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Improving Patellofemoral Pain Syndrome: A Randomized Clinical Trial Investigating the Impact of Functional Stabilization Exercises on Pain Relief, Functionality, and Biomechanics of the Lower Extremity

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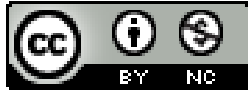
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Abstract

Background

Patellofemoral pain (PFP) is a common musculoskeletal condition that affects many individuals. Hence our objective was to identify the effectiveness of functional stabilization exercises on pain relief, functionality, and biomechanics of the lower extremity in patients with PFP.

Methods

It was a double-blinded, randomized controlled trial that enrolled 60 participants diagnosed with PFP, randomly assigned to functional stabilization and conventional treatment group. Both groups received exercises for 8 weeks with 3 sessions on non-consecutive days of the week. Pain levels, functional performance, and lower extremity biomechanics were assessed.

Results

The mean age of the participants was 23.48 ± 4.89 in FST and 21.98 ± 3.42 in the CT group, with improvements observed in all variables in both groups. However, more significant results were reported in the FST group with mean differences of 2.15 ± 0.5 , 6.75 ± 3.88 , 14.47 ± 12.21 , and 1.7 ± 0.47 for pain, physical function, single-leg triple hop, and Q-angle respectively.

Conclusion

Functional stabilization exercises are an effective treatment option for patients with PFPS. It can significantly improve pain levels, functional performance, and lower extremity biomechanics in patients with PFPS. The findings of this study support the use of functional stabilization training as a treatment option for patients with PFPS.

Keywords

Exercise, Musculoskeletal Disorders, Pain, Patellofemoral Pain Syndrome, Physical Function.

Introduction

Knee pain is the second most common musculoskeletal condition, with patellofemoral pain (PFP) being one of the most common conditions¹, with a prevalence of approximately 15% to 45%². PFP is described as diffuse discomfort around or behind the patella aggravated by activities that raise patellofemoral joint compressive stresses³. It is more common in young, physically active adults, especially females⁴. Initially, PFP was discussed as a self-limiting course. However, the new evidence showed that it may increase the risk of Patellofemoral Osteoarthritis (PFOA)⁵⁻⁶. It is reported that around 39% of the young population aged 30 or above suffer from PFOA⁷. Hence there is a need to design an exercise program to treat PFP at the earliest to decrease the progression of PFOA. Previous researches were focused on addressing the local etiological factors of PFP, while some advised quadriceps strengthening to reduce knee pain. However, recent researches are focused on a multimodal treatment approach that deals with proximal factors contributing to PFP⁵.

Weak hip muscles and abnormal hip and trunk movements are proximal factors that may cause PFP. Research indicates that hip and trunk musculature strength is lower in PFP patients compared to normal people⁸. People with PFP have increased hip adduction, medial rotation, and ipsilateral trunk inclination excursions during functional activities that increase knee joint valgus, pressuring the lateral side of the patellofemoral joint⁵. Research has been done to identify the exercise effects targeting hip and trunk muscles in PFP⁹⁻¹⁰. A study conducted in 2019 on the effectiveness of isolated hip exercise, knee exercise, or free physical activity for patellofemoral pain revealed no difference observed in three groups that received hip-focused, knee-focused, or free physical activity combined with patient education¹¹.

In contrast, a systematic review was conducted in 2021 on trunk, hip, and knee exercises to reduce PFP symptoms. The results revealed that combined hip and knee exercises might be a primary treatment approach compared to knee-only exercises¹². It has been hypothesized that improved lower limb and trunk movement control, increased eccentric hip strength, and improved pain and functionality are all related to people who engage in hip-strengthening

exercises. However, evidence to support these claims needs to be more extensive. Hence current study aims to identify the impact of functional stabilization exercises that includes trunk, hip, and knee exercises on pain, physical function and knee biomechanics among PFP patients.

Methodology

A double-blinded randomized controlled trial was conducted in the Department Of Rehabilitation Sciences, Sialkot. Patients were invited to the study via flyers posted in OPDs, and those coming to the OPD from June 2022 to December 2022 via consecutive sampling technique. Potential participants were then screened for confirmation of PFJ diagnosis, and selected participants underwent screening with measurements recorded at baseline and after 8 weeks of intervention. Informed consent with a brief and concise treatment plan and potential risks and benefits was shared with the participants to confirm their voluntary participation.

A total of 60 participants were then randomly divided into two groups; Group A, which received functional stabilization exercises (n=30) and Group B, which received conventional treatment (n=30). All patients between the age of 25 and 40 years reported pain ≥ 4 on the VAS scale for at least 8 weeks before the inclusion in the trial. All those participants with diagnosed intra-articular pathology, unstable patella, knee sprain, and hip or knee surgery in the last 12 months were excluded from the study¹³.

Randomization

Randomization was performed after the baseline assessment using a computer-generated sequence of consecutive numbers. At first, the target population was identified, and the desired sample sizes for each group were determined. Next, the researcher utilizes computer software to generate random numbers to select participants from each population. Randomization was performed by the researcher blinded to the participant's details, who provided the group allocation to the treating therapist. Participants were also blinded about the group allocation; the treatment to both groups was provided at different timings to ensure the blinding.

Outcome Measures

Pain: Pain was one of the primary outcome measures, assessed on a 0-10 cm continuum of visual analogue scale in which the lowest value represents minimum pain and the highest showing maximum pain¹⁴.

Function: The Lower Extremity Functional Scale (LEFS) and single-leg triple-hop (SLTH) test assessed physical function. LEFS is a self-report questionnaire with a 20-item questionnaire indicating that orders the difficulty level of executing ADLs from 0 (extreme difficulty) to 4 (no problem). A score of 80 implies greater lower extremity function¹⁵. This scale has high test-retest reliability and good validity in patients with PFP.

Intervention

Patients in both groups received the treatment for 8 weeks, with 3 sessions per week, on non-consecutive days. Each session lasted between 90 and 120 minutes in the FST group and 75 to 90 minutes in the ST group. Two trained physiotherapists supervised the treatment for both groups. An orientation session was set in which the physiotherapist demonstrated each exercise for the patient's clarity so that the patient may efficiently perform it. The patients were instructed to avoid physical activity that might increase knee pain. A detailed description of both protocols is given below:

Group A: Functional Stabilization Exercises (FST)

FST was aimed to improve motor control of hip and trunk musculature for the initial 2 weeks. For the next 3 weeks, treatment was performed to enhance the strength of the trunk and hip muscles, including weight-bearing activities to enhance motor control. For the last 3 weeks, the complexity of exercise increased with patients being educated to perform all exercises while keeping their lower extremities in a neutral position to avoid dominance of the quadriceps. The detailed description of the protocol is as follows:

Transversus Abdominis and Multifidus Muscle Training

The exercise was performed in week 1 and 2. The patients were asked to perform 15 repetitions for 2 sets with a 10-sec isometric contraction in the quadruped and prone position. The following exercise was sitting on a Swiss ball in which a 20 seconds isometric contraction was performed 5 times. The intensity was increased by increasing the 5 seconds hold.

Lateral Bridge and Ventral Bridge

The exercise was performed from week 3 to 8. In week 3 to 6, patients performed 5 sets for 30 seconds. The progression was applied by increasing the 5 seconds hold. In week 6 to 8, the sets remained the same; with contraction, time increased by 45 to 60 seconds with a progression of 5-seconds hold.

Isometric Hip Abduction/ Extension/ Lateral Rotation in Side-Lying

In the initial 2 weeks, patients performed two sets, 20 repetitions each with a hold of 5 seconds. Resistance was provided via ankle weight. Initially, the load was at 20% 1RM, which increased by 0.5 Kgs. In week 3 to 5, the number of sets increased to 3, with 12 repetitions performed in each set. The intensity was increased up to 75% of 1RM. The same protocol was performed in weeks 6 to 8.

Pelvic Drop in Standing

The exercise was performed from week 3 to 8. Patients performed 3sets of 12 repetitions in which resistance was set at 75% of 1RM using ankle weights. Progression was made by increasing weight from 1 to 2 Kgs.

Hip Lateral Rotation in a Closed Kinetic Chain

The exercise was performed from week 3 to 8. The patients were asked to perform the exercise using elastic bands, 3 sets of 12 repetitions.

Prone Knee Flexion

In week 1 to 2, the patient performed 2 sets of 20 repetitions with resistance set at 50% of 1 RM using the weight-training device. The progression was done by increasing 1 to 2 Kgs. In week 3 to 8, the sets increased to 3 with 12 repetitions, with intensity set at 75% of 1RM.

Seated Knee Extension (90°-45° of Knee Flexion)

In week 1 to 2, the patient performed 2 sets of 20 repetitions with resistance set at 50% of 1 RM using the weight-training device. The progression was done by increasing 2 to 5 Kgs. In week 3 to 8, the sets increased to 3 with 12 repetitions, with intensity set at 75% of 1RM.

Group B: Conventional Training

Participants in Group B received standardized conventional training, with each session lasting 75-90 minutes. The treatment included stretches of lower limb muscles, including the quadriceps, hamstring, lateral retinaculum, gastrocnemius, soleus, and iliotibial band. The frequency of the set was designed to be 3 with a 30 seconds hold. Straight leg raise, seated knee extension, leg press, and step and own were also performed with a frequency of 3 sets, each having 12 repetitions and intensity set at 50% of 1 RM.

Data Analysis

The analysis of data was performed on SPSS version 23. For demographic variables, frequency and percentage charts were formulated. Inferential statistics were analyzed using a parametric test at a 95% Confidence Interval. Paired t-test was run within the group analyses, and an independent t-test was applied between the group analysis. The level of significance was determined at cut off value of $p < 0.05$.

Ethical Considerations

All participants enrolled in the study were informed regarding the purpose of the study. Written consent was taken, and all the information from the participants was kept confidential. The participants were given complete autonomy to withdraw from the study at any time of trial.

Ethical approval for conducting the study was taken from Memon Medical Trust Hospital, Hyderabad (IRB#ALR/MRC-029/2/22).

Results

A total of 60 participants were enrolled in the study. Two dropped from the FST group after the initial sessions and one from the CT group. Baseline readings were recorded before assigning them to any of the treatment groups. The demographic characteristics of participants are depicted in Table-1.

Table-1 Depicting participants demographic at baseline		
Variables	FST (n=28)	CT (n=29)
	Mean±S.D	Mean±S.D
Age (Years)	23.48± 4.89	21.98±3.42
Height (Meters)	1.56±0.2	1.59±0.1
BMI (Kg/m2)	24.32±3.89	22.48±4.56

BMI: Body Mass Index
SD: Standard Deviation

Within the group, change was analyzed using paired t-tests, as data was normally distributed for both variables at a 95% Confidence Interval. The results showed significant improvement in both groups. However, participants in the FST group showed more effective results with a mean difference of 4.99± 0.22, 14.23±4.86, 13.6±5.7, and 4.05± 1.35 for pain, physical function, single-leg triple hop, and Q-angle respectively as compared to CT group that showed a mean difference of 2.84±0.72, 7.42±0.98, 28.07±17.91, and 2.35±0.88 for the said variables (Table-2).

Table-2 Showing within group effects of training on pain and physical function				
	Baseline	8-week intervention	Within group change at end of intervention	P-value
<i>Pain (0-10)</i>				
FST	7.01 ± 1.7	2.02± 1.9	4.99±0.22	<0.05
CT	6.52 ± 1.29	3.68 ± 2.01	2.84±0.72	
<i>Lower Extremity Functional Scale (0-80)</i>				
FST	51.26±13.42	65.49±8.56	14.23±4.86	<0.05
CT	54.89±8.24	62.31±7.26	7.42±0.98	
<i>Single-Leg Triple Hop</i>				
FST	316.2±74.21	329.8±68.51	13.6±5.7	<0.05
CT	321.4±29.32	349±47.23	28.07±17.91	
<i>Q-angle</i>				
FST	18.26± 4.85	14.21±2.5	4.05± 1.35	<0.05
CT	17.58± 3.98	15.23±3.1	2.35±0.88	

FST: Functional Stabilization Training
 CT: Conventional Training
 Mean±S.D.

Discussion

The results of our study revealed that all three variables, i.e. pain, physical function, and Q-angle, significantly improved in both groups (p<0.05). However, more significant results were reported in the FST group with a mean difference of 2.15±0.5, 6.75±3.88, 14.47±12.21, and 1.7±0.47 for pain, physical function, Single-leg triple hop, and Q-angle respectively. The

findings are consistent with another study published in 2019 on the effects of hip vs. knee exercises on hypoalgesia among PFP patients. The results showed a general hypoalgesic response to progressively increasing pressure stimuli following hip and knee exercises and reduced conditioned pain modulation¹⁶. The proximal and distal mechanical factors are critical to maintaining the joint's standard mechanics of the joint¹⁷. A study by Kısacık et al. revealed that Short Foot Exercises (SFE) included in an intervention programme resulted in positive outcomes in lowering knee pain, improving navicular position, and improving rear foot posture. Furthermore, increased hip extensor strength from SFE may contribute to enhanced stabilization¹⁸. In contrast to these studies, a recent study published in 2022 investigated whether the targeted leg/foot exercise is more effective than the targeted trunk/hip. They found that exercises focused on strengthening the leg and foot muscles can serve as alternatives to exercises targeting the core and hip muscles in a lower limb exercise-based rehabilitation programme for women with PFP¹⁹. Despite the findings, there are literatures supporting treatments that target proximal and distal local mechanical factors that may contribute to PFP. However, the study had certain limitations. The sample size of this study is one of its limitations. A bigger sample size would give a more accurate population representation and boost the findings' generalizability. Another limitation was the duration of treatment. The study's intervention programme may have been too short to capture long-term effects. Extending the intervention time may provide a better understanding of the long-term viability of the observed changes. The third limitation was the lack of follow-up. Long-term outcomes and the durability of marked improvements over an extended follow-up time would help establish the intervention's success.

Conclusion

Functional stabilization exercises are an effective treatment option for patients with PFPS. It can significantly improve pain levels, functional performance, and lower extremity biomechanics in patients with PFPS. The findings of this study support the use of functional stabilization training as a treatment option for patients with PFPS.

Authors Contribution

Mehmood Z: Conception, design and data acquisition.

Bhutto MA: Design and data acquisition.

Rana ZJ: Data acquisition and analysis.

Nasir MF: Data analysis and drafting.

Waheed A: Revising the draft.

Tariq F: Final approval.

Declaration of Interest

None.

Funding Sources

None.

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