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Review Article Open Access

An Evidence-Based Practice Approach to the Efficacy of Kinesio Taping for Improving Pain and Quadriceps Performance in Physically-Active Patellofemoral Pain Syndrome Patients

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Abstract

Background: Patellofemoral Pain Syndrome (PFPS) is the most commonly diagnosed musculoskeletal condition in physically active patients. Sports medicine clinicians typically use physical rehabilitation and therapeutic taping techniques to control pain and improve muscular performance in patients with PFPS. Recently, Kinesio Tape (KT) has gained popularity among sports medicine clinicians and athletes for the treatment of various musculoskeletal disorders; however, its efficacy in the treatment of most orthopedic conditions, including PFPS, has not been widely investigated.

Objective: The purpose of this review was to critique evidence for the efficacy of KT in improving clinical outcomes in PFPS patients.

Methods: English-language publications from 2003 to 2013 were surveyed by searching PubMed, CINAHL, SPORTDiscus, and the Cochrane Library databases using the terms Kinesio tape, Kinesio taping, and knee. Studies focused on generally healthy, physically-active individuals with PFPS who had KT applied at the knee were selected. Pain during activity and/or knee extensor performance was the measures of interest.

Results: Conflicting results found in studies of varying methodological quality show that KT application does not differ significantly from McConnell medial glide taping technique with regard to pain reduction or knee extensor performance, and that pain may decrease and knee extensor performance may increase with KT application. Conclusions: The best evidence suggests that KT may be used in place of or in conjunction with traditional therapies to improve pain and performance of the knee extensors. Currently, there is limited high level, high quality evidence available.

Keywords: Knee-joint; Strength; Isokinetic; Clinical-outcomes; PFPS: Patellofemoral pain syndrome; KT: Kinesio Tape

Introduction

Patellofemoral pain syndrome (PFPS) is the most commonly diagnosed orthopedic pathology in physically active individuals [1]. Traditionally, PFPS was seen as the maltracking of a dynamic patella on a stable femur; however, more recent research has shown that PFPS may in fact be the result of abnormal dynamic femoral movement underneath a stable patella, which causes a reciprocal increase in the dynamic Q-angle [2]. This excessive movement, coupled with a decrease in patellar contact with the femur, is hypothesized to cause the pain common to PFPS [2].

The development of PFPS is multifactorial in nature; as a result, bringing about a resolution of symptoms can be clinically challenging. Traditionally, physical rehabilitation has focused on increasing knee extensor strength and flexibility and therapeutic taping techniques have been employed. McConnell taping is a frequently utilized patellar taping technique that is proposed to have up to three effects: patellar glide, patellar tilt, and patellar rotation [1]. The McConnell medial glide technique is commonly used in the treatment of PFPS [3]. In these patients, the femur tends to adduct relative to a stable patella during movement [2]. By applying a medial glide McConnell taping, it is hypothesized patellar tracking will be improved due to the force of the tape pulling the patella medially and improving patellofemoral kinematics [1].

Kinesio tape (KT) is a relatively new modality that has become popular with athletes and clinicians alike in the treatment of musculoskeletal pathologies. It is a cotton and elastic blend athletic tape that was designed to match the texture and elasticity of human skin [4]. It is theorized that the use of KT can enhance joint stability by providing support to or around affected muscles [4]. Additionally, it has been proposed that KT can be used for neuromuscular re-education, for pain reduction, to improve performance, to prevent injury, and to improve circulation and healing [4]. These claims purport that KT is useful in both injured and uninjured populations; however, the physiological basis for these claims are not yet well understood. It is possible that KT may function to reduce pain in PFPS patients by providing them with cutaneous stimulation via large afferent fibers achieved through deformation of the slowly adapting mechanoreceptors in the skin. It is also proposed that KT may facilitate muscle contraction, the mechanism for which remains unknown.

While KT application has become increasingly popular in recent years, evidence to support its efficacy has been conflicting. In healthy individuals, the application of KT at varying sites, including the forearm, shank, and thigh, has not been shown to improve strength, endurance, or functional performance [5-9]. In injured individuals,

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the efficacy of KT application is conflicting. In two separate systematic reviews of the use of KT to treat pathologies, Morris et al. [10] and Mostafavifar et al. [11] concluded that more research needs to be done before KT can be recommended for clinical use over other treatments. The latter indicated that the benefits with regard to pain could not be entirely discounted [11]. Both reviews also noted a lack of high-quality randomized controlled trials (RCTs) available for systematic review [10,11]. Conversely, other non-RCT research [12-14] has shown that KT has beneficial effects on both pain and functional performance in patients with shoulder impingement and lateral ankle sprain.

Evidence-based practice is a process common to multiple allied health professions and assists clinicians in determining the best plan of care for each patient. Based on results from existing literature [3,15-18], it is possible that KT may have an effect on pain and knee extensor performance in PFPS patients. Thus, the purpose of this systematic review is to determine if the application of KT can improve clinical outcomes, including pain and knee extensor strength and endurance, in physically active patients diagnosed with PFPS.

Materials and Methods

Search strategy

A comprehensive survey of scientific studies published between 2003 and 2013 was conducted. A series of literature searches used PubMed, SPORT Discus, CINAHL, and the Cochrane Library electronic databases. The keywords used across databases were Kinesio tape, Kinesio taping, and knee. We screened the titles of all retrieved hits and identified potentially relevant studies by analyzing associated abstracts in reference to the specified Patient Intervention Comparison Outcome (PICO) model (Figure 1), which was broad in order to allow for more than one study to meet the criteria. Entire studies were obtained if we deemed the research study satisfied inclusion criteria.

Inclusion Criteria

Inclusion criteria consisted of scientific publications that evaluated the effects of KT application on ratings of pain in patients with PFPS. Peer-reviewed studies were eligible for inclusion in the critical appraisal if they were categorized at a minimum of level 2 evidence [19], which includes RCTs and cohort studies. Participants enrolled in the studies must have been diagnosed with PFPS and all studies included in this review used reliable measurement tools employed in the biomedical, health, and rehabilitation sciences.

P	physically or recreationally active and patellofemoral pain syndrome
I	kinesio tape or kinesio taping
C	McConnelltherapeutic taping or physical rehabilitationor no treatment and patellofemoral pain syndrome
O	pain or knee extensor performance

Figure 1: Description of terms used to guide search strategy using the PICO model.

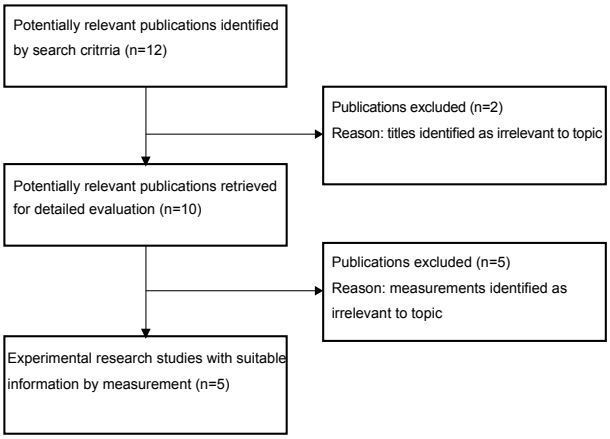

Figure 2: QUORUM-statement flow diagram illustrating the results of the literature search.

Exclusion Criteria

Studies published in languages other than English or prior to 2003 were excluded. Research studies investigating the effects of KT application on various measures in healthy individuals and research studies investigating the effects of KT application in individuals with osteoarthritis or other knee conditions were also excluded. Additionally, any evidence less than level 2, including pilot or case studies, were omitted [19].

Data Extraction and Critical Appraisal

The following data were extracted from selected publications to assess the effectiveness of KT application in patients with PFPS and to analyze outcomes in retrieved research studies: experimental design; population size; patients/participants treated; control group; comparison method; concomitant interventions; outcome measures. Relatively little evidence is currently available regarding the effects of KT application in patients with PFPS; as a result, interventions and outcomes were expanded in order to increase the number of studies available for analysis.

Additionally, methodological quality of all scientific studies was critically appraised as per the levels of evidence categorized by the Centre for Evidence-Based Medicine (CEBM) [19]. Randomized control trials were further scrutinized with a validity score using the PEDro scale and all studies were scrutinized for methodological quality using the Downs and Black revised checklist [20,21]. These appraisals were performed by the first author.

Results

Eleven studies were identified in this search of the respective databases, indicating a dearth of information detailing the effects of KT application on clinical outcomes in physically active PFPS patients. A total of five studies were selected for this review (Figure 2).

The five relevant research studies [3,15-18] were classified according to levels of evidence as described by the CEBM [19]. When applicable (RCTs), studies were further scrutinized with a validity score (PEDro) assessment [20]. Additionally, Downs and Black's [21] revised checklist was employed to assess the methodological quality of the selected studies.

A review of the literature was conducted in order to identify studies with a minimum of level 2 evidence [19] on the efficacy of the application of KT in patients with PFPS. Two randomized controlled trials [15,16] and three crossover studies [3,17,18] were selected for analysis. Relevant research studies outlined in Table 1 were recognized as the "best" available evidence. These studies were selected on the basis of having investigated the effect of KT application in physically active patients with PFPS, and having described KT's effects on pain and/or quadriceps strength and endurance.

Table 1: Summary of Best Evidence.

	Akbas et al. [15]	**Aytar et al. [16]**	**Lee et al. [17]**	**Osorio et al. [3]**	**Campolo et al. [18]**
Level of evidence	1b	1b	2c	2b	2c
Participants	31 female participants: KT group [n=15], control [n=16] KT group mean 41.00 y ± 11.26 control mean 44.88 y ± 7.75 Patients included if they were referred by an orthopedist for unilateral PFPS and were between the ages of 17-50 Patients excluded if diagnosed with tendonitis, Osgood-Schlatter syndrome, known articular cartilage, meniscus or ligament damage, history of patellar subluxation or dislocation and previous knee surgery No significant differences in age, BMI, ITB/TFL length, or hamstring tension between KT group and control group before treatment	22 female participants: KT group [n=12],PKT group [n=10] KT group mean 22.41 y ± 1.62 PKT group mean 26.20 y ± 3.52 Patients included if they had retro-patellar pain for >6 months of insidious onset and pain elicited with various activities Patients excluded if they were allergic to the tape, had a history of knee pain, trauma, surgery or joint disease or if they were competitive athletes Groups did not differ significantly in BMI, or duration of pain; PKT group was significantly older than KT group ($p<0.05$) 2 participants assigned to PKT group dropped out	15 male participants; mean 23 y Patients included if they had anterior or retropatellar pain of insidious onset and pain elicited with various activities, and if they had not previously received treatment Patients excluded if they had signs of knee osteoarthritis, history of knee surgery, dislocation or subluxation of patella, injury to meniscus or knee ligament, pain due to spinal cord injury, or patellar tendonitis or other type of anterior pain	7 male, 13 female participants; mean = 21.2 y ± 2.9 Patients included if they were recreationally active, diagnosed with PFPS by a physician within 6 months of participation, not following a physical therapy program and were between the ages of 16-35. Patients excluded if they had musculotendinous, capsuloligamentous, or meniscal pathology, history of contra- or ipsilateral ankle or hip injury, history of cerebral or metabolic dysfunction that impairs sensorimotor function, or sustained a concussion within 6 months of participation	5 male, 15 female participants; mean = 23 y ± 3 Patients included if they had knee pain with running, squatting, kneeling and stair ascent and descent, and were between 13-30 years old Patients excluded if they had knee surgery within a year, knee pain for greater than a year, corticosteroid injection within 3 months, tenderness in the joint line, moderate-severe arthritis based on radiographs, any other knee pathology, or were pregnant or had the potential to be
	31 female participants: KT group [n=15], control [n=16] KT group mean 41.00 y ± 11.26 control mean 44.88 y ± 7.75 Patients included if they were referred by an orthopedist for unilateral PFPS and were between the ages of 17-50 Patients excluded if diagnosed with tendonitis, Osgood-Schlatter syndrome, known articular cartilage, meniscus or ligament damage, history of patellar subluxation or dislocation and previous knee surgery No significant differences in age, BMI, ITB/TFL length, or hamstring tension between KT group and control group before treatment	22 female participants: KT group [n=12],PKT group [n=10] KT group mean 22.41 y ± 1.62 PKT group mean 26.20 y ± 3.52 Patients included if they had retro-patellar pain for >6 months of insidious onset and pain elicited with various activities Patients excluded if they were allergic to the tape, had a history of knee pain, trauma, surgery or joint disease or if they were competitive athletes Groups did not differ significantly in BMI, or duration of pain; PKT group was significantly older than KT group ($p<0.05$) 2 participants assigned to PKT group dropped out	22 female participants: KT group [n=12],PKT group [n=10] KT group mean 22.41 y ± 1.62 PKT group mean 26.20 y ± 3.52 Patients included if they had retro-patellar pain for >6 months of insidious onset and pain elicited with various activities Patients excluded if they were allergic to the tape, had a history of knee pain, trauma, surgery or joint disease or if they were competitive athletes Groups did not differ significantly in BMI, or duration of pain; PKT group was significantly older than KT group ($p<0.05$) 2 participants assigned to PKT group dropped out		
Intervention investigated	Both groups received 6 weeks of at-home physical therapy exercises with progressions KT group received individually designed applications every 5 days that remained on the skin until subsequent visits	KT group received Y-Shaped Chane kinesio tape to KT on quadriceps; PKT group received same Y-Shaped taping with sticking plaster Examiners and patients were blinded	All participants completed baseline testing followed by the same testing with KT applied	All participants received spider KT and McConnell medial glide taping randomly separated by a 72-hour wash-out period	All participants underwent no tape, KT and McConnell tape conditions
Control	6 week home physical therapy program	PKT application	Baseline measurement	Baseline measurement	No tape

Experimental	Individualized KT application every 5 days with 6 week home physical therapy program	KT application	KT with same protocol at 45 minutes post application	McConnell medial glide taping and Upper Knee Spider KT with same protocol at 72 hours post and 114 hours post application	KT and McConnell taping applications
Outcome Measures (Primary and Secondary)	Pain using visual analog scale (VAS) during 9 specified activities and Kujala score Mediolateral position of the patella using a modified Vernier caliper ITB/TFL length using a modified Ober's test Hamstring tension using a goniometer	Quadriceps strength at 60˚/s and 180˚/s using isokinetic dynamometer Joint position sense using and isokinetic dynamometer Balance using a Kinesthetic Ability Trainer for dynamic balance Pain using VAS during various activities	MVIC with knee extension using a digital dynamometer VMO and VL activation during stair ascent and descent using EMG surface electrodes Pain using VAS during MVIC, and stair ascent and descent	Quadriceps strength using an isokinetic dynamometer at 60˚/s Quadriceps endurance using an isokinetic dynamometer at 240˚/s Pain using VAS and Kujala score Activity level using the Tegner Activity Scale	Pain using the Numeric Pain Intensity Scale (NPIS) during squatting with 10% of body weight plus 8.5lbs (weight box) and during stair ascent and descent
Main Findings	Pain decreased significantly for each of the nine positions from pre-treatment measures for both KT group and control ($p<0.05$), but KT group was not significantly different from control Hamstring tension decreased significantly from pre-treatment measures ($p<0.05$) for both KT group and control, though KT group decreased faster (3 weeks vs. 6 weeks) ITB/TFL length increased significantly from pre-treatment measures ($p<0.05$) for both KT group and control, though KT group increased faster (3 weeks vs. 6 weeks) Patellar tilt did not differ significantly from pre-treatment measure in either group ($p>0.05$) Kujala score increased significantly from pre-treatment measures for both KT group ($p=0.012$) and control ($p=0.002$), but KT group was not significantly different from control ($p>0.05$)	Strength increased significantly from pre-treatment measures at 60˚/s for both KT ($p=0.028$) and PKT ($p=0.007$); strength increased significantly at 180˚/s for KT ($p=0.012$) Static balance improved significantly from pre-treatment measures for both KT ($p=0.012$) and PKT ($p=0.042$); dynamic balance improved significantly from pre-treatment measures for KT ($p=0.046$) Joint position sense was not different from pre-treatment measures for either KT or PKT Pain did not decrease significantly from pre-treatment measures for either KT or PKT group There were no difference between KT and PKT for any of the measures	MVIC increased significantly after tape application ($p<0.01$) VMO and VL activation decreased significantly after tape application with stair ascent ($p<0.01$) VMO and VL activation decreased significantly after tape application with stair descent ($p<0.05$) Pain decreased significantly after tape application ($p<0.05$)	Quadriceps strength increased significantly from baseline with McConnell medial glide taping and KT, but there was no difference between McConnell medial glide taping and KT; effect size was greater with KT (ES=0.262 vs. ES=0.287) Quadriceps endurance increased significantly from baseline with McConnell medial glide taping and KT, but there was no difference between McConnell medial glide taping and KT; effect size was greater for KT (ES=0.254 vs. ES=0.548) During both strength and endurance testing, pain decreased significantly from baseline with McConnell medial glide taping and KT; effect size was greater with KT for both conditions (strength: ES=0.269 vs. ES=0.316,endurance: ES=0.254 vs. ES=0.417)	No differences among groups with regard to pain during squatting ($p=0.275$) KT application significantly decreased pain during stair ascent and descent compared to no tape ($p=0.034$) McConnell tape application did not cause a significant decrease in pain during stair ascent and descent compared to no tape ($p=0.105$) KT application did not decrease pain significantly more than McConnell tape during stair ascent and descent ($p=0.869$)
Validity Score	PEDro 5/10	PEDro 7/10	NA	NA	NA
Conclusion	The use of KT in conjunction with a physical therapy program may be useful in decreasing hamstring tension and increasing ITB/TFL length faster than physical therapy alone in patients with PFPS	KT may be used to increase quadriceps strength at 180˚/s and dynamic balance, but does not appear to be more effective than PKT in decreasing pain or improving joint position sense in patients with PFPS	KT may increase MVIC during knee flexion, decrease VMO and VL activation during stair ascent and descent and decrease pain during these activities in patients with PFPS	KT is more useful than no treatment and may be more useful than McConnell medial glide taping in increasing quadriceps strength and endurance and decreasing pain in patients with PFPS	Both KT and McConnell tape can be useful to reduce pain during stair ascent and descent

PFPS, Patellofemoral Pain Syndrome; KT, Kinesio tape; PKT, Placebo Kinesio Tape; VAS, Visual Analog Scale; MVIC, maximum voluntary isometric contraction; ITB, iliotibial band; TFL, tensor fascia latae; VMO, vastusmedialis oblique.

Table 2: Downs and Black's revised checklist for measuring study quality [14] (scores by article).

Article	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	Total
Akbas et al. [15]	1	1	1	1	0	1	1	0	0	0	0	0	1	0	1	1	1	0	0	1	1	0	1	0	0	0	0	13
Aytar et al. [16]	1	1	1	1	0	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	0	0	0	18
Lee et al. [17]	1	1	1	1	0	1	1	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	1	0	15
Osorio et al. [3]	1	1	1	1	0	1	1	0	1	1	0	0	1	0	0	1	1	1	1	1	1	1	0	0	0	1	0	17
Campolo et al. [18]	1	1	1	1	0	1	1	0	1	1	0	0	1	0	0	1	0	1	1	1	0	0	0	0	0	1	0	14

1=yes; 0=no, or unable to be determined based on available information

Discussion

Four of the research studies [3,15-18] systematically reviewed reported a decrease in pain with KT application compared to pre-treatment measures. Akbas et al. [15] investigated the effect of KT application in physically active patients with PFPS during a traditional physical rehabilitation regimen. Both physical rehabilitation and physical rehabilitation with KT application significantly decreased pain as measured by both Visual Analog Scale (VAS) and Kujala scores at the end of a 6-week intervention; however, there were no differences in pain measures between groups after 6 weeks of related treatments. Lee et al. [17] compared VAS scores in a cohort of physically active PFPS patients during stair ascent and descent both before and after KT application and noted that pain significantly decreased with KT application. Osorio et al. [3] compared the effects of McConnell medial glide taping to KT application on VAS scores during isokinetic concentric knee extensor strength and endurance testing in associated patients. Pain significantly decreased for both taping interventions during inclusive strength and endurance assessments, but the respective effect sizes were greater with KT application indicating KT may have a greater clinical impact. Similarly, Campolo et al. [18] compared the effects of KT and McConnell taping to no tape on pain during squatting and stair ascent and descent as measured by the Numeric Pain Intensity Scale. Though no differences in pain were found among groups during squatting, pain decreased significantly for the KT group in comparison to the no tape group during the stair task. However, pain with McConnell taping did not differ from pain with no tape, and pain with KT did not differ from pain with McConnell taping during the stair tasks [18]. While Aytar et al. [16] found that pain decreased from pre-treatment measures during most functional activities for both KT and placebo KT application groups, the decreases were not statistically significant. These results demonstrate the potential elicitation of a placebo effect, which has been found to be useful in reducing knee pain [22]. Thus, despite the fact that the reduction in pain by KT was not statistically significant, the findings of Aytar et al. [16] suggest that KT may be clinically useful for the purpose of reducing pain in patients with PFPS. The results of these studies indicate that KT can be used as an adjunct to traditional physical rehabilitation, as a stand-alone treatment or as an alternative to McConnell taping to decrease pain in physically active PFPS patients without risk of negative side effects.

Three of the research studies [3,16-17] reviewed reported an increase in isokinetic concentric quadriceps strength associated with KT application and one study [3] furthermore reported a corresponding increase in endurance. Aytar et al. [16] found that quadriceps strength at 60˚/s increased significantly for both KT and placebo KT groups compared to pre-treatment measures. Again, the results demonstrate the potential elicitation of a placebo effect. These findings compliment the work of Whittingham et al. [22], who investigated the effects of McConnell medial glide taping to placebo with and without physical rehabilitation. Additionally, strength increased significantly at 180˚/s for the KT group only compared to pre-treatment. However, no significant differences were found between KT and placebo KT groups after application for either isokinetic strength measure. Similar to the results of Aytar et al. [16], Osorio et al. [3] found that isokinetic concentric quadriceps strength at 60˚/s increased significantly following the application of KT and McConnell medial glide taping compared to a baseline measure; however there was no statistical difference and a weak effect size between taping interventions. Additionally, Osorio et al. [3] investigated the effect of KT and McConnell medial glide taping application on isokinetic concentric quadriceps endurance. Both taping techniques significantly increased knee extensor endurance from baseline, though the effect size was great for KT application, suggesting KT may have a greater related clinical impact. Lee et al. [17] found that maximum voluntary isometric contraction during knee extension increased significantly after KT application when compared to pre-treatment measures. Results from these studies indicate the KT application may be used to increase knee extensor strength and endurance in physically active PFPS patients. The application of KT in physically active PFPS patients may be useful in decreasing pain and increasing knee extensor strength and endurance in the short term during the execution of functional performance tasks.

Additional longitudinal research is needed to investigate the effects of KT application over time on pain and strength and endurance measures. Furthermore, subsequent RCTs should focus on the effect of KT application on knee extensor endurance in physically active PFPS patients as existing literature on this topic is sparse. Additionally, these investigations should focus on improving the level of methodological quality as determined by the Downs and Black [14] revised checklist. Table 2 demonstrates the results of this qualitative assessment, which indicate that the average score for studies included in this review was a 15.4/27. This demonstrates that the experiments included in this review account for only 57% of the essential components necessary to be deemed a high quality research study. Future assessments may also focus on self-reported and functional outcomes as measured by more low cost functional measures that can be more readily and easily applied in a clinical setting.

Ensuing analyses should address the limitations of this review. For example, studies published in any language but English were excluded from the analysis. As a result, relevant published works were omitted that may have affected the strength of recommendation. It should also be noted that this review has addressed all available literature regarding the effects of KT application in patients with PFPS. Thus, future related investigations should recognize and address this specific notable limitation and it may be beneficial to repeat appraisal of this clinical question when more research, and more methodologically sound research, becomes available.

Conclusion

Limited evidence from this review suggests that the application of KT may improve clinical outcomes in patients with PFPS. Specifically, it indicates that KT may result in decreases in perceived pain and increased quadriceps strength and endurance in PFPS patients. Kinesio tapeis time and cost effective, can (in some cases) be easily applied by the patient, and is not associated with known negative side effects. To date, level B evidence [19] exists that supports the use of KT with or without a traditional physical rehabilitation regimen, or in place of alternative taping techniques, such as those proposed by McConnell, for a short-term decrease in pain and increase in knee strength and endurance in physically active patients diagnosed with PFPS.

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