur rotation led to greater lateral patellar movement which resulted in a lateral knee tilt that produced increased tension in the patellofemoral joint. The biomechanical literature shows that patients with PFPS demonstrate excessive internal rotation of their hips and adduction of their hips while displaying reduced muscle strength in their hip abductors and external rotators and hip extensors when compared to their pain-free counterparts.[8,3]

The latest studies found positive results from hip muscle strengthening exercises which researchers applied before beginning standard knee-strengthening exercise programs for patients with PFPS. The hip muscle-strengthening intervention together with the knee-strengthening program produced better results for pain management during daily activities than the knee-strengthening program by itself. [9]

Patellofemoral pain syndrome is a long-term disorder which causes retropatellar and peripatellar pain that becomes worse through squatting, sitting, walking up stairs, and running activities. The etiology of patellofemoral pain syndrome remains poorly understood because the syndrome develops from multiple local and nonlocal factors. The local determinants of patellofemoral joint function include all factors which affect joint mechanics and all quadriceps muscle failures. The proximal and distal joints display nonlocal mechanical factors which cause excessive foot pronation and excessive hip adduction and medial rotation during weight-bearing activities. Theoretical understanding holds that weak hip abductors and weak lateral rotators and weak extensors cause excessive hip adduction and medial rotation which leads to abnormal tibiofemoral and patellofemoral joint movements and increased stress on the patellofemoral joint. [10]

The proposal suggests that strengthening hip abductors and lateral rotators and extensors muscles together with knee strengthening should be used to reduce excessive hip adduction and medial rotation during weight-bearing activities which will protect the patellofemoral joint from added stress. The recent prospective research has shown that recreational runners develop patellofemoral pain because they exhibit two specific risk factors which are peak hip medial rotation angle during a landing task and peak hip adduction angle. The intervention on individuals with patellofemoral pain syndrome who received hip strengthening treatment showed positive results by reducing their pain while improving their daily living activities.[11]

II. NEED FOR THE STUDY

- The impact of hip abductors and later rotators strength training on pain and functional outcome of patients with patellar femur pain syndrome is scarcely explored.
- Evidence have been documented that various muscular imbalance has been observed in patients with patellofemoral pain syndrome at a considerably higher lateral translation(maltracking).
- Recent studies have indicated that the functional mal-alignment is not developed at the knee joint, but through internal rotation of the femur caused by weakness of external rotators and abductors of the hip.
- There is need therefore to establish the effectiveness of hip abductors and lateral rotators strength. Pain and functional outcome training of patients with patella-femoral pain syndrome.

III. AIM OF STUDY

- To establish whether hip abductors and lateral rotators strength training is more effective in reducing pain and functional outcome in patients with PFPS.
- To compare the effectiveness of isolated hip strengthening with the traditional knee based strengthening in PFPS patients.
- To compare and conclude the evidence base of therapist-guided quadriceps muscle-strengthening exercises (on their own or in combination with

other treatments) as a PFPS treatment intervention.

IV. METHODOLOGY

A literature search and review were performed using Google Scholar, PEDRO, PubMed, Scholar and PubMed. The search was limited to articles published within past 10 years. The focus of search was to rule out Efficacy of Lower Limb Muscle Strengthening Strategies in the Physiotherapeutic Management of Patellofemoral Pain Syndrome.

4.1 SEARCH STRATEGIES

Keywords Used: Relevant keywords were found using medical subject headings [MeSH] used to search. The keywords of other relevant articles were also applied. The keywords were as follows, Patellofemoral pain syndrome, physiotherapy, quadriceps strengthening, hip muscles, core stability, proprioception, anterior knee pain, rehabilitation.
Databases Searched: PubMed, Science direct, google scholar, PEDRO

4.2 SEARCH TECHNIQUES

The methods employed in searching articles to obtain articles to be included in this literature review are: - Boolean operators such as OR and AND have been applied.

4.3. Keywords

Patellofemoral pain syndrome, physiotherapy, quadriceps strengthening, hip muscles, core stability, proprioception, anterior knee pain, rehabilitation.

Eligibility Criteria

Inclusion Criteria

- Articles in English language.
- Inclusion criteria 1 Patients with Patellofemoral Pain Syndrome (PFPS) with a duration of anterior or peripatellar knee pain of at least 6 weeks.
- Young people (>14 years old) and adults (up to 50 years).

Functional pain manifestations (e.g., squatting, stair climbing, running, or sitting);

- Studies that investigated exercise-based or multimodal physiotherapy interventions for PFPS
- Studies reporting outcomes related to pain and/or function
- Study type: Randomized controlled trials(RCTs), Cohort studies, case controlled studies, and systematic reviews published in peer-reviewed journals.
- Studies published in the last 6 years only

Exclusion Criteria

- Patients with structural knee injuries (meniscal tears, ligament injuries, osteoarthritis, prior knee surgery)
- Non-exercise-based interventions only (e.g., electrotherapy, surgery, pharmacological- only approaches)
- Studies not reporting validated outcome measures (VAS, AKPS, LEFS, Kujala, etc.)
- Non-English publications and studies with inadequate methodological quality.

V. MANAGEMENT

The management of Patellofemoral Pain Syndrome (PFPS) is directed toward pain reduction, correction of patellar maltracking, restoration of joint mobility, and optimization of lower limb biomechanics. Evidence suggests that a multimodal approach combining manual therapy and electrotherapy may provide short-term symptomatic relief, particularly when integrated with exercise-based rehabilitation. The management is subdivided into Manual Therapy and Electrotherapy.[2,11]

1. Manual Therapy

Manual therapy interventions are primarily aimed at improving patellar alignment, restoring joint mobility, and reducing soft tissue restrictions contributing to abnormal patellofemoral joint stress.

1.1 Patellar Mobilization

Patellar mobilization techniques, particularly medial glide and inferior glide mobilizations, improve patellar tracking and decrease lateral patellar compression. These techniques enhance joint nutrition and reduce pain by correcting biomechanical dysfunction. Research indicates that combining patellar mobilization with strengthening exercises results in superior short-term functional

outcomes compared to exercise alone.[4,7]

1.2 Tibiofemoral Joint Mobilization

Anterior and posterior tibial glides are applied to restore normal arthrokinematics of the knee joint. Restricted tibiofemoral mobility has been associated with altered patellofemoral joint loading. Joint mobilization may improve range of motion and reduce pain by stimulating mechanoreceptors and inhibiting nociceptive input.[3]

1.3 Soft Tissue Mobilization

Myofascial release and trigger point therapy targeting tight structures such as the iliotibial band, quadriceps (especially vastus lateralis), hamstrings, and gastrocnemius help reduce abnormal lateral forces acting on the patella. Evidence suggests that addressing these restrictions improves movement patterns and decreases patellofemoral stress.[19,23]

1.4 Manual Stretching

Stretching of shortened musculature, including the hamstrings, gastrocnemius-soleus complex, hip flexors, and tensor fascia lata, reduces patellofemoral joint stress by improving flexibility and dynamic alignment.[20]

1.5 Patellar Taping (McConnell Technique)

McConnell taping provides short-term pain relief by mechanically correcting patellar alignment and enhancing proprioceptive feedback. Studies demonstrate that taping combined with strengthening protocols improves immediate functional performance in patients with PFPS.[2]

2. Electrotherapy

Electrotherapy modalities are commonly used as adjunctive treatments for pain modulation, inflammation control, and facilitation of muscle activation in PFPS management.

2.1 Transcutaneous Electrical Nerve Stimulation (TENS)

TENS is widely used for pain modulation through the gate control mechanism. Clinical evidence suggests that TENS provides short-term symptomatic relief but does not address underlying biomechanical causes.[11]

2.2 Interferential Therapy (IFT)

IFT is applied to reduce pain and enhance local circulation. Although some studies report symptomatic improvement, electrotherapy alone is insufficient for long-term functional recovery.[21]

2.3 Ultrasound Therapy

Therapeutic ultrasound, administered in pulsed mode during acute stages and continuous mode during chronic stages, may promote tissue healing and reduce inflammation. However, systematic reviews suggest limited long-term effectiveness when used in isolation.[22]

2.4 Cryotherapy

Cryotherapy is recommended in the acute phase to reduce inflammation and pain through vasoconstriction and decreased nerve conduction velocity. It is considered an effective adjunct for symptom control.[3]

2.5 Neuromuscular Electrical Stimulation (NMES)

NMES is utilized to facilitate quadriceps activation, particularly the vastus medialis oblique (VMO), which plays a crucial role in patellar stabilization. Evidence suggests that NMES combined with strengthening exercises may improve muscle recruitment patterns in the early stages of rehabilitation.[15]

VI. DISCUSSION

The symptoms of patellofemoral pain syndrome (PFPS) consist of pain in the anterior part of the knee with its origin at the patellofemoral joint, in which involves patella, as well as fibrous tissue located on the mediolateral retinaculum. The aetiology is abnormal patella kinematics as a result of excessive load on patellofemoral joint, inadequate proximal neuromuscular control, and weak hip muscle.

The current reviews narrates the changing position of lower limb strengthening methods in the physiotherapeutic treatment of Patellofemoral Pain Syndrome (PFPS). In the 14 reviewed studies, one consistent truth is that isolated measures, i.e., strengthening of the quadriceps or the hip, can bring a measurable reduction in pain and functioning, but that multimodal interventions combining hip, knee, and core strengthening with proprioceptive training would have better outcomes.[13]

The hip and knee strengthening programs also minimize pain besides eliminating knee valgus and hip internal rotation biomechanical deficits. The importance of these biomechanical effects is that maltracking and abnormal joint mechanics are both significantly related to PFPS, which implicated proximal stabilization as a key factor in symptom

reduction of PFPS.[12,22] Early interventions involving exercise therapy, education and load management in adolescents. This is a biopsychosocial approach, which shows that PFPS is not a purely biomechanical issue, but it also depends on psychological and behavioral determinants[14] In the same manner, exercise therapy is the basis of PFPS treatment although more advantages are obtained when it is used together with other adjunctive support such as taping, orthoses, or patient education.[15]

A number of studies focused directly on hip and quadriceps strengthening, indicating clinical equality between the two approaches, and implying the ability to customize the intervention to the needs of individual patients. Nevertheless, hip strengthening resulted in earlier pain relief, and higher proximal muscle, compared to quadriceps training alone[18]. This is in line with Pollatos et al., who found significant reduction in pain, function, and muscular strength after the programs that focused on hip and knee musculature along with neuromuscular re-education let down studies.[19]

Recent studies have indicated that functional malalignment is not present in the knee joint but as an internal rotation of the femur because of the weakness of hip external rotators and abductors (M. gluteus medius and minimus). The hip muscles (abductors and lateral rotators) are required in stabilization of the knee and pelvis during ambulation. On the other hand, weak hip abductors can lead to an augmentation in femur adduction which increases lateral force (Knee Valgum) in the contact area between the lateral facet of the patella with the lateral femur condyle. Therefore, poor muscles of the hips (primarily abductors and lateral rotators) can be regarded as one of the key factors in the aetiology of PFPS [21,24]. The best intervention programs involved exercises that assist the hip external rotator and abductor muscles. It has been put forward that, regardless of knee strengthening, reinforcing of the hip abductors, lateral rotators and extensors can help to decrease excessive hip adduction and medial rotation during weight-bearing moves and lower patellofemoral joint stress. Thus, hip strengthening can be added to the rehabilitation of individuals with patellofemoral pain and can decrease the pain and enhance the performance of activities of daily living [12,13,25]

Core training also appeared through the role of the core strengthening as Shabbir et al discovered core strengthening as more efficient than isolated quadriceps strengthening which is believed to be indirectly useful in the reduction of knee stress during functional activities. They showed that even without the major changes in the static position, quadriceps strengthening has a better effect on the pain, and dynamical neuromuscular control has an impact on the static anatomical variables, too.[18]

PFPS rehabilitation is best realized by having interventions, which are not confined to only isolated quadriceps strengthening to include hip, core, and proprioceptive training in a multimodal context. Although quadriceps training is beneficial in itself, proximal control is done by strengthening the hips, which deal with the biomechanical factors of dynamic valgus and internal rotation of the femur, thus giving better results. This is further supplemented by core stability which improves the overall kinetic efficiency of the chain. [18,23]

The objective of the research was to establish the impact of hip abductors and lateral rotators strength training on functional outcome and pain patients of patella femoral pain syndrome. I have conducted 14 review of literature in that outcome of all study indicated that hip abductors and lateral rotators strength and core training is the most effective in the case of Patello femoral pain syndrome.

VII. LIMITATIONS

1. Scarcity of high-quality trials – A significant portion of trials were pilot or small-scale studies which had variably high level of methodological rigor, which weakens the evidence.
2. Small sample sizes – A number of the trials have small sample sizes (e.g., 30 patients) and thus this can affect the generalizability.
3. Heterogeneity in diagnostic criteria – In the research, the diagnosis of patellofemoral pain syndrome (PFPS) and inclusion criteria differ among studies (age groups, activity levels, duration of pain), which reduces their comparability.
4. Limited long-term follow-up – The majority of the trials only measured results at short-term (6 to 12 weeks), and few studies measured long-term effects (more than 1 year).

5. Underreporting of bilateral symptoms and gender differences – Underreporting Bilateral cases PFPS is predominant in females, but there is little literature that stratified outcome by gender or laterality of symptoms.
6. Variability in treatment protocols – The treatments were highly diversified (hip strengthening, orthoses, taping, multimodal therapy), and therefore it was not possible to create uniform clinical guidelines.
7. Lack of sport- and region-specific data – The amount of specific sport/region/differences evidence on the management of PFPS is very minimal.
8. Limited focus on prevention strategies – The majority of research involved symptom control instead of prevention methods among the risk groups (ex: athletes, adolescents).
9. Challenges in adolescent compliance – Adolescent compliance in exercise programs is typically not optimally achieved, a factor that can decrease the effectiveness of interventions.

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VIII. CONCLUSION

The review of literature made inferences that Quadriceps-based and hip-based strengthening therapies are effective in the management of Patellofemoral Pain Syndrome (PFPS), Integration of hip and core strengthening offers better results in controlling pain, enhancing functioning and biomechanical positioning. strength training proves to be quite effective in pain management during functional activities. It can also decrease pain and enhance activities of daily living performance among patients with patellofemoral pain syndrome thus, multimodal physiotherapeutic interventions utilizing hip, knee and core muscle fortification with proprioceptive and functional exercises are the best methods of attaining both long-term pain management and restoration of functions.

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