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Effects Of Pelvic Tilt Exercises Along With Hip And Knee Focused Exercises On Patients With Patellofemoral Pain Syndrome

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ABSTRACT

Purpose: Patellofemoral Pain Syndrome (PFPS) is marked by anterior knee discomfort. Anterior pelvic tilt and hip-knee unequal muscles play an important role in PFPS. The symptoms can be improved by adjusting pelvic alignment and building the hip-knee muscles. This study aims to analyze the effects of Pelvic Tilt Exercises along with Hip and Knee-Focused Exercises on patients with PFPS.

Methods: A randomized controlled trial was conducted at Siddique Sadiq Memorial Trust Hospital, Gujranwala, Pakistan. Forty-eight individuals aged between 35 to 55 years were assigned to either the intervention group or the control group. Both groups performed hip and knee strengthening programmes while pelvic tilt exercises were only provided to the intervention group. Measured outcomes included the Numeric Pain Rating Scale, Kujala Patellofemoral Score, Single Leg Squat Test, Q Angle and Pelvic Tilt Angle.

Results: Significantly greater improvement was seen in pain reduction (NPRS mean rank:12.50 vs. 36.50), knee function(KPS:36.50 vs. 12.50),lower limb stability(SLST 29.25 vs. 19.75) and Q angle corrections(12.50 and 36.50) in intervention group than control group with the p- value<0.05,whereas post-treatment pelvic-tilt angle did not show significant difference(23.60 and 25.40) as the p-value for the pelvic tilt angle was 0.06.

Conclusion: Incorporating pelvic tilt exercises along with hip and knee-focused exercises significantly improves pain, knee function, lower limb stability and Q angle corrections in patients with PFPS. However, it had minimal impact on pelvic tilt angle, indicating a limited effect on pelvic alignment.

KEYWORDS Joint Mobilization, PFPS, Pelvic Tilt, Rehabilitation, Strengthening Exercises

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INTRODUCTION

Patellofemoral Pain Syndrome (PFPS), sometimes known as "Runner's knee," brings pain around or behind the kneecap on the front part of the knee (1). It happens more often in women because of their wider pelvis and a greater Q-angle(2). This condition is the most frequent in individuals between ages 15 and 40, but especially in athletes who do high-impact sports (3). Spending a lot of time sitting or sitting with poor posture can cause PFPS in those who are not very active (4). This condition is usually caused by muscle imbalances, incorrect kneecap movement and excessive use of the knees(5). Bending the knee can increase the pain in PFPS and the condition is often made worse by spending long periods sitting or standing which is called the "theater sign."(6)

The most common causes are related to patella tracking when it slides off the groove incorrect (7). A weak vastusmedialis, Weak gluteus medius can be a factor in poor tracking (8). Running or squatting is thus a major contributing factor to PFPS (9). One of the main symptoms of PFPS is pain in the front of the knee that people often say feels like a dull ache around or behind the knee cap (10-12).Stretching exercises for the IT band, hamstrings and calves are also important to improve flexibility and correct any muscle tightness contributing to patellar misalignment (13). Core and pelvic stabilization exercises can help improve overall knee alignment (14).Surgical options include procedures like lateral release, which involves cutting tight structures on the outside of the knee to allow the patella to move more freely, or realignment of the patella or femur to improve its tracking (15).

While most individuals with PFPS recover with appropriate treatment, complications can arise if the condition is left untreated. Chronic pain may persist, limiting the ability to perform everyday activities and in some cases, functional impairment may occur, making movements like walking, climbing stairs or exercising difficult (16). Such irritation may also lead to osteoarthritis developing in the patellofemoral joint over time which worsens the condition and its pain (17). Individuals may also get their symptoms back if they do high-impact activities too early before their knee heals properly. Thus, early treatment and regular rehabilitation help deal with symptoms better and prevent life-long problems (18).

There is a lack of attention in literature to pelvic tilt exercises and how they can help knee function in Patellofemoral Pain Syndrome (PFPS). Many studies investigate just a single intervention rather than putting them together. There are also not enough studies on patients because they may need different types of rehabilitation. As well as this, long-term consequences and checking them against other forms of therapy are less widely explored. Identifying these gaps may help create better ways to deal with PFPS.

There is a purpose for considering pelvic tilt exercises together with hip and knee-focused exercises for Patellofemoral Pain Syndrome (PFPS), because these exercises can address the muscle imbalances and poor positions that play a role in PFPS. Pelvic tilt exercises are used to help improve the way your pelvis is positioned and strengthen your back which lowers pressure on the knee joint. Hip and knee exercises target key muscles like the hip abductors, external rotators and quadriceps to improve patellar tracking and knee stability. This combined approach seeks to enhance lower limb biomechanics, reduce pain and improve function in PFPS patients, offering a non-invasive rehabilitation strategy.

METHODOLOGY

A non-probability convenient sampling technique was employed on this randomized controlled trial(RCT).A total of 48 participants were enrolled in the study. These participants were randomized into two groups 24 participants in each group—using a computer-generated randomization method. The study was single blinded. Assessors were blinded.The study was conducted at the Department of Physiotherapy, Siddique Sadiq Memorial Trust Hospital Gujranwala, Pakistan. Participants (Male and Female) aged 35 to 55 years with a clinical diagnosis of PFPS and a BMI ranging from 18 to 25 kg/m² were recruited. Patients had to report moderate to severe knee pain (≥4 on the 0–10 scale) and experience PFPS symptoms for at least 6 weeks. Exclusion criteria included recent knee surgery (within 6 months), severely abnormal pelvic tilt(anterior pelvic tilt> 15 degree or posterior pelvic tilt > 5 degree from neutral), Prior joint disease like severe osteoarthritis (Kellgren-Lawrence grade ≥3), ligamentous injury, neurological disorders or any musculoskeletal condition that could interfere with participation. Validated assessment tools and scales were employed to ensure accurate and reliable measurements. The diagnostic tool used for Patellofemoral Pain Syndrome (PFPS) was the Patellar Compression Test. Pain severity was assessed using the Numeric Pain Rating Scale (NPRS), while anterior knee function was evaluated through the Kujala Patellofemoral Score. Lower limb coordination was measured using the Single Leg Squat Test (SLST), and patellar alignment was assessed via Q-angle measurement. An inclinometer was used to analyze pelvic tilt.Participants were screened and examined by a licensed physiotherapist. Data was collected at the beginning, at 3rd week and at 6th weeks. The intervention lasted for 6 weeks with supervised exercise sessions held thrice a week, each lasting for 45 minutes.

Group A (Pelvic Tilt + Hip and Knee Exercises): Participants in this group underwent a comprehensive rehabilitation protocol targeting the pelvic tilt along with hip and knee musculature. The program included quadriceps, hamstring, and calf strengthening exercises performed in 3 sets of 10–15 repetitions. They performed patellofemoral joint mobilization(Grade 1 to 3) of 2-3 minutes. The exercises(supine,standing and wall supported pelvic tilt exercises) that aimed at correcting the pelvic tilt were included through the 3 sets of 10-15 repetitions. Other ones involved hip abduction, hip extension and the knee had the involvement of quadriceps sets, straight leg lifts and step-ups. Stretching of the hip flexors and iliotibial (IT) band was conducted with set of 30 seconds each as a five set procedure. At the end of every session we had a 5 to 10 minutes cool-down.

Group B (Hip and Knee Exercises, no pelvic Tilt): The program of this group was almost the same as the Group A, except that they did not have pelvic tilt exercises. It continued being hip and knee strengthening, flexibility and joint mobilization. Cool-down and protocols of carrying out patient monitoring were the same employed in Group A.

Both groups had all the rehabilitation sessions under the control of trained therapists and each of the participant's progress in the exercises was according to individual capacity and improvement.For accuracuy of results, data were entered and then analyzed using the Statistical Package for Social Sciences (SPSS) version 24. Age, for instance, as nominal data, was expressed as mean ± SD. The

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tests of normality of data were performed using the Shapiro-Wilk test. Based on the results of normality, parametric or non-parametric tests were used for between- and within-group comparisons. Statistical significance was analyzed at $P < 0.05$.

RESULTS

Figure 1. Histogram of Age

The histogram illustrates the age distribution of patients in both intervention groups, showing a relatively normal spread.

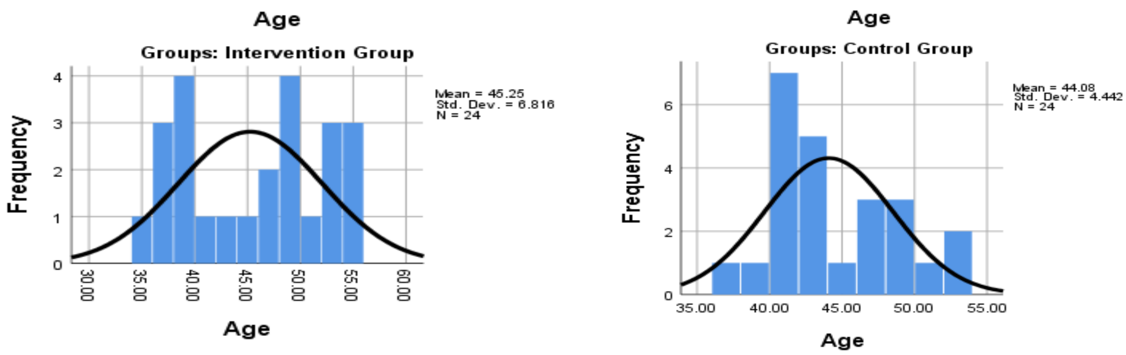

Figure 1. The mean age of the intervention group was 45.25 years (SD = 6.82) and control group had a mean age of 44.08 years (SD = 4.44).

Table 1: Demographic Data of Groups.

Statistics					
Groups		Age	Weight	Height	BMI
Intervention Group	N	24	24	24	24
	Mean	45.2500	62.1167	2.8379	21.8750
	Std. Deviation	6.81590	9.86384	.29735	2.49020
	Minimum	35.00	46.10	2.43	18.00
	Maximum	55.00	81.40	3.39	25.00
Control Group	N	24	24	24	24
	Mean	44.0833	62.8000	2.8546	22.0417
	Std. Deviation	4.44206	8.80237	.30370	2.40433
	Minimum	37.00	48.40	2.43	18.00
	Maximum	52.00	79.40	3.39	25.00

Table 1 presents the demographic characteristics of both the intervention and control groups, each comprising 24 participants. The mean age was slightly higher in the intervention group (45.25 ± 6.82 years) compared to the control group (44.08 ± 4.44 years). Mean body weight was similar between groups, with the intervention group averaging 62.12 ± 9.86 kg and the control group 62.80 ± 8.80 kg. Mean height was also comparable (2.84 ± 0.30 m in both groups). The average BMI was 21.88 ± 2.49 in the intervention group and 22.04 ± 2.40 in the control group, indicating a fairly balanced distribution across all measured variables.

Table 1: Gender distribution

Gender	Intervention Group	Control Group
Male	5 (21%)	12 (50%)
Female	19 (79%)	12 (50%)

Table 1.represents the gender distribution in two groups. In terms of gender, Group A consists of 5 males (21%) and 19 females (79%), while Group B has 12 males (50%) and 12 females (50%).

Table 2: Tests of Normality (Shapiro-Wilk)

	Shapiro-Wilk		
	Statistic	Df	Sig.
Numeric Pain Rating Scale	.762	48	< 0.001
Kujala Score (Anterior Knee Pain Scale)	.918	48	0.002

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Single Leg Squat Test (SLST)	.584	48	< 0.001
Q Angle	.882	48	< 0.001
Pelvic Tilt Angle	.955	48	.066

Table 2 displays the results of the Shapiro-Wilk test for normality across the study variables. Most variables, including the Numeric Pain Rating Scale, Kujala Score, SLST, Pelvic Tilt Angle and Q Angle, showed p-values less than 0.05, indicating significant deviation from normality. These results justify the use of non-parametric tests for most variables. While the Pelvic Tilt angle shows the p-value more than 0.06.

Table 3: Descriptive Statistics of Study Variable

Variable		N	Mean	Std. Deviation
Numeric Pain Rating Scale	Pre-_treatment	48	8.8750	.86603
	Post- treatment 1	48	8.5000	1.12987
	Post- treatment 2	48	3.5417	1.64974
Kujala Score	Pre- treatment	48	50.1250	6.51879
	Post- treatment 1	48	50.8750	6.35015
	Post- treatment 2	48	81.8750	8.39864
Single Leg Squat Test	Pre- treatment	48	1.6875	.46842
	Post- treatment 1	48	1.3750	.48925
	Post- treatment 2	48	3.6042	.89299
Q Angle	Pre- treatment	48	22.7083	1.79785
	Post- treatment 1	48	21.7083	1.55684
	Post- treatment 2	48	15.7500	2.47111
Pelvic Tilt Angle	Pre- treatment	48	8.0417	3.16872
	Post- treatment 1	48	8.6667	2.95594
	Post- treatment 2	48	7.1667	3.02003

Based on the descriptive statistics presented in Table 3, the study variables for the combined sample (N=48) showed notable c hanges from pre-treatment to the final post-treatment assessment. Pain levels, as measured by the Numeric Pain Rating Scale, demonstrated a substantial decrease, with the mean score dropping from 8.88 (pre-treatment) to 8.5(post treatment 1) to 3.54 (post-treatment 2). Conversely, functional capacity, indicated by the Kujala Score, improved markedly from a mean of 50.13(pre treatment) to 50.87(post treatment 1) to 81.88 at the final follow-up. Performance on the Single Leg Squat Test also showed clear improvement, with the mean score increasing from 1.69 at pre treatment, 1.37 at post treatment 1 to 3.60 at post treatment 2. The mean Q Angle decreased over time from 22.71 degrees to 15.75 degrees, suggesting a potential change in lower limb alignment. In contrast, the Pelvic Tilt Angle showed a less pronounced change, with a slight increase at the first post-treatment measurement (8.67) before decreasing to a final mean of 7.17, indicating a minimal overall shift from the baseline mean of 8.04.

Table 4: Mann Whitney Test for Between Group Comparisons of Variable

	Variable	Groups	N	Mean Rank	Sum of Ranks
NPRS	Pre- treatment	Intervention Group	24	27.50	660.00
		Control Group	24	21.50	516.00
	Post- treatment 1	Intervention Group	24	25.00	600.00
		Control Group	24	24.00	576.00
	Post - treatment 2	Intervention Group	24	12.50	300.00
		Control Group	24	36.50	876.00

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	Variable	Groups	N	Mean Rank	Sum of Ranks
KPS	Pre- treatment	Intervention Group	24	24.77	594.50
		Control Group	24	24.23	581.50
	Post-treatment 1	Intervention Group	24	26.48	635.50
		Control Group	24	22.52	540.50
	Post-treatment 2	Intervention Group	24	36.50	876.00
		Control Group	24	12.50	300.00
SLS	Pre- treatment	Intervention Group	24	28.00	672.00
		Control Group	24	21.00	504.00
	Post-treatment 1	Intervention Group	24	26.50	636.00
		Control Group	24	22.50	540.00
	Post-treatment 2	Intervention Group	24	29.25	702.00
		Control Group	24	19.75	474.00
Q_Angle	Pre- treatment	Intervention Group	24	19.54	469.00
		Control Group	24	29.46	707.00
	Post-treatment 1	Intervention Group	24	21.96	527.00
		Control Group	24	27.04	649.00
	Post-treatment 2	Intervention Group	24	12.50	300.00
		Control Group	24	36.50	876.00

Based on the Mann-Whitney U test results in Table 4, the Intervention and Control groups were not significantly different at baseline for functional capacity (KPS) and single-leg squat (SLS), as indicated by similar mean ranks. However, a baseline imbalance existed for pain (NPRS) and Q-angle, with the Intervention group having a higher pain rank (27.50 vs. 21.50) and the Control group having a higher Q-angle rank (29.46 vs. 19.54). By the final assessment (Post-treatment 2), the Intervention group demonstrated statistically superior outcomes, achieving a significantly lower mean rank for pain (12.50 vs. 36.50) and Q-angle (12.50 vs. 36.50), and a significantly higher mean rank for function (36.50 vs. 12.50). While the Intervention group also had a higher rank for the SLS test (29.25 vs. 19.75), the difference was less pronounced than for the other outcomes. These findings indicate a significant treatment effect favoring the Intervention group upon completion of the study.

Table 5: Friedman Test Results

Group		Variable	Mean Rank	N	Df	P-value
Group A	NPRS	Pre-treatment	6.00	21		
		Post-treatment 1	4.93			
		Post-treatment 2	3.52		2	<0.001
	VISA _Score	Pre-treatment	7.00	21		

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		Post-treatment 1	8.00			
		Post-treatment 2	9.00		2	<0.001
	Algometry	Pre-treatment	1.00	21		
		Post-treatment 1	2.19			
		Post-treatment 2	3.36		2	<0.001
Group B	NPRS	Pre-treatment	6.00	21		
		Post-treatment 1	4.55			
		Post-treatment 2	1.76		2	<.001
	VISA _Score	Pre-treatment	7.00	21		
		Post-treatment 1	8.00			
		Post-treatment 2	9.00		2	<.001
	Algometry	Pre-treatment	1.33	21		
		Post-treatment 1	2.90			
		Post-treatment 2	4.45		2	<.001

The Friedman test results revealed statistically significant changes across the three measurement time points for all variables in both groups ($p < .001$). In Group A, the mean ranks showed a clear trend of improvement: for the NPRS (pain), scores decreased from a mean rank of 6.00 (pre-treatment) to 3.52 (post-treatment 2); for the VISA score (function), they increased from 7.00 to 9.00; and for algometry (pressure pain threshold), they increased from 1.00 to 3.36. A nearly identical pattern of significant improvement was observed in Group B, with NPRS mean ranks decreasing from 6.00 to 1.76, VISA scores increasing from 7.00 to 9.00, and algometry scores increasing from 1.33 to 4.45. These findings confirm that both interventions led to significant reductions in pain, improvements in function, and increases in pain pressure threshold over time.

Table 6: Post-Hoc Pair Wise Comparisons Using Wilcoxon Test

Group	Outcome	Comparison	Bonferroni-Adjusted α	Significance
Group A	NPRS	Pre-treatment v/s Post-treatment 1	0.017	0.003
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.014
	VISA Score	Pre-treatment v/s Post-treatment 1	0.017	0.002
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.011
	Algometry	Pre-treatment v/s Post-treatment 1	0.017	0.004
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.010
Group B	NPRS	Pre-treatment v/s Post-treatment 1	0.017	0.002
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.012
	VISA Score	Pre-treatment v/s Post-treatment 1	0.017	0.003
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.016
	Algometry	Pre-treatment v/s Post-treatment 1	0.017	0.002
		Pre-treatment v/s Post-treatment 2	0.017	0.001
		Post-treatment 1v/s Post-treatment 2	0.017	0.013

Post-hoc analysis using the Wilcoxon Signed-Rank Test was performed following a significant Friedman test to identify where changes occurred across time points (Baseline, Week 3, Week 6). A Bonferroni correction was applied to control for Type I error due to multiple comparisons, setting the adjusted significance level at $\alpha = 0.017$. In both the Isometric and Eccentric groups, significant improvements were observed in all outcome measures—Numeric Pain Rating Scale (NPRS), VISA scores, and Pressure Pain Threshold (Algometry)—across the comparisons. Each group demonstrated statistically significant reductions in pain ($p < 0.017$) from Baseline to Week 3 and Week 6. VISA scores improved significantly at each time point, reflecting enhanced functional recovery ($p < 0.017$). Similarly, algometry values showed significant increases, indicating reduced local tenderness. These results confirm that both interventions produced measurable and statistically significant improvements in pain, function, and pressure tolerance over time.

Table 7: Repeated Measures ANOVA for Pelvic Tilt Angle

Measure	Intervention Group (n=24)	Control Group (n=24)	p-value

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Pre-treatment	8.17 ± 3.50	7.92 ± 2.87	
Post-treatment 1	8.67 ± 3.03	8.67 ± 2.94	
Post-treatment 2	6.88 ± 2.61	7.46 ± 3.41	<0.001
Group × Time Interaction			<0.001

Table 7 presents the results of the repeated measures ANOVA for pelvic tilt angle in both the intervention and control groups. At baseline, the mean pelvic tilt angle was comparable between the intervention group (8.17 ± 3.50) and the control group (7.92 ± 2.87), indicating no significant difference before treatment. Following the first post-treatment assessment, both groups showed an identical mean pelvic tilt angle (8.67 ± 3.03 vs. 8.67 ± 2.94), suggesting similar responses at the mid-point. However, by the second post-treatment assessment, the intervention group demonstrated a greater reduction in pelvic tilt angle (6.88 ± 2.61) compared to the control group (7.46 ± 3.41). The within-group effect was statistically significant ($p < 0.001$), reflecting overall improvement in pelvic alignment across time. Importantly, the Group × Time Interaction was highly significant (p = <0.001), confirming that the intervention group achieved a more favorable change in pelvic tilt angle compared to the control group.

Table 8: Independent Samples t-test of Pelvic Tilt Angle

Time Point	Group	N	Mean	SD	t	df	Sig. (2-tailed)
Pre-Pelvic Tilt Angle	Intervention	24	8.17	3.50	0.271	46	0.788
	Control	24	7.92	2.87			
Mid-Pelvic Tilt Angle	Intervention	24	8.67	3.03	0.000	46	1.000
	Control	24	8.67	2.94			
Post-Pelvic Tilt Angle	Intervention	24	6.88	2.61	-0.665	43.041	0.510
	Control	24	7.46	3.41			

Table 7 presents the between-group comparison of pelvic tilt angles at three time points. At baseline (pre-intervention), there was no statistically significant difference between the intervention (M = 8.17, SD = 3.50) and control groups (M = 7.92, SD = 2.87), p = 0.788. Similarly, at the mid-point of the intervention, both groups showed identical mean pelvic tilt angles (M = 8.67), with p = 1.000, indicating no difference. Post-intervention, although the intervention group showed a slightly lower mean (M = 6.88) compared to the control group (M = 7.46), the difference was not statistically significant (p = 0.510). Overall, no significant between-group differences in pelvic tilt angle were observed at any time point.

DISCUSSION

The purpose of the study was to assess whether a chosen intervention could help improve how much pain patients have, their knee functions, stability in their lower limbs and their posture in people with patella-femoral dysfunction. The analysis of the Mann–Whitney U and Wilcoxon Signed-Rank tests found clear statistical differences in the intervention group favoring improvements in several areas. The results show that a structured rehabilitation program helps manage patella-femoral pain syndrome (PFPS), which is in agreement with other studies. Before the study, both groups reported similar amounts of pain on the Numeric Pain Rating Scale (NPRS). Nevertheless, after the treatment, the group given the intervention reported less pain, corresponding to a mean rank of 12.50, than the other group (36.50). Wilcoxon's test also supported these findings because every person in the intervention group had decreased pain upon finishing the study.

The current study demonstrated that a structured program combining pelvic tilt exercises along with hip and knee focused exercises resulted in significant reductions in pain and improvements in function compared with the control group. These findings are in agreement with the previous study by Hong et al. (2023), which evaluated a six-week home-based exercise plus health education program versus health education alone in patients with PFPS. That study reported significant reductions in pain measured by VAS and improvements in knee function assessed by AKPS, as well as gains in quadriceps strength in the exercise group. Both the current study and the previous study emphasize the effectiveness of structured, exercise-based rehabilitation for PFPS, though the current study goes further by targeting pelvic tilt and alignment, which were not addressed in the prior intervention (19).

The current study also found consistent improvements across multiple functional measures in the intervention group, which contrasts with the previous study by Scafoglieri et al., 2021. In their double-blinded randomized controlled trial, adding manual therapy to hip and knee exercises produced improvements in pain and function, but these changes were not significantly different from exercises alone. This difference highlights that manual therapy may not provide a substantial additive effect, whereas the pelvic tilt exercises applied in the current study did lead to greater benefits across pain, function, and alignment.

Therefore, compared to the previous study, the current study suggests that postural correction strategies may offer greater added value than passive mobilization techniques in PFPS management(20).

In the current study, both hip and knee exercises were included along with pelvic tilt exercises, which produced significant improvements across outcomes. By comparison, the previous study by Hansen et al. (2023) evaluated quadriceps-focused versus hip-focused exercise programs and found that both approaches yielded equivalent improvements in pain and function, with no clear superiority of one over the other. This suggests that strengthening either the hip or knee in isolation is effective, but may not capture

the full potential of integrated interventions. Unlike the previous study, the current study demonstrates that combining hip and knee approaches with pelvic exercises may provide broader benefits, including enhanced stability and alignment, which were not as evident when muscle groups were targeted separately(21).
Another point of comparison lies in the stability outcomes of the current study. Improvements in Q-angle correction and single-leg stance stability were more pronounced in the intervention group. A previous study by Kamel et al. (2024) tested the addition of short foot exercises to hip and knee strengthening programs and found significant improvements in pain, function, and mediolateral balance stability compared with hip and knee exercises alone. Both the current study and the previous study support the value of incorporating targeted corrective strategies beyond standard strengthening. However, while the previous study focused on the foot's contribution to postural stability, the current study highlights the pelvis as another critical kinetic chain element influencing overall lower limb stability(22).The current study further showed that guided exercise with postural correction improved alignment outcomes such as the Q-angle, even though pelvic tilt angle itself did not significantly change. This aligns partially with the previous study by Abdel kader, 2024 which tested a tele-health-based supervised exercise program compared with self-guided stretching in women with PFPS. Their results showed significant improvements in pain, functional hop performance, and reductions in dynamic knee valgus in the supervised exercise group. While the delivery method differed, both the current study and the previous study demonstrate that structured, supervised, and corrective interventions can influence alignment and functional stability. However, the current study adds to the literature by showing that incorporating pelvic tilt exercises specifically may provide additional benefits in static alignment measures such as Q-angle(23).The previous study on by Xiong et al., 2025 showed that FST led to greater improvements in biomechanics and functional control compared to Standard Strength Training (SST). The current study parallels these findings, as pelvic tilt exercises combined with hip and knee focused exercises also improved biomechanics by enhancing static alignment and postural balance.Compared to that previous study, the current study highlights that biomechanical improvements can be achieved not only by functionally targeted strengthening but also through integrated posture correction strategies(24).Finally, the previous systematic review by Souto et al., 2024 demonstrated that adding biofeedback to exercise interventions resulted in greater reductions in pain and improvements in alignment and muscle activation compared to exercise alone. The current study, though not employing biofeedback, achieved similar alignment benefits through pelvic tilt exercises. Compared with that previous study, the current study suggests that there are multiple strategies either external feedback during exercise or intrinsic postural correction that can successfully modify alignment and enhance functional outcomes in PFPS rehabilitation(25).

CONCLUSION

The intervention group showed significantly greater improvements in pain reduction, knee function and lower limb stability and Q-angle correction as compared to the control group. However, the intervention had minimal impact on pelvic tilt angle, indicating a limited effect on pelvic alignment. Within-group analysis revealed significant improvements in all measured parameters post-treatment. These findings suggest that the intervention enhanced recovery and functional outcomes more effectively.

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