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The Effectiveness of Patellar Taping Combined with Exercise on Pain in Adults with Patellofemoral Pain Syndrome (PFPS)

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CRITICALLY APPRAISED TOPIC

Title: The Effectiveness of Patellar Taping Combined with Exercise on Pain in Adults with Patellofemoral Pain Syndrome (PFPS)

Clinical Scenario: The patient who led me to pursue this question is a 24-year-old female with a diagnosis of PFPS. Medical treatment to date includes self-referral to physical therapy where she received lower extremity strengthening and stretching exercises as well as patellar taping. Problems identified include patellar malalignment, lower extremity weakness (especially of the quadriceps and hip external rotators), and loss of lower extremity flexibility.

Brief Introduction: For the purposes of my clinical question, I want to know what the research says about the use of patellar taping on patients with PFPS. The patients in the outpatient orthopedic clinic where I am working often have anterior knee pain classified as PFPS. One treatment technique for patellofemoral pain that is frequently used in conjunction with exercise is patellar taping. Patellar taping is thought to decrease pain by realigning the position of the patella and increasing the contraction of the vastus medialis oblique (VMO), however research to support this has often been contradictory or inconclusive.[1]

My Clinical Question: Does patellar taping and exercise reduce knee pain in adults with patellofemoral knee pain more than exercise alone?

Clinical Question PICO:

Population: Adults with patellofemoral knee pain

Intervention: Patellar taping and exercise

Comparison: Exercise

Outcome: Pain as measured by the visual analog scale (VAS)

Overall Clinical Bottom Line: Based on the results of the two studies by Clark *et al.* and Whittingham *et al.*, there is inconclusive evidence to suggest that for individuals with PFPS, patellar taping combined with exercise results in an additional decrease in anterior knee pain compared to exercise alone. According to the study by Whittingham *et al.*, application of individualized patellar taping before daily exercise for four weeks may decrease anterior knee pain in the short-term in young adults with acute PFPS. However, the study by Clark *et al*. showed that in those with PFPS lasting more than three months, standardized patellar taping and exercise six times over three months may not be beneficial in decreasing anterior knee pain one year later. There are at least four main differences between the studies that could account for the different results. First, Clark *et al.* used a standardized tape application for patella glide only, whereas Whittingham *et al.* used an individualized approach in which tape was applied to correct specific patella malalignments (glide, tilt, or rotation) identified by the sole treating therapist.

The taping protocol performed by Whittingham *et al.* is more closely aligned with what would be observed clinically and presents a more valid way to test the efficacy of patellar taping. Second, the studies used different exercise protocols. Clark *et al.* utilized an active warm-up and closed kinetic chain exercises (CKC) and Whittingham *et al.* began with open kinetic chain (OKC) isometric exercises and progressed subjects to CKC exercises. Third, the acuteness and chronicity of the subjects' PFPS likely played a role in treatment response. It is possible that the subjects with acute PFPS in Whittingham *et al.* responded more favorably to all of the interventions than the subjects with chronic PFPS recruited by Clark *et al.* Last, differences between studies in terms of frequency and duration of treatment and type and timing of outcome measures also make it difficult to draw definitive conclusions from the results. External validity of the study by Whittingham *et al.* was limited by their protocol involving 28 consecutive visits over four weeks with 100% compliance that is likely not feasible for the clinical population. The small sample size and the narrow populations from which subjects were recruited further decrease the ability to apply these study results to a larger population. More research on this topic should include larger populations, individuals with similar chronicity of PFPS, individualized patellar taping as opposed to standardized taping, short-term versus long-term benefits, influence of different exercise protocols (OKC vs. CKC, isometric vs. dynamic, variations in initial exercises and exercise progression), and look at the differences in effectiveness between therapist-applied tape and patient-applied tape. In addition, studies could examine patient tolerance to exercise with and without individualized patellar taping due to potential immediate decreases in pain; this may allow for more active treatment sessions and more rapid strength gains.

Search Terms: patellofemoral pain syndrome, patella, patellofemoral joint, anterior knee pain, McConnell, taping, athletic tape

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Rationale for chosen articles: The databases utilized in the search for studies applicable to the clinical PICO included Academic Search Premier, AgeLine, MEDLINE, CINAHL, PEDro, SPORTDiscus, and Web of Science. Using these databases and search terms, I was able to find more than a few studies related to my topic and from there narrowed the collection down to three studies of interest. Rationale for the chosen articles included their PEDro score as reported on the PEDro database (Table 1); applicability to my clinical PICO; and continuity in patient criteria, treatment, methods, and outcome measures so that results could be compared and generalized to my population of interest. The article by Clark *et al.* matched my clinical PICO well and received a PEDro score of 7/10 for lack of therapist and subject blinding as well as not

concealing subject allocation. The second article by Kowall *et al.* was given a low PEDro score of 4/10; however, its study methods closely aligned with my clinical PICO. The article by Whittingham *et al.* was one of the few studies to attempt blinding of subjects and received the highest PEDro score with an 8/10 (only missing points for lack of therapist blinding and concealed allocation). Although the population for the article by Whittingham *et al.* was comprised of Army recruits and may not be representative of the general population, it did include female subjects of the same age as my patient of interest. While the exercise protocols were different between studies, some form of lower extremity stretching and strengthening exercises that included the quadriceps muscle group was performed. Method of taping was similar between studies. Two groups specifically stated they used the McConnell patellar taping technique and one study using a similar technique but not identifying it as McConnell. All studies used a VAS to evaluate pain during a functional activity as their outcome measure. Ultimately the article by Kowall *et al.* was not used to write this critically appraised paper due to its low PEDro score, low number of subjects, and being the least recent published study.

(1) Clark DI, Downing N, Mitchell J, Coulson L, Syzpryt EP, Doherty M. Physiotherapy for anterior knee pain: a randomized controlled trial. *Ann Rheum Dis.* 2000;59:700-704.

PEDro Score: 7/10

Patient: 40 patients aged between 16 and 40 years with anterior knee pain lasting more than three months

Intervention: Patient education, stretching and strengthening knee exercises, and standardized patellar taping

Comparison: Patient education, stretching and strengthening knee exercises

Outcome measures: A visual analog pain score based on two 100-mm VAS scores rating pain during the functional activities of stair climbing and ambulation

(2) Kowall MG, Kolk G, Nuber GW, Cassisi JE, Stern SH. Patellar taping in the treatment of patellofemoral pain. A prospective randomized study. *Am J Sports Med.* 1996;24(1):61-66.

PEDro Score: 4/10

Patient: 25 patients aged between 14 and 40 years with patellofemoral pain for more than one month

Intervention: Four-week physical therapy program including a home exercise program (HEP) and patellar taping

Comparison: Four-week physical therapy program including a HEP

Outcome measures: A 10-point VAS relating to pain frequency, severity of pain, effect of

pain on athletic activities, and the effect of pain on adult daily living activities

(3) Whittingham M, Palmer S, Macmillan F. Effects of taping on pain and function in patellofemoral pain syndrome: A randomized controlled trial. *J Orthop Sports Phys Ther.* 2004;34(9):504-510.

PEDro Score: 8/10

Patient: 30 army recruits aged between 17 and 25 years with acute PFPS

Intervention: Standardized exercise program and individualized patellar taping

Comparison: Standardized exercise program and placebo taping, and a standardized exercise program alone

Outcome measures: Three 10-cm horizontal VAS scores relating to average pain over the previous 24 hours, pain upon stepping down from an 8-inch gym bench with patellar taping, and pain upon stepping down without tape applied

Table 1. Comparison of PEDro Scores

	Clark *et al.*	Kowall *et al.*	Whittingham *et al.*
Random	Yes	Yes	Yes
Concealed Allocation	No	No	No
Baseline comparability	Yes	Yes	Yes
Blind Subjects	No	No	Yes
Blind Therapists	No	No	No
Blind Assessors	Yes	No	Yes
Adequate Follow-up	Yes	Yes	Yes
Intention-to-Treat	Yes	No	Yes
Between Group	Yes	Yes	Yes
Point Estimates & Variability	Yes	No	Yes
Total Score	7/10	4/10	8/10

Based on the above comparisons, I have chosen to write this critically appraised paper on the articles by Clark *et al.* and Whittingham *et al.*

Article: Clark *et al.*, 2000.

Clinical Bottom Line: Based on the results of this randomized controlled study with 40 adults with PFPS, there is moderate evidence to suggest that standardized patellar taping in addition to patient education, lower extremity stretches, and strengthening knee exercises results in no additional decrease in anterior knee pain compared to patient education, lower extremity stretches, and strengthening knee exercises alone. Subjects received treatment six times over three months. Knee pain during functional activity was assessed using two 100-mm VAS scores at baseline, three months, and 12 months. Both groups showed statistically significant decreases in knee pain at all timepoints compared to baseline with differences larger than the minimal clinically important difference (MCID) of 26 mm established in the literature. There were no statistically significant differences in VAS pain *between* groups at any timepoint. The number of treatments, exercise protocol, minimal financial cost, and time requirement in tape application outlined in this study are feasible in an outpatient orthopaedic setting. The authors did not report the patient compliance rate and is it not clear if patient adherence to a HEP and self-taping is necessary for the results seen. Moderate threats to internal validity included: lack of therapist and subject blinding and standardized tape application (as opposed to the more commonly used individualized application of patellar taping performed clinically). Subjects were recruited from one region in the United Kingdom and there may be cultural or regional differences that could affect the generalizability of results to a larger population. Further research on the efficacy of patellar taping in decreasing anterior knee pain with larger multi-region populations and study designs utilizing individualized patellar taping and lower extremity exercise to both a control sham taping group and a placebo group to allow for subject blinding would be beneficial in determining whether the typical clinical application of patellar taping decreases anterior knee pain in adults with PFPS.

Article PICO:

Population: 40 patients aged between 16 and 40 years with anterior knee pain lasting more than three months

Intervention: Patient education, stretching and strengthening knee exercises, and standardized patellar taping

Comparison: Patient education, stretching and strengthening knee exercises

Outcomes: A visual analog pain score based on two 100-mm VAS scores rating pain during the functional activities of stair climbing and ambulation

Blinding: The assessors were blinded to subject group allocation. The therapists and subjects were not blinded to the intervention given. Lack of therapist and subject blinding presents a moderate threat to the internal validity.

Controls: The control group received the same education, knee stretches, and knee exercises as the treatment group. The only difference in interventions between groups was the addition of patellar taping (the independent variable) to the treatment group. Both groups received the same number of treatments over the course of the study; however, the authors did not state the length of these treatments. It is unknown if the treatment group had longer treatment sessions and received more therapist contact time to allow for taping which could present a minor threat to the internal validity.

Randomization: Subjects were allocated to groups using an individualized computer generated randomization program. Randomization was considered successful as there were no significant differences between subjects in terms of age, duration of knee pain, employment, body mass index (BMI), use of pain medication or anti-inflammatory medication, quadriceps strength, or VAS score for knee pain at baseline. Randomization was not concealed to therapists.

Study: This was a randomized clinical trial involving 40 individuals between the ages of 16 and 40 years recruited from general practitioners, orthopaedic consultants, and rheumatology consultants in the Nottingham area of the United Kingdom. Subjects were included if they had a history of anterior knee pain lasting more than three months. Subjects were excluded if they had a history of true locking, arthritis, patella dislocation, laxity of the knee ligaments, abnormal knee radiographs, malignancy, infection, or previous physiotherapy treatment for their knee. Subjects were randomly assigned to a treatment group (n=20) or a control group (n=20). Each group received six treatment sessions over three months. The authors did not state the length of each treatment session. All subjects received the same education consisting of a leaflet from the Arthritis Research Campaign regarding knee pain in young adults and information provided by the therapist at each session. The therapist discussed information on knee anatomy, anterior knee pain, footwear, appropriate activities, pain medication, ice, massage, stress reduction, diet, and weight with each subject. All patients performed lower extremity stretches and exercises focused on the knee extensors. Stretches were performed for the hamstrings, iliotibial band (ITB), quadriceps, and gastrocnemius with ten-second holds and ten repetitions. Exercise began with a three-minute warm-up on a stationary bike followed by wall squats, sit to stands, step downs, balance exercises using a small trampoline, and other exercises for the gluteus medius and maximus that were not described by the authors. Patients were instructed to perform exercises daily and were supplied a diary sheet to help with compliance; the volume of exercises prescribed was not detailed. In addition to education, stretching, and strengthening, the treatment group received patellar taping. Taping was applied to all subjects in a standardized way to improve patella glide. Tape was applied from the lateral border of the patella and pulled superiorly and medially onto the medial femoral condyle. Tape was applied until it reduced pain on the squat test and wall/step down test. At the first three sessions, taping was applied before beginning activity. Patients were also given tape at the first three sessions but the authors did not state if patients were taught to apply tape independently at home. Taping was only applied during painful activities at the fourth and fifth session and was not applied at the sixth.

Outcome Measures: Pain was measured at baseline, three months, and 12 months using two horizontal VASs that rated subject difficulty with stair climbing and ambulation on a level surface. The two VASs were 0-100 mm with 0 indicating "no pain" and 100 indicating "extreme pain" for a total possible score of 200. The authors did not report on the MCID, reliability, or validity of the VAS although it is a widely used tool for measuring pain. In the absence of a gold standard for pain assessment, the criterion validity of the VAS cannot be determined; however, Carlsson *et al.* showed it to be a valid tool for measuring self-perceived pain and intensity.[2] Crossley *et al.* reported good reliability of an activity based VAS for individuals with patellofemoral pain and an MCID of 13 cm on a 100 mm VAS.[3]

Study Losses: At three months, four subjects (20%) from each group withdrew. At the 12-month follow-up, six additional subjects (30%) from the treatment group and four (20%) from the control group did not return questionnaires. Subjects who withdrew were included in the authors' statistical analysis on an intention-to-treat basis. The study authors did not give an explanation for study loses, elaborate on how the intention-to-treat analysis was performed, nor did they state if there were differences between subjects who completed the study and those who failed to attend.

Summary of Internal Validity: The internal validity of this study is fair to good (PEDro score 7/10). I identified four threats total: two moderate and two minor threats. Lack of therapist and subject blinding presents a moderate threat and introduces the possibility of the Hawthorne effect and therapist bias during treatment. While it may have been difficult to completely blind the therapists providing treatment, sham taping could have easily been applied to blind subjects. The standardized method of tape application that was used also presents a moderate threat. For all subjects in the treatment group, tape was applied to correct patella glide only. However, in a clinical setting, tape is applied to correct specific patellar malalignments that are found during the examination and clinicians utilize more than one taping strategy. Clinically, taping could be applied to remedy patellar glide, tilt, or rotation until the patient no longer experiences pain during functional activities. The difference between the study's standardized tape application and real-world clinical application decreases the internal validity. Because the authors did not state the length of treatment sessions or whether subjects receiving patellar taping had additional time with the therapist, the possible effect of additional therapist contact time is considered a minor threat. The high drop-out rate, the failure of the authors to report on their intention-to-treat method, and the lack of data regarding differences between subjects who completed the study and those who withdrew presents an additional minor threat.

Evidence: Knee pain during functional activities measured by VAS at baseline, three months, and at 12 months are indicators of the effectiveness of treatment group interventions compared to control group interventions in decreasing anterior knee pain. The authors reported no statistically significant differences between the treatment and control group at baseline, three months, or 12 months; therefore effect size between groups was not calculated. Both intervention groups showed statistically significant decreases in VAS pain at all timepoints compared to baseline

(P<0.0001) with all mean differences larger than the MCID established by Crossley *et al.*. The authors did not publish their raw data and values were calculated from mean VAS scores reported by the authors.

Because the authors found statistically significant within-group changes from baseline at both follow-up timepoints, I calculated effect size based on mean VAS scores at baseline, three months, and 12 months to show the magnitude of change in pain within groups from baseline to three and 12 months.

Table 2. Within-group mean differences in VAS score for knee pain from baseline to three months

	Treatment Group (n=20)	Control Group (n=20)
VAS pain in mm at baseline (mean ± standard deviation (SD))	75.6 (32.6)	77.1 (44.4)
VAS pain in mm at three months (mean ± SD)	35.9 (28.7)	30.0 (39.9)
Mean difference (95% confidence interval (CI))	39.7 (19.1 – 60.3)	47.1 (18.8 – 75.4)
Effect size (95% CI)	1.3 (0.6 – 2.0)	1.1 (0.5 – 1.8)

Table 2 lists the mean VAS scores at baseline and three months, the mean difference from baseline to one month within groups, and the effect size from baseline to one month within groups. For both groups, there was a statistically significant decrease in knee pain at three months compared to baseline (P<0.0001). The mean difference for both groups was larger than the 26.0 mm MCID, although the lower end of the 95% CI did not reach the MCID for either group. Both groups exhibited a large effect size from baseline to three months with the low end of the 95% CI still considered a medium effect size.

Table 3. Within-group mean differences in VAS score for knee pain from baseline to 12 months

	Treatment Group (n=20)	Control Group (n=20)
VAS pain in mm at 12 months (mean ± SD)	35.1 (45.1)	37.8 (43.4)
Mean difference from baseline to 12 months (95% CI)	40.5 (14.1 – 67.0)	29.8 (22.0 – 37.7)
Effect size (95% CI)	1.0 (0.4 – 1.7)	0.9 (0.3 – 1.6)

Table 3 lists the mean VAS scores at 12 months, the mean difference from baseline to 12 months within groups, and the effect size from baseline to 12 months within groups. For both groups, there was a statistically significant decrease in knee pain at 12 months compared to baseline (P=0.007). Again, the mean difference for both groups was larger than the 26.0 mm MCID, but the low ends of the 95% CI for both groups did not reach the MCID. The point estimate of the effect size from baseline to 12 months for each group was considered large.

Applicability of Study Results:

Benefits vs. Costs: Based on the results of this study, there did not appear to be a benefit to the addition of standardized patellar taping to an exercise and educational program on decreasing patellofemoral pain. The costs of patellar taping include the cost of taping materials, training of therapists in application, and patient and therapist time to apply the tape. While no adverse events were reported in this study, tape can cause skin irritation in individuals with skin sensitivities. Considering the results of this study showing no benefit to the addition of patellar taping in the treatment of PFPS, it does not appear that the benefits of patellar taping outweigh the costs.

Feasibility of Treatment: While not all aspects of the study were described well enough to be reproduced, the treatment is still feasible in an outpatient orthopaedic setting. The authors did not report the amount of time therapists spent with subjects at each session, however six visits is likely an acceptable number to most insurance companies. There was no description of the amount or progression of exercises over the course of the study. Although the study exercise protocol may not be fully reproducible, the training and expertise of a physical therapist would allow for individualized and appropriate exercise prescription for PFPS. Patient education similar to that provided in the study is usually part of standard physical therapy treatment for patellofemoral pain. The application of taping in the study was described well enough but there was no mention of what type of tape was used or if patients were instructed in self-taping before performing their HEP. The cost of tape commonly used in physical therapy is manageable

considering patellar taping requires a minimal amount of tape. Therapist training, patient education in self-taping, and tape application are not time-consuming and are also feasible in an outpatient orthopedic setting. Treatment is also reasonable for patients, aside from those with skin sensitivities, although it does require participation in a HEP and possibly self-taping and patient adherence could be an issue.

Summary of External Validity: The internal validity of the study is fair to good with two moderate and two minor threats that do not significantly affect the generalizability of the results to a larger population. Clinical applicability of results is limited by the fact that both groups had an educational component to their treatment whereas the comparison of interest is taping and exercise to exercise alone. The addition of patient education only presents a minor threat considering that patients often receive similar education from their physical therapist as part of treatment. The subject sample was similar to the clinical population in terms of age, sex, and diagnosis of anterior knee pain. The authors required subjects to have a history of anterior knee pain of at least three months while not every patient seen in a clinical setting will be at the same progression in their condition. Since the authors did not report the HEP compliance rate of subjects, it is not clear if subject adherence was comparable to that of patients seen in a clinical setting. The subjects lived in the Nottingham area of the UK and there may be cultural or regional differences that could affect the generalizability of results to a larger population. With these minor limitations, I believe the results of this study can be applied to the clinical population.

Article: Whittingham *et al.*, 2004.

Clinical Bottom Line: Based on the results of this randomized controlled study with 30 army recruits, there is moderate evidence to suggest that individualized patellar taping in addition to an exercise program results in an additional decrease in anterior knee pain compared to placebo taping and an exercise program as well as to an exercise program alone in young adults with acute PFPS. Subjects received treatment daily for four weeks. Knee pain over the past 24 hours and upon step down from an eight-inch gym bench with and without patellar tape were assessed using 10-cm VAS scores at baseline and weekly until study completion. All intervention groups showed statistically significant decreases in knee pain from baseline to week four with differences larger than the MCID on the VAS of 2.0 cm for 24-hour pain and 1.3 cm for step down pain established in the literature. There were statistically significantly larger decreases in all pain measures in the taping and exercise group compared to the placebo taping plus exercise group and to the exercise only group at week four with large effect sizes ranging from 1.8 to 3.4. There were no statistically significant differences in pain measures between the placebo taping plus exercise group and the exercise only group at any time point. Lack of blinding of the single therapist administering all of the interventions presented a minor threat to the internal validity of the study. The study protocol involved 28 consecutive daily visits which is likely not acceptable to insurance companies nor to patient schedules. The 100% compliance rate with the exercise program that was achieved by study subjects is also likely impracticable for patients in a clinical setting. Subjects were army recruits comprised of mainly young males, which decreases the ability to generalize results to a larger population. Subjects were also stationed in England, UK and there may be cultural or regional differences that could affect the generalizability of results. Further research on the efficacy of individualized patellar taping in a reasonable number of treatment sessions, with a more typical HEP compliance rate, and in a larger population would be beneficial in helping fully answer this clinical question.

Article PICO:

Population: 30 army recruits aged between 17 and 25 years with acute PFPS

Intervention: Standardized exercise program and individualized patellar taping

Comparison: Standardized exercise program and placebo taping, and standardized exercise program alone

Outcomes: Three 10-cm horizontal VAS scores relating to average pain over the previous 24 hours, pain upon stepping down from an eight-inch gym bench with patellar taping, and pain upon stepping down without tape applied

Blinding: Assessors and subjects were blinded to group assignment. Therapists providing treatment were not blinded to subject group allocation and this presents a threat to the internal validity of this study.

Controls: All subjects performed the same standardized exercise program and had the same number of treatment sessions. The taping and exercise group, which served as the experimental group to test the independent variable of individualized patellar taping, received taping to correct patellar malalignment. The placebo taping and exercise group, which served as the comparison group testing the efficacy of individualized versus sham taping, received patellar taping with no patellar malalignment correction. The third group, the exercise only group, did not receive any taping so that the efficacy of individualized taping could be compared to no taping.

Randomization: Subjects were assigned to groups using a block randomization process. A subject randomly chose one of three labeled envelopes, the next subject chose from the remaining two envelopes, and the third subject was given the last envelope to determine group allocation. This process was repeated until all 30 subjects were assigned to a group. Randomization was considered successful as subjects were similar at baseline in terms of age, height, mass, 24-hour VAS pain score, and step down without tape VAS pain score. Differences between groups in initial step down with tape VAS pain scores were not considered to affect subject similarity at baseline as an intervention was applied before this outcome measurement.

Study: This was a randomized clinical trial involving 30 army recruits between the ages of 17 and 25 years stationed at the Army Training Regiment Bassingbourn in England, United Kingdom. Subjects were given a diagnosis of acute PFPS by the Unit Medical Officer and referred for physiotherapy. Referred subjects were included if they had pain with at least two of the following activities: squatting, ascending or descending stairs, sitting for long periods of time, or increased physical activity. Subjects were excluded if they had a history of patellar subluxation or dislocation, knee cruciate ligament laxity, past knee surgery, meniscal damage, or any other condition that would have prevented them from performing exercises. Subjects were randomly assigned to a taping and exercise group (n=10), a placebo taping and exercise group (n=10), or an exercise only group (n=10). Each group received daily treatments for four weeks. The authors did not state the length of each treatment session. All subjects performed a standardized exercise program intended to enhance VMO activation. This included straight leg raises, isometric quadriceps contraction in sitting, quarter squats, single leg quarter squats, step-downs, and hip external rotation exercises. Subjects could not progress to the next exercise until three sets of 10 repetitions of the previous exercise could be performed without experiencing pain. Stretches for the quadriceps, hamstrings, gastrocnemius and ITB were also performed with 20-second holds and four repetitions. No HEP was given since subjects received treatment daily. Subjects in the taping and exercise group received a patellar taping technique as detailed by McConnell to correct patellar malalignments of tilt, glide, or rotation as seen appropriate by the sole treating therapist. The placebo taping and exercise group received tape applied across the surface of the patella without malalignment correction. Taping was applied before performing exercises and subjects were instructed to remove it at the end of the day. The exercise only group did not receive any taping. The same therapist applied individualized patellar taping, applied placebo taping, and supervised the exercise program of all subjects.

Outcome Measures: Subjects rated average knee pain in the past 24 hours and knee pain while stepping down from an eight-inch gym bench using a 10-cm VAS with 0 indicating "no pain" and 10 "worst pain possible". Subjects in the taping and exercise group and the placebo taping and exercise groups rated pain while stepping down both with and without tape applied. The exercise only group rated pain while stepping down without tape twice. Outcome measures were taken at baseline and once a week for the remaining four weeks of the study. The authors cited the psychometric properties of the VAS in patients with PFPS, but did not mention a MCID. Crossley *et al.* published an MCID of 2.0 cm for usual pain and 1.3 cm for pain on activity using a 10-cm VAS in patients with PFPS.[3]

Study Losses: No subjects were lost and all subjects were analyzed in the group to which they were randomized. The authors calculated that a sample size of 10 per intervention group was needed to have 90% power to detect a 10% change in VAS over the past 24 hours. With no subject withdrawals, this sample size was maintained.

Summary of Internal Validity: The internal validity of this study was deemed to be good (PEDro score 8/10) with one minor threat noted. Lack of blinding the therapist who administered interventions introduces the possibility of bias during delivery of the interventions. It would have been more ideal to have one therapist apply tape and another therapist who was blinded to subject allocation supervise the exercise program to assure that there were no differences in how exercises were performed, corrected, or progressed between subject groups.

Evidence: Knee pain over the past 24 hours and during the functional activity of a step down as measured by VAS at baseline and weekly for four weeks are indicators of the effectiveness of individualized taping and exercise compared to placebo taping and exercise and to exercise alone in decreasing anterior knee pain. Each group showed statistically significant decreases in all outcome measures within groups from baseline to four weeks. The authors did not publish their raw data and values were calculated from mean VAS scores reported by the authors.

Table 4. Mean difference (95% CI) within groups in VAS pain scores, step down without tape VAS pain scores, and step down with tape VAS pain scores in cm from baseline to week four

VAS pain scores	Taping and Exercise Group	Placebo Taping and Exercise Group	Exercise Only Group
24 hour	7.5 (6.8 – 8.2)	6.6 (5.9 – 7.3)	5.7 (4.9 – 6.5)
Step down without tape	7.4 (6.7 – 8.1)	6.3 (5.8 – 6.8)	5.7 (4.9 – 6.5)
Step down with tape	3.6 (3.3 – 3.9)	6.5 (5.6 – 7.4)	6.5 (5.7 – 7.3)

Table 4 shows that from baseline to week four, all groups had statistically significant mean decreases in three different assessments of pain well above their respective MCIDs. The low ends of the 95% CIs are also well above the MCIDs for each outcome measure.

Table 5. Mean difference (95% CI) between groups in VAS pain scores, step down without tape VAS pain scores, and step down with tape VAS pain scores in cm at week four

VAS pain scores	Taping and Exercise Group vs. Placebo Taping and Exercise Group	Taping and Exercise Group vs. Exercise Only Group	Placebo Taping and Exercise Group vs. Exercise Only Group
24 hour	0.9 (0.4 – 1.4)	1.8 (1.2 – 2.4)	0.9 (0.1 – 1.7)
Step down without tape	1.2 (0.9 – 1.5)	1.7 (1.1 – 2.3)	0.5 (-0.2 – 1.2)
Step down with tape	1.1 (0.8 – 1.4)	1.4 (0.9 – 1.9)	0.3 (-0.3 – 0.9)

Table 5 shows the mean difference between groups in all three measures of pain at week four. The taping and exercise group had statistically significant decreases in all three pain measures at week four compared to the placebo taping and exercise group and to the exercise only group ($P<0.01$). The largest differences were seen between the taping and exercise group and the exercise only group. While small differences were observed between the placebo taping and exercise group and the exercise only group, there were no statistically significant differences in outcome measures noted at any time point between these groups. The statistically significant differences noted between the taping and exercise group and the placebo taping and exercise group indicates that results seen were not due to a placebo effect of taping since there were no statistically significant differences in pain measures between the placebo taping plus exercise group and the exercise only group. However, the statistically significant differences observed between the taping and exercise group and the placebo taping and exercise group were not clinically significant because they did not reach the MCID for any outcome measure.

Table 6. Effect size (95% CI) between groups at week four in 24 hour VAS pain scores, step down without tape VAS pain scores, and step down with tape VAS pain scores

VAS pain scores	Taping and Exercise Group vs. Placebo Taping and Exercise Group	Taping and Exercise Group vs. Exercise Only Group	Placebo Taping and Exercise Group vs. Exercise Only Group
24 hour VAS	1.8 (0.8 – 2.9)	2.8 (1.6 – 4.1)	1.1 (0.2 – 2.1)
Step down without tape	3.4 (2.0 – 4.8)	2.7 (1.5 – 3.9)	0.7 (-0.2 – 1.6)
Step down with tape	3.1 (1.8 – 4.4)	2.8 (1.6 – 4.1)	0.5 (-0.4 – 1.4)

Effect size calculated from mean VAS scores shows the magnitude of change in outcome measures between intervention groups at week four (Table 6). The differences in interventions between the taping and exercise group and exercise only group and also between the taping and exercise group and placebo taping and exercise group were large with effect sizes ranging from 1.8 to 3.4. A medium effect size was shown between the exercise only and placebo taping and exercise group when looking at step down VAS scores, however negative low ends of the 95%

CIs are observed. The effect size for the 24 hour VAS score between the placebo taping and exercise group and exercise only group is large but has a large ranging 95% CI.

Applicability of Study Results:

Benefits vs. Costs: Based on the results of this study, there appeared to be a benefit to the addition of individualized patellar taping to an exercise program on decreasing patellofemoral pain. The costs of patellar taping include the cost of the taping materials, training of therapists in application, and the time to apply the tape. While no adverse events were reported, tape can cause skin irritation in individuals with skin sensitivities. Considering the results of this study and the relatively small expense of patellar taping, the benefits of individualized patellar taping seem to outweigh the costs.

Feasibility of Treatment: Most aspects of the study were described well enough to be reproduced. The authors gave a reasonable description of the taping technique used but did not mention what type of tape they used. The exercise program was also described in enough detail to be closely reproduced. The authors failed to report on the length of each visit but stated that patients were seen daily for four weeks. 28 visits are likely not acceptable to most insurance companies and daily visits are unfeasible for most patients. The cost of tape commonly used in physical therapy is manageable considering patellar taping requires a minimal amount of tape. Therapist training and tape application are not time-consuming and are feasible in an outpatient orthopedic setting. Treatment is also reasonable for patients, aside from those with skin sensitivities.

Summary of External Validity: The internal validity of this study is good with only one minor threat that does not significantly affect the ability to generalize results to a larger population. The subject sample was similar to the patient of interest in terms of age and diagnosis of knee pain but the narrow age range and acute nature of subject's PFPS may not be representative of all patients encountered in clinic. Subjects (army recruits) performed exercises during their daily treatments ensuring 100% compliance, whereas the typical patient in a clinical setting likely would not adhere fully to a daily exercise regimen. The majority of study subjects were males and there may be differences in treatment response between sexes that could affect generalizability of results. Army recruits and may not be representative of the typical patient seen in an outpatient orthopaedic setting. The subjects were stationed in England, UK and there may be cultural and regional differences that could affect the generalizability of results to a larger population. Despite these limitations I believe the results of this study can be applied to the clinical population with some caution.

Synthesis/Discussion

The two studies that I analyzed had different results as to the effectiveness of patellar taping to produce an additional decrease in anterior knee pain when combined with exercise. Clark *et al.* showed that standardized taping provided no additional pain relief, while Whittingham *et al.* showed that individualized taping provided additional benefit. While many aspects of the two study protocols were similar, they differed in six ways that may contribute to the differences in results and affect the clinical applicability of results. First, subjects differed in their chronicity of PFPS with those in the study by Clark *et al.* having had anterior knee pain for at least three months and subjects in the Whittingham *et al.* study diagnosed with acute PFPS. It may be easier to treat patients with acute PFPS than those who have had PFPS for a longer duration of time, which would help explain the positive results observed by Whittingham *et al*. Second, while study interventions for exercise were similar with both studies including some type of lower extremity strengthening and performing stretches for the same muscle groups, there were notable differences in the exercises performed. The exercise protocol by Clark *et al.* started with a bicycle warm-up and then had subjects perform CKC exercises targeting the lower limb extensors. On the other hand Whittingham *et al.* began their exercise regimen with OKC isometric exercises and progressed to weightbearing exercises that targeted the VMO. Clinically, individual patient presentation and tolerance dictates whether initial exercises include an active warm-up, OKC, or CKC. OKC isometric exercises can be a good starting point for patients with acute pain to learn proper activation of the quadriceps; however, CKC exercises produce more functional movements and often have increased carry-over to real-world demands. Differences in exercise protocols may be due to the acuteness or chronicity of the subject population, therapist preference, or perhaps individuals with PFPS respond better to a slower progression as was demonstrated by Whittingham *et al.* A third difference was in their taping protocol. Clark *et al.* used a standardized tape application for patella glide only and Whittingham *et al.* used an individualized approach in which tape was applied to correct specific patella malalignments (glide, tilt, or rotation) identified by the sole treating therapist. The taping protocol by Whittingham *et al.* is closely aligned with what would be observed clinically and presents a more valid way to test the efficacy of patellar taping. Fourth, the study by Whittingham *et al.* included a group that received sham taping and a group that received no taping which ensures that the results were indeed due to the efficacy of individualized patellar taping and not just a placebo effect of tape application or the result of history or maturation. The inclusion of a group that received sham taping also allowed Whittingham *et al.* to blind subjects and decreased the Hawthorne effect. Fifth, the studies differed in their timing of outcome measures with Clark *et al.* taking measurements at baseline, three months, and 12 months while Whittingham *et al.* had a much shorter follow-up taking measurements at baseline and weekly until study completion at week four. Perhaps the effects of patellar taping are not long-lasting, which would help explain for the differences in results between studies. Last, while both studies used a VAS to measure pain, pain was assessed during different functional activities. Whittingham *et al.* measured pain over the past 24 hours and during step down from an eight-inch bench while Clark *et al.* assessed

pain during ambulation and stair climbing; stair climbing and ambulation may be more challenging and painful activities and help account for the differences in results.

With respect to feasibility of reproducing these studies and external validity, Whittingham *et al.* had better method description increasing the ability to reproduce the intervention; however, the number of treatment sessions is likely not feasible in an outpatient orthopaedic setting. Due to daily treatments, Whittingham *et al.* was able to ensure 100% subject compliance with exercises; however patients in a clinical setting rarely achieve complete adherence to a daily HEP. The duration and frequency of treatments demonstrated by Clark *et al*. is more realistic in a clinical setting. The study performed by Clark *et al.* also included a more equal distribution of males and females, had a larger age range of subjects, and sampled the general population in the area that the study was performed. Whittingham *et al.* performed their study on young adult army recruits who may not be representative of the clinical population. Both studies had a small number of subjects from one region decreasing the strength of their results. Based on these differences between studies and the conflicting results that were found, I cannot confidently answer my clinical question. Individualized patellar taping, if applied before daily activity, may have an additional short-term benefit to exercise on decreasing anterior knee pain in those with acute PFPS. In those with PFPS lasting more than 3 months, standardized patellar taping may not decrease anterior knee pain in the long-term more so than exercise alone.

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