ORIGINAL ARTICLE

Effect of Strengthening versus Neuromuscular Training on Pain and Functionality in Individuals with Patellofemoral Pain Syndrome

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Abstract

Background: Patellofemoral pain syndrome (PFPS) is a disorder that commonly affects young adults and athletes and causes disability in physical function and quality of life. Therefore, effective management strategies, including but not limited to exercise interventions, are necessary to relieve symptoms and improve outcomes.

Methods: A total of 45 PFPS patients were randomly assigned to either a group receiving strengthening exercises (EG 1) and neuromuscular training (EG 2) combined with conventional Physical Therapy, or a control group (CG) that only received conventional Physical Therapy. The interventions were conducted 3 times/week for 4 weeks. Kujala AKPS and KOOS scores were measured before and after the intervention period.

Results: The AKPS and KOOS scores improved significantly in all the groups after the interventions ($p<0.001$). The greatest improvement was observed in the EG 1 group, followed by the EG 2 group, and the least improvement was observed in the CG. However, a significant time, group, and interaction effect was demonstrated regarding AKPS ($p<0.05$) and KOOS ($p<0.05$) through repeated measures of ANOVA.

Conclusion: The findings of the study indicate that strengthening exercises are more effective than neuromuscular training and conventional therapy for treating PFPS. This study provides consistent evidence to support the use of targeted exercise interventions to improve clinical outcomes and quality of life for individuals with PFPS.

Keywords

Exercise, Patellofemoral Pain Syndrome, Physical Function, Quality of Life.

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Introduction

Patellofemoral pain syndrome (PFPS) is a common musculoskeletal disorder, most frequently presenting as anterior knee pain or pain behind the patella[1]. It typically occurs in young women and is common among adolescents, athletes, and active adults[2]. PFPS usually worsens during activities that apply a weight-bearing force through the patellofemoral joint, for instance, when climbing stairs, squatting, and jumping[1-2]. The aetiology of PFPS is complex and multifactorial. Biomechanical factors, specifically abnormal patellar tracking, muscular imbalance, and a deficiency of dynamic stability, play a predominant role[3]. Generally, patients with PFPS demonstrate marked muscular insufficiency of the lateral trunk flexors, hip abductors, lateral rotator muscles and knee extensors. Lower extremity pain may also directly impair a bnormal movement patterns during PFPS and weight-bearing activities[1-3].

PFPS significantly impacts affected individuals' physical functioning and quality of life worldwide[4]. A systematic review carried out in 2018 noted that PFPS is one of the most prevalent forms of knee pain, affecting around 22.7% of the general population and approximately 28.9% of adolescents[5]. The disorder may also lead to severe disability if not appropriately managed, leading to primarily adverse long-term outcomes for patients[4-5]. PFPS also contributes to psychological issues such as anxiety and depression, worsening the impact on patients and global healthcare systems[6]. In Asia, PFPS incurrence has been equally high[7]. In one Chinese study, it was revealed that 20.7% of young adults had PFPS, while 35.6% had knee pain[8]. Another study on a population in Saudi Arabia showed that a higher percentage was reported in females[9]. These studies underline how widespread PFPS is among different populations and call for effective management strategies.

PFPS has yet to be studied in depth in Pakistan, but it is probably a significant issue due to regional trends and the growing emphasis on physical activity and sports[10]. It affects an individual's ability to perform routine daily activities and sports, leading to poor quality of life and increased health care use[11]. It is essential to understand the local epidemiology, risk factors, and natural history to cater to the development of interventions for PFPS management and prevention[12].

PFPS interventions generally include exercise programs to strengthen the quadriceps and gluteal muscles, which have been found to alleviate pain and improve movement of the lower extremities and motor function[13]. However, neuromuscular training, including joint position exercises during an active movement, is also increasingly recognized as a critical intervention in controlling PFPS. It effectively remediates the neuromuscular control deficits to correct the body sways and improves the dynamic alignment of the lower limbs, like in strengthening exercises, so it is practically essential in proper rehabilitation[14].

Compared to conventional physical therapy in PFPS, the effectiveness of strengthening exercises versus neuromuscular training has yet to be well-documented. Thus, this study aimed to compare the effects of these exercises, aiming to achieve better outcomes and quality of life for patients.

Methodology

Study Design

It was a 3-arm, randomized controlled trial comparing the effects of strengthening exercises, neuromuscular training added to conventional physical therapy, and conventional physiotherapy alone in patients with PFPS.

Participants Recruitment

A total of 45 patients diagnosed with PFPS were recruited from outpatient physiotherapy clinics in Karachi. Patients of both genders, aged between 18 and 40 years old, having at least three months of lasting knee pain diagnosed as PFPS by a primary care physician and <85 scores on The Kujala Anterior Knee Pain Scale (AKPS), were included as subjects of this study. Patients who had knee surgery, a severe knee injury in the last six months, or any other lower extremities musculoskeletal ailments or neurological issues that impact balance and muscular strength were excluded.

Randomization and Group Allocation

Patients were randomly assigned to three groups using a computer-generated randomization sequence. Each group consisted of n=15. The group interventions were blinded to the participants. All patients were provided with informed consent forms before the start. After consent was obtained, baseline measurements were conducted at pre-intervention and 4 weeks post-intervention. The interventions were applied 3 times/week for 4 weeks.

Experimental Group 1 (EG 1) patients performed hip abductor and external rotator strengthening exercises. The exercises used were as follows:

- Side-lying hip abduction
- Standing hip abduction with band
- Clamshell exercise
- Prone hip extension

All exercises were performed in three sets of 10-15 reps with progressive resistance.

Experimental Group 2 (EG 2) performed neuromuscular training tasks, which included the following:

- Step-up and step-down exercises
- Lateral step-ups
- Single-leg squats
- Forward lunges with a balance element (on a foam pad)

All exercises were done in three sets of 10-15 reps with a progressive increase in difficulty level.

Control Group (CG) participants were only conventionally treated with physical therapy, which included:

- Stretching of the iliotibial band, hamstrings, and quadriceps
- Patellar mobilization techniques
- Pain management

Outcome Measures

Pain and functioning were measured using the following measures:

- The **Kujala AKPS** is a self-reported 13-item questionnaire that considers pain and functional disabilities in people suffering from PFPS. The scores range from 0 to 100, where higher scores mean better knee function and less pain. It is used in clinical and research settings due to its reliability and sensitivity[15].

- The **Knee Injury and Osteoarthritis Outcome Score (KOOS)** is a validated self-reported questionnaire that assesses pain, symptoms, activities of daily living, sports and recreation function, and knee-related quality of life. Ratings vary from 0 to 100, with higher ratings indicating better outcomes[16].

Statistical Analysis

Descriptive statistics (means and standard deviations) were calculated for participant demographics and baseline characteristics to ensure comparability across the three groups. The normality of the data was assessed using the Shapiro-Wilk test. A repeated measures ANOVA was used to assess within-group changes in AKPS and KOOS scores over time and between-group differences. The model included group (EG 1, EG 2, CG) as the between-subject factor and time (pre-intervention, post-intervention) as the within-subject factor. The effects of interaction between time and group were also examined. Post-hoc pairwise comparisons with Bonferroni correction were used to discover significant differences between groups. The magnitude of differences was determined by calculating effect sizes (partial eta-squared). The level of statistical significance was fixed at $p<0.05$. All analyses were carried out using SPSS software version 26.0.

Results

All 45 subjects comprised the trial with no dropouts. Table-1 summarizes the baseline characteristics for all groups' subjects. There were no significant differences between the groups in terms of age, distribution of gender, and baseline scores calculated for AKPS and KOOS.

Table-1 Baseline characteristics of participants

Characteristic	EG 1 (n=15)	EG 2 (n=15)	CG (n=15)	P-value
Age (years)	27.8±5.4	28.2±4.9	28.0±5.1	0.92
Gender (M/F)	8/7	7/8	7/8	0.96
Baseline AKPS	65.3±10.2	64.8±9.9	65.1±10.5	0.98
Baseline KOOS	45.7±8.4	46.1±7.9	45.9±8.2	0.94

Changes in AKPS and KOOS Scores

All groups demonstrated significant improvement in AKPS and KOOS scores following the intervention compared to the pre-intervention stage ($p<0.001$). The most significant improvement was observed in EG 1, followed by EG 2, and the least in CG.

Table-2 Changes in AKPS and KOOS scores

Time Point	EG 1 (n=15)	EG 2 (n=15)	CG (n=15)
Pre-intervention AKPS	65.3±10.2	64.8 ± 9.9	65.1 ± 10.5
Post-intervention AKPS	88.4±8.1	82.6 ± 9.3	75.7 ± 10.1
Mean Change AKPS	23.1±7.4	17.8 ± 6.9	10.6 ± 7.3
Pre-intervention KOOS	45.7± 8.4	46.1 ± 7.9	45.9 ± 8.2
Post-intervention KOOS	72.5± 6.9	67.3 ± 7.2	59.4 ± 8.0
Mean Change KOOS	26.8±7.5	21.2 ± 7.0	13.5 ± 7.6

The results of the repeated measures ANOVA showed a significant time impact on both the AKPS ($F=185.34$, $p<0.001$) and KOOS ($F=160.42$, $p<0.001$), indicating that scores improved over time. There was also a significant effect of the group on both AKPS ($F = 4.82$, $p < 0.05$) and KOOS ($F = 5.34$, $p < 0.05$), as well as an interaction effect between time and group in both AK.

Table-3 Repeated measures ANOVA results			
Source	F-value	P-value	Partial η^2
Time (AKPS)	185.34	<0.001	0.68
Group (AKPS)	4.82	<0.05	0.18
Time × Group (AKPS)	7.96	<0.01	0.45
Time (KOOS)	160.42	<0.001	0.64
Group (KOOS)	5.34	<0.05	0.20
Time × Group (KOOS)	6.89	<0.01	0.41

The post-hoc pairwise comparison using Bonferroni correction revealed that EG 1 significantly improved AKPS and KOOS scores compared to both EG 2 ($p<0.01$) and CG ($p<0.001$). EG 2 significantly improved compared to CG ($p < 0.05$). The intervention had a notably high effect on AKPS ($\eta^2=0.68$) and KOOS ($\eta^2=0.64$). The interaction time per group moderately affected AKPS ($\eta^2=0.45$) and KOOS ($\eta^2=0$.

Discussion

This study showed how three different treatments helped 45 patellofemoral pain patients. The results after treatment were very favorable for all groups, with the most improvement seen in the group doing strengthening exercises and neuromuscular training and the slightest improvement in the control group. This suggests that focusing on targeted interventions such as hip abductor and external rotator strengthening is more effective than neuromuscular training and traditional physical therapy alone.

The efficiency of hip abductor and external rotator strengthening exercises in improving PFPS symptoms is compatible with research conducted previously[17-18]. A study have suggested that the strengthening program effectively reduces pain intensity and improves function among PFPS patients[19]. This builds further on the evidence base of strengthening hip muscles in treating PFPS and its effect on knee function and decreasing pain.

In contrast, neuromuscular training has been less well-researched but may hold the potential for developing practical lower extremity control skills and proprioception necessary for PFPS management. The results suggest that EG 2 showed better improvements than CG but not as strong as that seen with hip-strengthening exercises (EG 1). This may imply that the neuromuscular regimen may only be an adjunct to conventional therapy and may not match the effectiveness of a strengthening regimen in bringing about significant relief of symptoms in PFPS.

The implications of such a study underline the need for PFPS rehabilitation to be coupled with a suitably designed exercise program, with an all-important emphasis on hip abductor and external rotator strengthening[20]. This helps develop muscle force, improves knee joint stability, and reduces patellofemoral joint load in the knees, simultaneously reducing symptoms and augmenting functional results.

Future research could further explore the long-term impacts of these interventions over and above the four weeks under observation in this study. However, exploring optimal combinations of different therapeutic approaches, such as integrating neuromuscular training and some particular muscle-strengthening exercises, is expected to provide additional information on enhancing treatment potency for PFPS patients.

Conclusion

The findings provide evidence to support hip abductor and external rotator strengthening exercises as a cornerstone in managing PFPS. Conclusively, the study aids in more accuracy of clinical practice and results for treating this common knee disorder, which will be put into a position of specifying the differential impacts of various modes of treatment.

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Conflict of Interest
None.

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None.

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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design: Bhutto MA, Nazir AU, Katta RK

Acquisition, Analysis or Interpretation of Data: Bhutto MA, Rani M, Talha M

Manuscript Writing & Approval: Nazir AU, Talha M, Sheikh N

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.