# THE EFFECTIVENESS OF KINESIO TAPE ON PAIN MODULATION IN ACTIVE INDIVIDUALS WITH PATELLAR TENDINOPATHY

A THESIS SUBMITTED TO THE GRADUATE DIVISION OF THE
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Introduction:

Kinesio-tape (KT), an elastic, hypoallergenic, cotton-fiber tape with acrylic heat-activated backing, is a modality widely used within sports. The elastic properties of KT allow it to stretch up to 40% of its resting length along its longitudinal axis. To enhance a seamless feel to the body, KT is designed to be the approximate weight and thickness of skin. When applied correctly, KT is proposed to offer a multitude of benefits depending on the dysfunction including reducing pain and inflammation, facilitating muscle function, and assisting the body's return to homeostasis[1,2].

Tendons are greatly innervated by mechanoreceptors and autonomic nerve fibers which may influence the tendon's nociceptive response. When a tendon experiences injury or trauma, increased pressure on these free nerve endings and nociceptors can occur below the epidermal layer from inflammation in the area. This signal is relayed by the afferent sensory fibers causing an increased pain response, which would ultimately result in inhibition and apprehension for the activities and alteration of normal mechanics[3]. Kinesio tape is suggested to be able to regulate this pain response by lifting the skin and decreasing the amount of pressure in the areas of tape application[1,2].

Patellar tendinopathy is an inflammatory condition of the patellar tendon where it connects from the apex of the patella to the tibial tuberosity. This pathology is common in individuals who undergo large volumes of running or jumping and has an insidious onset caused by the knee-extensor mechanism used in these activities[4-9]. Common complaints include anterior knee pain when running or jumping, with symptoms progressing to point tenderness along the patellar tendon or at its points of attachment; both at the apex of the patella and at the tibial tuberosity [4-6]. If untreated, the pain itself can also progress to a point of debilitation for some individuals, lasting from months to years, necessitating a removal from sports participation. The development of the pathology is also influenced by a variety of intrinsic and extrinsic factors, making the treatment and intervention for each individual more difficult[7-9].

Previous studies regarding the effects of KT on patellar tendinopathy have been limited. Studies investigating the proposed benefits of KT on the knee joint have focused more on general knee pathologies, such as patellofemoral pain syndrome[10,11] and anterior knee pain[12]. The efficacy of KT in decreasing pain levels during activity has also been inconclusive. Campolo et. al reported that KT decreased pain at the anterior knee, yet there was no significant difference between the experimental and placebo groups[12]. Recently Shakeri et. al reported decreased levels of pain during movement and at night in subjects with diagnosed shoulder impingement when KT was applied, indicating the pain modulating effects of KT[13]. However, the effect of KT on patellar tendinopathy has not been examined.

Therefore, the purpose of this study is to examine the effects of KT on pain modulation for active individuals with patellar tendinopathy during functional activity. It was hypothesized that the application of KT would increase the functional outcome measures and decrease pain during functional testing.

## Methods:

### Research Design:

A repeated measures design was used to examine the effects of KT on subjects' pain level during a maximum vertical jump test, single-leg squats, and isometric knee extension. Subjects completed each test under three conditions (1) no-tape (NT), (2) kinesio tape (KT) and

(3) sham in randomized order with each session separated by a minimum of three days. Pain level measured by numerical pain scale (NPS) and functional outcomes were compared.

Subjects:

Seven active college-aged females with patellar tendinopathy (age 19.7 ± 0.9 y/o) underwent three testing sessions (KT, sham and NT). Of the seven subjects, six had bilateral patellar tendinopathy, therefore, a total of 13 knees were included in the data analysis. Inclusionary criteria for the subjects were: (1) Anterior knee pain that increased with jumping and/or squatting, (2) pain with palpation at the tibial tuberosity, the patellar tendon, and/or at the apex of the patella (3) insidious onset of this pain, and (4) currently participating in physical activity at least three days a week. Exclusionary criteria for the subjects included: (1) injury from direct trauma to the anterior knee, (2) medical history of surgery at the knee joint within the past six months, (3) presence of any non-orthopedic diseases at the knee and (4) suspected or confirmed pregnancy.

Instrumentation:

Numeric Pain Scale (NPS) was used to record subject's pain level before the testing session and after each functional test. The NPS is a 100 mm (10 cm) scale ranging from zero to 10, with zero representing no pain, five as moderate pain and 10 being unbearable pain. Subjects verbally stated their level of pain after being instructed of the numeric values on the scale and shown their relation to pain intensity.

Kinesio Tex tape (2-inch Kinesio Tex Gold, Kinesio Holding Corporation, Albuquerque, New Mexico, USA) was used for KT and sham conditions. For the KT condition, the tape was applied in accordance with the KT instruction using a facilitative strip on vastus medialis obliques (VMO) and a tendon corrective strip on patellar tendon with appropriate tensions. Tension within the KT condition was standardized based on the Kinesio Tex Tape's inherent ability to stretch up to a maximum of 40% of its resting length. Therefore, to attain 100% tension on a specific portion of the tape, the tape must be stretched 40% further than its originally measured length. The tension was standardized as follows: seventy-five percent tension was reached at an increase of 30% of its original length, 50% tension at an increase of 20% its original length, and 25% tension at an increase of 10% its original length. For the sham condition, the tape was applied in an identical pattern on the involved extremity with zero stretch placed on the tape to evaluate the effect of correct KT application method.

A stationary bike was used to allow the subject to properly warm up their lower extremities before performing the functional testing. The subject warmed up for a total of five minutes, working at an intensity level of 64-74% of their maximum heart rate. Maximal heart rate was calculated from the maximal heart rate prediction equation (220-age). Heart rate was monitored by a Polar heart rate monitor (Pacer T31, Polar Electro, Oy, Findland)[14]. A Vertec (Sports Imports, Hilliard, Ohio, USA) was used to measure vertical jump height. Jump height for each subject was measured in half inches. A 20° wooden slant board from the Saake Athletic Training room at the University of Hawai'i at Mānoa was used as the foot platform for the subjects during the single-leg squat trials. It was placed on the floor away from any walls to allow the subject ample space to perform their task and a chair was placed behind them to assist and catch the subject in case of falling backwards.

A MicroFet2 Hand Held Dynamometer (HHD) (Hoggan Health Industries Inc., West Jordan, UT) was used to measure force output at the knee during extension. The HHD was held in place with a strap at an 80% distance from the knee segment to standardize lever arms amongst individuals of varying heights. The knee extension strength was tested at 90° of knee flexion. A goniometer was used to position the subject at the correct angles [15-17].

Procedure:

Each subject in the study was examined for level of pain before and during the performance of three functional activities: a maximum vertical jump, single-leg squats, and isometric knee extensions. Each subject was asked to report current pain level immediately following the performance of each test using the NPS. Subjects' testing condition (KT, sham, and NT) was randomly selected with each testing session separated by at least 3 days. Subjects were instructed to maintain their regular routine of exercise and treatment for their injury.

At the beginning of clinical testing, the anthropometric data and baseline knee pain level were recorded. For the KT and sham conditions, the subject was blindfolded while the clinician applied the tape to the involved leg in accordance with the condition of that day[2]. The area of the involved leg to be taped was prepped by removing excess dirt and oils, and trimming hair if necessary, to ensure proper tape adhesion. The same certified Kinesio-taping practitioner applied the tape for all subjects in all conditions.

The subject was placed in 30° of knee flexion for tape application. For the experimental condition, tendon corrective I strip was applied with the middle third being stretched to 75-100% tension over the patellar tendon. The two outer thirds served as anchors and were laid with 0% tension along the lateral and medial aspects of the thigh moving superiorly towards the pelvis. A Y-strip was laid proximally to distally along the VMO in an effort to facilitate the muscle function. This Y-strip was also divided into thirds, the first third was designated as the tail and the remaining two-thirds was used as the Y-divisions. The tail of the Y was placed with 0%

tension at the proximal origin of the VMO. Each strip of the Y divisions was applied medially and laterally, respectively, around the VMO with 25-35% tension, ending with 0% tension at the anchors. The same strips were applied in the same patterns with no standardized tensions for the sham condition.

After the tape application, the blindfold was removed and the functional testing began. The subject first performed a warm-up on a stationary bike. The subject was then taken to the slant board and instructed to perform a single-leg squat reaching at least 45° of knee flexion. Instructions for this test were delivered to the subject verbally and through physical demonstration by the researcher. Following a maximum of two familiarization trials, a five repetition working trial was completed. After the trial, the subject reported their level of pain at the knee to the tester.

The subject was then given five minutes of rest before being taken to the Vertec to begin the testing for maximum vertical jump. The subject was instructed to stand with feet shoulder width apart directly next to the Vertec, jump straight up as high as possible, and reach to touch their highest point on the Vertec. The subject was allowed to perform their normal jumping mechanics to reach their highest possible point, as long as they jumped from a standing position and did not use any type of approach-jump mechanics. After a maximum of two warm-up trials the subject was given three minutes of rest. The subject performed three working trials of the vertical jump with one minute of rest between jumps, and the highest jump height was used for the data analysis. Pain level was recorded immediately after each jump. The pain level during the highest jump was used for data analysis.

After another five minutes of rest, the subject performed isometric knee extensions strength tests against the HHD. Data were collected from a seated position with hips and knees flexed to 90°. Subjects were instructed to exert maximal pressure and to sustain pressure for three seconds, beginning upon the command "Go" and ceasing upon the command "Stop". Following a submaximal familiarization trial, maximal trials were recorded on the involved side with a minimum of 90 seconds rest between trials. If the first two trials differed by more than 10%, a third trial was performed; mean torque of two or three trials was used for the data analysis. Any trials with obvious attempts to rotate the trunk and use adjacent muscles were discarded and re-tested. Pain level was recorded immediately after the completion of each trial, and mean pain score was used for the data analysis.

Statistical Analysis:

Statistical analysis was completed using repeated measures ANOVA with a significance level set at $P < .05$. The independent variable was the condition (KT, sham and NT) and the dependent variables were subject pain level and functional outcomes obtained via HHD and Vertec.

Results:

Reported pain scores were significantly lower ($P$=.05) during the maximum vertical jump test for the KT condition (3.38 ± 1.26 in) compared to the NT condition (4.54 ± 2.22 in); there was no significant difference between the KT and sham ($P$=.383), and between the sham and NT ($P$=.392) conditions (Table 1). No significant difference was found between conditions for reported pain score during the single-leg squat test (*P=.145)* and the knee extensor strength test ($P$=.055). Significantly lower jump heights were found under KT condition (17.73 ± 3.06 in) during the maximum vertical jump test compared to the sham (18.65 ± 2.17 in, $P$=0.000) and NT conditions (18.81 ± 2.93 in, $P$=0.008) (Table 2). No statistical significance was observed for the isometric knee extensor strength between conditions (Table 3).

**Table 1. Pain Scores during Maximum Vertical Jump Test (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | Kinesio-tape | Sham | No-Tape |
| Single-Leg Squat | 3.92±2.43 | 4.54±2.67 | 4.23±2.35 |
| Max Vertical Jump | 3.38±1.26* | 3.92±2.10 | 4.54±2.22 |
| Isometric Knee Extension | 3.51±1.77 | 4..40±2.38 | 4.05±1.63 |

*indicates significant difference compared to Sham and No-Tape at $P \leq .05$

**Table 2. Jump Heights during Maximum Vertical Jump Test (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | Kinesio-tape | Sham | No-Tape |
| Jump Height (inches) | 17.73±3.07* | 18.65±2.17 | 18.81±2.93 |

*indicates significant difference compared to Sham and No-Tape at $P < .05$

**Table 3. Mean Torque Production during Maximal Isometric Knee Extension (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | Kinesio-tape | Sham | No-Tape |
| Torque (N*m) | 36.32 ±23.69 | 40.54±37.09 | 39.51±34.66 |

Discussion:

Pain scores under the KT condition were significantly decreased compared to the sham and control conditions during the maximal vertical jump tests indicating the unique effect of KT in reducing pain. Aytar et. al[12] examined the KT effect on pain control during functional movement comparing KT and an inelastic placebo tape. The results of that study indicated that both KT and placebo tape significantly decreased pain scores associated with patellofemoral pain syndrome during isokinetic muscle strength tests as well as dynamic balance tests. The results are supported by Shakeri et. al[13] and Thelen et. al[18] who similarly measured the effect of KT compared to a sham KT condition (incorrectly applied KT) for subjects with shoulder impingement or rotator cuff tendinitis. These studies indicated the pain reduction effects in both KT and sham conditions up to 1 week of tape application, with greater pain reduction effects in KT condition immediately after the tape application. These authors explained that the pain control effects seen in both KT and placebo tape or sham condition may be due to gate control theory elicited from cutaneous stimulation as well as enhanced proprioception resulting in restoring normal movement. Our study, however, did not support the pain control effect of sham condition, suggesting that the gate control theory may not be the primary mechanism of reduced pain for patellar tendinopathy.

Vertical jump height was negatively influenced by KT as indicated by significantly decreased jump height compared to sham and NT conditions. This is in contrast to previous studies reporting that KT application did not inhibit or facilitate subject performance during maximum vertical jump testing[19-23]. This may be due to the difference in taping procedures used for these studies; a mechanical correction, muscle facilitation, or combination of both[19-23]. These different taping procedures are theorized to elicit unique effects on pain and muscle function. Muscle facilitation procedures are the preferred method to improve function when a muscle is weak from chronic injury or while undergoing rehabilitation. This is accomplished by pulling the tape distally from the proximal origin of the target muscle with 15-35% tension, which results in the tape recoiling toward the proximal attachment supporting the muscle contraction in parallel. Mechanical correction techniques are used to provide a positional hold around a joint, which is accomplished by applying KT with 50-75% tension with a “downward and inward” pressure on the target tissue while the joint is at a desired resting position. The KT methods used for the present study were a muscle facilitative Y strip at the VMO, and a tendon corrective I strip at the site of the patellar tendon as determined to be the most appropriate method for patellar tendinopathy. The tendon corrective I strip method for patellar tendinopathy involves applying the tape horizontally with 75%-100% tension over the patellar tendon to dissipate stress. Applying the tape perpendicular to the tendon is theorized to enhance proprioceptive signals through the cutaneous receptors providing feedback to avoid painful movements[24]. This is accomplished by KT’s limited ability to stretch perpendicular to its length, restricting the stretch of the skin over patellar tendon along its longitudinal axis. These proposed effects of tendon corrective methods may have influenced the normal range of motion during the vertical jump by avoiding the painful range, altering the stretch-reflex mechanism at the patellar tendon resulting in decreased jump heights.

Knee extensor strength was not influenced by either KT or sham conditions in the current study. In contrast, Slupik et. al found an increase in bioelectrical activity and torque at the knee using the same muscle facilitative KT method on vastus medialis [25]. The study reported a significant increase in bioelectrical activity, measured using EMG, at 24 and 72 hours post KT application. The study also observed a significant increase in torque production at 24 hours and increased further at 72 hours post KT application; however no increase in bioelectrical activity or torque was found immediately after taping. These results may indicate that greater amounts of time after tape application is needed to elicit the effects of fascial manipulation and muscle facilitation. Research by Shleip has shown that in order to make any significant deformation in areas of fascial or muscle restriction, significant amount of force or time is needed[26]. As muscle facilitation method does not exert an extensive amount of force on target tissues, the extent of time after application may be a significant factor for taping outcomes, which may have resulted in no significant findings in the current study. Of note, Slupik et. al, along with most studies examining KT's effects on maximum vertical jump height[19, 21, 22] examined the effects on the healthy subjects making the results less attributable to the injured population.

The patellar tendon strap is one of the most commonly used methods to reduce patellar tendon pain during activity. Lavagnino et. al (2011) found that application of a patellar tendon strap reduced the average and maximum localized tendon strain at the site of application. This was attributed to the strap's ability to increase the patella-patellar tendon angle and decrease the patellar tendon length[27]. Since the tendon corrective I-strip is applied over the patellar tendon in a fashion similar to infrapatellar tendon strap with 100% tension, it is possible that the pain reduction effect found in this study is associated with the mechanism similar to the infrapatellar strap. Lavagnino et. al also reported that an increase in strain due to decreased patella-patellar tendon angle and increased patellar tendon length was further enhanced by a weight bearing position at 60° of knee flexion and explained that the patellar tendon undergoes its highest strain at 60° of knee flexion during a simulated jump landing[28]. In the current study, significant pain reduction was indicated during the vertical jump test, however, not during the single-leg squats and isometric knee extension strength test. The non-weight bearing procedure of isometric knee extension strength test, and slower loading, compared to loading during jump landing, on extensor mechanism during the single-leg squat may have resulted in less patellar tendon strain as compared to vertical jump test. In addition, the single-leg squats were performed at the ranges of 30-45° of knee flexion while the isometric knee extension strength test was performed at 90°

of flexion. Both tests did not include the knee flexion angle that elicit the highest patellar tendon strain, while it is most likely that subjects experienced the knee flexion range of 60° during vertical jump test, especially during landing phase. It is plausible that the knee extensor strength test and single-leg squat did not elicit enough patellar tendon strain for the KT tape to be effective; a larger sample size to detect smaller effect size may be warranted to clarify this theory.

There were several confounding factors that could influence the study results. During extended periods between trials, the subjects were instructed to maintain their regular routine of activity and therapy, which could affect the pain data in either direction. Prior knowledge and experience with KT or a patellar tendon strap also could have influenced the pain data. Single blinded randomized procedure with a placebo condition was implemented to control for these confounding factors. The one-way ANOVA comparing the baseline pain level on each condition indicated no significant difference, suggesting that these confounding factors did not influence the baseline pain level.

In conclusion, KT tape with a muscle facilitative Y strip on VMO and a tendon corrective I strip on patellar tendon was found to be effective for decreasing pain associated with patellar tendinopathy during jump landing activity. This specific KT tape method used in the current study negatively influenced the jump performance decreasing the maximum jump height; the knee extensor strength was uninfluenced. Our study findings seem to be specific to the type of injury, patellar tendinopathy, and KT method used for the injury. Pain reduction effect was not found during the single-leg squat and knee extensor strength test, possibly due to a small sample size. The mechanism of KT's pain reduction effect and decreased vertical jump height remain unclear.

References:

1. Kase, K., Wallis, J., and Kase, T. (2003) Clinical therapeutic applications of the kinesio taping method®. Ken Ikai Co. Ltd, Tokyo, Japan.
2. McDuffie, M., Terrazas, J., Marrujo, C., & Schell, C. (2013). *KT1: fundamental concepts of the kinesio taping method*. Albuquerque, NM: KINESIO IP, LLC.
3. Scott A, Docking S, Vicenzino B, Alfredson H, Murphy RJ, Carr AJ, Zwerver J, Lundgreen K, Finlay O, Pollock N, Cook JL, Fearon A, Purdam CR, Hoens A, Rees JD, Goetz TJ, & Danielson P. (2013). Sports and exercise-related tendinopathies: a review of selected topical issues by participants of the second international scientific tendinopathy symposium (ists) vancouver 2012. *British Journal of Sports Medicine, 47*(9), 536-544.
4. Cook, J., Khan, K., Harcourt, P., Grant, M., Young, D., & Bonar, S. (1997). A cross sectional study of 100 athletes with jumper's knee managed conservatively and surgically. the victorian institute of sport tendon study group. *British Journal of Sports Medicine, 31*, 332-336.
5. Witvrouw, E., Bellemans, J., Lysens, R., Danneels, L., & Cambie, D. (2001). Intrinsic risk factors for the development of patellar tendinitis in an athletic population. *The American Journal of Sports Medicine, 29*(2), 190-195.
6. Martens, M., Wouters, P., Burssens, A., & Mulier, J. (1982). Patellar tendinitis: pathology and results of treatment. *Acta Orthopaedica, 53*, 445-450. Retrieved October 1, 2014.
7. Lian, Ø, Engebretsen, L., & Bahr, R. (2005). Prevalence of jumper's knee among elite athletes from different sports. *The American Journal of Sports Medicine, 33*(4), 561-567.

8. Ferretti, A. (1986). Epidemiology of jumper's knee. *Sports Medicine, 3*(4), 289-295.
9. Rudavsky A, Cook J. (2009). Management of patellar tendinopathy (jumper’s knee). *Journal of Physiotherapy, 60*, 122-129.
10. Chen PL, Hong WH, Lin CH, Chen WC. Biomechanics effects of kinesio taping for persons with patellofemoral pain syndrome during stair climbing. *IFMBE Proceedings.*2008; 21: 395–397.
11. Aytar, A., Ozunlu, N., Surenkok, O., Baltaci, G., Oztop, P., & Karatas, M. (2011). Initial effects of kinesio taping in patients with patellofemoral pain syndrome: a randomized, double-blind study. *Isokinetics and Exercise Science, 19*, 135-142.
12. Campolo, M., Babu, J., Dmochowska, K., Scariah, S., & Varughese, J. (2013). A comparison of two taping techniques (kinesio and mcconnell) and their effect on anterior knee pain during functional activities. *The International Journal of Sports Physical Therapy, 8*(2), 105-110.
13. Shakeri, H., Keshavarz, R., Arab, A., & Ebrahimi, I. (2013). Clinical effectiveness of kinesiological taping on pain and pain-free shoulder range of motion in patients with shoulder impingement syndrome: a randomized, double blinded, placebo-controlled trial. *The International Journal of Sports Physical Therapy, 8*(6), 800-810.
14. Heyward, V. (2010). Designing cardiorespiratory exercise programs. In *Advanced fitness assessment & exercise prescription* (6th ed., pp. 110-111). Champaign, IL: Human Kinetics.
15. Kim, W. K., Kim, D., Seo, K. M., & Kang, S. H. (2014). Reliability and validity of isometric knee extensor strength test with hand-held dynamometer depending on its fixation: a pilot study. *Ann Rehabil Med Annals of Rehabilitation Medicine, 38*(1), 84-93.

16. Bohannon, R. W. (1997). Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. *Archives of Physical Medicine and Rehabilitation, 78*(1), 26-32.

17. Andrews, A., Thomas, M., & Bohannon, R. (1996). Normative values for isometric muscle force measurements obtained with hand-held dynamometer. *Physical Therapy, 76*(3), 248-259.

18. Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of kinesio tape for shoulder pain: a randomized, double-blinded, clinical trial. *J Orthop Sports Phys Ther Journal of Orthopaedic & Sports Physical Therapy, 38*(7), 389-395.

19. Aktas G., Baltaci G., Isokinetics and Exercise Science. (2011). Does kinesiotaping increase knee muscles strength and functional performance? *Isokinetics and Exercise Science.* 19*,* 149-155.

20. Schiffer, T., Möllinger, A., Sperlich, B., & Memmert, D. (2015). Kinesio taping and jump performance in elite female track and field athletes. *J Sport Rehabil*. *24*(1), 47-50.

21. De Hoyo M., Álvarez-Mesa A., Sañudo B., Carrasco L., & Domínguez S. (2013). Immediate effect of kinesio taping on muscle response in young elite soccer players. *J Sport Rehabil*. *22*(1), 53-58.

22. Nakajima MA., Baldridge C. (2013). The effect of kinesio® tape on vertical jump and dynamic postural control. *Int J Sports Phys Ther*. *8*(4):393-40.

23. Kümmel J., Mauz D., Blab F., & Vieten M. (2011). Effect of kinesio taping on performance in counter-movement jump. *Portuguese Journal of Sports Sciences.* 11(2), 605-607.

24. McDuffie, M., Terrazas, J., Marrujo, C., & Schell, C. (2013). *KT2: advanced concepts and corrective techniques of the the kinesio taping method*. Albuquerque, NM: KINESIO IP, LLC.

25. Slupik, A., Dwormik, M., Białoszewski, D., & Zych, E. (2007). Effect of kinesio taping on bioelectrical activity of vastus medialis muscle. preliminary report. *Ortop Traumatol Rehabil, 9*(6), 644-651.

26. Schleip R. (2003). Fascial plasticity – a new neurobiological explanation: part 1. *Journal of Bodywork and Movement Therapies*. *7*(1), 11-19.

27. Lavagnino, M., Arnoczky, S., Dodds, J., & Elvin, N. (2011). Infrapatellar straps decrease patellar tendon strain at the site of the jumper's knee lesion: a computational analysis based on radiographic measurements. *Journal of Sports Health.* 3(3), 296-302.

28. Lavagnino M, Arnoczky S, Elvin N, Dodds J. (2008). Patellar tendon strain is increased at the site of the jumper's knee lesion during knee flexion and tendon loading. *Am J Sports Med*. *36*(11), 2110-2118.

Appendix:

Tables:

**Table 1. Pain Scores during Maximum Vertical Jump Test (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | KT | Sham | NT |
| Single-Leg Squat | 3.92±2.43 | 4.54±2.67 | 4.23±2.35 |
| Max Vertical Jump | 3.38±1.26* | 3.92±2.10 | 4.54±2.22 |
| Isometric Knee Extension | 3.51±1.77 | 4..40±2.38 | 4.05±1.63 |

*indicates significant difference compared to Sham and NT(No-Tape) at *P*<.05

**Table 2. Jump Heights during Maximum Vertical Jump Test (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | KT | Sham | No-Tape |
| Jump Height (inches) | 17.731±3.07* | 18.65±2.17 | 18.81±2.93 |

*indicates significant difference compared to Sham and NT (No-Tape) at *P*<.05

**Table 3. Mean Torque Production during Maximal Isometric Knee Extension (Mean±SD)**

| | Condition | | |
|---|---|---|---|
| | KT | Sham | No-Tape |
| Torque (N*m) | 36.32 ±23.69 | 40.54±37.09 | 39.51±34.66 |

Abbreviations:

- KT: Kinesio Tape
- NT: No-tape
- VMO: Vastus medialis obliques
- NPS: Numerical Pain Scale
- HHD: Handheld Dynamometer
- ANOVA: Analysis of variance
- SD: Standard Deviation

Consent Form:

**RESEARCH STUDY INFORMED CONSENT FORM**

## I. INVESTIGATORS

Principle Investigators: Bruce Hamelin, ATC; Portia B. Resnick, MA, ATC, LMT, Kaori Tamura, PhD, ATC

## II. TITLE

The Effectiveness of Kinesio Tape on Pain Control in Active Individuals with Patellar Tendinitis

## III. INFORMED CONSENT

The purpose of this consent form is to provide you with information about this research to help you decide if you would like to participate in this study. Please take your time to review this consent form. If there are any words or sections in this consent form that you do not understand or want to clarify, please do not hesitate to ask the research staff at anytime.

## IV. WHY IS THIS STUDY BEING DONE?

This study will examine the effectiveness of Kinesio Tape on pain control for individuals with patellar tendinitis. When applied with certain tensions, Kinesio Tape creates a lifting effect on the skin theorized to decompress the underlying soft tissue. This decompression would create less pressure on nerve fibers in inflamed areas such as the patellar tendon and potentially less pain experienced by the individual. Currently no studies have been done to examine the ability of Kinesio Tape to control the symptomatic pain in those with the injury. It is important for the allied medical professional to have evidence of the effects of Kinesio Tape in order to provide quality medical care. The current study will measure pain levels via subject feedback and outcomes measured during the performance of functional tests.

## V. VOLUNTARY PARTICIPATION

A total of 20 participants will take part in this study. You are being asked to participate because you are between the ages of 18 and 30 years old and have the following criteria: (1) anterior knee pain that increases with jumping and/or squatting, (2) pain with pressure applied to the front of the knee from the bottom of the kneecap to 2-3 inches below the kneecap (the tibial tuberosity, the patellar tendon, and/or at the apex of the patella) (3) gradual development and increase of this pain, and (4) are currently participating in physical activity at least 3 days a week. It is important to understand that participation in this study is completely voluntary. You may decide not to participate, or withdraw at any time, and it will not affect you in any way. Deciding not to participate or withdrawing from the study will in no way affect your relationships with the principal investigators or the University of Hawaii at Manoa. If you decide to participate in this study, you will be asked to sign this consent form. Once you are verified as an eligible participant for the study, you will be scheduled for the data collection sessions.

VI. **STUDY PROCEDURES**

If you decide to participate in this study, you will be asked to attend 3 data collection sessions separated by at least 3 days. Data collection sessions will take place at the Athletic Training Research Lab located at the University of Hawaii (1337 Lower Campus Road). You will perform 3 functional tests during each data collection session. You will also be asked to report your pain level upon the completion of each test in reference to the Numerical Pain Scale. Participants will be asked to refrain from taking any unprescribed OTC (over the counter) short acting pain medication prior to data collection. At each of the visits, we will measure your height, body mass and the length of the thigh on the involved side.

At the beginning of clinical testing, you will arrive to the testing room to record your height, body mass and leg lengths and will be asked for a baseline level of pain if any. Your thigh and knee will then be prepared for taping, removing any excess hair at the site of tape application and cleaning the areas with alcohol to remove any lotions or oils. After the tape has been applied the functional testing will begin. You will first perform a light warm-up on a stationary bike to increase your heart rate and prepare your muscles for the functional testing. After this is completed you will be asked your level of pain, if any, during the performance of three functional activities: a maximum vertical jump, body weight single leg squats, and knee extensions with a handheld dynamometer. After all three tests are completed and pain levels have been recorded, Kinesio Tape will be removed and you will be rescheduled for the next day of testing, which will be at least 3 days later. During the period between testing days you will be asked to maintain your normal course of treatment or rehabilitation along with your regular physical activity.

At the second and third days of testing you will be asked to complete the same series of tests under another taping condition. You will undergo the same warm up and procedures as completed on day 1. Once all three days of testing have been conducted, nothing more will be required of you for the study.

VII. **RISKS**

There is minimal risk of an allergic reaction to the Kinesio Tex Tape. Should any redness, swelling, discomfort or irritation occur while wearing the tape, please inform the research team. Incorrect removal of the tape may lead to some minor skin irritation and redness. The researchers will instruct you on how to remove tape safely on the first day, or may remove the tape for you at the end of the clinical testing to help minimize these risks.

You may experience pain or discomfort during the clinical testing. If at any point the pain reaches an uncomfortable level you are to report this to the clinician and to cease testing immediately. A certified athletic trainer, as well as emergency equipment, are available on site to deal with unexpected medical or injury related situations that may arise.

VIII. **BENEFITS**

You may not receive any direct or immediate benefits. Kinesio Taping has been theorized to increase decrease pain and increase range of motion. You may feel these effects while being taped. In addition, your participation will help to further understand the effects of Kinesio Taping. You will also be given the opportunity to learn your standing maximum vertical jump height and your force production during knee extension.

## IX. COSTS

All clinic and professional testing fees will be provided at no cost to you. Parking fees will be reimbursed to you.

## X. COMPENSATION

No compensation will be given for your participation. The researchers can provide you with your vertical jump scores and handheld dynamometer measurements for your records.

## XI. CONFIDENTIALITY

All information about you will be held confidential to the extent allowed by state and federal law. Your personal information will not be given to anyone outside of the research team without your written permission. A code will be used as identifier instead of your name for this study. Research records that contain personal information, including code key, will be kept in a secure locked file in the Department of Kinesiology and Rehabilitation Science at the University of Hawaiʻi at Mānoa. These documents will be permanently destroyed no later than 5 years after the completion of the study.

Information gathered in this research study may be published or presented in public forums, however your name and other identifying information will not be disclosed. Agencies with research oversight, such as The University of Hawaiʻi Committee on Human Studies Program, have the right to review research records. You would be asked to sign an authorization form to allow the researcher to release any of your personal information obtained through the research process

## XII. INJURY RELATED TO THE STUDY

Should any injury or medical emergency occur during the data collection, first responder care (first aid and CPR) is available, and appropriate referral will be made. First responder care will be provided for free of charge, however, you will be responsible for the cost associated with referral thereafter. If your insurance will not pay for these costs, they will be your responsibility. The University of Hawaiʻi has no program to pay or compensate you in any way for your injuries. Should any injuries occur during the study participation outside of data collection, please contact your physician for assistance, and inform research personnel as soon as possible.

## XIII. QUESTIONS

If you have any questions related to the study participation, please contact **Bruce Hamelin at 321-427-4579 or bhamelin@hawaii.edu**. If you have questions or concerns about your rights as a research participant, please contact the Human Studies Program at (808) 956-5007.

## XIV. STATEMENT OF CONSENT

I have read the above information, or it has been read to me. I have had the opportunity to discuss this research study with research staff, and I have had my questions answered by them in language I understand. I take part in this study of my own free will, and I understand that I may withdraw from participation at any time and this will not affect me in any way. Deciding not to participate or withdrawing from the study will in no way affect my relationships with the principal investigators or the University of Hawaii at Manoa. My consent to participate in this study does not take away any of my legal rights in the event of negligence or carelessness of anyone working on this project. A copy of this consent form has been given to me.

## XV. SIGNATORIES

**I agree to take part in this study.**

______________________________________________

**Print Name**

______________________________________________

**Signature** **Date**

______________________________________________

**Researcher Name (print)**

______________________________________________

**Researcher Signature** **Date**

Data Collection Sheet:

# **Data Collection Sheet**

Subject ID: _____________

Date: ____________

Testing Day: 1 2 3

Testing Condition: NT KT PKT

Involved Side: L / R

Gender M / F

Age: __________

Height: __________

Weight: ___________

Length of involved thigh (greater trochanter to lateral knee joint line): _________

Length of involved lower leg (lateral knee joint line to lateral malleolus):__________

HHD distance from knee: ___________

| Period of Testing | Subject Reported Pain Score (0-10) |
|---|---|
| Baseline | |
| Post warm-up | |
| Post max vertical jump 1 | |
| Post max vertical jump 2 | |
| Post max vertical jump 3 | |
| Post eccentric single leg squats | |
| Post isometric KE trial 1 | |
| Post isometric KE trial 2 | |
| Post isometric KE trial 3 | |

**Related Outcome Measures**

| | |
|---|---|
| Jump height 1 (inches) | |
| Jump height 2 (inches) | |
| Jump height 3 (inches) | |
| # of eccentric single leg squats completed | |
| Force produced during KE trial 1 | |
| Force produced during KE trial 2 | |
| Force produced during KE trial 3 | |
| Torque produced during KE trial 1 | |
| Torque produced during KE trial 2 | |
| Torque produced during KE trial 3 | |
| Average force produced during KEs | |
| Average torque produced during KEs | |

Literature Review:

Efficacy of Kinesio Tape

The current literature does not provide enough evidence on the effectiveness and efficacy of kinesio tape (KT) to strongly support or discourage KT as a useful intervention. Subject outcomes in physical performance, pain and function, and muscle activation were examined by recording subject jump heights, maximum repetitions for certain muscle groups, and pain levels during testing. Biodex systems and EMG data were also used to record joint position sense, fatigue and muscle activation during testing.

Bicici et. al (2012) investigated potential differences between athletic tape and kinesio tape on functional performance in athletes with chronic lateral ankle sprains. The study used 15 subjects between the ages of 18 and 22 who all sustained at least three inversion ankle sprains and were diagnosed with functional ankle instability (FAI) in accordance with the Cumberland Ankle Instability Tool. The subjects performed a hopping test, single limb hurdle test, standing heal raises, vertical jump test, the star excursion balance test and the kinesthetic ability trainer to measure differences in tape groups on agility, endurance, balance and coordination. For the athletic tape group, two anchor strips were placed at level of the lower leg were the calf begins to widen. Two medial to lateral and horizontal stirrups were used along with medial and lateral heel locks and figure eight patterns were applied No negative effects were resulting from the application of the kinesio tape, yet no significant difference between the taping methods in regards to improvements in a heel raise test and jump height test were seen. However, different taping methods were used between the athletic tape and KT groups. The athletic taping method used a technique which directly limits plantarflexion, whereas the KT group did not. This may have caused differences in subject results[1].

Campolo et. al (2013) investigated the effects of kinesio taping compared to McConnell taping on pain level in subjects with unilateral anterior knee pain. Taping techniques for both KT and McConnell tape was consistent with each material's accepted method for patellofemoral pain syndrome. Subjects performed a weighted squat lift and stairclimbing, reporting pain via the numerical pain intensity scale both before functional testing and during. There was a decrease in subject pain between the taping methods used compared to its no-tape group, but no significant difference in level of pain reduction was found between McConnell and KT using the same taping methods[2].

Chen et. al (2008) examined the effectiveness of applying kinesio tape on the vastus medialis obliquus muscle (VMO) for treating patellofemoral pain syndrome (PFPS). Subjects were comprised of 15 women diagnosed with PFPS and 10 subjects without PFPS for their experimental and control groups, respectively. Subjects were divided into a KT group, placebo group using athletic tape and a control group using no tape. All taping groups were taped in accordance to the KT manual. Changes in tension-producing capacity and/or timing of VMO activity were observed then compared to any changes in patient pain during stressful movements, specifically when climbing stairs. Data was allocated using AMTI force-plates to measure the ground-reaction force (GRF) during each step. Simultaneously an MA-300 EMG system with electrodes placed longitudinally on the muscles bellies of the VMO and vastus lateralis (VL) was used to monitor the EMG activity of VMO and VL. Calculation of the GRFs and the EMG activity timing and ratio of VMO and VL was completed for no tape, placebo tape, and kinesio tape conditions for both PFPS and control groups during the ascending and descending portions of the stair trials. During the stair trials, vertical GRF's, onset of VMO activity and the activity ratio between the VMO and VL were all significantly different between the PFPS groups who received kinesio tape and those without tape. However, there was no significant difference in all three of the measures between the kinesio taping group and the placebo taping group[3].

Aytar et. al (2011) measured the effects of kinesio tape application compared to a sham application on pain, strength, joint position sense and balance in subjects with PFPS. An isokinetic dynamometer measured quadriceps strength from a seated position with hips and knees flexed to 90 degrees. Tests were done at 60 and 180 deg/sec with five repetitions at each speed. Joint position sense was measured using the same dynamometer and having the patients blindfolded, alerting the examiner when they believed their knee to be at 45 degrees of flexion. The Kinesthetic Ability Trainer (KAT) 3000 was used to measure balance. Patients were instructed to stand on the KAT 3000 platform with a bilateral stance and while focusing on an eye-level target on the monitor in front of them. While standing, the platform would increase and decrease in stability by changing pressure within an airbladder below the platform. It would then measure the deviations of motion from the horizontal plane. Pain was measured with a visual analog scale which was taken while the patient ascended and descended 12 stairs, and while walking a distance of 50 meters. Outcome measures were recorded before and 45 minutes after tape application. Results were of significant difference between the pre-post testing for strength at 60 deg/sec and at 180 deg/sec, and static and dynamic balance for the kinesio group. However, there were significant differences between pre and post testing for the placebo kinesio tape group for strength at 60 deg/sec and in static balance scores. No significant differences were found between the two groups in all measured outcomes[4].

Han and Lee (2014) measured the effectiveness of kinesio tape compared to no intervention on healthy subjects' joint position sense and repositioning error at the knee following fatiguing of the quadriceps. Three reflective markers were attached to the subjects' skin at the greater trochanter, the lateral epicondyle of the femur, and the lateral malleolus. A digital goniometer was placed at these sites to measure joint position. The subjects fatigued their quadriceps by performing body weight squats at a pace of 20 beats per minute. The subject performed three sets of 10 repetitions with a 30 second rest period between each set. The subject then sat in a relaxed position while KT was applied. Starting from 90° of flexion, the tester randomly performed passive knee extension of the dominant leg to a target angle of either 30°, 45°, or 60° determined using the digital goniometer. After holding this position for 3 seconds, the tester returned the knee to the starting position. The subject was instructed to actively reproduce that same target angle. Repositioning error of the knee was measured by the digital goniometer for one trial, combined with random selection of the target angle in an effort to minimize learning effect. Measurements for repositioning error were recorded immediately after the quadriceps muscle fatigue protocol and immediately after kinesio tape application. There was a significant increase in repositioning error following the quadriceps fatigue compared to the pre-fatigue measures with a lower repositioning error for the kinesio taping group after the fatigue protocol[5].

Thelen (2008) evaluated the effictiveness of KT on shoulder pain compared to a sham tape application. The study used subjects diagnosed with rotator cuff tendonitis/impingement for their population and randomly assigned them to either a therapeutic KT group where tape was applied with a correct KT protocol, or sham KT group with no tension and specific application procedure. Self reported pain and shoulder range of motion were measured at 3-day intervals to compare time of application to outcome measures. Results of the study showed that the KT group with proper application had immediate improvement in pain-free ROM with shoulder abduction. However, no other significant differences were observed between groups for any other outcome measure and at any other time interval[6].

Slupik et. al (2007) evaluated the effects of KT on bioelectrical activity at the vastus medialis muscle during isometric contractions. Twenty-seven healthy subjects were taped with KT in a y-pattern cut over the vastus medialis. Bioelectrical activity of the muscle was measured using EMG at 24 and 72 hours after application. The results of the study found a significant increase in bioelectrical activity at the vastus medialis at both time intervals after application[7].

Schiffer et. al (2015) examined the effects of KT (K Active Tape) application on improving jump function of 18, college-aged, healthy, uninjured female track and field athletes. The tape was applied without tension over the gastrocnemius heads, hamstrings, rectus femoris, and iliopsoas muscles while the tissues were placed on a stretch. Subjects performed three trials of single leg distance, testing each leg once per trial. The taped leg for the first trial was chosen randomly. After a rest period, the next trial began in which the opposite leg was taped with the same application as the first leg. The final trial was performed with both legs under a no-tape condition. The study compared the results between trials. The findings did not show any statistical significance in jumping performance between testing trials[8].

Kümmel et. al (2011) investigated the effect of flexible tap application without tension on subject jump height and ground reaction force. Twenty-three subjects were used for the study and randomly placed into a control or intervention condition. Subjects performed two trials of a counter-movement jump without supporting arm-swing, during which ground reaction forces were measured by an AMTI force plate. For the first trial subjects performed three maximal jumps to record baseline measures. For the second trial a flexible tape (Physiotape Kinseo) was applied in a y-pattern over both the vastus lateralis and vastus medialis for subjects within the intervention group. The control group did not receive any tape application for the second trial. After a 15-minute rest period, subjects from each group performed three more maximal jumps. Analyzing the data, no significance was found for jump height between conditions.

Nakajima et. al (2013) examined the effects of KT application on vertical jump height and dynamic postural control. Fifty-two subjects were included within the study, all without ankle or lower extremity injury or disorder. Subjects were randomly placed into an experimental KT group with proper KT application, or a control/placebo group, receiving KT application without any tension. The study used a VertiMetric device to measure vertical jump height and the Star Excursion Balance Test to measure dynamic postural control. The two tests were performed without taping as baseline measure, then again immediately after taping, and lastly at 24 hours after taping. No significance was found between conditions for both tests at each time interval[10].

De Hoyo et. al (2013) attempted to examine the effects of KT (Cure Tape) application on strength, jump ability, speed, and muscle contraction. Subjects consisted of 18 soccer players with a mean age of 18 years. Subjects were randomly placed into either an experimental group where they received KT application or a control group with no KT application. Subjects in the experimental condition had a y-pattern strip of tape applied to the rectus femoris. The subjects all underwent the same trials under their respective condition. Subjects were tested using TMG analysis to record muscle contractile properties. Subjects performed a concentric squat to measure power output, a countermovement jump to measure jump height, and a 10-meter sprint to measure speed. Results of the study did not show any significant difference in any of the outcome measures between groups[11].

Aktas and Baltaci (2011) attempted to examine the effects on subjects while wearing a knee brace, KT or both on strength and functional performance. Twenty healthy, physically active individuals were all tested under four conditions: no intervention, brace, KT, KT plus brace. A DonJoy tru pull advance system brace was used, and a quadriceps facilitative strip with patellar correction was used for the kinesio tape application. Subjects' strength was measured using an isokinetic dynamometer while subjects performed concentric/concentric quadriceps and hamstring contractions at 180°/s, and 60°/s. Jump performance was measured using a vertical jump test and single-leg hop test for distance. Results from this study showed a significant increase in hop distance in subjects' dominant and non-dominant legs, and an increase in peak torque at 180°/s. However, no other significance was found between conditions for the other outcome measures[12].

The results of these studies do not sufficiently elicit evidence in support of or refute the effectiveness of kinesio tape application. Though some studies found significant results within kinesio tape groups, there was so significant difference in the studies using a different tape application. This warrants the need for further investigation on kinesio tape and its effectiveness within injured populations.

Epidemiology of Patellar Tendinopathy:

The occurrence of patellar tendinopathy (PT) can be seen in a multitude of sports, varying in prevalence within those particular athletes. The literature examines the occurrence of PT amongst several groups, describing the populations most susceptible to developing the condition. The studies also describe extrinsic and intrinsic factors influencing the risk of developing PT, as well as symptom duration.

Patellar tendinopathy, or jumper's knee, is reported in the literature as having the highest incidence within volleyball and basketball groups[13]. Symptom duration was reported to last an average of 32 months, ranging as from one to 144 months. Greater height and body mass of subjects were associated with more current cases of jumper's knee, as was increased training. Jumping athletes with jumper's knee also participated in significantly more training than those without[13-16]. In addition, Ferreti[15] (1986) and Rudavsky et. al (2009)[16] found the most influential cause of this jumper's knee was functional overloading, induced by repetitive stress during sports activities. Those who used the knee extensor mechanism continuously and violently, as seen in jumping sports, were also more likely to be affected. Subjects who reported training more than four times a week had a greater likelihood of experiencing symptoms of jumper's knee. Pain was reported frequently after abrupt introduction of activity after an extended break from participation. There was also a higher likelihood of developing jumper's knee when training on concrete compared to wood[15,16].

Patients with a history of jumper's knee show significantly higher knee angular velocities, faster ankle plantar flexor moment development, a tendency of faster knee extensor moment development and higher vertical ground reaction force during landing when compared to the control group of healthy athletes. Furthermore, subjects regarded as having acute onset of PT group showed even higher knee angular velocities, faster ankle plantar flexor moment development, and a tendency of faster knee extensor moment development and a higher vertical ground reaction force, indicating a stiffer landing technique compared to the group with a history of jumper's knee[17].

Gisslen (2005) examined the patellar tendons between junior level volleyball players and non-athletes using sonogrpahic imaging. Fifty-seven volleyball players between the ages of 15-19 years of age were studied and compared to 55 control subjects who were considered active and healthy. Subjects from each group were diagnosed with patellar tendinopathy who reported history of exercise/volleyball associated pain at the inferior pole of the patella, palpable tenderness at the same area, and pain during functional tests of the knee (single-leg squats and body weight jumps). Examination of symptomatic tendons via ultrasound showed structural changes in combination with clinical examination to support a diagnosis of patellar tendinitis. Structural changes were also found within the control group of asymptomatic patients suggesting that clinical examination alone, or sonograpahic findings by themselves may not be adeqaute to diagnose an individual with patellar tendon pathologies[18].

Lavagnino et. al (2008) used cadaveric knees to assess the effect of knee position and patellar angle on patellar tendon strain. The application of strain was based on a computational model derived from radiographs of healthy knee joint complexes. The computed model input patella–patellar tendon angles corresponding to knee flexion angles between 0° and 60°. After application of the strain was applied to the cadaveric tissues, ultrasound images of the patella and patellar tendon were obtained to to identify any damaged tissue. Results of the imaging showed that tendon strain increased with an increased patellar length with a decrease in the patella-patellar tendon angle. The study also showed peak strain on the patellar tendon at 60° of knee flexion during simulated jump-landing[19].

Shleip (2003) examined the complexity of fascia and its properties. The article describes the relationship between force and time and the impact of both on achieving fascial manipulation. The article also covers the connection between fascia and soft tissue with subcutaneous sensory receptors and the nervous system, describing how the stimulation of these receptors can change the tonus and viscosity of the surrounding innervated tissue[20].

From these studies there is a relationship of injury prevalence and development within populations undergoing similar stresses at the knee. The relationships for extrinsic factors like running surface and intrinsic factors like subject anthropometrics, soft tissue anatomy and knee flexion angles can influence injury development. Additionally, increased training intensity and repetitive forceful moments at the knee increase the risk for developing the pathology.

Injury Definition of Patellar Tendinopathy:

The definition for a clinical diagnosis of PT can vary between authors. Common characteristics in PT will continually manifest in inclusionary criteria for subjects, but may change depending on the population. The literature presents these recurring subjective and objective subject criteria, in addition to the anatomical and physiological structure of the patellar tendon.

Kannus (2000) describe the composition of tendon structure to better understand the pathology of different tendon injuries. Tendons function to transmit force generated by the muscles to the bone through the attachments. Muscles like the quadriceps are designed to create powerful resistive forces via short broad tendons. Healthy tendons have a fibro-elastic composition and are very resilient in resisting mechanical loads. Tendons have multiple extratendinous structures designed to reduce friction as the tendon glides and slides around surrounding structures. Most tendons are surrounded by loose areolar connective tissue called paratendon acting as an elastic sleeve permitting free movement of the tendon[21].

Cook et. al (1997) reviewed a large sample of athletes with jumper's knee to describe their course of injury management. The study defined jumper's knee/PT through patient symptoms including anterior knee pain with activity, especially with landing or sudden stopping, point tenderness at the inferior pole of the patella and the absence of other knee pathologies. One hundred subjects were used in the study, consisting of 80 men and 20 women, ranging from 16-52 years of age. Seventy-one percent of patients reported an insidious onset of pain, beginning before the age of 23. Most of the subjects played in either basketball or Australian football, while the remaining subjects played various sports. A significant number of subjects had symptoms long enough to cause them to remove themselves from activity for a minimum of four weeks with some removed for more than 12 months[7].

According to Witvrouw et. al (2001), patients diagnosed as having PT had the following characteristics: history of pain in the quadriceps or patellar tendons, or at their patellar or tibial insertions, be palpably tender at the corresponding painful areas, and the presence of a hypoechogenic nodular lesion in the patellar tendon. The study was conducted to scientifically determine intrinsic risk factors for PT, creating the basis for the current study to analyze, prospectively, presuming risk factors play a significant role in the development of the tendinopathy. The study was performed over a two year period and examined 138 undergraduate students who participated in the same sports program for approximately 12-14 hours a week. The program included the following sports: swimming, track and field, gymnastics, soccer, basketball, jazz dance, volleyball and judo. A decrease in flexibility within the hamstrings and quadriceps muscle groups increased the likelihood of developing PT. No correlation was determined between isokinetic muscle strength and the prevalence of injury. There was also no indication of height or weight relating to an increased risk of tendinitis development[22].

Patellar tendinopathy, though seen among many sports, is most prevalent in athletes who participate in volleyball and basketball (Martens et. al 1982). The overwhelming majority of patients within this study did not recall any specific incident causing injury. Subjects were classified according to their reported symptoms using Blazina's stages with slight modifications. Stage 1 included pain only after sports activity and stage 2 included pain at the beginning of sports activity, disappearing after warming up and reappearing at fatigue. Stage 3 consists of constant pain at rest and during activity in addition to being unable to participate in sports at previous level. Stage 4 includes subjects with a complete rupture of the patellar tendon. Sports requiring repetitive movement of the extensor mechanism of the knee can result in focal degeneration and microtearing within the tendon near its insertion. Subjects' height compared with a control group of athletes concluded that the height of the subject does not correlate with the condition, rather, specific sport correlated with the prevalence of the lesion[23].

Zhang et. al (2014), compared the elastic properties of patellar tendons between dominant and non-dominant sides among healthy subjects, and compared these findings to subjects with diagnosable PT to determine whether any changes in elasticity of the tendon were related to pain and dysfunction. Subjects were diagnosed with PT if findings included local tenderness at the inferior pole of patella, or the proximal part of patellar tendon, increased pain during single leg squatting and jumping, and/or thickening of the proximal part of patellar tendon in regions of hypoechoic signals. Using an Aixplorer ultrasound unit in conjunction with a 50-mm linear-array transducer at 4–15 MHz frequency, painful tendons were found to be significantly thicker in cross-sectional area compared to the non-painful side. The shear elastic modulus in the painful side was 40.8% higher than the non-painful side[24].

Scott et. al (2013), reviewed current topical points on exercise related tendinopathies. A tendon's neural anatomy has a large influence on patient pain perception. The mechanoreceptors that innervate the tendon and its surroundings contribute towards the nociception signaling. A large amount of autonomic fibers innervating the tendon were likely to affect the level of pain signaling[25].

These clinical definitions all seemingly revolve around the same general characteristics to diagnose PT. While ultrasound and MRI can be used in conjunction with patient signs and symptoms, this is not always practical in the clinical setting. However, subjects' inclusionary criteria did continually include the same painful and palpably tender anatomical landmarks along with similar mechanisms providing an agreeable definition for subject testing.

Current Treatment for Patellar Tendinopathy:

Current treatment for PT varies between different theories of tendon deloading, ranging from changing patellar tendon angle and rehabilitative exercises. The common interventions seen in the college athletic environment include patellar tendon straps, rehabilitation programs and cortisone injections for more severe cases.

Lavagnino et. al (2011), found that applying a patellar tendon strap could reduce the average and maximum localized tendon strain at the site of application. Twenty subjects had lateral radiographs taken at 60° of knee flexion weight bearing and non-weight bearing, both with and without the two types of knee straps. Radiographs were used to measure the thickness of the patellar tendon at the proximal, middle and distal portions of the tendon. Radiographs also determine the infrapatellar strap's position in relation to the tendon. However, the study was conducted using only males and patients without patella/patellar tendon abnormalities[26]. Frohm et. al (2007) found that a 12-week rehabilitation program focusing on eccentric exercise and overloading the tendon were significantly effective in treating PT. The study used 20 competitive and recreational athletes who were diagnosed with PT using MRI or ultrasound imaging. The study measured subject pain and function using the Victorian Institute of Sports Assessment for the Patellar tendon (VISA-P) score as well as the visual analog scale. Subjects experienced improvements in level of pain, symptoms, strength of knee extension, and in functional testing[27].

Martens et. al (1982) described that cortisone injections were inadequate for yielding lasting improvements for patients with PT. The authors stated that the treatment may increase the likelihood of an individual experiencing a full tendon rupture. The study showed four of the five complete ruptures within the group of subjects had received injections because of symptoms of PT. Cortisone injections at the tendon do not repair the tissue and multiple injections may cause the tendon to weaken increasing risk rupture[14].

These studies describe the effectiveness of rehabilitation on improving subject pain and function, and patellar tendon straps on decreasing the amount of strain experienced at the knee. However, rehabilitation plans can take several months to elicit results and patellar tendon straps may not be able to simultaneously improve performance or function in an active individual, specifically in those with tendinopathies.

Equipment Reliability:

The following studies describe current research designs used to monitor the efficacy and effectiveness of kinesio tape in improving patient pain and function. Multiple scales and scoring systems for recording pain levels are used between the studies including the numerical pain rating scale and visual analog scale. Additionally, there are a variety of tests such as joint range of motion, maximum vertical jump, squat lifts and stair climbing chosen to act as measure performance for active individuals. These articles also serve to validate the usefulness of some instrumentation used to gather data such as the cybex dynamometer, EMG electrode activity and the handheld dynamometer.

Merino-Marban et. al (2013) attempted to observe any effects of kinesio tape (KT) on range of motion (ROM) for ankle dorsiflexion and calf pain in healthy athletes immediately after application of KT and after competition. Calf pain was measured using the numerical pain rating scale (0-no pain; 10- maximum pain) represented as a graphical line on a sheet with the range of numbers spanning the line. Ankle dorsiflexion ROM was measured using an inclinometer. The measures were taken before KT application, immediately after application, and 10-15 minutes after competing in a duathlon. Application of KT occurred 20-90 minutes prior to the start of competition. The taped side served as the experimental leg while the non-taped leg served as the control. There was a significant improvement with KT on ankle dorsiflexion ROM immediately after application, but not after the duathlon. In regard to calf pain, all athletes reported much greater levels of calf pain compared to baseline levels and after KT application. However, perceived level of pain was reported lower in comparison between the control and experimental legs after competition[29].

Stedge et. al (2012) aimed to determine the effects of kinesio-taping (KT) on muscular endurance ratio, blood flow, circumference, and volume of the gastrocnemius. This design was based off of the proposed benefit that kinesio tape helps to increase blood flow and the delivery of oxygen to tissue, ultimately improving function. Subjects who were considered healthy and active were randomly assigned to a treatment KT, sham KT, or control group. The study measured blood flow, circumference, volumetric water displacement, and endurance ratio of the gastrocnemius at 24, and 72 hours after intervention. Blood flow was measured using a laser Doppler, secured to the skin 5 cm below the popliteal fossa however, no research has been completed to confirm the reliability and validity of this device. Circumference was measured with a spring measuring tape from the base of the medial and lateral malleoli, through the lower leg, to the head of the fibula at 4-cm increments. Volumetric measurements were taken from water displacement in milliliters. Endurance ratio of the subjects was taken as the total work of the gastrocnemius. Measurements of work were taken using a CYBEX NORM dynamometer. Isokinetic muscle strength was measured at 60, 120 and 180 °/sec. There were no significant effects found within or between groups on endurance ratio of the gastrocnemius, circulation, blood flow, circumference or volumetric water displacement[30].

Shakeri et. al (2013) examined the effect of kinesio tape (KT) on pain intensity during movement, pain experienced during the night, and pain-free shoulder range of motion (ROM) in patients with shoulder impingement syndrome (SIS). These measures were taken immediately after taping, three days after taping and one week after taping. Subjects were instructed to not take non-steroidal anti-inflammatory drugs during the study, even if prescribed. Participants were also instructed not to participate in upper extremity exercises during the study to control for activity level. The experimental group received taping procedures in accordance with the methods described in the KT manual for shoulder impingement. Placebo group received tape but with no significant pattern without any tension in the tape. Pain measurements were conducted using a visual analog scale. A goniometer was used to measure shoulder ROM for flexion, abduction and scapular plane elevation. Improvements in pain levels during shoulder ROM was found in both groups immediately after taping, with a greater improvement in the experimental group. The experimental group had a larger reduction in pain intensity both during movement and at night when compared to the control group[31].

Huang et. al (2011) measured the effects of elastic taping on the triceps surae muscle during a maximal vertical jump. Healthy subjects who did not engage in regular exercise were recruited for the study. Both elastic (KT) and non-elastic athletic tape were applied to the subjects. The subject first performed five jumps to be used as baseline measures. After these baseline jumps were conducted, the tape was applied bilaterally to the posterior calves of the subject, who was blinded to the type of tape used, either KT or non-elastic athletic tape. After application the subject would perform a warm-up by walking on the treadmill for five minutes followed by the working jump trials. The vertical jump was performed by standing on the force plate with both feet and having the subject place both hands on their hips. In an effort to reduce error from fatigue, the subjects were given 30 minutes of rest with the tape still applied. After this rest period, the subject then performed five more vertical jumps. There were three days between testing sessions to disallow any cumulative effects of the taping techniques. To analyze EMG activity at the muscle, electrodes were placed on the calf at the medial gastrocnemius, tibialis anterior and the soleus muscles. Vertical ground reaction force was measured using a force plate and jump height was analyzed by a motion capture system. The results demonstrated an increase in vertical ground reaction force and EMG activity at the medial gastrocnemius while

KT was applied. Jump height was insignificantly affected by KT in the participants, while placebo tape subjects saw a reduction in jump height. The placebo tape group also showed no change in EMG activity in all three muscles and vertical ground reaction force[32].

Campolo et.al (2013) compared the effectiveness of Kinesio Tape (KT) and McConnell Tape with a no tape group during a squat lift and stair climbing in subjects with anterior knee pain. Subjects performed a weighted box squat lift at 10% of their body weight plus the weight of the box. The subjects also ascended and descending three flights of stairs. Subjects underwent all three conditions: no tape, KT or MT tape. Techniques used for KT and MT taping techniques were consistent with the accepted methods by each brand. Pain levels during each test were measured using the 0-10 Numeric Pain Intensity Scale before and during activity. Before continuing on to the next test, subjects were given 15-30 minutes of rest to allow pain to return to a baseline level. The results were a reduction in pain with the taping methods compared to the no-tape group. There was no significant difference in the level of reduction between the MT and KT groups[2].

Kim et. al (2014) examined the reliability and validity of a hand-held dynamometer (HHD) for measuring force production between a fixed and non-fixed method of testing. The study used both methods to measure isometric knee extensor strength on 27 healthy individuals. Testing was performed in both a seated and supine position under three testing conditions: isometric knee extension by isokinetic dynamometer, non-fixed HHD, and fixed HHD. Subjects knees were positioned at 35° of knee flexion with the HHD placed at the distal tibia. The study's results showed that the fixed HHD method had higher validity and reliability compared to the non-fixed method along with producing similar results to the isokinetic dynamometer[33].

Additionally, studies by both Andrews et. al (1996) and Bohannon (1997) attempt to evaluate and establish HHD normative values for maximum voluntary isometric force using multiple extremity movements. The studies found reliability and validity in testing knee extension force production with hips and knees flexed to 90°[34-35].

The results of these studies show the validity of using pain rating scales as a means of recording subject pain levels and subject jump height as a means of measuring functional performance. The literature also describes a HHD as a valid tool for measuring force production and joint range of motion at different joints, specifically the knee.

References:


1. Bicici, S., Karatas, N., & Baltaci, G. (2012). Effect of athletic taping and kinesiotaping on measurements of functional performance in basketball players with chronic inversion ankle sprains. *The International Journal of Sports Physical Therapy,7*(2), 154-166.

2. Campolo, M., Babu, J., Dmochowska, K., Scariah, S., & Varughese, J. (2013). A comparison of two taping techniques (kinesio and mcconnell) and their effect on anterior knee pain during function activities. *The International Journal of Sports Physical Therapy, 8*(2), 105-110.
3. Chen PL, Hong WH, Lin CH, Chen WC. (2008). Biomechanics effects of kinesio taping for persons with patellofemoral pain syndrome during stair climbing. *IFMBE Proceedings.*2008; 21: 395–397.
4. Aytar, A., Ozunlu, N., Surenkok, O., Baltaci, G., Oztop, P., & Karatas, M. (2011). Initial effects of kinesio taping in patients with patellofemoral pain syndrome: a randomized, double-blind study. *Isokinetics and Exercise Science, 19*, 135-142.

5. Han, J., & Lee, J. (2014). Effects of kinesiology taping on repositioning error of the knee joint after quadriceps muscle fatigue. *J. Phys. Ther. Sci., 26*(6), 921-923.

6. Thelen, M. D., Dauber, J. A., & Stoneman, P. D. (2008). The clinical efficacy of kinesio tape for shoulder pain: A randomized, double-blinded, clinical trial. *J Orthop Sports Phys Ther Journal of Orthopaedic & Sports Physical Therapy, 38*(7), 389-395.

7. Slupik, A., Dwormik, M., Białoszewski, D., & Zych, E. (2007). Effect of kinesio taping on bioelectrical activity of vastus medialis muscle. preliminary report. *Ortop Traumatol Rehabil, 9*(6), 644-651.

8. Schiffer, T., Möllinger, A., Sperlich, B., & Memmert, D. (2015). Kinesio taping and jump performance in elite female track and field athletes. *J Sport Rehabil*. *24*(1), 47-50.

9. Kümmel J., Mauz D., Blab F., & Vieten M. (2011). Effect of kinesio taping on performance in counter-movement jump. *Portuguese Journal of Sports Sciences.* 11(2), 605-607.

10. Nakajima MA., Baldridge C. (2013). The effect of kinesio® tape on vertical jump and dynamic postural control. *Int J Sports Phys Ther*. *8*(4):393-40.

11. De Hoyo M., Álvarez-Mesa A., Sañudo B., Carrasco L., & Domínguez S. (2013). Immediate effect of kinesio taping on muscle response in young elite soccer players. *J Sport Rehabil*. *22*(1), 53-58.

12. Aktas G., Baltaci G., Isokinetics and Exercise Science. (2011). Does kinesiotaping increase knee muscles strength and functional performance? *Isokinetics and Exercise Science.* 19*,* 149-155.

13. Lian, Ø, Engebretsen, L., & Bahr, R. (2005). Prevalence of jumper's knee among elite athletes from different sports. *The American Journal of Sports Medicine, 33*(4), 561-567.

14. Cook, J., Khan, K., Harcourt, P., Grant, M., Young, D., & Bonar, S. (1997). A cross sectional study of 100 athletes with jumper's knee managed conservatively and surgically. the victorian institute of sport tendon study group. *British Journal of Sports Medicine, 31*, 332-336.

15. Ferretti, A. (1986). Epidemiology of jumper's knee. *Sports Medicine, 3*(4), 289-295.

16. Rudavsky A, Cook J. (2009). Management of patellar tendinopathy (jumper's knee). *Journal of Physiotherapy, 60*, 122-129.

17. Bisseling, R., Hof, A., Bredeweg, S., Zwerver, J., & Mulder, T. (2007). Relationship between landing strategy and patellar tendinopathy in volleyball. *British Journal of Sports Medicine,41*(7), E8-E8. Retrieved October 6, 2014.

18. Gisslen, K. (2005). High prevalence of jumper's knee and sonographic changes in Swedish elite junior volleyball players compared to matched controls. *British Journal of Sports Medicine, 39*(5), 298-301.

19. Lavagnino M, Arnoczky S, Elvin N, Dodds J. (2008). Patellar tendon strain is increased at the site of the jumper's knee lesion during knee flexion and tendon loading. *Am J Sports Med*. *36*(11), 2110-2118.

20. Schleip R. (2003). Fascial plasticity – a new neurobiological explanation: part 1. *Journal of Bodywork and Movement Therapies*. *7*(1), 11-19.

21. Kannus, P. (2000). Structure of the tendon connective tissue. *Scandinavian Journal of Medicine and Science in Sports, 10*, 312-320.

22. Witvrouw, E., Bellemans, J., Lysens, R., Danneels, L., & Cambie, D. (2001). Intrinsic risk factors for the development of patellar tendinitis in an athletic population. *The American Journal of Sports Medicine, 29*(2), 190-195.

23. Martens, M., Wouters, P., Burssens, A., & Mulier, J. (1982). Patellar tendinitis: pathology and results of treatment. *Acta Orthopaedica, 53*, 445-450.

24. Zhang, Z., Ng, G., Lee, W., & Fu, S. (2014). Changes in morphological and elastic properties of patellar tendon in athletes with unilateral patellar tendinopathy and their relationships with pain and functional disability. *PLOS ONE, 9*(10), E108337-E108337.

25. Scott A, Docking S, Vicenzino B, Alfredson H, Murphy RJ, Carr AJ, Zwerver J, Lundgreen K, Finlay O, Pollock N, Cook JL, Fearon A, Purdam CR, Hoens A, Rees JD, Goetz TJ, & Danielson P. (2013).Sports and exercise-related tendinopathies: a review of selected topical issues by participants of the second international scientific tendinopathy symposium (ISTS) vancouver 2012. *British Journal of Sports Medicine, 47*(9), 536-544.

26. Lavagnino, M., Arnoczky, S., Dodds, J., & Elvin, N. (2011). Infrapatellar straps decrease patellar tendon strain at the site of the jumper's knee lesion: a computational analysis based on radiographic measurements. *Journal of Sports Health, 3*(3), 296-302.

27. Frohm, A., Saartok, T., Halvorsen, K., & Renstro¨m, P. (2007). Eccentric treatment for patellar tendinopathy: a prospective randomised short-term pilot study of two rehabilitation protocols. *British Journal of SportsMedicine, 41*(7), 1-6.

28. Merino-Marban, R., Mayorga-Vega, D., & Fernandez-Rodriguez, E. (2013). Effect of kinesio tape application on calf pain and ankle range of motion in duathletes. *Journal of Human Kinetics, 37*, 129-135.

29. Stedge, H., Kroskie, R., & Docherty, C. (2012). Kinesio taping and the circulation and endurance ratio of the gastrocnemius muscle. *Journal of Athletic Training, 47*(6), 635-642.

30. Shakeri, H., Keshavarz, R., Arab, A., & Ebrahimi, I. (2013). Clinical effectiveness of kinesiological taping on pain and pain-free shoulder range of motion in patients with shoulder impingement syndrome: a randomized, double blinded, placebo-controlled trial. *The International Journal of Sports Physical Therapy, 8*(6), 800-810.

31. Huang, C., Hsieh, T., Lu, S., & Su, F. (2011). Effect of the kinesio tape to muscle activity and vertical jump performance in healthy inactive people. *BioMedical Engineering OnLine, 10*(70).

32. Kim, W. K., Kim, D., Seo, K. M., & Kang, S. H. (2014). Reliability and validity of isometric knee extensor strength test with hand-held dynamometer depending on its fixation: a pilot study. *Ann Rehabil Med Annals of Rehabilitation Medicine, 38*(1), 84-93.

33. Andrews, A., Thomas, M., & Bohannon, R. (1996). Normative values for isometric muscle force measurements obtained with hand-held dynamometer. *Physical Therapy, 76*(3), 248-259.

34. Bohannon, R. W. (1997). Reference values for extremity muscle strength obtained by hand-held dynamometry from adults aged 20 to 79 years. *Archives of Physical Medicine and Rehabilitation, 78*(1), 26-32.