



Short-term effects of hip and knee muscles strengthening in improving pain and functional status in sedentary females with Patellofemoral pain syndrome: A Randomized Clinical pilot study

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CONFLICT OF INTEREST

None declared.



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ABSTRACT

Objective: To compare the short-term effects of knee-muscle strengthening alone with combined knee- and hip-muscle strengthening on pain intensity and lower-extremity functional status in sedentary females with patellofemoral pain syndrome (PFPS).

Methods: This single-blind randomized clinical pilot study included 40 females with PFPS, allocated equally to two groups by lottery-based simple randomization. Group A received knee-muscle strengthening with lower-limb stretching, while Group B received the same knee protocol with additional hip abductor and lateral-rotator strengthening. The intervention was delivered over two weeks (two sessions per week). Pain was measured using the Numeric Pain Rating Scale (NPRS), and lower-extremity function was assessed using the Lower Extremity Functional Scale (LEFS). Repeated-measures analysis of variance was used for within-group comparisons, and independent-samples t tests compared change scores between groups.

Results: Pain decreased significantly over time in both groups ($p < 0.001$). Mean NPRS reduction was 2.70 ± 0.57 points in Group A and 3.60 ± 0.50 points in Group B; the between-group difference in improvement was 0.90 points (95% CI 0.56 to 1.24; $p < 0.001$). LEFS scores also improved significantly over time in both groups ($p < 0.001$). The reported mean functional improvement was 8.55 ± 1.19 points in Group A and 11.30 ± 1.22 points in Group B, corresponding to a 2.75-point greater improvement in Group B (95% CI 1.98 to 3.52; $p < 0.001$).

Conclusion: Over two weeks, both exercise approaches improved pain and lower-extremity function in sedentary females with PFPS. The combined knee- and hip-strengthening programme produced greater short-term improvement than knee strengthening alone. These findings support further evaluation in adequately powered trials with longer follow-up.

Keywords

Hip; Knee; Muscle strengthening; Pain; Patellofemoral pain syndrome; Rehabilitation.

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Naqvi J et al. Short Title

Hip and Knee Strengthening in PFPS





INTRODUCTION

Patellofemoral pain syndrome (PFPS), commonly referred to as patellofemoral pain, is characterized by pain around or behind the patella that is typically aggravated by activities that load the patellofemoral joint during knee flexion, including stair negotiation, squatting, kneeling, running, and prolonged sitting. The condition is multifactorial and may involve local knee factors, proximal hip mechanics, muscle performance, movement patterns, and activity-related loading. Contemporary evidence supports exercise therapy and education as core components of conservative management. [1,2] Reduced strength or altered function of the hip abductors and external rotators may contribute to impaired control of femoral motion during weight-bearing tasks. Although hip weakness may not represent a single causal mechanism, biomechanical and clinical evidence indicates that hip muscle performance is relevant to symptoms and function in people with PFPS. [3-5] This is particularly important in females, in whom patellofemoral pain is commonly studied and proximal strengthening has shown clinically useful effects.

Exercise programmes targeting the knee improve pain and function, while programmes that incorporate hip strengthening can provide comparable or, in some studies, greater short-term benefits. Recent systematic reviews and clinical trials indicate that combined hip- and knee-targeted rehabilitation is an appropriate evidence-based option, although the magnitude of superiority over isolated knee- or hip-focused exercise varies between studies. [2-10] These findings suggest that strengthening both proximal and local muscle groups may be clinically useful, especially when treatment is individualized. Despite the growing evidence base, comparatively little information is available on very short-duration strengthening programmes in sedentary females with PFPS. The present pilot study therefore evaluated the short-term effects of knee-muscle strengthening alone versus combined knee- and hip-muscle strengthening on pain and lower-extremity functional status in sedentary females with PFPS. The study hypothesized that adding hip abductor and lateral-rotator strengthening to a knee-focused programme would result in greater improvement in pain and function.

MATERIALS AND METHODS

This was a single-blind, randomized clinical pilot study conducted over four months in an orthopedic outpatient setting. Fifty-five patients were assessed for eligibility. Forty sedentary females diagnosed with PFPS by an orthopedic surgeon and meeting the eligibility criteria were enrolled using convenience sampling. After informed consent, participants were randomized in a 1:1 ratio by lottery method to Group A (n=20) or Group B (n=20). The trial was reported with reference to CONSORT principles for parallel-group randomized trials. [13] The study sample size was 40 participants, calculated using OpenEpi software. Twenty participants were allocated to each group. Recruitment and group allocation were distinct processes: eligible participants were recruited by convenience sampling, while treatment allocation was performed by simple randomization using the lottery method.

Eligible participants were sedentary females aged 21-50 years with unilateral anterior knee pain for at least three months and pain during at least two activities or clinical situations associated with patellofemoral loading, including stair ascent or descent, kneeling, prolonged sitting, or palpation of the medial or lateral patellar facet. Diagnosis was established by an orthopedic surgeon using clinical examination and radiographic assessment as described in the original protocol. Exclusion criteria were pregnancy, bilateral anterior knee pain, chondromalacia patellae, neurological disorders, trauma involving the hip or ankle, lower-extremity surgery within the previous six months, low-back or sacroiliac pain, rheumatoid arthritis, previous corticosteroid or NSAID use as specified in the study protocol, red-flag conditions including uncontrolled diabetes, uncontrolled hypertension or unresolved pyrexia, meniscal or ligament injury, tendinopathy, osteoarthritis, patellar instability, and epiphysitis.

Group A received stretching of the quadriceps, iliotibial band, hamstrings and plantar flexors, together with strengthening exercises for the quadriceps and hamstrings. Group B received the same knee-focused programme with additional strengthening of the hip abductors and lateral rotators. Each exercise was performed for 10 repetitions per session. Treatment was provided for two weeks at a frequency of two sessions per week, resulting in four treatment sessions. The same intervention schedule was used throughout the study period. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), an 11-point scale ranging from 0 (no pain) to 10 (worst imaginable pain), with lower scores indicating less pain. Lower-extremity function was measured using the Lower Extremity Functional Scale (LEFS), a 20-item patient-reported measure scored from 0 to 4 per item for a total score of 0-80; higher scores indicate better functional ability. The LEFS is an established measure of lower-extremity functional status. [12] Assessments were recorded before treatment, immediately after the initial treatment session, and at subsequent assessment points reported as 3, 7 and 11 days after the first session.

All participants were informed about the study purpose and procedures and provided written informed consent before participation. Participant confidentiality, dignity and safety were maintained. The study received ethical approval from the institutional review board. The clinical trial was registered in the Iranian Registry of Clinical Trials (IRCT20230615058490N2). Data were analyzed using SPSS version 20. Descriptive statistics were used for demographic characteristics and outcome measures. Repeated-measures one-way ANOVA was used to evaluate changes in NPRS and LEFS scores across the reported assessment times within each group. Independent-samples t tests were used to compare the magnitude of improvement between Group A and Group B. Statistical significance was set at $p < 0.05$. Where the original output reported $p = 0.00$, results are presented as $p < 0.001$ in accordance with standard statistical reporting practice.



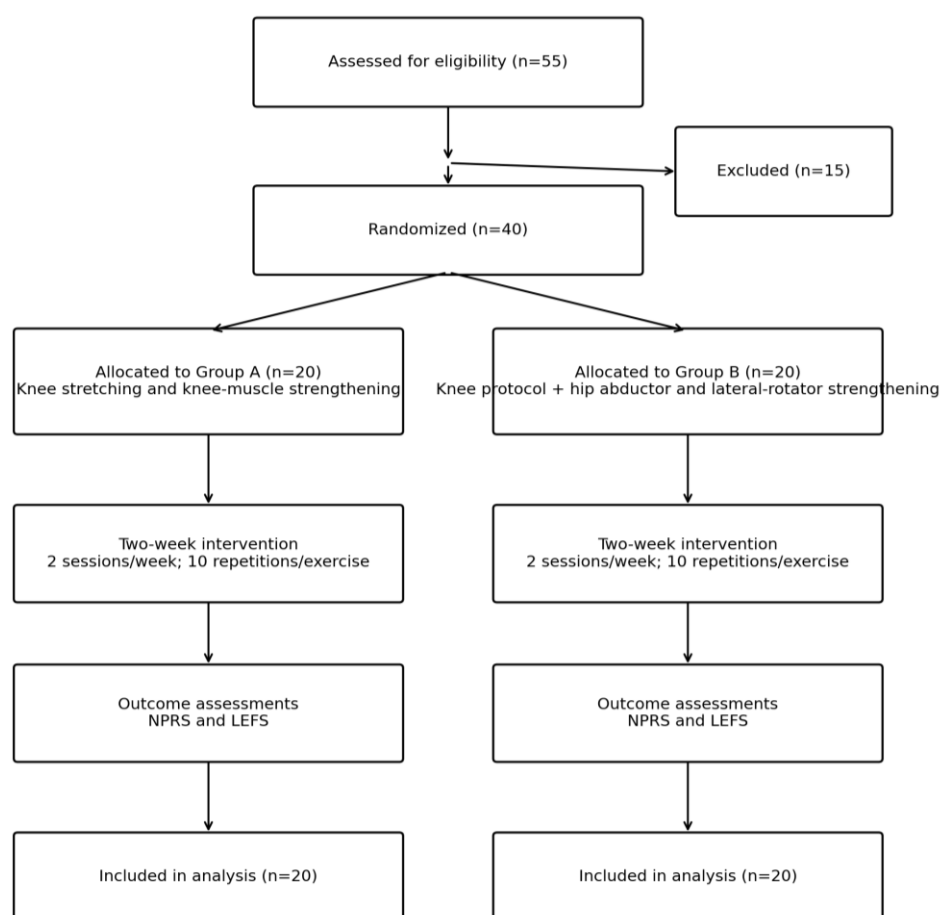


Figure 1. Participant flow through recruitment, randomization, intervention and analysis.

RESULTS

Forty participants were included in the study and randomized equally between the two treatment groups. The overall age distribution was 5 participants aged 21-30 years, 26 aged 31-40 years and 9 aged 41-50 years. According to BMI category, 18 participants were of normal weight, 13 were overweight and 9 were obese.

Characteristic	Category	n	%
Age	21-30 years	5	12.5
	31-40 years	26	65.0
	41-50 years	9	22.5
BMI	Normal weight (18.5-24.9 kg/m ²)	18	45.0
	Overweight (25.0-29.9 kg/m ²)	13	32.5
	Obese (≥30.0 kg/m ²)	9	22.5

Table 1. Demographic distribution of the total study sample.

NPRS scores decreased progressively across the assessment period in both groups. Group A improved from 7.70 ± 0.86 at baseline to 5.00 ± 0.97 at day 11, while Group B improved from 7.75 ± 0.63 to 4.15 ± 0.67 . Repeated-measures ANOVA demonstrated a significant change over time in Group A, $F(4,76)=339.15$, $p<0.001$, and Group B, $F(4,76)=315.79$, $p<0.001$.

Assessment	Group A mean $\pm$ SD	Group B mean $\pm$ SD
Pre-treatment	7.70 ± 0.86	7.75 ± 0.63
Same day/post-treatment	7.50 ± 1.00	7.25 ± 0.91
After 3 days	6.55 ± 0.94	6.10 ± 0.85





After 7 days	5.55 ± 0.94	5.05 ± 0.68
After 11 days	5.00 ± 0.97	4.15 ± 0.67

Table 2. NPRS scores across assessment times. Repeated-measures ANOVA: Group A $F(4,76)=339.15$, $p<0.001$; Group B $F(4,76)=315.79$, $p<0.001$.

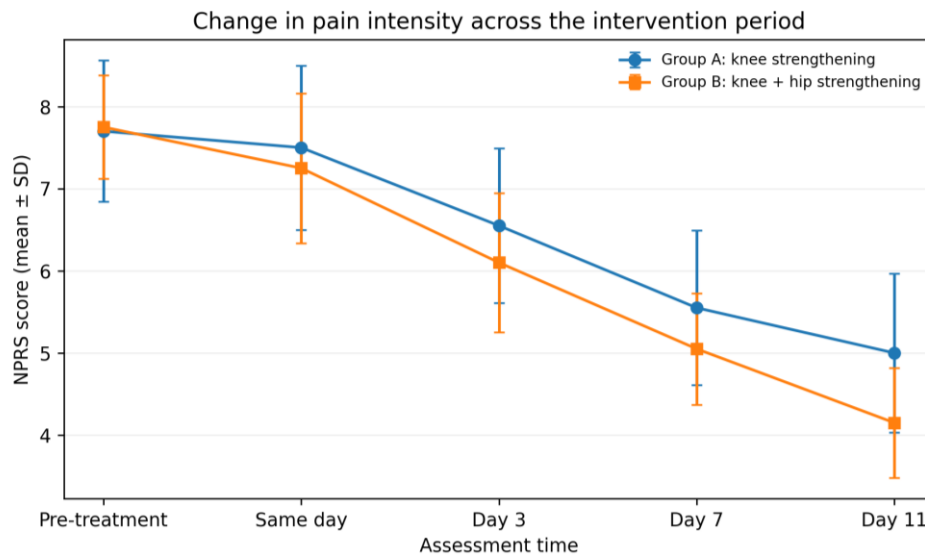


Figure 2. Mean NPRS scores ($\pm$ SD) across the intervention period.

LEFS scores increased across the assessment period in both groups. Group A increased from 27.60 ± 11.35 at baseline to 36.15 ± 11.38 at day 11, while Group B increased from 26.15 ± 12.38 to 37.50 ± 12.44 . Repeated-measures ANOVA demonstrated significant improvement over time in Group A, $F(4,76)=532.63$, $p<0.001$, and Group B, $F(4,76)=360.64$, $p<0.001$.

Assessment	Group A mean $\pm$ SD	Group B mean $\pm$ SD
Pre-treatment	27.60 $\pm$ 11.35	26.15 $\pm$ 12.38
Same day/post-treatment	27.60 $\pm$ 11.35	26.15 $\pm$ 12.38
After 3 days	30.85 $\pm$ 11.46	29.65 $\pm$ 12.37
After 7 days	33.65 $\pm$ 11.54	33.95 $\pm$ 12.19
After 11 days	36.15 $\pm$ 11.38	37.50 $\pm$ 12.44

Table 3. LEFS scores across assessment times. Repeated-measures ANOVA: Group A $F(4,76)=532.63$, $p<0.001$; Group B $F(4,76)=360.64$, $p<0.001$.

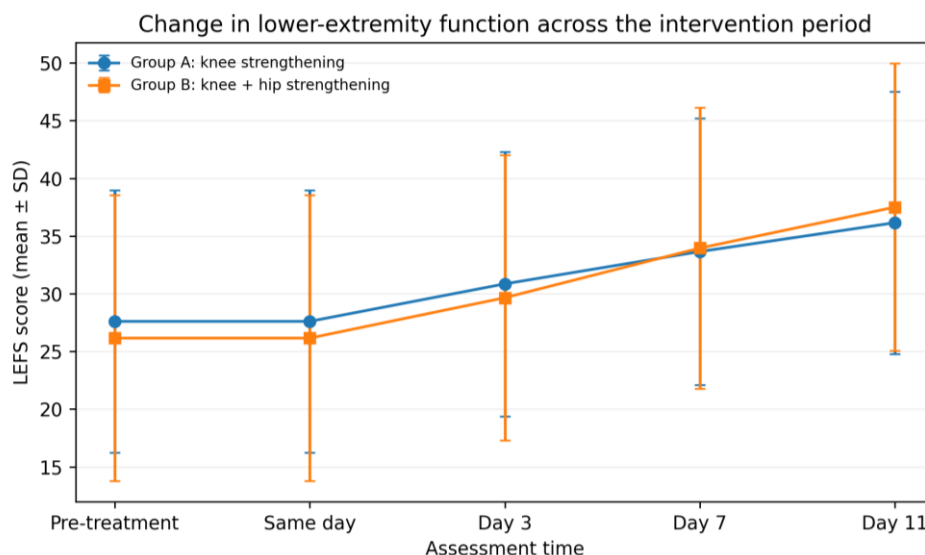


Figure 3. Mean LEFS scores ($\pm$ SD) across the intervention period.



The mean reduction in NPRS was 2.70 ± 0.57 points in Group A and 3.60 ± 0.50 points in Group B. The 0.90-point greater reduction in Group B was statistically significant, $t(38) = -5.29$, $p < 0.001$; the 95% confidence interval for the difference in improvement was 0.56 to 1.24 points. The reported mean LEFS improvement was 8.55 ± 1.19 points in Group A and 11.30 ± 1.22 points in Group B. This represented a 2.75-point greater improvement in Group B, $t(38) = -7.22$, $p < 0.001$; the 95% confidence interval for the difference was 1.98 to 3.52 points.

Outcome	Group A change mean $\pm$ SD	Group B change mean $\pm$ SD	t (df)	p-value	Difference in improvement (95% CI)
NPRS reduction	2.70 ± 0.57	3.60 ± 0.50	-5.29 (38)	<0.001	0.90 (0.56 to 1.24)
LEFS improvement	8.55 ± 1.19	11.30 ± 1.22	-7.22 (38)	<0.001	2.75 (1.98 to 3.52)

Table 4. Between-group comparison of change scores. CI values were calculated from the reported group means, standard deviations and sample sizes.

DISCUSSION

This randomized clinical pilot study found that both knee-focused strengthening and combined knee- and hip-focused strengthening were associated with short-term reductions in pain and improvements in lower-extremity function in sedentary females with PFPS. The combined programme produced a greater reduction in NPRS and a greater improvement in LEFS change scores than the knee-focused programme over the two-week intervention period. The direction of these findings is consistent with contemporary syntheses supporting exercise therapy as the central component of PFPS management. The 2024 best-practice guide recommends knee-targeted exercise, with or without hip-targeted exercise, supported by education and individualized adjuncts. [1] A 2022 systematic review of high-quality trials likewise found short-term efficacy for knee-targeted exercise and additional benefit from hip-and-knee-targeted exercise for pain and function in some comparisons. [2]

The present results also align with systematic reviews specifically examining proximal strengthening. Manojlović et al. reported that hip-and-knee programmes were effective for pain and functional outcomes, while Na et al. found that both isolated hip and knee strengthening improved symptoms, with some studies showing earlier pain reduction after hip-focused treatment. [4,6] More recent evidence continues to support hip abductor and external-rotator strengthening as a useful component of rehabilitation, although the relative superiority of one exercise focus over another is not uniform across trials. [7-10] A plausible explanation for the additional short-term benefit observed in Group B is that strengthening the hip abductors and lateral rotators may improve proximal control of the femur during lower-limb loading, potentially reducing adverse movement strategies that increase patellofemoral stress. Current biomechanical evidence supports an association between PFPS and altered hip muscle performance or lower-limb mechanics, while also emphasizing that PFPS is multifactorial rather than attributable to a single strength deficit. [5] This interpretation supports combining proximal and knee-targeted exercise rather than viewing either muscle group in isolation.

The short duration of this trial should be considered when interpreting the magnitude and durability of benefit. Trials using longer programmes have demonstrated improvement with both hip- and quadriceps-focused exercise, and some have found broadly equivalent outcomes between exercise approaches. [8,9] Therefore, the current findings are best interpreted as evidence of a short-term signal favoring the combined programme in this sample rather than proof of long-term superiority. The study was a pilot trial with a small sample and short two-week intervention period, limiting precision and long-term inference. Participants were sedentary females recruited from a single clinical setting, which limits generalizability to males, athletic populations and other care settings. Convenience recruitment may have introduced selection effects despite randomized treatment allocation. The intervention description was based on a relatively brief exercise protocol, and the study did not evaluate persistence of treatment effects beyond the immediate short-term period. In addition, the single-blind design cannot eliminate all performance-related bias inherent to exercise interventions. Larger trials with longer follow-up, standardized progression of exercise dosage and blinded outcome assessment are warranted.

Future studies should use larger samples, longer intervention and follow-up periods, standardized exercise progression, clearly defined allocation and assessor-blinding procedures, and clinically meaningful outcome thresholds. Rehabilitation programmes may consider integrating hip and knee strengthening while tailoring exercise selection and progression to the individual clinical presentation.

CONCLUSION

Both knee-focused strengthening and combined knee- and hip-focused strengthening improved pain and lower-extremity function over two weeks in sedentary females with PFPS. The combined programme produced greater short-term improvement in NPRS and LEFS change scores. These pilot findings support inclusion of hip abductor and lateral-rotator strengthening alongside knee strengthening and justify confirmation in larger, adequately powered trials with longer follow-up.

AUTHORS' CONTRIBUTION

JN, IT, MA, SM and LS were responsible for the study's conception and design, research methodology, supply of study materials, and data collection and organization. MA and KA analyzed and interpreted data. IT and AS wrote the initial and final drafts of the





article and managed its logistics. KS and HT amended the article's initial version. All authors have reviewed and approved the work's final manuscript and are also accountable for the materials and similarity index.

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