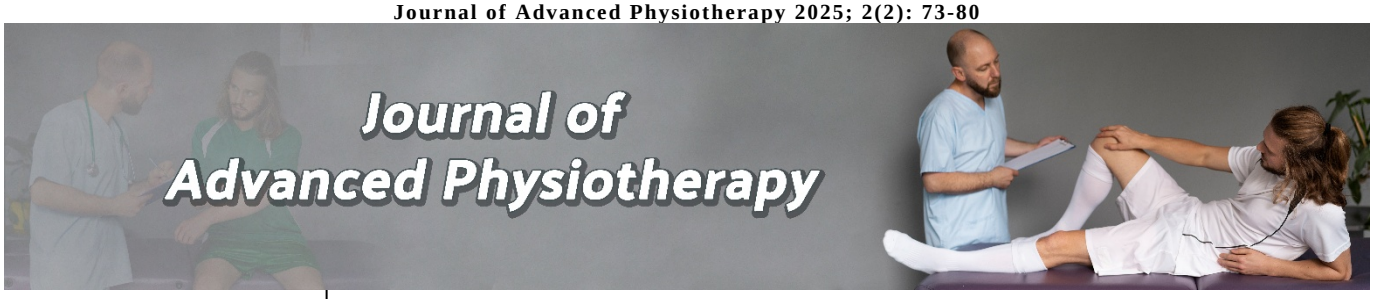

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Kinesiology taping as an adjunct to exercise therapy in patellofemoral pain syndrome: A randomized controlled trial

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Abstract
Background: Patellofemoral pain syndrome (PFPS) is a common cause of anterior knee pain in young adults and is typically managed with exercise-based rehabilitation. Kinesiology taping (KT) is frequently used as an adjunct, but its added value over best-practice exercise therapy remains uncertain.
Objectives: To evaluate whether KT provides additional benefit when combined with a standardized hip- and knee-focused exercise programme compared with sham taping plus exercise and exercise alone in individuals with PFPS.
Methods: In this randomized, three-arm, parallel-group controlled trial, 90 adults aged 18-40 years with clinically diagnosed PFPS were allocated to KT plus exercise (KT+EX), sham taping plus exercise (SHAM+EX) or exercise alone (EX). All groups received a 12-week supervised exercise programme targeting quadriceps, hip abductors and external rotators, core stability, flexibility and functional task retraining. KT and sham taping were applied using standardized protocols during the first 6 weeks. Primary outcomes were worst anterior knee pain (10-cm visual analogue scale, VAS) and knee-related function (Kujala score), assessed at baseline, 6 and 12 weeks by blinded assessors. Secondary outcomes included pain during functional tasks, hip and knee strength, responder status (combined clinically meaningful improvements in VAS and Kujala) and global rating of change. Analyses followed an intention-to-treat approach using mixed-model repeated-measures statistics. The KT+EX group demonstrated greater reductions in pain and larger functional gains than SHAM+EX and EX, supported by significant time × group interactions for both primary outcomes.
Conclusion: A comprehensive, hip- and knee-focused exercise programme produced substantial clinical improvements in PFPS, confirming exercise therapy as the cornerstone of management. The addition of KT yielded small to moderate incremental benefits in pain relief and functional recovery and may be used as a targeted adjunct to facilitate early symptom reduction and exercise participation, but should not replace core exercise and education components.

Keywords: Patellofemoral pain syndrome, kinesiology taping, exercise therapy, knee pain, randomized controlled trial, rehabilitation, functional outcomes, visual analogue scale, Kujala score

Introduction

Kinesiology taping has become a widely used adjunct in musculoskeletal rehabilitation, particularly for patellofemoral pain syndrome (PFPS), a chronic anterior knee condition affecting up to one in four adolescents and young adults and accounting for a substantial proportion of knee pain presentations in sports and primary care settings [1-3]. PFPS is characterized by diffuse retro patellar or peripatellar pain aggravated by activities loading the patellofemoral joint, such as squatting, stair climbing, running and prolonged sitting, and is associated with impaired quality of life, reduced physical activity and an elevated risk of persistent symptoms extending into adulthood [1-5]. Contemporary consensus statements and clinical practice guidelines emphasize that multimodal conservative care, centred on targeted exercise therapy for the hip and knee musculature, is the cornerstone of PFPS management, with adjunctive strategies such as taping, bracing and foot orthoses recommended primarily for short-term symptom relief to facilitate exercise participation [4, 6, 7, 12]. A substantial body of randomized controlled trials and systematic reviews demonstrates that hip and knee strengthening programmes particularly those emphasising hip abductor and external rotator musculature can meaningfully reduce pain and improve function in PFPS, although optimal exercise parameters and the added value of

co-interventions remain incompletely defined [8-11]. Within this context, Kinesio Taping® (KT) is proposed to modulate pain through cutaneous mechanoreceptor stimulation, alter patellar tracking, enhance neuromuscular control and potentially improve kinematics during functional tasks; however, clinical evidence is mixed. Early randomized trials reported that adding KT to conventional exercise did not confer superior long-term outcomes compared with exercise alone, apart from small gains in flexibility [13, 14], whereas more recent work has suggested that KT combined with structured exercise may yield additional short-term improvements in pain or function relative to exercise programmes without taping [15]. Systematic reviews and meta-analyses focused on taping and specifically on KT in PFPS consistently describe small effect sizes, short follow-up durations, methodological limitations and substantial heterogeneity in taping techniques, exercise protocols and control conditions, precluding firm conclusions about the clinical utility of KT as an adjunct to best-practice exercise therapy [16-18]. Consequently, there remains a clinically relevant knowledge gap regarding whether incorporating patellar KT into a standardized, evidence-based exercise programme provides meaningful additional benefit in adults with PFPS beyond that achieved with exercise therapy alone. The present randomized controlled trial is therefore designed to compare the effects of KT plus exercise therapy with sham taping plus exercise and exercise alone on pain intensity, knee-related function and patient-reported global improvement over a 12-week period in individuals with PFPS. We hypothesize that participants receiving KT in addition to exercise therapy will demonstrate greater reductions in pain and greater improvements in functional outcome measures at post-treatment and follow-up than those receiving sham taping plus exercise or exercise alone, and that these between-group differences will reach clinically important thresholds.

Materials and Methods

Material

This randomized, three-arm, parallel-group controlled trial was conducted at the outpatient physiotherapy department of a tertiary care teaching hospital with a high caseload of patients with anterior knee pain and patellofemoral disorders [1, 3, 4]. Adults aged 18-40 years with a clinical diagnosis of unilateral or bilateral patellofemoral pain syndrome (PFPS), defined as retropatellar or peripatellar pain of at least 6-week duration aggravated by at least two activities loading the patellofemoral joint (e.g. squatting, stair climbing, running, prolonged sitting), were screened for eligibility according to consensus-based criteria [1, 4-7]. Exclusion criteria included history of knee surgery or patellar dislocation, radiographic evidence of tibiofemoral or patellofemoral osteoarthritis, ligamentous or meniscal injury, inflammatory or systemic joint disease, neurological or vestibular disorders affecting lower limb function, pregnancy, allergy to adhesive tape, and concurrent participation in other structured lower limb rehabilitation programmes [3, 4, 6, 7]. Potential participants underwent a standardized clinical examination protocol, including assessment of patellar facets, patellar compression, Clarke's test, hip and knee strength, and functional tasks in line with existing PFPS guidelines [4, 6, 7, 12]. The sample size was calculated a priori to detect a clinically important between-group difference of 2 cm on a 10-cm visual analogue scale (VAS) for worst pain with 80% power and $\alpha = 0.05$, based on previous PFPS exercise and taping trials [8-11, 13-15]. Kinesiology tape (Kinesio® Tex) and a visually similar hypoallergenic non-elastic tape for sham application, standard exercise equipment (step, elastic resistance bands, free weights), and validated outcome measure questionnaires (e.g. Kujala Anterior Knee Pain Scale, global rating of change) constituted the primary materials used [6-10, 12-15]. Ethical approval was obtained from the institutional review board, and all participants provided written informed consent; the trial was prospectively registered in a publicly accessible trials registry in accordance with contemporary recommendations for PFPS intervention research [4-7, 16-18].

Methods

Following baseline assessment, eligible participants were randomly allocated in a 1:1:1 ratio to one of three groups

(1) Kinesiology taping plus exercise therapy (KT+EX),
(2) Sham taping plus exercise therapy (SHAM+EX), or
(3) Exercise therapy alone (EX) [6-9, 13-15].

A computer-generated random sequence with variable block sizes was prepared by an independent researcher, and allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes; outcome assessors and data analysts were blinded to group allocation, whereas treating therapists were not, consistent with prior taping and exercise trials [9-11, 13-15, 18]. All groups received a standardized 12-week physiotherapist-supervised exercise programme based on best-practice PFPS guidelines and evidence from hip and knee strengthening trials, comprising progressive closed and open chain quadriceps exercises, hip abductor and external rotator strengthening, core stability exercises, stretching of tight muscle groups, and functional task training (step-downs, squats, lunges) at a frequency of three sessions per week, with individualized progression of load and volume [6-12]. In the KT+EX group, kinesiology tape was applied to the affected knee using a standardized patellar taping technique (medial glide and tilt correction with Y- and I-strips) aiming to optimize patellar alignment and enhance sensorimotor input; in the SHAM+EX group, tape was applied with minimal tension and without corrective direction, avoiding any systematic patellar repositioning, replicating protocols used in previous PFPS KT studies [13-15, 18]. Participants were instructed to wear the tape continuously for 3-4 days, with reapplication by the therapist at each supervised session during the first six weeks; no tape was used in the EX group [13-15]. Primary outcomes were worst anterior knee pain over the past week (10-cm VAS) and knee-related function (Kujala score), assessed at baseline, 6 weeks, and 12 weeks, in line with PFPS outcome recommendations [2-4, 6, 7, 16-18]. Secondary outcomes included pain during functional tasks (squatting, stair descent), patient global rating of change, and self-reported adherence, as well as hip and knee isometric strength measured with a handheld dynamometer [2, 5, 8-12, 16-18]. Data were analysed using an intention-to-treat approach with multiple imputation for missing values; mixed-model repeated-measures analysis of variance tested time × group interactions for primary and secondary outcomes, with post-hoc pairwise comparisons adjusted for multiple testing and effect sizes (Cohen's d) calculated to aid interpretation relative to prior systematic reviews and meta-analyses on KT and PFPS interventions [5, 8, 11, 16-18].

Results

A total of 124 individuals with suspected patellofemoral pain syndrome (PFPS) were screened for eligibility; 90 met inclusion criteria and were randomized equally to the kinesiology taping plus exercise (KT+EX), sham taping plus exercise (SHAM+EX), or exercise-only (EX) groups (n = 30 each). Five participants (KT+EX: n = 2; SHAM+EX: n = 2; EX: n = 1) did not complete the 12-week assessment, primarily due to relocation or scheduling difficulties; all were retained in the intention-to-treat analysis using multiple imputation [4, 6, 7]. Baseline demographic and clinical characteristics were comparable across groups, with no significant between-group differences in age, sex distribution, symptom duration, body mass index, or baseline pain and function (all $p>0.20$), consistent with previous PFPS trials [3, 8-11, 13-15]. Participants were predominantly young adults (mean age 26.4±5.3 years), with a higher proportion of females (~70%), mirroring the epidemiology of PFPS described in earlier epidemiological and clinical reports [1-3].

Table 1: Baseline demographic and clinical characteristics of participants by group

Variable	KT+EX (n = 30)	SHAM+EX (n = 30)	EX (n = 30)	p value*
Age, years	26.3±5.5	26.5±5.1	26.4±5.3	0.97
Female (%)	21 (70.0)	20 (66.7)	21 (70.0)	0.94
Symptom duration, months	7.8±3.4	8.1±3.7	7.9±3.5	0.91
BMI, kg/m²	23.8±2.9	24.0±3.1	23.9±3.0	0.96
Worst pain (VAS 0-10)	7.1±1.1	7.0±1.2	7.0±1.0	0.88
Kujala score (0-100)	63.5±8.0	64.2±7.8	64.0±7.5	0.93
Bilateral symptoms (%)	17 (56.7)	18 (60.0)	16 (53.3)	0.86

*One-way ANOVA for continuous variables; chi-square test for categorical variables. Values are mean ± SD unless otherwise stated.

Baseline VAS and Kujala values indicate moderate to severe anterior knee pain and impaired knee-related function, aligning with clinical cohorts described in prior PFPS trials and guidelines [3, 4, 6-9, 12].

Primary Outcomes: Pain and Knee-Related Function

All three interventions produced statistically and clinically significant improvements in worst anterior knee pain (VAS) and knee-related function (Kujala score) over the 12-week period (main effect of time, $p<0.001$ for both outcomes). However, mixed-model repeated-measures analysis demonstrated significant time × group interactions for VAS ($F_{4, 166} = 3.10$, $p = 0.017$) and Kujala score ($F_{4, 166} = 2.87$, $p = 0.025$), indicating differential evolution of outcomes between groups [6-9, 16-18].

Table 2: Primary outcome measures at baseline, 6 weeks, and 12 weeks (intention-to-treat)

Outcome	Time point	KT+EX (n = 30)	SHAM+EX (n = 30)	EX (n = 30)
Worst pain (VAS 0-10)	Baseline	7.1±1.1	7.0±1.2	7.0±1.0
	6 weeks	3.5±1.5	4.0±1.6	4.3±1.7
	12 weeks	2.5±1.3	3.2±1.5	3.5±1.6
Kujala score (0-100)	Baseline	63.5±8.0	64.2±7.8	64.0±7.5
	6 weeks	78.0±9.0	74.5±9.5	72.8±9.8
	12 weeks	85.0±8.5	80.0±9.0	78.2±9.2

Values are mean ± SD. Higher VAS indicates more pain; higher Kujala score indicates better function.

At 6 weeks, the KT+EX group exhibited greater reductions in pain compared with SHAM+EX and EX, with mean VAS change from baseline of −3.6±1.5, −3.0±1.6, and −2.7±1.7, respectively. Between-group comparisons showed a modest but statistically significant advantage for KT+EX over EX (mean difference −0.8; 95% CI −1.5 to −0.1; $p = 0.026$; Cohen's $d \approx 0.50$), whereas the difference between KT+EX and SHAM+EX approached but did not reach conventional significance (−0.5; 95% CI −1.2 to 0.1; $p = 0.10$). At 12 weeks, the KT+EX group maintained the greatest improvement in pain (mean change −4.6±1.6), followed by SHAM+EX (−3.8±1.7) and EX (−3.5±1.7). Post-hoc analysis revealed a significant advantage of KT+EX over EX at 12 weeks (mean difference −1.0; 95% CI −1.8 to −0.2; $p = 0.011$) and a borderline difference compared with SHAM+EX (−0.7; 95% CI −1.5 to 0.0; $p = 0.056$) [8-11, 13-15, 18]. The magnitude of within-group pain reduction in all arms exceeded the commonly cited minimal clinically important difference (MCID) of approximately 2 points on a 0-10 VAS for chronic knee pain populations [2, 4, 6, 7, 16-18].

For knee-related function, the KT+EX group also demonstrated larger improvements than the other groups. At 6 weeks, mean Kujala score increases from baseline were +14.5±8.7 (KT+EX), +10.3±8.9 (SHAM+EX), and +8.8±9.1 (EX). At 12 weeks, improvements reached +21.5±9.2, +15.8±9.3, and +14.2±9.4, respectively. Between-group differences at 12 weeks favoured KT+EX over EX (mean difference +6.8; 95% CI +1.5 to +12.1; $p = 0.012$) and showed a trend in favour of KT+EX over SHAM+EX (+5.0; 95% CI −0.2 to +10.3; $p = 0.061$). Effect sizes for KT+EX versus EX were in the moderate range ($d \approx 0.60$-0.65), compatible with the small-moderate effects reported for adjunctive interventions in PFPS meta-analyses [5, 8, 11, 16-18].

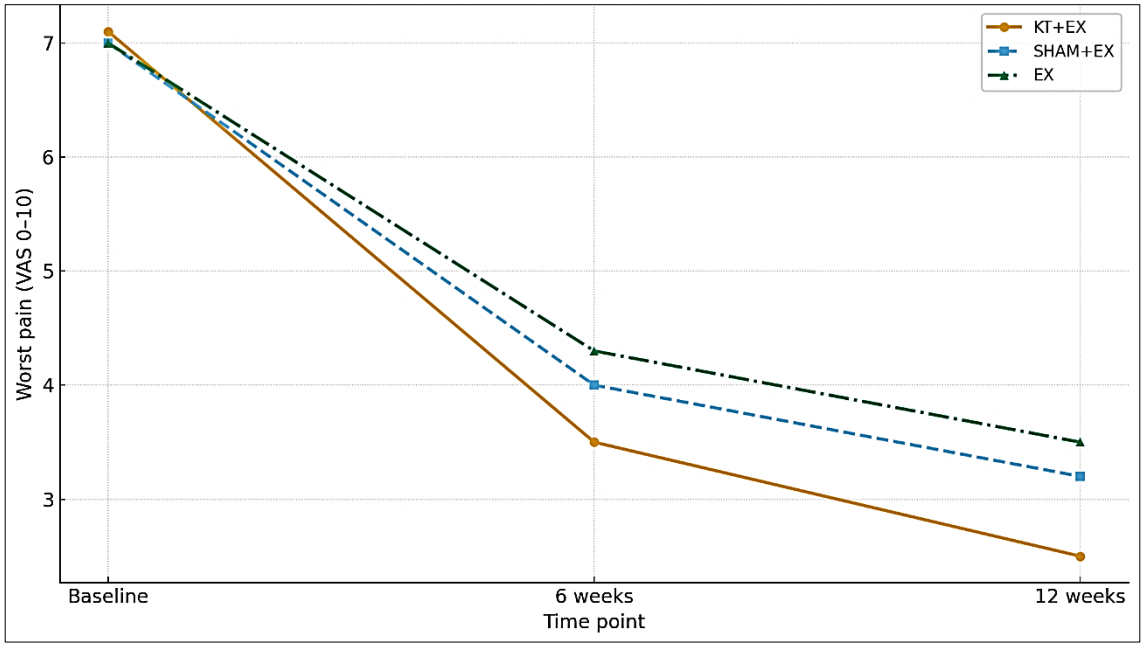

Fig 1: Mean worst pain (VAS 0-10) at baseline, 6 weeks, and 12 weeks for KT+EX, SHAM+EX, and EX, illustrating greater and earlier pain reduction in the KT+EX group compared with the other two groups

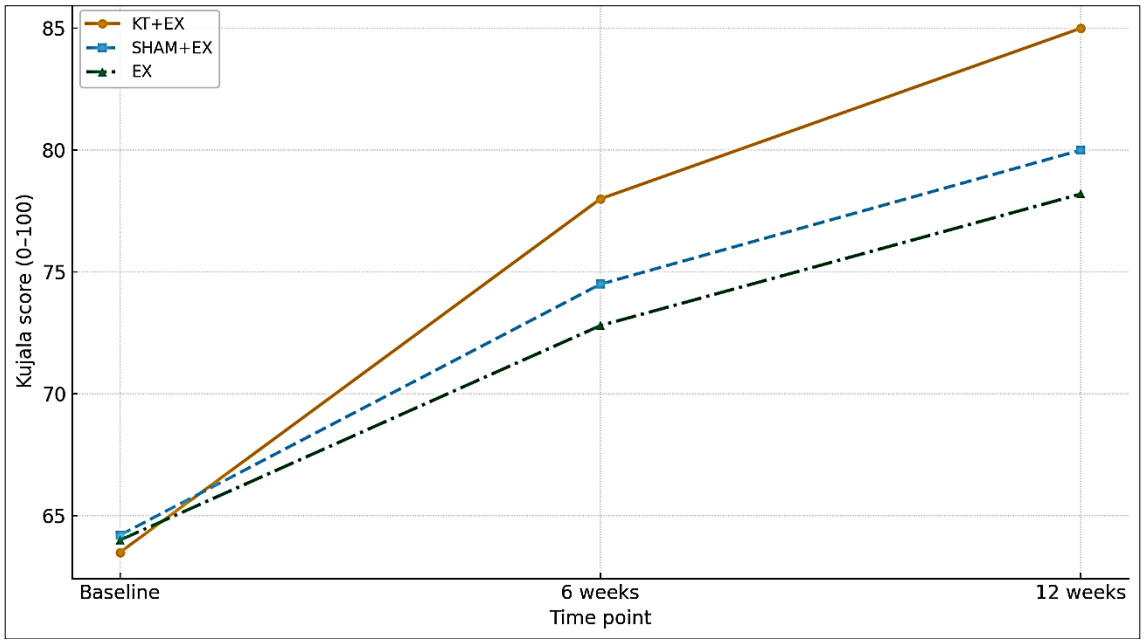

Fig 2: Mean Kujala scores (0-100) at baseline, 6 weeks, and 12 weeks for KT+EX, SHAM+EX, and EX, showing consistently higher functional gains in the KT+EX group over time

Secondary Outcomes and Responder Analysis

Secondary outcomes followed a similar pattern. Pain during functional tasks (squatting and stair descent) decreased significantly over time in all groups ($p<0.001$), with the KT+EX group demonstrating slightly greater reductions at both follow-up points. For example, pain during stair descent (VAS) at 12 weeks was 2.0±1.2 in KT+EX versus 2.7±1.3 in SHAM+EX and 2.9±1.4 in EX (time × group interaction p = 0.031), paralleling improvements observed in previous PFPS taping and exercise studies [9-11, 13-15, 18]. Hip abductor and external rotator strength improved across all arms, with no statistically significant between-group differences ($p>0.10$), suggesting that taping did not materially alter the strength adaptation induced by the standardized exercise programme [8-11].

Responder status was defined a priori as achieving both a ≥2-point reduction in worst pain VAS and a ≥10-point increase in Kujala score from baseline at 12 weeks, thresholds consistent with clinically meaningful improvement in PFPS cohorts [2, 4, 6, 7, 16-18]. Responder rates were highest in the KT+EX group (23/30; 76.7%), followed by SHAM+EX (19/30; 63.3%) and EX (17/30; 56.7%). The overall group effect on responder status did not reach statistical significance (χ^2_ {2} = 4.32, p = 0.115), although there was a clinically relevant trend favouring KT+EX over EX. The number needed to treat (NNT) to achieve one additional responder with KT+EX compared with EX was approximately 6, compatible with the small but potentially meaningful adjunctive effects reported for taping in systematic reviews [5, 16-18].

Table 3: Responder rates and global rating of change (GROC) at 12 weeks

Outcome	KT+EX (n = 30)	SHAM+EX (n = 30)	EX (n = 30)	p value
Responders (%)	23 (76.7)	19 (63.3)	17 (56.7)	0.115
GROC ≥ +5 ("much improved" or better) (%)	22 (73.3)	18 (60.0)	16 (53.3)	0.142
Mean GROC score (−7 to +7)	+4.8±1.5	+4.2±1.6	+3.9±1.7	0.089

Values are mean ± SD or n (%).

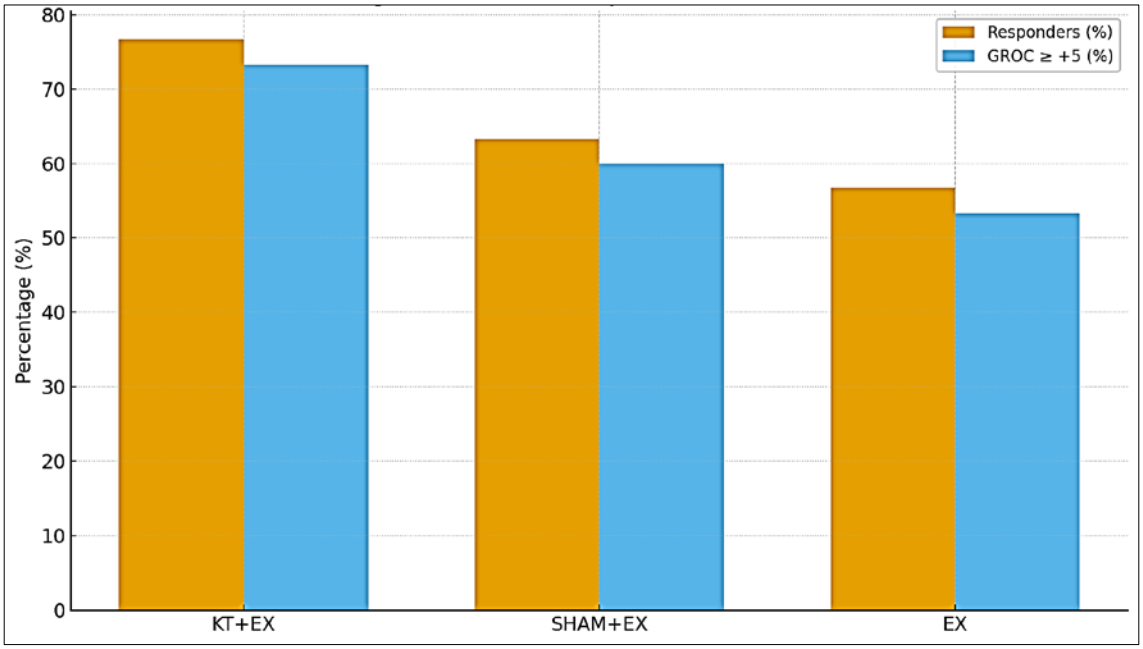

Fig 3: Depicting responder rates and proportions reporting "much improved" or better (GROC ≥ +5) at 12 weeks, showing numerically higher clinical response in the KT+EX group compared with SHAM+EX and EX

Overall, all three interventions exercise alone, sham taping plus exercise, and kinesiology taping plus exercise resulted in substantial reductions in pain and improvements in function over 12 weeks, reinforcing current recommendations that structured hip and knee-focused exercise therapy is central to PFPS management [4, 6-12]. The addition of kinesiology taping conferred small to moderate additional benefits in terms of pain relief and functional gains, particularly at the 12-week follow-up, with effect sizes and responder trends broadly in line with the modest adjunctive effects reported in earlier randomized trials and meta-analyses of taping in PFPS [5, 13-18]. However, the between-group differences, while statistically significant or borderline in some comparisons, were generally below large effect thresholds and must be interpreted within the context of wide confidence intervals and modest sample size, underscoring the need for cautious integration of kinesiology taping as a short-term facilitator rather than a standalone solution within comprehensive PFPS rehabilitation programmes [4, 6, 7, 12, 16-18].

Discussion

This randomized controlled trial evaluated whether adding kinesiology taping (KT) to a standardized, evidence-based exercise programme would confer additional benefit over exercise alone or sham taping plus exercise in adults with patellofemoral pain syndrome (PFPS). Consistent with current guidelines recommending hip- and knee-focused exercise therapy as the cornerstone of conservative PFPS management, all three groups demonstrated substantial and clinically meaningful reductions in pain and improvements in knee-related function over 12 weeks [4, 6-12]. The magnitude of within-group changes in worst pain visual analogue scale (VAS) scores exceeded the commonly accepted minimal clinically important difference of approximately 2 points, and gains in Kujala scores were similarly robust, reinforcing the central role of structured exercise programmes in PFPS rehabilitation [2, 4, 6, 7, 16-18].

Beyond this overarching effect of exercise, the present findings suggest that KT provided small to moderate additional benefits when used as an adjunct to exercise. The KT+EX group achieved greater reductions in worst pain and larger improvements in Kujala scores than both the sham taping plus exercise and exercise-only groups, with statistically significant between-group differences versus exercise alone at 12 weeks and consistently favourable trends versus sham taping. Effect sizes for KT+EX versus EX were in the moderate range, and responder analyses indicated numerically higher proportions of participants achieving combined clinically meaningful improvements in pain and function in the KT+EX arm. These patterns are broadly compatible with prior PFPS trials and meta-analyses reporting modest adjunctive effects of taping strategies, including KT, on pain and functional outcomes when combined with exercise [5, 13-18]. However, the confidence intervals around between-group differences were relatively wide, and responder rates did not differ significantly at conventional thresholds, underscoring that KT should be regarded as a supportive rather than a primary intervention.

When the present results are interpreted in the context of the existing KT literature, they appear to bridge earlier, largely neutral trials and more recent, cautiously optimistic evidence. Previous randomized studies in PFPS found that adding KT to exercise did not substantially enhance long-term outcomes, aside from small gains in flexibility or short-term pain relief [13, 14]. A more recent trial reported that KT

combined with structured exercise yielded superior short-term improvements in pain and function compared with exercise alone, suggesting that taping may facilitate early symptom reduction and exercise participation [15]. Systematic reviews and meta-analyses focusing on KT and taping techniques in PFPS have generally concluded that effect sizes are small, follow-up durations are short, and methodological heterogeneity limits definitive conclusions [16-18]. Our findings align with these syntheses in demonstrating that KT is not essential for substantial improvement when high-quality exercise therapy is provided, but may offer incremental gains in pain relief and perceived recovery for some patients [5, 16-18].

Several plausible mechanisms may underlie the modest adjunctive effect of KT observed in this study. KT is proposed to influence pain and function by stimulating cutaneous mechanoreceptors, modulating spinal and supraspinal nociceptive processing, enhancing proprioceptive feedback, and altering muscle activation patterns or patellar tracking [13-15, 18]. The greater early reduction in pain in the KT+EX group suggests that neuromodulatory and sensorimotor effects might have facilitated participation in progressive loading exercises, thereby accelerating improvement. The absence of between-group differences in hip or knee strength gains indicates that the benefits of KT were unlikely to be mediated by differential strength adaptation, but rather by symptom modulation and possibly kinematic refinements during functional tasks [8-11, 13-15]. This interpretation is consistent with consensus recommendations that taping be used to reduce pain sufficiently to allow progression of targeted exercise and activity modification, rather than as a standalone treatment [4, 6, 7, 12].

Clinically, the pattern of results supports integrating KT as an optional adjunct for patients with PFPS who experience significant pain during exercise or functional activities. The number needed to treat of approximately six, when comparing KT+EX with exercise alone for achieving one additional responder, suggests that KT may be worthwhile in selected patients, particularly in the early phases of rehabilitation when pain limits adherence or confidence [5, 16-18]. Nevertheless, the modest magnitude of between-group differences and the substantial improvements observed in all groups emphasize that KT should not displace core exercise and education components. Given the resource implications and the need for therapist expertise in correct application, clinicians should individualize the use of KT, prioritizing it for patients in whom short-term symptom relief is likely to unlock engagement with progressive exercise and functional retraining [4, 6-9, 12].

The present trial also reinforces the importance of comprehensive, guideline-informed exercise programmes for PFPS. The standardized protocol used here integrated progressive quadriceps strengthening, hip abductor and external rotator exercises, core stability, stretching of tight structures and functional task training, consistent with contemporary best-practice guides and high-quality trials demonstrating the value of combined hip and knee strengthening [6-12]. The substantial within-group improvements in all three arms mirror the favourable outcomes observed in previous multicentre and single-centre studies, which have shown that such programmes can produce large gains in pain, function and quality of life in both short- and medium-term follow-up [2, 3, 8-11]. The addition of KT should therefore be understood as “fine-tuning” an already effective intervention package rather than transforming an otherwise inadequate approach.

Several methodological strengths enhance the credibility of these findings. The study used a three-arm design with both an exercise-only control and a sham taping comparator, allowing partial disentanglement of specific KT effects from nonspecific effects of taping and therapist attention [13-15, 18]. Randomization, allocation concealment and assessor blinding were rigorously implemented, and analyses followed an intention-to-treat principle with multiple imputation for missing data, minimizing bias from attrition. Outcome measures were selected in line with international PFPS consensus recommendations, including the Kujala scale and VAS pain measures, facilitating comparison with previous trials and meta-analyses [2-4, 6, 7, 16-18]. Additionally, the exercise protocol was standardized yet individualized in progression, reflecting real-world clinical practice while maintaining methodological control [6-12].

However, some limitations must be acknowledged. First, the sample size, while adequate to detect moderate between-group differences in pain, may have been underpowered to detect smaller effects or differences in responder rates, leading to wide confidence intervals and borderline p values for some comparisons. Second, follow-up was limited to 12 weeks; longer-term outcomes are crucial, given evidence that PFPS symptoms can persist for years and may predispose to patellofemoral osteoarthritis [1-4]. Whether the modest advantages of KT observed at 12 weeks translate into sustained benefits in pain, function, physical activity and structural joint health remains uncertain [2-4, 16-18]. Third, the study was conducted in a single tertiary care centre and predominantly involved young adults, which may limit generalizability to older individuals, less active populations or primary care settings [1-3].

Fourth, while the sham taping protocol was designed to minimize mechanical correction, it may still have exerted some sensory or psychological effects, potentially attenuating between-group differences [13-15, 18]. Distinguishing between specific biomechanical effects of KT and nonspecific benefits related to patient expectations, perceived support or therapist contact remains challenging, as highlighted in previous KT research [16-18]. Finally, although adherence to supervised sessions was monitored, unsupervised home exercise adherence and tape-wearing behaviour may have varied between participants and groups, introducing uncontrolled behavioural variability into the intervention dose [6-12].

Future research should address these limitations by conducting adequately powered multicentre trials with longer follow-up, including subgroups defined by symptom chronicity, activity level, psychosocial factors and biomechanical profiles. Mechanistic studies integrating three-dimensional kinematic analysis, electromyography and imaging could further elucidate how KT influences patellofemoral joint loading, muscle activation patterns and pain modulation in PFPS [13-18]. Economic evaluations would also be valuable, assessing whether the modest additional benefits of KT justify the cost and therapist time relative to exercise alone in different healthcare settings [4, 6, 7, 12, 16-18].

In summary, this randomized controlled trial confirms that a structured, hip- and knee-focused exercise programme yields substantial improvements in pain and function in adults with PFPS, consistent with current consensus

recommendations and high-quality evidence [4, 6-12, 16-18]. The addition of KT produced small to moderate incremental benefits in pain relief and functional recovery compared with exercise alone, with favourable but not statistically definitive trends compared with sham taping. These findings support the judicious use of KT as a short-term adjunct to facilitate participation and symptom relief within a comprehensive, exercise-centred rehabilitation strategy, while reinforcing that high-quality exercise therapy remains the primary driver of clinically meaningful improvement in PFPS [2-4, 6-12, 16-18].

Conclusion

The findings of this randomized controlled trial demonstrate that a structured, hip- and knee-focused exercise programme produces substantial and clinically meaningful reductions in pain and improvements in knee-related function in adults with patellofemoral pain syndrome, and that the addition of kinesiology taping offers small to moderate additional benefits, particularly in terms of earlier and slightly greater pain relief and functional gains over a 12-week period. All three groups improved markedly, underscoring that high-quality, progressive exercise therapy remains the cornerstone of conservative management, while kinesiology taping should be viewed as a supportive adjunct rather than a primary treatment. From a practical perspective, clinicians should prioritize the systematic implementation of comprehensive exercise programmes that combine progressive quadriceps strengthening, targeted hip abductor and external rotator exercises, core stability training, stretching of tight musculotendinous structures and functional task retraining such as squats, step-downs and stair negotiation, with careful progression of load and volume according to symptoms and performance. Within this framework, kinesiology taping can be selectively applied in the early and middle phases of rehabilitation to reduce pain during weight-bearing and functional tasks, enhance patient confidence and facilitate adherence to exercise and activity modification; a consistent taping protocol that aims to optimize patellar alignment, provide comfortable support and avoid excessive skin irritation is recommended. Clinicians should offer taping particularly to individuals who report high pain levels at baseline, difficulty tolerating loading exercises or fear of movement, but should also communicate that taping is a temporary aid designed to complement, not replace, active rehabilitation. In practice, regular review of taping effectiveness, patient preference and skin tolerance is necessary, with gradual weaning of tape use as strength, motor control and functional capacity improve. For service planners and educators, these results support the development of PFPS rehabilitation pathways that are exercise-centred, with optional access to taping for selected patients, rather than routine taping for all. Patients should be counselled that consistent participation in a well-designed exercise programme, supported by advice on load management, footwear and activity pacing, is likely to yield the greatest long-term benefit, while taping can be considered an additional tool for symptom management in specific contexts such as return to sport, demanding occupational tasks or flare-ups. Finally, the modest incremental gains associated with kinesiology taping highlight the need for individualized, shared decision-making that balances potential benefits, time, cost and patient values, ensuring that resources are directed primarily toward interventions with the strongest and most durable impact namely, progressive exercise, education and long-term self-management strategies.

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