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Short-Term Effects of Patellar Kinesio Taping on Pain and Hop Function in Patients With Patellofemoral Pain Syndrome

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Background: Patellofemoral pain syndrome (PFPS) is the most prevalent orthopaedic condition among physically active individuals, contributing to an estimated 30% to 40% of all sports medicine visits. Techniques using Kinesio Tape (KT) have become increasingly popular; however, there has been scant research supporting its use on patients with PFPS.

Hypothesis: The use of patellar KT to treat patients with PFPS will provide a statistically significant improvement in short-term pain and single-leg hop measures as compared with sham placement of KT.

Study Design: Nonrandomized controlled clinical trial with repeated-measures design.

Level of Evidence: Level 3.

Methods: Forty-nine subjects (41 females, 8 males) between the ages of 12 and 24 years with PFPS participated in this study. Each subject underwent patellar kinesio taping with both experimental and sham applications while completing 4 functional tasks and the single-leg triple jump test (STJT). The treatment outcome was analyzed using separate paired *t* tests to measure improvement on a numeric pain rating scale. A 2-way, 2 × 2 analysis of variance was used to analyze the relationship between taping condition (experimental vs sham) and side (involved vs uninvolved) for STJT scores.

Results: Separate paired *t* tests found step-up, step-down, and STJT pain improvement statistically significant between taping conditions. The 2-factor analysis of variance yielded a significant main effect for taping condition, but the main effect for side was not significant. The interaction between taping condition and side was significant. This showed there was little change in STJT distance between repeated measures performed on the untaped, noninvolved leg. However, subjects' STJT distances were significantly greater for the experimental KT application than the sham application for the involved side.

Conclusion: Patellar kinesio taping provided an immediate and statistically significant improvement in pain and single-leg hop function in patients with PFPS when compared with a sham application. However, improvement in STJT scores did not surpass the minimally detectable change value, and therefore, the clinical effectiveness of KT for improving single-leg hop function was not established in the current study.

Clinical Relevance: Kinesio Tape provides a viable, short-term method to control pain.

Keywords: patellofemoral pain syndrome; kinesio taping; single-leg triple jump test

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Patellofemoral pain syndrome (PFPS) is the most prevalent orthopaedic condition among physically active adolescents and young adults, contributing up to an estimated 30% to 40% of all sports medicine visits.^{2,3,18} Patellar malalignment along with abnormal patellar tracking are precursors to PFPS.^{14,33,45} There are several risk factors associated with PFPS development, including lower extremity muscle weakness, soft tissue tightness, abnormal vastus medialis obliquus (VMO)/vastus lateralis (VL) reflex timing, lower extremity anatomical abnormalities, and altered hip/lower extremity kinematics.^{6,9,11,13,31-34,36,37,40,42,44} Moreover, because of the self-propagating nature common to the disorder, there appears to be psychological factors associated with the development of PFPS.^{7,19,29,30,44} Because of the variable etiology and spectrum of pain pathogenesis associated with this disorder, treatment approaches are numerous.

Patellar taping is a common adjunct in the physical therapy management of PFPS. Taping is intended to provide a mechanical shift to the patella, thus decreasing pain and allowing for early progression of treatment.^{11,24,41} Techniques using Kinesio Tape (KT; Kinesio) differ from traditional taping applications using nonelastic tape. Kinesio Tape is intended to mimic the elastic qualities of the skin, providing proper positional stimulus rather than providing musculoskeletal support to joint structures.²⁰ The majority of tape applications involve techniques detailed by McConnell²⁴ using nonstretch tape. The technique is intended to improve patellar orientation within the trochlear groove, thus improving patellar tracking.^{7,11,24,41}

Kinesio Tape is designed to mimic the elastic properties of skin, stretching 30% to 40% lengthwise.^{10,20,21} Furthermore, KT is water resistant, with a reported wear time of 3 to 5 days.²⁰

Application of KT to the skin over affected muscle and joint structures is purported to alleviate pain and facilitate microcirculation by providing proper positional stimuli through the skin, influencing interstitial tissue to normalize skin tension.^{20,21}

Preliminary evidence suggests that KT may be beneficial in treating ankle,²⁷ shoulder,³⁸ trunk,⁴⁶ cervical,¹⁶ and patellar dislocation²⁸ pain and improving VMO/VL activation ratios.⁸ The purpose of this study was to investigate the immediate effect of a generalized patellar KT application in improving pain and single-leg hop function in patients with PFPS. We hypothesized that an application of patellar KT would provide statistically significant improvement in pain and hop function as compared with a sham application.

MATERIALS AND METHODS

Subjects

Institutional review board approval for this study was obtained from Children's Healthcare of Atlanta and from the Rocky Mountain University of Health Professions. Subjects were recruited through physician referral with either a diagnosis of unilateral PFPS or anterior knee pain. An additional 7 subjects

were recruited through local high school and sports club physical therapy screening without a physician's referral.

All subjects and guardians (if applicable) signed approved informed consent and assent forms prior to study enrollment. To be eligible, subjects were between the ages of 12 and 25 years with unilateral anterior knee pain in one or both knees, lasting greater than 4 weeks, and without a related trauma to the area. Additional inclusion requirement included 2 or more of the following pain complaints:

1. ascending/descending stairs
2. squatting
3. sitting with knee bent greater than 15 minutes
4. running, jumping, or hopping

Exclusion criteria were previous patellar subluxation or dislocation; patellar fracture; knee surgery within the past 2 years; systemic disease; adhesive allergies; diagnosed systemic soft tissue disorder; neurological impairment that may impede physical activity; pregnancy; patellar tendonitis; apophyseal stress syndromes of the knee, including Osgood Schlatter or Sinding-Larson Johansson; internal derangement or ligamentous injury of the knee; and infection.

A total of 49 subjects meeting the qualifications for the study were consecutively selected to participate. The sample size of 49 was determined based on achieving a power of 0.80, an α level of 0.05, and an estimated large effect size.

Numeric Pain Rating Scale

Patients' overall assessment of pain was provided using the numeric pain rating scale (NPRS)^{12,23} following performance for each of 3 functional tasks associated with PFPS (squatting, ascending, and descending a 12-inch step). Additionally, subjects reported the maximum pain encountered using the NPRS on their involved knee following completion of the single-leg triple jump test (STJT).

Single-Leg Triple Jump Test

The STJT is performed on 1 foot, and the subject is instructed to complete 3 consecutive hops along a straight line for maximum distance. The total distance covered for each leg is measured from the beginning to final standing position in centimeters. The better of 2 attempts on each leg is used to create an index, which is the ratio of distance achieved on the involved leg compared with the uninvolved. The single-leg hop index has been reported to be a reliable and valid outcome measure following rehabilitation for anterior cruciate ligament reconstruction with a minimal detectable change cited as 10.02%.³⁵ Subjects scored their pain performing the STJT on their involved lower extremity using the NPRS.

Testing Protocol

The lower extremity evaluation was completed on enrollment. To improve reliability, all clinical tests and measures were performed by the primary investigator only, with subjects



Figure 1. (a) Experimental kinesio taping technique. (b) Sham kinesio taping technique.

positioned on a treatment table starting with goniometric measurements, followed by special tests, and concluded with lower extremity strength measures (see Appendices 1 and 2, available at <http://sph.sagepub.com/content/suppl>).

Lower extremity strength measurements were taken using a handheld dynamometer, with pressure applied through the device to overcome muscle contraction (ie, break test). The better of 2 repeated measures was recorded in kilograms.⁴

Taping

All subjects received a generalized peripatellar application of KT (Kinesio Tex Tape; Kinesio) by a certified Kinesio taping practitioner.

Patellar kinesio taping. With the patient seated and leg extended, the base of the first “Y” tape was placed at the front of the thigh, approximately 2/3 up the length of the femur, and cut at the level of the tibial tuberosity. Then, with the knee flexed to 90°, the tails were wrapped around the kneecap with little to no overlap and no additional stretch than that provided by removing the tape from the backing. A second strip of identical length was applied in the same fashion, with the base 2/3 down the tibial shaft (Figure 1a).

Sham kinesio taping. Two strips of KT were placed horizontally both 5 cm above and 5 cm below the patella superior and inferior borders with the knee flexed to 90°. The approximate length of each strip was equal to the distance between the medial and lateral femoral condyles. This placement was chosen to avoid interaction of the KT with patellar positioning (Figure 1b).

Both taping conditions were applied to the involved knee only, and order of assignment was randomized a priori using a random-numbers table. Completion of the second taping condition and the test battery was completed on the next consecutive day or within 72 hours of the first test battery. Subjects were blinded to each taping condition. Prior to tape application for each testing session, the subject provided the

researcher with a baseline measure of knee pain using the NPRS to determine whether pain severity influenced outcomes.

Data Collection

Assessment of knee pain for 3 functional tasks (squatting, ascending steps, descending steps, and STJT) was collected using the NPRS for each taping condition. A 12-inch foot stool was used for the step-up and step-down activities. Subjects were given consistent directions for completion and timing of the functional tasks. To control for the recovery phase (ie, stepping back down or up), subjects were cued to return using their uninvolved leg after each of 10 repetitions. Squatting was performed with feet shoulder width apart and toes pointing forward. Subjects' knees were required to reach 90° of flexion, as determined visually, while performing the task. For consistency across subjects, all 10 repetitions were required to be completed consecutively and within 15 seconds. The testing order for each subject was counterbalanced to diminish the potential of carryover effect between tasks.

Single-Leg Triple Jump Test

Functional testing was performed using the STJT. Testing was performed twice on each leg, starting with the noninvolved leg. The distance hopped was recorded using a fixed measuring tape by the primary investigator only. The greater distance of the 2 attempts was scored for each leg. Here, once again, we assessed STJT for each taping condition; however, since taping was only applied to the involved extremity, the noninvolved extremity distance was used as a paired control with repeated measures taken over a 24- to 72-hour period.

Additionally, subjects provided an NPRS of their greatest knee pain while performing the STJT on their involved leg only for each taping condition. These data were treated mutually exclusive from the STJT scores and were analyzed as the fourth pain assessment task.

Statistical Analysis

Four separate paired *t* tests were performed comparing differences in NPRS for 4 functional tasks and taping condition. Paired *t* tests were used to compare each individual subject's pain scores taken at 2 separate times and the associated taping procedure. Testing each task individually allowed for identification of statistical significance for taping and each functional task independently. Additionally, a fifth paired *t* test was performed comparing an averaged composite score of the NPRS and taping condition. A composite score was generated for each subject and taping condition by adding the NPRS scores for each of the 4 functional tasks and dividing it by 4.

A 2-way repeated-measures analysis of variance was used to analyze the relationship between taping condition (experimental vs sham) and side (involved vs uninvolved) for STJT. The independent variable was the taping procedure (experimental vs sham), and the dependent variable was STJT distance (involved vs uninvolved). Comparison with the noninvolved

Table 1. Baseline characteristics and correlation with outcome measures

	Mean ± SD	Composite pain score	Outcome hop
Age, y	15.3 ± 3.4	-0.027	0.180
12–15 (34)		0.092	0.136
16–23 (15)		0.141	-0.192
Female (%)	42 (84)	-0.198	0.214
Baseline pain (NPRS)	2.4 ± 1.9	0.146	0.216
Pain duration, mo	6.4 ± 5.11	-0.221	0.254
BMI, kg/m ²	20.7 ± 2.5	-0.109	-0.115
FABQ (PA)	14.0 ± 5.3	-0.084	0.115
FABQ (W)	21.2 ± 6.5	-0.055	0.224
WONCA score	2.0 ± 0.5	0.014	-0.028
Ankle DF ROM, deg	13.6 ± 6.8	0.095	-0.232
90°/90° hamstring, deg	-24.5 ± 11.5	-0.056	0.119
Q angle, deg	13.1 ± 3.5	0.185	-0.098
Craig test, deg	10.9 ± 4.1	0.125	-0.309 ^a
Thomas test, ^b %	27(54) ± 2.5	-0.269	0.144
Ober test, ^b %	26 (52)	-0.325 ^a	0.007
J sign, ^b %	20 (40)	-0.241	-0.053
Theater sign, ^b %	26 (52)	0.267	0.030
Patellar tilt, ^b %	26 (52)	0.245	-0.122

BMI, body mass index; DF ROM, dorsiflexion range of motion; FABQ (PA), Fear Avoidance Behavior Questionnaire—Physical Activity sub-scale; FABQ (W), Fear Avoidance Behavior Questionnaire—Work sub-scale NPRS, numeric pain rating scale; Q, quadriceps.

^aCorrelation is significant at the 0.05 level (2-tailed).

^bDichotomous variables are expressed as number of positive findings and percentage in parentheses.

lower extremity served as a paired control and was performed at the same time as the involved for each taping condition. Therefore, it was analyzed as a repeated measure taken within a 24- to 72-hour period. Any statistically significant differences observed between the interactions or main effects were analyzed further using the Tukey post hoc test.

For all statistical analyses, an alpha level of $P < 0.05$ was used. All data were calculated using SPSS, version 19 software (SPSS for Windows; IBM).

RESULTS

Demographic homogeneity between the 2 recruitment samples was evident (Table 1). There were no adverse reactions or debilitating pain preventing subjects from completing the testing battery.

Test-retest reliability for 10 quantitative examination measures was determined prior to the beginning of our study. Ten individuals with PFPS were tested on 2 occasions by the sole examiner (SRF) 24 to 72 hours apart. Reliability of the paired test scores was in the acceptable range using Pearson correlation and ranged from 0.71 to 0.98 (see Appendix 3, available at <http://sph.sagepub.com/content/suppl>).

Pain Measures (NPRS)

The change in NPRS between the 2 taping conditions was statistically significant for 3 of the 4 functional tasks: step up, $t(49) = -2.31, P = 0.025, d = 0.33$; step down, $t(49) = -2.29, P = 0.026, d = 0.32$; and STJT, $t(49) = -4.29, P < 0.001, d = 0.61$ (Figure 2, Table 2). Change in NPRS while performing the double-leg squat ($t(49) = -0.94, P = 0.35, d = 0.13$) was not

Table 2. Paired *t* test comparing taping conditions

	Paired Differences					<i>t</i>	<i>df</i>	Significance (2-tailed); Cohen's <i>d</i>
	Mean	SD	SEM	95% CI of the Difference				
				Lower	Upper			
Step-up	-0.70000	2.1405 ^a	0.30271	-1.30832	-0.09168	-2.312	49	0.025 ^a ; 0.33
Step-down	-0.66000	2.03650	0.28801	-1.23877	-0.08123	-2.292	49	0.026 ^a ; 0.32
Squat	-0.26000	1.96718	0.27820	-0.81907	0.29907	-0.935	49	0.350; 0.61
STJT	-1.20000	1.97949	0.27994	-1.76256	-0.63744	-4.287	49	<0.001 ^a ; 0.13
Composite score ^b	-0.70420	1.56833	0.22180	-1.14991	-0.25849	-3.175	49	0.003 ^a ; 0.45

df, degrees of freedom; SEM, standard error of the mean; STJT, single-leg triple jump test.

^aSignificant at 0.05.

^bComposite score is an average of all activities.

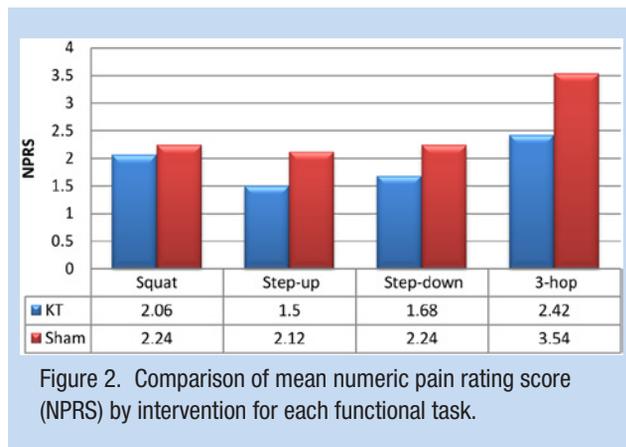


Figure 2. Comparison of mean numeric pain rating score (NPRS) by intervention for each functional task.

significant between the 2 taping conditions. However, when NPRS for all 4 tasks were compiled and averaged into a composite score, a statistically significant effect remained ($t(49) = -3.18$, $P = 0.003$, $d = 0.45$) between taping conditions. Cohen's *d* values for the 3 significant tasks (0.32-0.61) indicated the magnitude of the taping effect was small to moderate, with triple hop being the largest (0.61).

Hop Scores (STJT)

The 2-factor analysis of variance yielded a significant main effect for taping condition ($F(1, 48) = 8.38$, $P = 0.006$, $\eta^2 = 0.14$), indicating that paired lower extremity STJT scores taken during the experimental KT condition (mean, 369.78; standard deviation, 81.07) were greater than paired lower extremity measurements taken during the sham condition (mean, 353.63; standard deviation, 80.40) (Figure 3). There was no main effect

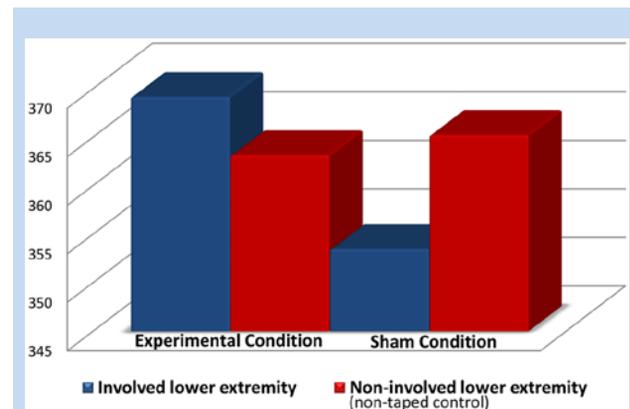


Figure 3. Comparison of intervention and patellofemoral pain syndrome (PFPS) involvement for mean single-leg triple jump test (STJT) distance in centimeters.

for side ($F(1, 48) = 0.41$, $P = 0.53$, $\eta^2 = 0.009$), indicating that the involved and uninvolved lower extremity STJT scores were similar. The interaction between taping condition and side was significant ($F(1, 48) = 11.27$, $P = 0.002$, $\eta^2 = 0.18$). This demonstrated there was little change in STJT distance between repeated measures performed on the untaped, noninvolved leg over a 24- to 72-hour period. However, subjects' STJT distances were significantly greater for the experimental KT application than for the sham application for the involved side.

DISCUSSION

In healthy subjects, KT application brought about a significant increase in both single-leg hop distance and isokinetic knee

extension peak torque when compared with patellar bracing.¹ However, a significant decrease in single-leg hop distance among healthy subjects was shown following medial glide patellar taping with athletic tape when compared with the no-tape control condition.¹⁷ Comparing the 2 taping applications, athletic tape does not possess the elastic properties unique to KT, allowing it to stretch with the skin and potentially limiting compressive loads on the patellofemoral joint.

Significantly lower reports of pain have been reported while performing a stepping task immediately following McConnell taping as compared with a placebo.⁴¹ However, there is a lack of consensus regarding the therapist's ability to accurately and consistently assess components of patellar tilt, glide, and rotation.³⁹ Furthermore, several studies have refuted the purported mechanism, reporting an unchanged patellar position using a variety of techniques, including radiographs,⁵ computed tomography scans,¹⁵ and magnetic resonance imaging.⁴⁵ Proving further merit to this claim, Wilson et al⁴³ reported on the effects of patellar taping applied in a medial, neutral, and lateral directions and found a statistically significant decrease in pain in patients with PFPS, irrespective of the taping condition.

This contrast between study findings and taping intervention provides some merit to the purported KT mechanism of providing proper positional stimuli through the skin requiring interstitial tissue to normalize, as detailed by Kase et al.²⁰ Additionally, the elastic qualities of KT are more forgiving, allowing skin to stretch along with knee flexion.²¹

The Ober test and the Craig test had significant correlation with our outcome measures. Through the anatomical attachments of the iliotibial band to the superficial oblique layer of the lateral retinaculum, a shortened iliotibial band can contribute to lateral patellar displacement and lateral patellofemoral joint stress.²⁵ Increased femoral anteversion angle, as determined by the Craig test, had a significant correlation with decreased STJT scores. The test is intended to be a clinical measure of femoral neck anteversion (internal femoral rotation). Excessive anteversion can contribute to lateral patellar displacement and increased patellofemoral joint pressures in patients with PFPS.²²

Study Limitations

This study compared a generalized KT application with a sham placement both 5 cm above and 5 cm below the patella. We assumed this placement was far enough away from the patellofemoral joint as to neither have an interaction on patellofemoral function nor facilitate quadriceps inhibition. Despite being blinded to taping condition, it is difficult to control for subject bias due to prior exposure or experience with KT. There was no comparison to McConnell taping or to matched controls in the current study.

This study only investigated short-term effects of patellar KT; therefore, long-term inferences cannot be determined. Last, the study was unable to account for any anti-inflammatory usage between testing sessions, which potentially could have influenced pain and/or function.

CONCLUSION

In patients with PFPS, patellar KT produced statistically significant improvements in short-term pain and STJT function. Reduction in pain level was found during step-up, step-down, and triple-hop tasks as compared with a sham KT application. Despite being statistically significant, improvement for LSI did not exceed the minimally detectable clinical change³⁵ of 10%.

This investigation provides preliminary evidence supporting the application of patellar KT in the management of patients with PFPS.

REFERENCES

- Atkas G, Baltaki G. Does kinesio taping increase knee muscles strength and functional performance. *Isokinet Exer Sci*. 2011;19:149-155.
- Basquie P, Bruncker P. Injuries presenting to an Australian sports medicine center: a 12-month study. *Clin J Sport Med*. 1997;7:28-31.
- Bizzini M, Childs JD, Piva SR, Delitto A. Systematic review of the quality of randomized controlled trials for patellofemoral pain syndrome. *J Orthop Sports Phys Ther*. 2003;33:4-20.
- Bohannon RW. Test-retest reliability of hand-held dynamometry during a single session of strength assessment. *Phys Ther*. 1986;66:206-209.
- Bockrath K, Wooden C, Worrell T, Ingersoll CD, Farr J. Effects of patella taping patella position and perceived pain. *Med Sci Sports Exerc*. 1993;24:989-992.
- Bolgia LA, Malone TR, Umberger BR, Uhl TL. Hip strength and hip kinematics during stair descent in females with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther*. 2008;38:12-18.
- Carolsson AM, Werner S, Mattlar CE, Edman G, Puukka P, Eriksson E. Personality in patients with long-term patellofemoral pain syndrome. *Knee Surg Sports Traumatol Arthrosc*. 1993;1:178-183.
- Chen PL, Hong WH, Lin CH, Chen WC. Biomechanics effects of Kinesio Tape for persons with patellofemoral pain syndrome during stair climbing. *Biomed*. 2008;21:395-397.
- Cichanowski HR, Schmitt JS, Johnson RJ, Niemuth PE. Hip strength in college female athletes with patellofemoral pain. *Med Sci Sports Exerc*. 2007;39:1227-1232.
- Cowan SM, Bennell KL, Hodges PW. Therapeutic patellar taping changes the timing of vasti muscle activation in people with patellofemoral pain syndrome. *Clin J Sport Med*. 2002;12:339-347.
- Crossley K, Cowan SM, Bennell KL, McConnell J. Patellar taping: is clinical success supported by clinical evidence? *Man Ther*. 2000;5:142-150.
- Farrar JT, Young JP Jr, LaMoreaux L, Werth JL, Poole RM. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain*. 2001;94:149-158.
- Fulkerson JP. The etiology of patellofemoral pain in young, active patients: a prospective study. *Clin Orthop Relat Res*. 1983;(179):129-133.
- Fulkerson J, Hungerford D. *Disorders of the Patellofemoral Joint*. 2nd ed. Baltimore, MD: Williams & Wilkins; 1990.
- Gigante A, Pasquinelli FM, Paladini P, Uisse S, Greco F. The effects of patellar taping on patellofemoral incongruence. A computed tomography study. *J Orthop Sports Phys Ther*. 2001;29:88-92.
- Gonzalez-Iglesias J, De La Peñas CF, Cleland J, Huijbregts P, Gutiérrez-Vega M. Short-term effects of cervical kinesio taping on pain and cervical range of motion in patients with acute whiplash injury: a randomized clinical trial. *J Orthop Sports Phys Ther*. 2009;39:515-521.
- Herrington L. The effect of patella taping on quadriceps strength and functional performance in normal subjects. *Phys Ther Sport*. 2004;5:33-36.
- Houghton KM. Review for the generalist: evaluation of anterior knee pain. *Pediatr Rheumatol*. 2007;5:8.
- Jensen R, Hystad T, Baerheim A. Knee function and pain related to psychological variables in patients with long-term patellofemoral pain syndrome. *J Orthop Sports Phys Ther*. 2005;35:594-600.
- Kase K, Wallis J, Kase T. *Clinical Therapeutic Applications of the Kinesio Taping Method*. Tokyo, Japan: Ken Ika Co Ltd; 2003.
- KMS LLC. About Kinsio® Tex Tape. <http://www.kinesiotaping.com/about/kinesio-taping-method>. Accessed January 6, 2014.

22. Lee TQ, Morris G, Csintalan RP. The influence of tibial and femoral rotation on patellofemoral contact area and pressure. *J Orthop Sports Phys Ther.* 2003;33:686-693.
23. Marx RG, Jones EC, Allen AA. Reliability, validity, and responsiveness of four knee outcome scales for athletic patients. *J Bone Joint Surg Am.* 2001;83:1459-1469.
24. McConnell J. Management of patellofemoral problems. *Man Ther.* 2000;1:60-66.
25. Merican AM, Amis AA. Iliotibial band tension affects patellofemoral and tibiofemoral kinematics. *J Biomech.* 2009;42:1539-1546.
26. Morrish GM, Woledge RC. A comparison of the activation of muscles moving the patella in normal subjects and in patients with chronic patellofemoral problems. *Scand J Rehabil Med.* 1997;29:43-48.
27. Murray H, Husk L. Effect of kinesio taping on proprioception in the ankle. *J Orthop Sports Phys Ther.* 2001;31:31-42.
28. Osterhues DJ. The use of kinesio taping in the management of traumatic patellar dislocation: a case study. *Physiother Theory Pract.* 2004;20:267-270.
29. Piva SR, Fitzgerald K, Irrgang JJ, et al. Associates of physical function and pain in patients with patellofemoral pain syndrome. *Arch Phys Med Rehabil.* 2009;9:285-295.
30. Piva SR, Fitzgerald K, Wisniewski S, Delitto A. Predictors of pain and function outcome after rehabilitation in patients with patellofemoral pain syndrome. *J Rehabil Med.* 2009;41:604-612.
31. Piva SR, Goodnite EA, Childs JD. Strength around the hip and flexibility of soft tissues in individuals with and without patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 2005;35:793-801.
32. Powers CM. The influence of altered lower-extremity kinematics on patellofemoral joint dysfunction: a theoretical approach. *J Orthop Sports Phys Ther.* 2003;33:639-646.
33. Powers CM. The influence of abnormal hip mechanics on knee injury: a biomechanical perspective. *J Orthop Sports Phys Ther.* 2010;40:42-51.
34. Powers CM, Landel R, Perry J. Timing and intensity of vastus muscle activity during functional activities in subjects with and without patellofemoral pain. *Phys Ther.* 1996;76:946-955.
35. Reid A, Birmingham TB, Stratford PW, Alcock GK, Giffin JR. Hop test provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther.* 2007;87:337-349.
36. Salsich GB, Perman WH. Patellofemoral joint contact area is influenced by tibiofemoral rotation alignment in individuals who have patellofemoral pain. *J Orthop Sports Phys Ther.* 2007;37:521-528.
37. Souza RB, Power CM. Differences in hip kinematics, muscle strength and muscle activation between subjects with and without patellofemoral pain. *J Orthop Sports Phys Ther.* 2009;39:12-19.
38. Thelen M, Dauber JA, Stoneman PD. The clinical efficacy of kinesio tape for shoulder pain: a randomized, double-blinded, clinical trial. *J Orthop Sports Phys Ther.* 2008;38:389-395.
39. Tomsich DA, Nitz AJ, Threlkeld AJ, Shapiro R. Patellofemoral alignment: reliability. *J Orthop Sports Phys Ther.* 1996;23:200-208.
40. Waryasz GR, McDermott. Patellofemoral pain syndrome (PFPS): a systematic review of anatomy and potential risk factors. *Dynam Med.* 2008;7:9.
41. Whittingham M, Palmer S, Macmillan F. Effects of taping on pain and function in patellofemoral pain syndrome: a randomized control trial. *J Orthop Sports Phys Ther.* 2004;34:504-510.
42. Wilson DM, Davis IS. Utility of frontal plane projection angle in females with patellofemoral pain. *J Orthop Sports Phys Ther.* 2008;38:606-615.
43. Wilson T, Carter N, Thomas G. A multicenter, single-masked study of medial, neutral and lateral patellar taping in individuals with patellofemoral pain syndrome. *J Orthop Sports Phys Ther.* 2003;33:437-448.
44. Witvrouw E, Lysens R, Bellemaans J, Cambier D, Vanderstraeten G. Intrinsic risk factors for the development of anterior knee pain in an athletic population a two-year prospective study. *Am J Sports Med.* 2000;28:480-489.
45. Worrell TW, Ingersoll CD, Farr J. Effects of patellar taping and bracing on patellar position: an MRI case study. *J Sport Rehabil.* 1994;2:146-153.
46. Yoshida A, Kahanov L. The effect of kinesio taping on lower trunk range of motions. *Res Sports Med.* 2007;15:103-112.

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