

EFFECT OF HIP ABDUCTOR STRENGTHENING COMBINED WITH PATELLAR TAPING ON PAIN AND FUNCTION IN PATIENTS WITH HOFFA'S FAT PAD IMPINGEMENT SYNDROME

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Abstract

Background: Hoffa's fat pad impingement syndrome (HFPIS) is a potential source of anterior knee pain that may impair movement and functional performance. Proximal biomechanical deficits, including reduced hip abductor strength and altered lower-limb control, may contribute to increase mechanical loading around the knee. Hip abductor strengthening may address these proximal deficits, whereas patellar taping may provide local mechanical and symptomatic support. However, evidence regarding their combined application remains limited. This study evaluated the effects of hip abductor strengthening combined with patellar taping on pain, functional ability, hip abductor strength, and knee range of motion in patients with HFPIS.

Objective: To determine the effect of hip abductor strengthening combined with patellar taping on pain, functional ability, hip abductor strength, and knee range of motion in patients with HFPIS.

Methods: A randomized controlled trial was conducted over a 6-month study period among 30 participants with HFPIS, randomly allocated to an experimental group (n=15) and a control group (n=15). The experimental group received hip abductor strengthening exercises, including clamshells and side-lying hip abduction, combined with McConnell patellar taping, whereas the control group received conventional physiotherapy comprising quadriceps strengthening, stretching, and physical modalities. The intervention was administered for 6 weeks. Pain, functional ability, hip abductor strength, and knee range of motion were assessed using the Numeric Pain Rating Scale, Kujala Anterior Knee Pain Scale, handheld dynamometry, and goniometry, respectively, before and after treatment. Within- and between-group differences were analyzed using appropriate statistical tests, with statistical significance set at $p \leq 0.05$.

Results: No significant baseline differences were observed between groups for the assessed outcomes ($p > 0.05$). Both groups demonstrated significant within-group improvements following treatment ($p < 0.001$). NPRS scores decreased

from 5.93 ± 0.80 to 2.33 ± 0.49 in the experimental group and from 5.93 ± 0.70 to 4.33 ± 0.49 in the control group, with a between-group difference in change of -2.00 points (95% CI: -2.55 to -1.45 ; $p < 0.001$). Kujala scores improved by 27.87 points in the experimental group compared with 13.60 points in the control group, yielding a between-group difference of 14.27 points (95% CI: 12.60–15.94; $p < 0.001$). Hip abductor strength increased by 4.55 kg versus 1.75 kg, while knee flexion ROM increased by 10.67° versus 4.60° in the experimental and control groups, respectively. Knee extension loss also showed greater improvement in the experimental group.

Conclusion: Hip abductor strengthening combined with patellar taping produced greater improvements in pain, functional ability, hip abductor strength, and knee range of motion than conventional physiotherapy in patients with HFPIS. The findings suggest that combining proximal strengthening with patellar taping may be a useful physiotherapy approach for managing HFPIS. Larger trials with longer follow-up are warranted to establish the durability and generalizability of these findings.

1. INTRODUCTION

The knee is a major weight-bearing joint essential for mobility and daily functional activities. The infrapatellar fat pad (IFP), or Hoffa's fat pad, is an intracapsular but extra synovial structure located beneath the patella and posterior to the patellar tendon. Because it is highly innervated and vascularized, it is particularly susceptible to mechanical irritation and inflammation. Impingement of the IFP can cause anterior knee pain, swelling, tenderness, and functional limitations, particularly during knee extension and prolonged weight-bearing activities [1, 2].

The development of Hoffa's Fat Pad Impingement Syndrome is multifactorial, with lower-limb biomechanics and neuromuscular control contributing to excessive mechanical stress. Hip abductor weakness may promote femoral adduction and internal rotation, contributing to dynamic knee valgus and altered patellofemoral mechanics. Consequently, hip abductor strengthening has gained attention as a proximal rehabilitation strategy for improving pelvic stability, lower-limb alignment, and functional performance in patients with anterior knee pain [3, 4].

Patellar taping, particularly the McConnell technique, is another commonly used conservative intervention for anterior knee pain. It may assist

patellar alignment and tracking while providing proprioceptive input and reducing mechanical stress on sensitive structures, including the infrapatellar fat pad [5]. Combining hip abductor strengthening with patellar taping may therefore address both proximal biomechanical dysfunction and local symptoms. However, although these interventions have been investigated in other anterior knee pain conditions, limited evidence is available regarding their combined application specifically for Hoffa's Fat Pad Impingement Syndrome [6].

This evidence gap is clinically relevant because physiotherapists frequently combine strengthening exercises with adjunctive techniques, yet the potential additional benefit of integrating proximal strengthening and patellar taping remains insufficiently established. Such interventions are non-invasive and relatively accessible, making them potentially useful where cost-effective rehabilitation approaches are required [7, 8].

Therefore, the present study aimed to evaluate the effect of hip abductor strengthening combined with patellar taping on pain, functional ability, hip abductor strength, and knee range of motion in patients with Hoffa's Fat Pad Impingement Syndrome. By targeting both biomechanical and symptomatic components of the condition, the

study sought to provide evidence regarding a combined physiotherapy approach for improving clinical and functional outcomes [9, 10].

2. CRITICAL ANALYSIS OF LITERATURE

The literature indicates a progressive shift from general anterior knee pain and patellofemoral biomechanics towards greater recognition of the infrapatellar fat pad as an independent pain-generating structure. Earlier research primarily focused on altered lower-limb kinematics, particularly dynamic knee valgus, femoral internal rotation, and adduction, providing a biomechanical rationale for addressing proximal muscle control [11]. Evidence concerning patellar taping subsequently suggested potential short-term benefits through mechanical and proprioceptive mechanisms, particularly when combined with exercise [12]. More condition-specific literature highlighted the rich innervation and vascularity of the infrapatellar fat pad and its susceptibility to mechanical irritation, inflammation, and repetitive micro trauma [13, 14]. However, much of this evidence remains focused on pathophysiology or broader anterior knee pain populations rather than intervention-specific trials in patients with Hoffa's Fat Pad Impingement Syndrome. Thus, although the biomechanical rationale for rehabilitation is increasingly established, direct clinical evidence remains comparatively limited.

Subsequent research strengthened the rationale for proximal strengthening by demonstrating the importance of hip abductor function in controlling femoral movement and lower-limb alignment. Hip abductor strengthening may improve pelvic stability and neuromuscular control, potentially reducing excessive mechanical loading around the knee [15]. At the same time, clinical literature has increasingly emphasized targeted management of Hoffa's syndrome, particularly reducing mechanical compression and addressing altered patellar mechanics [16]. Patellar taping may provide symptomatic relief and facilitate exercise participation, while strengthening may address underlying biomechanical deficits [17]. Nevertheless, the

available evidence is characterized by considerable heterogeneity in participant populations, intervention protocols, exercise dosage, taping techniques, and outcome measures. Importantly, findings from patellofemoral pain studies cannot necessarily be extrapolated directly to Hoffa's Fat Pad Impingement Syndrome because the underlying pathology and tissue involvement differ. Recent literature continues to identify a lack of high-quality RCTs directly evaluating combined hip abductor strengthening and patellar taping in this specific condition [18].

Overall, the literature provides a plausible theoretical basis for combining proximal strengthening with local patellar taping, but an important evidence gap remains regarding whether their combined application produces clinically meaningful benefits in Hoffa's Fat Pad Impingement Syndrome. Existing studies frequently evaluate strengthening or taping separately, use small or heterogeneous samples, and predominantly report short-term outcomes, limiting conclusions regarding comparative and sustained effectiveness [11-18]. In addition, inconsistent rehabilitation protocols make direct comparison between studies difficult, while limited assessment of objective measures such as muscle strength and knee range of motion restricts understanding of the broader functional effects of treatment. Therefore, a controlled trial using a standardised combined intervention and assessing pain, functional ability, hip abductor strength, and knee range of motion is warranted. The present study addresses these gaps by directly evaluating the clinical effects of hip abductor strengthening combined with patellar taping in patients with Hoffa's Fat Pad Impingement Syndrome.

OBJECTIVE AND HYPOTHESIS

Objective:

To determine the effect of hip abductor strengthening combined with patellar taping on pain, functional ability, hip abductor muscle strength, and knee range of motion in patients with Hoffa's Fat Pad Impingement Syndrome.

Null Hypothesis (H_0):

There is no significant difference in pain, functional ability, hip abductor muscle strength, or knee range of motion between patients with Hoffa's Fat Pad Impingement Syndrome treated with hip abductor strengthening combined with patellar taping and those treated with conventional physiotherapy.

Alternative Hypothesis (H_1):

There is a significant difference in pain, functional ability, hip abductor muscle strength, or knee range of motion between patients with Hoffa's Fat Pad Impingement Syndrome treated with hip abductor strengthening combined with patellar taping and those treated with conventional physiotherapy.

3. MATERIAL AND METHODS

STUDY DESIGN AND SETTING

A randomized controlled trial was conducted to determine the effect of hip abductor strengthening combined with patellar taping on pain, functional ability, hip abductor muscle strength, and knee range of motion in patients with Hoffa's Fat Pad Impingement Syndrome. The study was conducted at the physiotherapy departments of ULTH and Fatimah Jinnah Hospital. The study was completed within 6 months following approval of the research synopsis.

SAMPLE SIZE AND SAMPLING TECHNIQUE

A total of 30 participants with clinically diagnosed Hoffa's Fat Pad Impingement Syndrome were recruited and randomly allocated into two equal groups of 15 participants each. Consecutive sampling was used for participant recruitment, followed by simple random allocation to the intervention groups. The experimental group ($n = 15$) received hip abductor strengthening combined with patellar taping, whereas the control group ($n = 15$) received conventional physiotherapy treatment.

INCLUSION CRITERIA

Participants were eligible if they were aged 20–50 years, of either sex, and clinically diagnosed with Hoffa's Fat Pad Impingement Syndrome. Participants were required to have anterior knee pain aggravated by activities such as walking, stair climbing, prolonged standing, or knee extension, with a pain intensity of at least 3 on the Numeric Pain Rating Scale (NPRS) [23].

EXCLUSION CRITERIA

Participants were excluded if they had a history of knee surgery, including arthroscopy or ligament reconstruction; ligament injuries involving the ACL, PCL, MCL, or LCL; meniscal injuries or other intra-articular knee pathologies; advanced knee osteoarthritis; fractures around the knee joint; neurological disorders affecting lower-limb function; systemic inflammatory conditions such as rheumatoid arthritis; or skin allergies or conditions that prevented the application of patellar tape [24,25].

ETHICAL CONSIDERATIONS

The study was conducted in accordance with the ethical rules and regulations of Superior University, Lahore. Written informed consent was obtained from all participants before enrolment. Participants were informed about the study purpose, procedures, potential benefits, and possible risks. Participation was voluntary, and participants were informed of their right to withdraw from the study at any stage without penalty. Confidentiality and anonymity were maintained throughout the study, and personal information was not disclosed in any publication arising from the research. The study was intended to contribute to evidence-based physiotherapy practice by providing clinical information regarding the combined use of hip abductor strengthening and patellar taping for Hoffa's Fat Pad Impingement Syndrome.

DATA COLLECTION PROCEDURE

Participants were recruited from the physiotherapy departments of hospitals and clinics. Potential participants presenting with anterior knee pain

were screened according to the predefined inclusion and exclusion criteria. Those who fulfilled the eligibility criteria were invited to participate in the study. All eligible participants were informed about the purpose, procedures, potential benefits, and possible risks of the study. Written informed consent was obtained from all participants before participation, ensuring their voluntary involvement in the study.

Before initiation of the intervention, baseline data were collected from all participants. Pain intensity was assessed using the Numeric Pain Rating Scale (NPRS), while functional ability was evaluated using the Kujala Anterior Knee Pain Scale. Hip abductor muscle strength was assessed using a handheld dynamometer, and knee range of motion (ROM) was measured using a goniometer. Following the baseline assessment, participants were randomly allocated into two equal groups of 15 participants each using a simple randomization method, such as the lottery method or computer-generated randomization. Participants were assigned either to the experimental group or the control group.

The experimental group received hip abductor strengthening exercises, including clamshells and side-lying hip abduction, combined with McConnell patellar taping. The intervention was administered 3–4 sessions per week for a period of 6 weeks. The control group received conventional physiotherapy, including quadriceps strengthening exercises, stretching exercises, and physical modalities, according to the treatment protocol. Participants were monitored throughout the intervention period to ensure correct exercise performance and appropriate application of the treatment. Attendance and adherence to the prescribed treatment program were also recorded. Following completion of the 6-week intervention period, all participants were reassessed using the same outcome measures applied during the baseline assessment. Pain intensity was reassessed using the NPRS, functional ability using the Kujala Anterior Knee Pain Scale, hip abductor muscle strength using a handheld dynamometer, and knee range of motion using a goniometer. The pre- and post-intervention measurements were

subsequently compared within and between the two groups to determine the effects of the respective interventions on pain, functional ability, muscle strength, and knee ROM.

OPERATIONAL DEFINITIONS

Hoffa's Fat Pad Impingement Syndrome is a clinical condition characterized by irritation and inflammation of the infrapatellar fat pad, resulting in anterior knee pain, tenderness below the patella, and pain aggravated by knee extension or prolonged standing. In the present study, diagnosis was based on clinical examination and patient-reported symptoms [19]. Hip Abductor Strengthening refers to a structured exercise program targeting the hip abductor muscles, primarily the gluteus medius and minimus, using exercises such as side-lying hip abduction and clamshells. In this study, exercises were performed 3–4 sessions per week for 6 weeks with progressive resistance [20]. Patellar Taping refers to the application of adhesive tape using the McConnell technique to assist patellar alignment, reduce mechanical stress on the infrapatellar fat pad, and improve knee function. Taping was applied during treatment sessions and maintained during prescribed activities [21]. Pain refers to the participant's subjective experience of discomfort, assessed using the Numeric Pain Rating Scale (NPRS), ranging from 0 (no pain) to 10 (worst imaginable pain), with scores recorded before and after the intervention period [22].

OUTCOME MEASURES

The **primary outcome measure was pain**, assessed using the Numeric Pain Rating Scale (NPRS). The NPRS ranges from 0, representing no pain, to 10, representing the worst imaginable pain. Pain was recorded at baseline and after completion of the intervention. **Functional ability** was assessed using the Kujala Anterior Knee Pain Scale. The scale ranges from 0 to 100, with higher scores indicating better functional ability. It assesses functional activities and symptoms associated with anterior knee pain, including walking, running, stair climbing, and sitting. **Hip abductor muscle strength** was assessed using a handheld

dynamometer. Strength was recorded in kilograms or Newton's according to the device used, providing an objective measure of hip abductor muscle performance. **Knee range of motion** was measured using a goniometer. Knee flexion and extension were assessed and recorded in degrees (°) at baseline and following the intervention.

Timing of Assessment

All outcome measures were recorded at two assessment points: baseline (pre-intervention) and immediately after completion of the 6-week intervention period (post-intervention).

DATA ANALYSIS

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean $\pm$ standard deviation (SD) and categorical variables as frequencies and percentages. The Shapiro-Wilk test was used to assess normality. For within-group comparisons, the paired-samples t-test was used for normally distributed outcomes, while the Wilcoxon signed-rank test was applied to NPRS. Between-group comparisons were performed using the independent-samples t-test for normally distributed outcomes and the Mann-Whitney U test for NPRS. Changes from pre- to post-treatment were also compared between groups. A two-tailed $p < .05$ was considered statistically significant.

4. RESULTS

Table 1: *Demographic Characteristics of Participants at Baseline*

Variable	Experimental Group (n = 15)	Control Group (n = 15)	<i>p</i>
Age (years), <i>M</i> $\pm$ <i>SD</i>	27.60 $\pm$ 4.26	28.00 $\pm$ 3.78	.787
Male, <i>n</i> (%)	8 (53.3)	7 (46.7)	.715
Female, <i>n</i> (%)	7 (46.7)	8 (53.3)	.715

Note. *M* = mean; *SD* = standard deviation; *n* = frequency. Statistical significance was set at $p < .05$.

As shown in Table 1, the mean age was 27.60 $\pm$ 4.26 years in the experimental group and 28.00 $\pm$ 3.78 years in the control group, with no statistically significant difference between the groups ($p = .787$). The gender distribution was also

comparable between groups, with no statistically significant difference ($p = .715$). Thus, the groups were similar in their baseline demographic characteristics.

Table 2: *Shapiro-Wilk Test of Normality*

Outcome		Group	Pre-treatment <i>p</i>	Interpretation	Post-treatment <i>p</i>	Interpretation
NPRS		Experimental	.006	Non-normal	< .001	Non-normal
NPRS		Control	.006	Non-normal	< .001	Non-normal
Kujala Score		Experimental	.952	Normal	.714	Normal
Kujala Score		Control	.504	Normal	.938	Normal
Hip Abductor Strength		Experimental	.723	Normal	.082	Normal
Hip Abductor Strength		Control	.610	Normal	.988	Normal
Knee Flexion ROM		Experimental	.982	Normal	.878	Normal
Knee Flexion ROM		Control	.895	Normal	.413	Normal

Note. NPRS = Numeric Pain Rating Scale; ROM = range of motion. A *p*-value $> .05$ indicates no significant departure from normality, whereas a *p*-value $< .05$ indicates a significant departure from normality.

As shown in Table 2, the Shapiro-Wilk test indicated that the Kujala Score, hip abductor strength, and knee flexion ROM were normally distributed in both groups at both pre-treatment and post-treatment assessments ($p > .05$). In contrast, NPRS scores demonstrated a significant

departure from normality in both groups at pre-treatment and post-treatment assessments ($p < .05$). Therefore, parametric tests were appropriate for the normally distributed outcomes, whereas non-parametric tests were used for NPRS.

Table 3: Comparison of Pre-treatment Outcome Measures between Groups

Outcome Measure	Experimental Group (n = 15), $M \pm SD$	Control Group (n = 15), $M \pm SD$	Statistical Test	p
NPRS	5.93 $\pm$ 0.80	5.93 $\pm$ 0.70	Mann-Whitney U	1.000
Kujala Score	49.60 $\pm$ 3.29	49.00 $\pm$ 2.59	Independent-samples t-test	.583
Hip Abductor Strength (kg)	12.85 $\pm$ 0.73	12.57 $\pm$ 0.49	Independent-samples t-test	.227
Knee Flexion ROM (°)	128.33 $\pm$ 2.58	128.27 $\pm$ 1.98	Independent-samples t-test	.937
Knee Extension Loss (°)	5.33 $\pm$ 0.98	5.27 $\pm$ 0.88	Independent-samples t-test	.846

Note. NPRS = Numeric Pain Rating Scale; ROM = range of motion; M = mean; SD = standard deviation. A p -value $< .05$ was considered statistically significant.

As shown in Table 3, there were no statistically significant differences between the experimental and control groups in baseline NPRS ($p = 1.000$), Kujala Score ($p = .583$), hip abductor strength ($p = .227$), knee flexion ROM ($p = .937$), or knee

extension loss ($p = .846$). These findings indicate that the two groups were comparable in all assessed outcome measures before the intervention.

Table 4: Pre- and Post-treatment Comparison of Outcome Measures Within Groups

Outcome Measure	Group	Pre-treatment, $M \pm SD$	Post-treatment, $M \pm SD$	Mean Change	Test	p
NPRS	Experimental	5.93 $\pm$ 0.80	2.33 $\pm$ 0.49	-3.60	Wilcoxon signed-rank test	$< .001$
	Control	5.93 $\pm$ 0.70	4.33 $\pm$ 0.49	-1.60	Wilcoxon signed-rank test	$< .001$
Kujala Score	Experimental	49.60 $\pm$ 3.29	77.47 $\pm$ 4.39	+27.87	Paired-samples t-test	$< .001$
	Control	49.00 $\pm$ 2.59	62.60 $\pm$ 2.64	+13.60	Paired-samples t-test	$< .001$
Hip Abductor Strength (kg)	Experimental	12.85 $\pm$ 0.73	17.40 $\pm$ 0.99	+4.55	Paired-samples t-test	$< .001$
	Control	12.57 $\pm$ 0.49	14.31 $\pm$ 0.38	+1.75	Paired-samples t-test	$< .001$
Knee Flexion ROM (°)	Experimental	128.33 $\pm$ 2.58	139.00 $\pm$ 2.33	+10.67	Paired-samples t-test	$< .001$

	Control	128.27 ± 1.98	132.87 ± 1.51	+4.60	Paired-samples t-test	< .001
Knee Extension Loss (°)	Experimental	5.33 ± 0.98	1.00 ± 0.53	-4.33	Paired-samples t-test	< .001
	Control	5.27 ± 0.88	3.00 ± 0.65	-2.27	Paired-samples t-test	< .001

Note. M = mean; SD = standard deviation; NPRS = Numeric Pain Rating Scale; ROM = range of motion. Negative mean changes indicate reductions in pain or extension loss, whereas positive mean changes indicate improvements in Kujala score, hip abductor strength, and knee flexion ROM. $p < .05$ was considered statistically significant.

As shown in Table 4, both the experimental and control groups demonstrated statistically

significant within-group improvements across all assessed outcomes ($p < .001$). The experimental group showed greater numerical improvements in pain, functional ability, hip abductor strength, knee flexion ROM, and knee extension loss compared with the control group. These findings demonstrate improvement within each treatment group; however, the statistical comparison of whether one group improved significantly more than the other should be based on the between-group analysis in the subsequent table.

Table 5: Post-treatment Comparison of Outcome Measures Between Groups

Outcome Measure	Experimental, M ± SD	Control, M ± SD	Statistical Test	p
NPRS	2.33 ± 0.49	4.33 ± 0.49	Mann-Whitney U test	< .001
Kujala Score	77.47 ± 4.39	62.60 ± 2.64	Independent-samples t-test	< .001
Hip Abductor Strength (kg)	17.40 ± 0.99	14.31 ± 0.38	Independent-samples t-test	< .001
Knee Flexion ROM (°)	139.00 ± 2.33	132.87 ± 1.51	Independent-samples t-test	< .001
Knee Extension Loss (°)	1.00 ± 0.53	3.00 ± 0.65	Independent-samples t-test	< .001

Note. M = mean; SD = standard deviation; NPRS = Numeric Pain Rating Scale; ROM = range of motion. $p < .05$ was considered statistically significant.

As shown in Table 5, statistically significant between-group differences were observed for all post-treatment outcome measures ($p < .001$). The

experimental group had lower NPRS and knee extension loss and higher Kujala scores, hip abductor strength, and knee flexion ROM than the control group.

Table 6: Between-Group Comparison of Changes in Outcome Measures

Outcome Measure	Experimental Change	Control Change	Between-Group Difference	95% CI	p
NPRS	-3.60	-1.60	-2.00	-2.55 to -1.45	< .001
Kujala Score	+27.87	+13.60	+14.27	12.60 to	<

					15.94	.001
Hip Abductor Strength (kg)	+4.55	+1.75	+2.81	2.55 to 3.07	<	.001
Knee Flexion ROM (°)	+10.67	+4.60	+6.07	4.75 to 7.38	<	.001
Knee Extension Loss (°)	-4.33	-2.27	-2.07	-2.56 to -1.57	<	.001

Note. NPRS = Numeric Pain Rating Scale; ROM = range of motion; CI = confidence interval. Change was calculated as post-treatment minus pre-treatment. Negative values indicate reductions in NPRS and knee extension loss, whereas positive values indicate improvements in Kujala score, hip abductor strength, and knee flexion ROM. $p < .05$ was considered statistically significant.

As presented in **Table 6**, the between-group comparison of changes demonstrated statistically significant differences across all outcome measures ($p < .001$). The experimental group showed a greater reduction in NPRS and knee extension loss and greater increases in Kujala score, hip abductor strength, and knee flexion ROM compared with the control group.

4. DISCUSSION

The present study found significant improvements in pain, functional ability, hip abductor strength, and knee range of motion in both groups, with significantly greater improvements in the combined hip abductor strengthening and patellar taping group. These findings are consistent with previous research supporting exercise-based and multimodal rehabilitation for anterior knee pain [26]. The baseline comparability of the groups further supports that the observed differences were primarily related to the interventions rather than pre-treatment characteristics [27].

The greater reduction in pain observed in the experimental group is consistent with previous evidence supporting the use of patellar taping as an adjunct to exercise therapy for anterior knee pain [28]. Similar findings have been reported by Bolgla and Boling, who emphasized the contribution of hip abductor weakness and altered femoral mechanics to knee symptoms [29]. McConnell also described the potential of patellar

taping to modify patellar mechanics and reduce symptoms [30]. The greater pain reduction in the present study may therefore be explained by the complementary effects of both interventions: hip strengthening may improve pelvic stability and reduce excessive femoral adduction and internal rotation, while taping may alter patellar positioning, reduce local mechanical stress on the infrapatellar fat pad, and provide proprioceptive input.

Functional ability also improved more in the experimental group, which agrees with previous literature emphasizing proximal muscle control and multimodal rehabilitation for anterior knee conditions [31, 32]. This improvement may be related to the simultaneous reduction in pain and enhancement of hip abductor strength, allowing better lower-limb control during walking, stair climbing, and other functional activities. The greater improvement in knee ROM may similarly be associated with reduced pain and mechanical irritation of the highly innervated infrapatellar fat pad, allowing more comfortable knee movement [33]. Thus, improvement in symptoms may have facilitated movement, while improved proximal control may have contributed to more efficient lower-limb mechanics.

The present findings are particularly relevant because much of the existing evidence concerns patellofemoral pain rather than Hoffa's Fat Pad Impingement Syndrome, limiting direct comparison because the underlying pathology differs [34]. Previous multimodal rehabilitation studies have reported improvements with both active and conventional rehabilitation, with treatment effects influenced by the type of comparator used [35]. In the current study, the control group also received active conventional physiotherapy, yet the combined intervention

produced greater improvements, suggesting that adding proximal strengthening and patellar taping may provide additional benefits beyond conventional treatment [36]. These findings address an important gap in the limited condition-specific literature and support further investigation of combined rehabilitation approaches for Hoffa's syndrome [37].

5. CONCLUSION

The findings indicate that the combined intervention was associated with greater improvements in pain, function, hip abductor strength, and knee ROM than conventional physiotherapy in patients with Hoffa's Fat Pad Impingement Syndrome. Further larger-scale studies with longer follow-up are needed to determine the durability and generalizability of these findings.

6. LIMITATIONS

The present study had several limitations that should be considered when interpreting its findings. First, the small sample size of 30 participants, with 15 participants in each group, may limit the statistical power and generalizability of the findings to the wider population of patients with Hoffa's Fat Pad Impingement Syndrome. Second, although the overall study was conducted over a 6-month period, the intervention and post-treatment assessment were limited 6 weeks; therefore, the study primarily evaluated short- to intermediate-term treatment effects rather than sustained long-term outcomes. Third, participants were recruited from a limited number of clinical settings, which may restrict the applicability of the findings to patients treated in other hospitals, rehabilitation centers, or community settings. Fourth, long-term follow-up was not conducted, so it was not possible to determine whether the observed improvements in pain, functional ability, muscle strength, and knee range of motion were maintained after completion of treatment.

Furthermore, complete blinding of participants and treating physiotherapists was not feasible because the interventions involved exercise and visible patellar taping. This may have introduced

performance or expectation-related bias. Although outcome assessment was performed using established clinical measures, the study did not include broader patient-centered outcomes such as quality of life, treatment satisfaction, recurrence of symptoms, return to work, or return to sports. In addition, the study evaluated the combined intervention against conventional physiotherapy but did not include separate hip-strengthening-only or patellar-taping-only groups. Consequently, the individual contribution and potential additive effect of each component could not be determined. Finally, variations in adherence to exercises and activity levels outside supervised treatment sessions may also have influenced treatment outcomes.

7. RECOMMENDATIONS

Future studies should recruit larger samples to improve statistical power and generalizability and should preferably be conducted across multiple hospitals and physiotherapy centers. Longer follow-up periods after completion of the intervention are recommended to determine whether treatment-related improvements are maintained and whether recurrence of symptoms can be reduced. Future research should also use standardized and reproducible intervention protocols, including clearly defined exercise intensity, progression, frequency, duration, and patellar taping procedures.

Comparative trials involving hip abductor strengthening alone, patellar taping alone, their combined application, and conventional physiotherapy would help determine the individual and additive effects of these interventions. Future studies should also incorporate broader outcome measures, including quality of life, patient satisfaction, recurrence, return to work or sport, and functional performance. Larger high-quality randomized controlled trials specifically targeting Hoffa's Fat Pad Impingement Syndrome are warranted to strengthen the condition-specific evidence base and support the development of standardized physiotherapy protocols.

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