EFFECTS OF DIFFERENT PATELLOFEMORAL JOINT TAPING TECHNIQUES ON PERCEIVED PAIN AND KNEE NEUROMUSCULAR PERFORMANCE IN PATELLOFEMORAL JOINT DYSFUNCTION PATIENTS

ZACHARY T. BOSS
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A thesis submitted in partial fulfillment of the requirements for a baccalaureate degree in Kinesiology with honors in Kinesiology

Reviewed and approved* by the following:

S. John Miller
Assistant Professor of Kinesiology
Thesis Supervisor

Giampietro “John” L. Vairo
Instructor of Kinesiology
Coordinator, Athletic Training and Sports Medicine Research Laboratory
Thesis Co-Supervisor

Stephen J. Piazza
Associate Professor of Kinesiology
Honors Adviser

* Signatures are on file in the Schreyer Honors College.
ABSTRACT

EFFECTS OF DIFFERENT PATELLOFEMORAL JOINT TAPING TECHNIQUES ON PERCEIVED PAIN AND KNEE NEUROMUSCULAR PERFORMANCE IN PATELLOFEMORAL JOINT DYSFUNCTION PATIENTS

Boss ZT*, Vairo GL*, Miller SJ*, Bosha PJ†, Millard RL†, Aukerman DF†, Sebastianeli WJ†; *Athletic Training and Sports Medicine Research Laboratory, Department of Kinesiology, University Park PA; †Penn State Hershey Orthopedics and Sports Medicine – State College, State College PA

Objective: To compare pain, neuromuscular activity and dynamic balance in patients diagnosed with unilateral acute patellofemoral dysfunction (PDF) after receiving various therapeutic taping treatments. This research study examined differences among traditional and more contemporary associated therapeutic taping techniques. It was hypothesized that the application of a taping technique to the knee would improve outcome measures. An additional improvement was expected with the application of a hip taping technique. Design and Setting: Therapeutic knee taping condition was the independent variable. Dependent variables included self-reported pain, quadriceps neuromuscular activity and dynamic balance. Participants underwent one bilateral baseline testing and three unilateral taping (McConnell medial glide, Upper Knee SpiderTM, and Upper Knee SpiderTM combined with Hip SpiderTM) sessions. Forty-eight hours separated sessions. All testing took place in a controlled laboratory. Subjects: Thirteen (4 men and 9 women) participants (age = 21.6 ± 1.1 years, height = 1.70 ± .08 m, mass = 64.22 ± 9.06 kg, Tegner = 6 ± 1.6, Kujala = 82.46 ± 11.69) diagnosed with unilateral acute PFD by a sports medicine physician. Measurement: Self-reported pain
as measured by a standard visual analog scale (cm) during execution of the Star Excursion Balance Test (SEBT); SEBT anterior reach distances normalized to non-stance leg-length (%LL); quadriceps surface electromyographic activity normalized to maximum volitional isometric contraction during the SEBT. One-tailed paired t-tests were calculated to determine bilateral baseline differences. In instances of non-normality, the non-parametric Mann-Whitney test was computed to determine bilateral baseline differences. One-way analyses of variance with Tukey’s post hoc test were calculated to determine statistically significant differences among conditions (baseline, McConnell, Upper Knee Spider™, and Upper Knee Spider™ with Hip Spider™) for the involved leg. P < 0.05 denoted statistical significance. **Results:** Pain was significantly greater in the involved leg (median = 2.0) compared to uninvolved leg (median = 0.0) at baseline (95.4% CI = 1.5, 2.6). Pain decreased with tape when compared to baseline (no tape: 2.0 ± 0.9 cm; McConnell: 0.8 ± 0.7 cm; Upper Knee Spider™: 0.8 ± 1.0 cm; Upper Knee Spider™ combined with Hip Spider™: 0.6 ± 0.5 cm; P = 0.000). All other comparisons were statistically insignificant (P > 0.05). **Conclusion:** Therapeutic taping techniques decrease perceived pain in patients with unilateral acute PFD when compared to no tape. However, there appears to be a lack of differences among techniques. These outcomes suggest further research is warranted to determine the efficacy of such interventions. **Word Count:** 400.
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I would like to thank my parents for their full support in everything that I do. Thank you for the sacrifices you have made, the countless lessons you have taught, and the unconditional love that you give me. To Matt, De, and Bec thank you for always being there to always make my day better. Your encouragement and love is amazing. Last, I would all of my family and friends for their support.
CHAPTER 1: INTRODUCTION

Patellofemoral joint dysfunction (PFD) is characterized as anterior knee pain or peripatellar pain in response to elevated patellofemoral joint stress.\textsuperscript{1-4} Patellofemoral joint dysfunction is common among the physically active population.\textsuperscript{1,2} The precise etiology and mechanism of PFD are currently unknown.\textsuperscript{1-4} However, it is suggested that abnormal tracking of the patella in the trochlear groove is a contributing factor.\textsuperscript{3,4} Proximal musculature of the quadriceps is thought to affect patellar tracking.\textsuperscript{1,3,4} In particular, decreased or delayed activity of the vastus medialis relative to the vastus lateralis may lead to abnormal patellar tracking and pain.\textsuperscript{7,9,22} Another etiological theory suggests that poor proximal neuromuscular control, proprioception, and weakness of hip musculature leads to deficient control of frontal and transverse planes of motions of the hip.\textsuperscript{1,15,16,23} Given that the patella articulates with the distal femur research must focus on understanding how abnormal hip motions may contribute to PFD. Recent research suggests that patients with weak hip musculature demonstrate a malalignment pattern of femoral adduction, femoral internal rotation, valgus collapse at the knee, increased Q-angle, tibial internal rotation, and foot pronation.\textsuperscript{1,24}

Treatments for PFD often consist of non-operative interventions to correct or improve patellar tracking by increasing neuromuscular activation of the supporting musculature.\textsuperscript{1} Although the outcomes vary, the results of certain studies suggest that therapeutic taping techniques reduce patellofemoral pain during physical activity as well as increase functional performance and balance.\textsuperscript{10,12} Taping techniques at the knee, such as the McConnell medial glide, resist excess lateral patellar tracking.\textsuperscript{7} The McConnell medial glide method consists of noncompliant tape, which anchors the patella medially in
the trochlear groove. The medialization of the patella is thought to correct for stiff connective tissues, such as the lateral patellar retinaculum, in patients with PFD. At the same time, the application of tape increases sensory input to the central nervous system via stimulation of peripheral mechanoreceptors.

It is suggested that gluteal activation and coordination at the hip may be successful in rehabilitating injuries in the distal part of the limb such as the knee or ankle. Consequently treatments for PFD aim to correct patellar malalignments by the strengthening of hip abductors, external rotators, and extensors. There is little research on the effects of hip taping on PFD outcomes. However, in two respective studies taping techniques at the hip have resulted in an increase in muscle control and dynamic balance.

It is suggested that the use of kinesiotape implements additional benefits of improved circulation and reduced inflammation compared to other types of tape. Kinesiotape is a thin, cotton, porous fabric with an adhesive that is very compliant. The tape has elastic fibers imbedded in it that allow the tape to recoil when placed on the skin. It allows for partial to full joint range of motion. The elastic recoil in the tape is proposed to lift the skin and increases space between the skin and muscle, and thus provide the central nervous system with a large influx of afferent sensory input via mechanoreceptors. Kinesiotape is proposed to increase proprioception by providing constant cutaneous afferent stimulation. By way of this mechanism, kinesiotape leads to an increase in muscle activation and a decrease in pain through neurological suppression.
Various studies\textsuperscript{4,12,16,31} have investigated the effects of patellofemoral joint taping techniques on pain and quadriceps muscle activity. However, few studies\textsuperscript{12,31} have investigated quadriceps activity during the completion of a dynamic balance task. To this date there has been no study published examining the effects of kinesiotaping the hip on PFD outcomes. Therefore, the purpose of this research study is to investigate the effects of various patellofemoral therapeutic taping techniques at the knee and hip on dynamic balance, perceived pain and quadriceps muscle activity during the execution of a dynamic balance task. Based on the literature\textsuperscript{1,7-9,14-16,28} we hypothesized that taping techniques at the knee would improve outcome measures and that the combination of knee and hip taping will lead to additional improvements.
CHAPTER 2: METHODS

Experimental Design

A pretest-posttest true experimental design was used for this study. All research was conducted in the Penn State Athletic Training and Sports Medicine Research Laboratory. Baseline measures were taken for both the involved and uninvolved leg. The independent variable was the therapeutic taping method of the involved leg, which included: McConnell medial glide; Upper Knee Spider™; combined Upper Knee Spider™ and Hip Spider™. Dependent variables included: dynamic balance as measured by normalized anterior reach distances of the Star Excursion Balance Test (SEBT), neuromuscular activity of the vastus medialis and vastus lateralis via surface electromyography (SEMG), and perceived pain when executing the SEBT by way of a standardized visual analog scale (VAS). Order effects were prevented by randomization for the sequence of therapeutic taping methods via statistical software (Minitab 16, Minitab. Inc., State College, PA). The uninvolved contralateral leg served as an internal control. Comparisons were made at baseline between the involved leg and the uninvolved leg before the application of therapeutic tape. Additionally pairwise comparisons were made between the different therapeutic taping methods (McConnell medial glide, Upper Knee Spider™, combined Upper Knee Spider and Hip Spider™) for the involved leg. Participants underwent four testing sessions, each with a different taping condition (no tape, McConnell, Upper Knee Spider™ and combined Upper Knee Spider™ Hip Spider™). A 72-hour rest separated each of the four data collection sessions.
Participants

Thirteen (4 men, 9 women) participants were recruited from the student-body of The Pennsylvania State University, University Park Campus (University Park, PA). All participants in the study were diagnosed with acute unilateral PFD by a sports medicine physician. Enrolled participants were determined to have no history of traumatic injury to the lower extremities or sustained cerebral concussion with the past six-months. Additionally, participants were between the ages 18-35, received no formal rehabilitation, and had suffered from PFD for no longer than six months. All participants completed a written informed consent form (Appendix H) in accordance with the Institutional Review Board. Prior to beginning data collection, we measured demographic and anthropometric data for each participant. These included: height; mass; body mass index; reciprocal ponderal index; and length of both legs. Leg length was measured, in centimeters, from the inferior ridge of the anterior superior iliac spine to the apex of the medial malleolus while the participant was in a supine position. Demographic and anthropometric measures are displayed in Table 2.1. Before testing, participants completed a dynamic warm-up by walking at a rate of 1.2 m/s for five minutes on a standard horizontal treadmill (Woodway USA, Waukesha, WI) (Figure 2.1).
Table 2.1 Demographic and Anthropometric Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>M ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>13</td>
</tr>
<tr>
<td>Sex (Men / Women)</td>
<td>4 / 9</td>
</tr>
<tr>
<td>Age (years)</td>
<td>20.6 ± 1.1</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.7 ± 0.1</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>64.2 ± 9.1</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>22.2 ± 2.5</td>
</tr>
<tr>
<td>RPI(cm/kg¹/³)</td>
<td>42.5 ± 1.7</td>
</tr>
<tr>
<td>Kujala Questionnaire Score</td>
<td>82.5 ± 11.7</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation
Figure 2.1 Participant Warm-Up
**Kujala Questionnaire**

Before participating in the data collection, participants were required to complete the Kujala Questionnaire (Appendix E) which scores the degree of PFD. The questionnaire subjectively measures the performance and pain level in the knee joint during every day activity. No verbal cues were provided during its completion. The Kujala Questionnaire consists of 13 questions with multiple-choice answers. Each answer is associated with a point value, which is summed for every question to supply a value out of 100. A lower score denotes more severe the symptoms of PFD. The Kujala Questionnaire has shown to accurately assess knee function and pain and has a test-retest reliability of 0.95 and an internal consistency of 0.86.

**Tegner Activity Level Scale**

Before testing the participants were also required to complete the Tegner Activity Level Scale (Appendix D), which measures activity levels both before and after the onset of knee injury. The scale subjectively assesses the participants activity level on a range of 0-10, with 10 being the most active. No verbal cues were provided while completing the scale. A study by Briggs et al showed Tegner Activity level scale to have acceptable test-retest reliability of .9 and high validity in assessing knee pain.
Surface Electromyography

Surface electromyography (SEMG) activity of the quadriceps musculature was collected with a tethered MP100 Data Acquisition Unit (BIOPAC Systems Inc., Santa Barbara, CA), which is composed of multiple stationary modules that contain amplifiers (gain 2,000) filtering myoelectric data at a rate of Butterworth low-pass (10 Hz) and high-pass (500 Hz) with a common mode rejection ratio of 110 db. The amplifier relays surface EMG signals to a receiver where they are transformed from analog to digital by a converter (BIOPAC Systems, Inc., Santa Barbara, CA). The system converted raw analog SEMG signals, sampled at 2,000 Hz, from the quadriceps to digital data and analyzed by AcqKnowledge 3.9.1 (BIOPAC Systems Inc., Santa Barbara, CA) computer software. To obtain consistent data, the vastus medialis and vastus lateralis were palpated while the participant isometrically contracted their quadriceps musculature. The mid-bellies of the vastus medialis and vastus lateralis were shaved, abraded, and cleaned with alcohol before the application of surface electrodes. These preparation procedures were done to increase electrode bonding with the skin and reduce electrical impedance. Self-adhesive Ag/AgCl bipolar surface electrodes (BIOPAC Systems Inc., Santa Barbara, CA) with a diameter of 10 millimeters were placed in the direction of the muscle fibers in pairs 25 millimeters apart on the mid-bellies of vastus medialis and vastus lateralis. In addition, a reference electrode was positioned on the anteromedial portion of the tibial tuberosity (Figure 2.2). Reference marks were made on the skin in order to use consistent electrode placement between trials. Normalization of SEMG was accomplished with the collection of a maximum voluntary isometric contraction (MVIC).
The Biodex System 2 (Biodex Medical Inc., Shirley, NY, USA) was used in conjunction with the BIOPAC system to record MVIC’s. The MVIC was performed against a fixed arm at a 45° knee angle, which lasted for a six-second duration. Participants were given two warm up trials, one at 50% of their perceived MVIC and the other at 75% of their perceived MVIC. A one-minute rest period was given in between warm up sessions and a two-minute rest period was given before the recording of the MVIC data (Figure 2.3). Data was collected while the participant completed the anterior reach of the SEBT. The SEMG data was integrated for all muscle activation assessments. Three consecutive excursion trials were combined to construct a profile of quadriceps muscle activation characteristics. Mean amplitude for muscle activity of the vastus medialis and vastus lateralis were used for comparative analyses. Mean amplitudes for each muscle under investigation during the SEBT was normalized to MVIC.\(^{39}\) Validity and reliability of SEMG with applications to functional tasks have been established.\(^{39,48}\)
**Figure 2-2** Surface Electrode Placement
Figure 2.3 MVIC testing
Anterior Reach of the Star Excursion Balance Test

Testing dynamic balance was achieved by determining normalized anterior reach distances for the SEBT. Execution of the SEBT requires significant range of motion, strength, proprioception, and neuromuscular control of the ankle, knee, and hip.\textsuperscript{38-40} The SEBT has been shown to be sensitive enough to detect dynamic postural control deficits in patients with chronic ankle instability and PFD.\textsuperscript{39,41} The SEBT challenged the participant’s single leg balance ability as he/she reached as far as possible in the anterior direction with the contralateral, non-stance leg. Only the anterior reach was measured due to its functional demand on the quadriceps musculature and significant stress on the patellofemoral joint.\textsuperscript{12,31} Participants were instructed to assume “the ready position” and then expected to maintain balance while placing their hands on the hips while executing the anterior reach task. With shoes and socks removed, the great toe of the participant’s stance foot was aligned at the center of the SEBT grid. On the examiner’s verbal cue “go” the participant, while maintaining balance, reached as far as possible in the anterior direction then tapped the grid (Figure 2.4). Participants were informed to exert minimal pressure when tapping the grid. Participants were allowed four practice trials\textsuperscript{49} with a 15-second rest interval between each practice trials. A one-minute rest interval was given between practice and data collection trials. Then, 3 data collection trials were taken with a 15-second rest interval between trials. No verbal encouragement was given during this test. Distances were manually marked on the star with pen and measured in centimeters with a standard tape measure. The distances were measured from the center of the star to the point on the star where the reach foot tapped. The reach lengths were then normalized and expressed as a percent by the calculation: reach distance (cm) / length of
the reach leg (cm) x 100. Trails were discounted if the participant lost their balance, removed their hands from their hips, moved their stance foot out of the base of support, transferred too little or too much weight to the floor with the reaching foot, or did not touch the correct direction line of the SEBT. The SEBT has been demonstrated to be reliable in assessing dynamic postural control of the lower limbs in a number of studies and has been shown to be predictive of lower limb injury in athletes.\textsuperscript{38,40,42}.
Figure 2-4 Anterior Reach of the SEBT
Visual Analog Scale

The participants were asked to complete a visual analog scale (VAS) (Appendix F) for pain immediately after finishing the anterior reach of the SEBT. No verbal cues were given during this assessment. The VAS is a 10 cm horizontal line accompanied by word descriptors that measures the participant’s perceived pain when executing the anterior reach of the SEBT. The VAS ranges from values of 0 (no pain) to 10 (extreme pain). The patient placed a mark on the line which best judged their perception of pain in the knee joint during the SEBT. The VAS score was then calculated by measuring the distance from the left boundary to the subjects mark using a standard ruler and then converted into a pain score in centimeters. The VAS is commonly used in studies involving PFD and has been shown to be reliable in orthopedic medicine literature.

Therapeutic Taping Techniques

During the second through fourth data collection sessions, a different therapeutic taping technique was applied to the involved leg only. All therapeutic taping methods were applied by a licensed clinician. The order of taping technique was determined by separate randomized permutations for each participant. The therapeutic taping techniques included: McConnell medial glide, Upper Knee Spider™, and combined Upper Knee Spider™ and Hip Spider™.

The McConnell medial glide technique (Figure 2.5) was applied as described by McConnell. The Participant was to sit on the table with the knee at 20 degrees of flexion. Cover-roll was applied to the anterior portion of the knee that was secured with
McConnell tape (Leukotape™) was applied to the patella starting with the lateral border. The patella was medially glided and the tape was secured to the area of the medial femoral condyle of the knee. Thus far in the associated literature, a lack of evidence has been presented that quantifies the force of pull with a measure of skin crease related to the McConnell medial glide taping technique. Although previous authors have suggested the need for a standardized skin crease width in related research, there is currently a lack of empirical data supporting a specified skin crease width. Therefore, similar to Aminaka & Gribble we adopted an approximate 2 cm wide visible crease of skin at the medial knee upon completion of taping in an effort to standardize the amount of medialization.

The same licensed clinician applied all of the therapeutic taping methods in order to have consistent placement. The Upper Knee Spider™ (Figure 2.6) and Hip Spider™ (Figure 2.7) were applied per the Spider Tech™ “pre–cut applications instructions” on the package (Appendix J, Appendix K).
Figure 2-5 McConnell Medial Glide Taping Method
**Figure 2-6** Upper Knee Spider™ Taping Method
Figure 2-7 Combined Upper Knee Spider™ and Hip Spider™ Taping Method
**Statistical Analysis**

Descriptive statistics, such as group means and standard deviations were calculated for each dependent variable. Paired t-tests were conducted to assess bilateral statistical differences between the involved and uninvolved leg at baseline. Normal probability plots were constructed to confirm that the data met the assumptions for t-test analysis. In the instance of non-normality, a non-parametric Mann-Whitney test was conducted accordingly for bilateral comparisons. A one-way analysis of variance (ANOVA) with Tukey’s Honestly Significant Difference post hoc test was calculated to determine statistically significant differences among the three taping conditions for the involved leg. Inspection of the standardized residuals was conducted to verify the data meet the necessary assumptions for ANOVA. An *a priori* alpha level of $P < 0.05$ indicated statistical significance. A 95% simulations confidence interval was used to detect statistically significant pairwise comparisons.
CHAPTER 3: RESULTS

Activity Level

Analysis of activity level demonstrated a statistically significant decrease
(P = < 0.001) after the onset of symptoms in participants diagnosed with acute PFD.
Results for activity level are displayed in Table 3.1.

Dynamic Balance

Probability plots of these data determined normality (Appendix J), thereby
validating use of the paired t-test for baselines comparisons. Table 3.2 displays no
significant differences existed between reach distances for the involved leg compared to
uninvolved leg at baseline. Residual analyses for these data met the assumptions for
ANOVA. Results from ANOVA determined no statistically significant differences
(P = 0.900) in anterior reach among conditions for the involved leg. Pairwise
comparisons among taping conditions are displayed in Tables 3.3, 3.4, and 3.5.
Table 3.1 Tegner Activity Scale Scores

<table>
<thead>
<tr>
<th></th>
<th>Before PFD Symptoms</th>
<th>After PFD Symptoms</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>7.8 ± 1.1</td>
<td>6 ± 1.6</td>
<td>&lt; 0.001*</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation; *Denotes statistical significance (P < 0.05)
Table 3.2 Comparison of Anterior Reach Distance Between the Involved and Uninvolved Legs at Baseline (%LL)

<table>
<thead>
<tr>
<th>Involved Leg</th>
<th>Uninvolved Leg</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>74.8 ± 10.5</td>
<td>73.1 ± 9.9</td>
<td>0.925</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation; *Denotes statistical significance (P < 0.05)

Table 3.3 Pairwise Comparisons of Anterior Reach Distance Among Baseline and Taping Conditions for the Involved Leg (%LL)

<table>
<thead>
<tr>
<th>Condition</th>
<th>M ± SD</th>
<th>95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline vs:</td>
<td>73.1 ± 9.8</td>
<td></td>
</tr>
<tr>
<td>McConnell</td>
<td>75.3 ± 9.1</td>
<td>(-7.004, 11.463)</td>
</tr>
<tr>
<td>Knee Spider™</td>
<td>74.8 ± 8.1</td>
<td>(-7.533, 10.933)</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
<td>75.4 ± 8.1</td>
<td>(-6.896, 11.570)</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation

Table 3.4 Pairwise Comparisons of Anterior Reach Distance Among McConnell and Kinesiotaping Conditions for the Involved Leg (%LL)

<table>
<thead>
<tr>
<th>Condition</th>
<th>M ± SD</th>
<th>95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McConnell vs:</td>
<td>75.3 ± 9.1</td>
<td></td>
</tr>
<tr>
<td>Knee Spider™</td>
<td>74.8 ± 8.1</td>
<td>(-9.763, 8.704)</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
<td>75.4 ± 8.1</td>
<td>(-9.216, 9.341)</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation

Table 3.5 Pairwise Comparisons of Anterior Reach Distance Among Kinesiotaping Conditions for the Involved Leg (%LL)

<table>
<thead>
<tr>
<th>Condition</th>
<th>M ± SD</th>
<th>95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Spider™ vs:</td>
<td>74.8 ± 8.1</td>
<td></td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
<td>75.4 ± 8.1</td>
<td>(-8.596, 9.807)</td>
</tr>
</tbody>
</table>
Neuromuscular Activity

Probability plots of these data determined normality (Appendix K), thereby validating use of the paired t-test for baselines comparisons. Table 3.6 displays no significant differences existed in mean amplitude of quadriceps neuromuscular activity for the involved leg compared to uninvolved leg at baseline. Residual analyses for these data met the assumptions for ANOVA. Results from ANOVA determined no statistically significant differences ($P = 0.278$) in anterior reach among conditions for the involved leg. Pairwise comparisons among taping conditions are displayed in Tables 3.7, 3.8, and 3.9.
<table>
<thead>
<tr>
<th>Table 3.6 Comparison of Quadriceps Activity During the Anterior Reach of the SEBT for the Involved and Uninvolved Legs at Baseline (%MVIC/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Involved Leg</strong></td>
</tr>
<tr>
<td>22.3 ± 9.5</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation; *Denotes statistical significance (P < 0.05)

<table>
<thead>
<tr>
<th>Table 3.7 Pairwise Comparisons of Quadriceps Neuromuscular Activity Among Baseline and Taping Conditions for the Involved Leg (%MVIC/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition</strong></td>
</tr>
<tr>
<td>Baseline vs:</td>
</tr>
<tr>
<td>McConnell</td>
</tr>
<tr>
<td>Knee Spider™</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation

<table>
<thead>
<tr>
<th>Table 3.8 Pairwise Comparisons of Quadriceps Neuromuscular Activity Among McConnell and Kinesiotaping Conditions for the Involved Leg (%MVIC/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Condition</strong></td>
</tr>
<tr>
<td>McConnell vs:</td>
</tr>
<tr>
<td>Knee Spider™</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation

<table>
<thead>
<tr>
<th>Table 3.9 Pairwise Comparisons of Quadriceps Neuromuscular Activity Among Kinesiotaping Conditions for the Involved Leg (%MVIC/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditions</strong></td>
</tr>
<tr>
<td>Knee Spider™ vs:</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation
Perceived Pain

Probability plots of these data determined non-normality (Appendix L). This is most likely due to participants reporting no pain in the uninvolved leg with execution of the SEBT anterior reach. Therefore, the non-parametric Mann-Whitney test was used for baselines comparisons (Table 3.10). Residual analyses for these data met the assumptions for ANOVA. Results from ANOVA determined a statistically significant difference ($P < 0.001$) in perceived pain among conditions for the involved leg when comparing baseline to the three different taping methods (Figure 3.1). No significant differences were observed between conditions. Pairwise comparisons among taping conditions are displayed in Table 3.11 and Table 3.12.
Table 3.10 Comparison of Perceived Pain (VAS Score) During the Anterior Reach of the SEBT for the Involved and Uninvolved Legs at Baseline

<table>
<thead>
<tr>
<th>Involved Leg</th>
<th>Uninvolved Leg</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median Measure (cm)</td>
<td>Median Measure (cm)</td>
<td>(Lower Bound, Upper Bound)</td>
</tr>
<tr>
<td>2.000</td>
<td>0.000</td>
<td>95.4% (1.500, 2.600)</td>
</tr>
</tbody>
</table>

Values are; *Denotes statistical significance based on a 95.4% confidence interval

Table 3.11 Pairwise Comparisons of Perceived Pain Among McConnell and Kinesiotaping Conditions for the Involved Leg (cm)

<table>
<thead>
<tr>
<th>Condition</th>
<th>M ± SD</th>
<th>95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>McConnell vs:</td>
<td>0.8 ± 0.7</td>
<td></td>
</tr>
<tr>
<td>Knee Spider™</td>
<td>0.8 ± 1.0</td>
<td>(-0.87, 0.76)</td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
<td>0.6 ± 0.5</td>
<td>(-1.06, 0.57)</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation

Table 3.12 Pairwise Comparisons of Perceived Pain Among Kinesiotaping Conditions for the Involved Leg (cm)

<table>
<thead>
<tr>
<th>Conditions</th>
<th>M ± SD</th>
<th>95% Simultaneous Confidence Interval (Lower Bound, Upper Bound)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Spider™ vs:</td>
<td>0.8 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>Knee Spider™ &amp; Hip Spider™</td>
<td>0.6 ± 0.5</td>
<td>(-1.01, 0.62)</td>
</tr>
</tbody>
</table>

Values are Mean ± Standard Deviation
Figure 3.1 Perceived Pain During Anterior Reach of the SEBT for the Involved Leg

Error bars represent standard deviation;
*Denotes statistical significance based on a 95% simultaneous confidence interval
CHAPTER 4: DISCUSSION

Dynamic Balance

Our study found no significant bilateral baseline differences in performance of the anterior reach for the SEBT. Furthermore, no significant performance differences were discovered between baseline and the taping conditions or among the different knee taping techniques. Our results coincide with Breim et al\textsuperscript{60}, which found that the application of kineiotape to the lower extremity to elicit no significant performance differences when completing the SEBT. However, results of Aminaka et al\textsuperscript{12,31} found a significant decrease in the performance for the involved leg during the completion of the SEBT compared to the uninvolved leg. Lan et al\textsuperscript{57} and Nitya et al\textsuperscript{59} demonstrated increased anterior reach performance during the SEBT in PFD patients after the application of McConnell taping method. The previous studies by Lan et al\textsuperscript{57} and Nitya et al\textsuperscript{59} had an enrolled 100 and 30 participants respectively. The smaller number of participants and the lack of baseline differences between involved and uninvolved extremities may have limited our ability to demonstrate performance improvements in our study. Group differences in severity and duration of PFD symptoms may also lead to discrepancies. Lan et al. had a population with much more severe PFD symptoms (average involved leg baseline VAS = 4.9cm) than our participant population. The average VAS score in our population was 1.95cm, indicating a lower level of perceived pain in our participants. In addition, Nitya et al did not discriminate the duration of PFD symptoms and grouped suffers of acute and chronic PFD together. We only enrolled participants suffering from acute PFD symptoms in our study. Another possible explanation for this may be associated to leg dominance. In our study, eight of the 13 participants had PFD
symptoms in their dominant leg possibly accounting for these differences. However, Gribble and Robinson\textsuperscript{56} concluded that leg dominance does not affect performance of the SEBT. Thus, other factors, such as severity and chronicity of PFD symptoms, participant demographics such as activity level, variations in individual pain tolerance or variations in execution of different movement strategies, as evidenced by kinematic analysis, may be responsible for our specific observations.

**Muscle Activity**

We found no significant differences in muscle activity between the baseline and taping conditions as well as no significant differences when making comparisons among the taping techniques. McConnell and kinesiotaping techniques are proposed to provide the central nervous system with increased non-noxious afferent input through mechanoreceptor stimulization\textsuperscript{34}. In this capacity, patellofemoral taping techniques may decrease pain through neurological suppression, thereby removing inhibition and heightening muscle activation\textsuperscript{35} and improving lower extremity functional performance.\textsuperscript{12,32} Our findings complement the results of Vercelli et al\textsuperscript{61} who proposed no differences in the immediate effects of kinesiotaping on quadriceps performance. Fu et al.\textsuperscript{37} concluded kinesiotaping the thigh provided no increase or decrease in muscular activation or timing. Other researchers have found improvements in measures of muscle activation. Cowan el al\textsuperscript{35} applied a kinesiotaping method to the knee of participants with and without PFD and measured muscle activity of the vastus medialis and vastus lateralis when completing a stair climbing task. They found increased temporal characteristics of vastus medialis and vastus lateralis activation in participants with PFD, whereas placebo
tape had no effect in healthy participants. Chistou et al.\textsuperscript{55} found an increase in quadriceps activation with the application of the McConnell taping method in healthy individuals. Although we found no signification changes in muscle activation with taping, we did see a trend toward significantly improved activation with McConnell and Spider Knee and Hip taping techniques. It is interesting that the combined knee and hip kinesiotaping technique showed greater activation than taping the knee alone. This is consistent with Neumann et al.\textsuperscript{53} The insignificant change in muscle activation found in our study may be due to the lack of differences in baseline muscle activation levels in our participants. This may have been accentuated by our small number of participants and their lower level of disability (Kujula score and VAS).

**Perceived Pain**

A significant difference in perceived pain was found between the involved leg and to the uninvolved leg at baseline when performing the anterior reach of the SEBT. All three conditions (McConnell medial glide, Upper Knee Spider\textsuperscript{TM}, and combined Upper Knee Spider\textsuperscript{TM} and Hip Spider\textsuperscript{TM}) significantly reduced perceived pain. However, no significance was found among the conditions. Our results coincide with previous research, which concluded that therapeutic taping techniques are effective in significantly reducing patellofemoral related pain as measured by a standard VAS scale\textsuperscript{12, 16, 31, 39}. McConnell-taping studies propose the reduction in perceived pain to result from the medial stabilization of the patella.\textsuperscript{52} The repositioning of the patella via therapeutic taping is suggested to correct pathomechanical lateral tracking\textsuperscript{7, 12, 31, 52}. Lan et al.\textsuperscript{57} found McConnell taping to significantly reduce patellofemoral related pain with the execution
of a step down task. However, recent research\textsuperscript{30} using advanced medical imaging found that application of McConnell taping techniques do not result in significant anatomical differences for patellar position. Therefore, an alternative mechanism responsible for decreases in pain post-patellar taping observed in our participants may be associated with a change in afferent sensory input.\textsuperscript{8,10,12,31} Similar to our results, Aminaka et al\textsuperscript{32} found that the application of the McConnell taping method to decrease pain according to a VAS scale. The application of a therapeutic taping method to the quadriceps may lead to a change in afferent signals (increased mechanoreceptor input and decreased nociceptor input) leading to the inhibition (gating) of nociceptor input.\textsuperscript{34,35}

Unlike the McConnell medial glide technique, the two therapeutic kinesiotaping methods (Upper Knee Spider\textsuperscript{TM}, combined Upper Knee Spider\textsuperscript{TM} and Hip Spider\textsuperscript{TM}) examined in this investigation do not function to primarily correct malpositioning of the patella. However, similar to the aforementioned neurosensory mechanism associated with McConnell technique, kinesiotaping is proposed to provide the central nervous system with greater afferent input through mechanoreceptors\textsuperscript{34}. In this capacity, kinesiotaping may increase muscle activation leading to decreased pain through neurological suppression.\textsuperscript{35} Similar to our study, Thelen et al\textsuperscript{58} found kinesiotaping of the shoulder to be effective in significantly reducing pain as assessed by a VAS scale. The similarities in neurosensory responses proposed with the application of McConnell and kinesiotaping techniques may explain why no significant differences were found for patellofemoral-related pain among all the taping conditions presented in our study. Since we found no significant difference in pain reduction between taping conditions there appears to be no additional benefit in taping the hip along with the knee in PFD patients.
Limitations

Our research involved certain limitations. Previous studies on the efficacy of patellar taping have had 20 to 100 or more participants enrolled, whereas our study had only had 13 participants. Other factors previously stated, such as severity and chronicity of PFD symptoms, participant demographics such as activity level, variations in individual pain tolerance or variations in execution of different movement strategies, as evidenced by kinematic analysis, may be responsible for our specific observations. These factors could account for the lack of significance in muscular activity in the involved leg compared to the uninvolved leg at baseline and among the ensemble conditions for the involved leg. Our participants demonstrated low pain and higher relative Kujala scores. There were also no baseline differences in muscle activation or dynamic balance task performance, making it more difficult to demonstrate improved performance with an intervention. Additionally, the McConnell method utilized in this study only helped the patella track medially and did not account for tilts or rotations of the patella. It is proposed that tilts and rotations of the patella may account for PFD symptoms. Only one type of kinesiotape brand was used (Spider™), and no placebo taping method was administered to test for the placebo effect. Although, a previous study has demonstrated that placebo taping may result in a decrement in performance. Neuromuscular activity was recorded in the vastus medialis and vastus lateralis only. The effects of hip taping on neuromuscular activity of hip musculature such as the gluteus medius and gluteus maximus were not assessed. Lastly, this study focused on a specific population (18-22 year olds) and thus results may not be extrapolated to other populations with PFD.
CHAPTER 5: CONCLUSION

Within the limitations of our study it is reasonable to conclude that the application of a therapeutic taping method (McConnell medial glide, Upper Knee Spider™, and combined Upper Knee Spider™ and Hip Spider™) was effective in improving perceived pain responses during a dynamic balance task in patients diagnosed with unilateral acute PFD when compared to baseline. All taping methods studied are equally effective at reducing perceived pain. Since no additional benefit was seen with combined knee and hip kinesiotaping, knee taping alone is sufficient to achieve the desired pain reduction outcomes. Proposed beneficial effects of taping on neuromuscular activity and dynamic balance performance in the involved leg of PFD patients were not supported by the results of our study. Future investigations should focus on the role hip musculature and therapeutic hip-taping methods. Researchers should also pursue a more homogeneous categorization of PFD patients in terms of examination findings such as patellar positional faults. Symptom severity and duration as well as disability and varied population demographics must also be investigated.
REFERENCES


LITERATURE REVIEW

Introduction

Patellofemoral joint dysfunction (PFD) is a common condition characterized by pain anterior to the patella. The discomfort and pain caused from PFD is often disabling. Recent literature proposes therapeutic taping techniques at the knee and hip may lead to a reduction of PFD symptoms. These therapeutic taping techniques aim to align the patella, as well as increase muscle activation through greater proprioceptive input.

The purpose of this research study is to investigate the effects of knee and hip taping methods on pain, muscle activity, and dynamic posture control and balance in patients diagnosed with PFD.

Patellofemoral Joint Dysfunction (PFD)

Patellofemoral Joint Dysfunction is a common lower extremity condition observed in orthopedic practices. PFD is characterized as anterior knee pain or peripatellar pain in response to elevated patella femoral joint stress. The precise etiology and mechanism of PFD are currently unknown. One of the suggested contributing factors to PFD is abnormal patellar tracking within the trochlear groove of the femur. Abnormal patellar tracking has been linked to dysfunction in retinacular restraints as well as patellar shape and position. Proximal musculature of the quadriceps is thought to affect patellar tracking. In particular, the decreased or delayed activity of the vastus medialis muscle relative to the vastus lateralis muscle may cause abnormal patellar tracking and pain. Additionally, proximal motion impairments at the hip may contribute PFD. Powers et al suggested that larger hip adduction and
internal rotation during weight bearing can lead to an increased lateral patellar contact pressure as a result of an increase in dynamic quadriceps angle (Q-angle).\textsuperscript{1,14} Thus, it is proposed that PFD may result from decreased strength and muscle co-activation in abductor, external rotator, and extensor muscles,\textsuperscript{14,16-18} mainly the gluteus maximus and gluteus medius.\textsuperscript{19,20} Impaired trunk proprioception and deficits in trunk control are also thought to be factors contributing to PFD. In an effort to align the patella different therapeutic procedures have been incorporated including, increasing strength and endurance of the supporting musculature, stretching protocols, and most important of all, the incorporation of therapeutic taping techniques. These taping techniques aim to medially align the patella, as well as well as decrease inhibition of the muscles associated with patellar tracking.

**Proximal Factors Associated with PFD**

Given that the patella articulates with the distal femur research must focus on understanding how abnormal hip motions may contribute to PFD. The femur moves relative to the patella during weight bearing due to the fact that they are connected via quadriceps tendon.\textsuperscript{1} One etiological theory suggests that hindered proximal neuromuscular control, proprioception and weakness of hip musculature leads to reduced control of frontal and transverse planes of motions of the hip during single-legged activities.\textsuperscript{1,15,16,23} Research has shown patients with weak hip musculature show a malalignment pattern of femoral adduction, internal rotation, valgus collapse at the knee, increased Q-angle, tibial rotation, and foot pronation.\textsuperscript{1,24} To correct these malalignments it is proposed that the strengthening of hip abductors, external rotators, extensors will
help the patella to medially track.\textsuperscript{1,16,25} In addition to muscle strength, muscle activation timing may affect the patellar dynamics. Wilson\textsuperscript{26} et al. studied gluteal activation during running in females with and without PFD. They found that those with PFD showed delayed activation onset and shorter duration of activation of the gluteus medius compared to those without PFD. It is thought that delayed activation of the gluteus maximus and/or gluteus medius may lead to increased internal rotation and adduction of the hip. Other research has complemented Wilsons results, suggesting that a focus on gluteal activation and coordination at the hip may be successful in rehabilitating injuries in the distal part of the limb such as the knee or ankle.\textsuperscript{1,24}

**Therapeutic Taping Effects on PFD**

Although outcomes vary, many studies have suggested that knee taping techniques reduce patellofemoral pain and increase functional performance and balance.\textsuperscript{10,12} Patellar tape is employed as part of the treatment for PFD to facilitate pain-free activity. It may also reduce quadriceps inhibition and improve patellar tracking leading to decreased patellofemoral joint loading.\textsuperscript{11} The most common and widely accepted therapeutic taping technique for PFD is the McConnell method. The underlying concept of McConnell tape is that most patients with PFD would benefit from medialization of the patella, which theoretically would decrease compressive forces at the lateral patellofemoral joint.\textsuperscript{10} However recent research from Derasari et al.\textsuperscript{30} using a fast-phase MRI found McConnell taping to inferiorly displace the patella, partially explaining the previously documented decrease in pain due to increases in contact area.
In addition to decreasing pain, therapeutic taping methods may also help facilitate muscle activity of the quadriceps muscles.\textsuperscript{31} Gillear\textsuperscript{d} et al\textsuperscript{32} investigated the effect of patellar taping on the timing of vastus medialis and vastus lateralis muscle activity in female subjects with PFD during a stair climbing. Results found the onset of vastus medialis activity compared with vastus lateralis occurred earlier in the knee movement with patellar taping than without taping. They suggested that this early activation of the vastus medialis may be caused by cutaneous stimulation brought by the patellar tape. However, contradictory results of other research have shown no increase in quadriceps activity or timing with similar taping techniques.\textsuperscript{7,31}

**Kinesiotape**

Kinesiotape is a fairly new therapeutic taping technique that lacks large amount of research and understanding. Far more elastic than conventional athletic tape, Kinesiotape aims to provide the central nervous system with large amounts of afferent sensory input. Human hairy skin contains specialized cutaneous mechanoreceptors that encode joint position, much like the mechanism of muscle spindles in skeletal muscle.\textsuperscript{33} When a joint moves, certain portions of the skin are stretched different amounts. When these mechanoreceptors are stretched or strained they send constant afferent proprioceptive input to the brain. The brain then decodes the information and gains insight about the position of the joint.\textsuperscript{34} It is proposed that Kinesiotape works to increase proprioception by providing constant cutaneous afferent stimulation. In doing this Kinesiotape may increase muscle activation leading to decreasing pain through neurological suppression.\textsuperscript{35} However, studies on the efficacy of Kinesiotape have been extremely contradictory.
Conclusion

Symptoms associated with PFD can be disabling, fortunately recent therapeutic taping techniques have made PFD manageable. The McConnell medial glide and other patellar taping techniques have shown to decrease pain and help align the patella in the trochlear groove. In addition, research has revealed that therapeutic taping techniques such as kinesiotape may help to facilitate muscle activity though increased proprioceptive inputs. As of now more research needs to be conducted looking at how proximal factors affect PFD. This thesis will aim to discover the efficacy of different therapeutic taping techniques by comparing results from the Star Excursion Balance Test and VAS score. The purpose of this research study is to investigate the effects of knee and hip taping methods on pain, muscle activity and dynamic posture control and balance in patients diagnosed with PFD. Results of this proposed study will help advance the understanding of hip taping techniques on patellofemoral joint dysfunction.
APPENDIX A

Patellofemoral Joint Dysfunction Research Study

Participant Demographics Sheet

Participant Identification: _______________________

Age: ____________

Dominant Leg: Left Leg / Right Leg

Height: _________ (cm) _________ (m)

Weight: _________ (lbs) _________ (kg)

Body Mass Index: _________ (kg/m²)

Left Leg Length: _________ (cm) Involved Leg / Uninvolved Leg

Right Leg Length: _________ (cm) Involved Leg / Uninvolved Leg
APPENDIX B

Patellofemoral Joint Dysfunction Research Study

SEMG Normalization Data Sheet (MVIC)

Participant Identification: _______________________

Data Readings: Involved Leg / Uninvolved Leg

Vastus Medialis Maximum: ___________ (mV)

___________ (mV)

Vastus Lateralis Maximum: ___________ (mV)

___________ (mV)

Vastus Medialis Scaled: ___________ (%MVIC ms)

___________ (%MVIC ms)

Vastus Lateralis Scaled: ___________ (%MVIC ms)

___________ (%MVIC ms)
**APPENDIX C**

**Data Sheet: Anterior Reach of the SEBT**

Participant Identification: _______________________

Day 1: ________________

<table>
<thead>
<tr>
<th>Trial #</th>
<th>Distance Reached (cm) Affected</th>
<th>Distance Reached (cm) Unaffected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Day 2: ________________

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<th>Trial #</th>
<th>Distance Reached (cm) Affected</th>
</tr>
</thead>
<tbody>
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<td>1</td>
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</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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</table>

Day 3: ________________

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<th>Trial #</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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Day 4: ________________

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<tr>
<th>Trial #</th>
<th>Distance Reached (cm) Affected</th>
</tr>
</thead>
<tbody>
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<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX D

**TEGNER ACTIVITY LEVEL SCALE**

Please indicate in the spaces below the HIGHEST level of activity that you participated in BEFORE YOUR INJURY and the highest level you are able to participate in CURRENTLY.

**BEFORE INJURY:** Level __________  **CURRENT:** Level __________

<table>
<thead>
<tr>
<th>Level 10</th>
<th>Competitive sports—soccer, football, rugby (national elite)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 9</td>
<td>Competitive sports—soccer, football, rugby (lower division), ice hockey, wrestling, gymnastics, basketball</td>
</tr>
<tr>
<td>Level 8</td>
<td>Competitive sports—racquetball or handy, squash or badminton, track and field athletics (jumping, etc.), down-hill skiing</td>
</tr>
<tr>
<td>Level 7</td>
<td>Competitive sports—tennis, running, motorsports (speedway, handball)</td>
</tr>
<tr>
<td></td>
<td>Recreational sports—soccer, football, rugby, handy, ice hockey, basketball, squash, racquetball, running</td>
</tr>
<tr>
<td>Level 6</td>
<td>Recreational sports—tennis and badminton, handball, racquetball, down-hill skiing, jogging at least 5 times per week</td>
</tr>
<tr>
<td>Level 5</td>
<td>Work—heavy labor (construction, etc.)</td>
</tr>
<tr>
<td></td>
<td>Competitive sports—cycling, cross-country skiing,</td>
</tr>
<tr>
<td></td>
<td>Recreational sports—jogging on uneven ground at least twice weekly</td>
</tr>
<tr>
<td>Level 4</td>
<td>Work—moderately heavy labor (e.g. truck driving, etc.)</td>
</tr>
<tr>
<td>Level 3</td>
<td>Work—light labor (nursing, etc.)</td>
</tr>
<tr>
<td>Level 2</td>
<td>Work—light labor</td>
</tr>
<tr>
<td>Level 1</td>
<td>Work—sedentary (secretarial, etc.)</td>
</tr>
<tr>
<td>Level 0</td>
<td>Sick leave or disability pension because of knee problems</td>
</tr>
</tbody>
</table>


**SURGICAL HISTORY**

Have you had any additional surgeries to your knee other than those performed by Dr. Stone?

☐ Yes  /  ☐ No

If Yes:

What procedure(s) were performed?

When was the surgery performed?

Who performed the surgery?
APPENDIX E

APPENDIX

ANTERIOR KNEE PAIN (Sheet code: ________________________)

Name: ____________________________ Date: ________________________

Age: ____________________________

Knee: L/R

Duration of symptoms: _______ years _______ months

For each question, circle the latest choice (letter), which corresponds to your knee symptoms.

1. Limp
   (a) None (0)
   (b) Slight or periodical (3)
   (c) Constant (5)

2. Support
   (a) Full support without pain (5)
   (b) Painful (3)
   (c) Weight bearing impossible (0)

3. Walking
   (a) Unlimited (5)
   (b) More than 2 km (3)
   (c) 1-2 km (2)
   (d) Unable (0)

4. Stairs
   (a) No difficulty (10)
   (b) Slight pain when descending (8)
   (c) Pain both when descending and ascending (5)
   (d) Unable (0)

5. Squatting
   (a) No difficulty (5)
   (b) Repeated squatting painful (4)
   (c) Painful each time (3)
   (d) Possible with partial weight bearing (2)
   (e) Unable (0)

6. Running
   (a) No difficulty (10)
   (b) Pain after more than 2 km (8)
   (c) Slight pain from start (6)
   (d) Severe pain (3)
   (e) Unable (0)

7. Jumping
   (a) No difficulty (10)
   (b) Slight difficulty (7)
   (c) Constant pain (2)
   (d) Unable (0)

8. Prolonged sitting with the knees flexed
   (a) No difficulty (10)
   (b) Pain after exercise (8)
   (c) Constant pain (6)
   (d) Pain forces to extend knees temporarily (4)
   (e) Unable (0)

9. Pain
   (a) None (10)
   (b) Slight and occasional (8)
   (c) Interferes with sleep (6)
   (d) Occasionally severe (3)
   (e) Constant and severe (0)

10. Swelling
    (a) None (10)
    (b) After severe exertion (8)
    (c) After daily activities (6)
    (d) Every evening (4)
    (e) Constant (0)

11. Abnormal painful kneecap (patellar) movements (subluxations)
    (a) None (10)
    (b) Occasionally in sports activities (6)
    (c) Occasionally in daily activities (4)
    (d) At least one documented dislocation (2)
    (e) More than two dislocations (0)

12. Atrophy of thigh
    (a) None (5)
    (b) Slight (3)
    (c) Severe (0)

13. Flexion deficiency
    (a) None (5)
    (b) Slight (3)
    (c) Severe (0)

APPENDIX F

Visual Analog Scale

Participant

Procedure

---

* If used as a graphic rating scale, a 10 cm baseline is recommended.
* A 10 cm baseline is recommended for VAS scales.
APPENDIX G

Research Volunteers Needed

Are you interested in learning more about patellofemoral joint (kneecap) dysfunction?
If so, you may be interested in participating in our research study at Penn State.

Benefits: Measurement of knee muscle strength and endurance, knee muscle activity patterns during physical activity with and without application of different therapeutic taping techniques

Purpose of research study: Examine the effects of a patellofemoral (kneecap) joint taping technique on observed and self-reported knee performance

Four (4) one (1) hour visits to the Athletic Training Research Laboratory in 21E Recreation Building over two (2) weeks

Eligibility Criteria:
- Boys, girls, men and women ages 16 – 35 years old
- Good general health
- Not overweight
- Physically-active

John Vairo, Dr S John Miller, Dr Philip Bosha, Dr Roberta Millard and Dr Doug Aukerman
Departments of Kinesiology, Orthopaedics and Rehabilitation

If you are under the age of 18 years old, your parent or legal guardian must also agree to your participation in this research study.

For more information, contact John Vairo at glv103@psu.edu or 814-865-2725
Informed Consent Form for Biomedical Research
The Pennsylvania State University
PATELLOFEMORAL JOINT DYSFUNCTION PATIENTS

Title of Project: Effects of a Patellofemoral Taping Technique on Knee Neuromuscular Performance

Principal Investigator: Giampietro L Vairo, MS, ATC
Instructor of Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
glv103@psu.edu
814-865-2725

Advisor: S John Miller, PhD, PT, ATC
Assistant Professor of Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
sjm221@psu.edu
814-865-67822

Other Investigator(s): Philip J Bosha, MD, Roberta L Millard, MD and Douglas F Aukerman, MD
Assistant Professors of Orthopaedics and Rehabilitation / Staff Physicians
Penn State | Hershey Orthopaedics – State College
1850 East Park Ave, Suite 112
State College PA 16803
pjb35@psu.edu, rlm8@psu.edu, dfa3@psu.edu
814-865-3566

Research Assistant(s): Zachary T Boss and Javier Osorio
Schreyer Honors College Undergraduate Student
Department of Kinesiology
146 Recreation Building
University Park PA 16802
klp5137@psu.edu and jao5086@psu.edu
814-865-4303

1. Purpose of the study: The purpose of this research is to study the effects of different taping techniques on knee performance in people diagnosed with patellofemoral (kneecap) joint dysfunction. Patellofemoral (kneecap) joint
dysfunction is the most common knee complaint in physically active people that is treated by sports medicine specialists. The results of this research study will help us better understand what happens to the muscles and level of pain during physical activity after taping the kneecap in those people diagnosed with patellofemoral joint dysfunction.

2. **Procedures to be followed:** If you chose to participate in this research study, you will be asked to perform the following tests during four (4) identical sessions. The first session will be testing you without tape application. The second session three (3) days later will test with a tape application. The third session three (3) days later will test you with a different tape application. The fourth session three (3) days later will test you with the another different tape application.

**Testing Procedures**

A. We will begin the study by measuring your height and weight. We will then ask you to lie on your back upon an examination table so we can measure your right and left leg lengths. To record the length of your legs we will measure the distance between your hip and ankle bones using a standard tape measure. Measuring leg lengths will allow us to better compare all the participants results performing the single-leg balance tasks.

B. At the start of the first session you will be asked to complete a short survey of thirteen questions that ask you about your knee diagnosed with patellofemoral (kneecap) joint dysfunction. This survey will help us understand how you would personally describe your knee if asked to perform simple tasks such as sitting with your knee bent for a long time or more athletic things like running. The results of this survey will help us predict how you will perform on the tests in this research study. You will not need to repeat this survey during the second session.

C. We will ask to place ten (10) self-adhesive surface electrodes on each leg over the skin covering your hamstrings, quadriceps and calves muscles. In order for surface electrodes to stick on your skin a one-inch square area will have to be shaven, lightly rubbed by an emery board and cleaned with rubbing alcohol. Surface electrodes are connected to a system that sends signals to a computer measuring the amount and timing of muscle activity. The muscle activity of your legs will be measured as you perform a single-leg balancing task called the Star Excursion Balance Test. For the Star Excursion Balance Test you stand in place on one leg in the middle of the star and reach as far as possible with your other leg in eight different directions: front, same-side diagonal front, same-side, same-side diagonal back, back, opposite-side diagonal back, opposite-side, opposite-side diagonal front. A picture of the Star Excursion Balance Test is below.
You will be given four (4) practice trials and complete three (3) testing trials. You will be given a five (5) minute rest period between the practice and test trials. After you finish performing the Star Excursion Balance Test on each leg we will ask you to rate the level of knee pain you felt doing this task. To rate the amount of knee pain you felt performing the Star Excursion Balance Test we will ask you to mark an ‘X’ on a line drawn on a piece of paper. The further left you mark the ‘X’ means you felt less pain. The further right you mark the ‘X’ means you felt more pain. You will be asked to perform the Star Excursion Balance Test on each leg separately. You will be asked to flip a coin to decide which leg is tested first.

D. Finally we will measure the strength and endurance of your leg muscles (hamstrings, quadriceps and calves) with an exercise machine. The exercise machine is an instrument that records muscle strength and endurance by you exerting force against a set resistance that does not change. During this part of testing you will be seated and secured in the exercise machine while exerting force by bending and straightening your knee against two different resistances. While seated and secured in the exercise machine you will repeat this type of testing to record force in pointing and raising your ankles against two different resistances. Before high resistance testing you will be given two (2) practice trials of three (3) less than maximal effort repetitions separated by a one (1) minute rest period. We will then ask you to perform three (3) maximum effort repetitions against a high resistance to measure strength. After high resistance testing you will be given a two (2) minute rest before testing your endurance. After you finish strength testing on each leg we will ask you to rate the level of knee pain you felt doing this. To rate the amount of knee pain you felt performing strength testing we will ask you to mark an ‘X’ on a line drawn on a piece of paper. The further left you mark the ‘X’ means you felt less pain. The further right you mark the ‘X’ means you felt more pain. Before low resistance testing you will be given one (1) practice trial of five (5) less than maximal effort repetitions. We will then ask you to perform as many maximal effort repetitions as you can against a low
resistance for 45 seconds to measure endurance. After you finish endurance testing on each leg we will ask you to rate the level of knee pain you felt doing this. To rate the amount of knee pain you felt performing endurance testing we will ask you to mark an ‘X’ on a line drawn on a piece of paper. The further left you mark the ‘X’ means you felt less pain. The further right you mark the ‘X’ means you felt more pain. You will be asked to perform these strength and endurance tests separately with both legs. You will be asked to flip a coin to decide which leg is tested first.

E. After you’re done with testing procedures A through D you have finished your first session. You will then be asked to come back to the Athletic Training Research Laboratory every three (3) days until you have completed your fourth session. For your second, third, and fourth sessions you will only repeat testing procedures C and D. After completing the fourth session your participation in the research study is done.

3. Discomforts and risks: The discomforts and risks with participation in this type of research study are minimal. The tests used and the levels of exertion are well within expected ranges for physically-active people. To lessen the chance for injury, you will always be shown how to properly perform every task in the experiment. Also, only experienced researchers will always record your tests. Possible discomforts may be mild skin irritation from applying self-adhesive surface electrodes to your legs or mild bruising from the exercise machine stabilizing straps. Additional discomforts may be muscle soreness for two to three days after testing, which is common with many types of physical activity. Participating in this research study may aggravate symptoms you usually experience in your patellofemoral (kneecap) joint dysfunction leg. As with any experiment it is possible that harmful effects that are unknown may happen. However, the injury rate in this type of research study is minimal and happens in less than 1% of people and may include muscle strains, ligament sprains or bone breaks. We will take every possible precaution to watch for and help prevent against any discomforts and risks.

4. Benefits: There is no direct benefit to you from participating in this research study. The benefits to society include recognizing potential advantages from tape application in patients suffering from patellofemoral (kneecap) joint dysfunction, which is the most common knee complaint of athletic people treated by sports medicine specialists.

5. Duration/time of the procedures and study: The four (4) sessions are at least three (3) days apart and last about one hour each. All testing will be held in the Athletic Training Research Laboratory of Penn State’s Department of Kinesiology in 21 Recreation Building on University Park Campus.

6. Alternative procedures that could be utilized: There are no known
alternative procedures used to answer the research questions of this study.

7. **Statement of confidentiality:** Your participation in this research study is confidential. The Pennsylvania State University’s Office for Research Protections and Institutional Review Board, and the Office for Human Research Protections in the Department of Health and Human Services may review records related to this project. All records associated with your participation in the study will be subject to the usual confidentiality standards applicable to medical records (e.g., such as records maintained by physicians, hospitals, etc.). In the event of any publication resulting from the research, no personally identifiable information will be disclosed. Penn State policy requires that research records be kept for a minimum period of three years at the end of the study. All records will be secured in locked file cabinets within the Athletic Training Research Laboratory and access will be restricted to investigators listed on the first page of this document. A unique case number will indicate your identity on research records. Three years following the end of this research study all records will be appropriately destroyed.

8. **Right to ask questions:** Please contact Giampietro L Vairo at 814-865-2725 or 412-225-5276 with questions, complaints or concerns about the research. You can also call this number if you feel this study has harmed you. If you have any questions, concerns, problems about your rights as a research participant or would like to offer input, please contact The Pennsylvania State University’s Office for Research Protections (ORP) at (814) 865-1775. The ORP cannot answer questions about research procedures. Questions about research procedures can be answered by the research team. Referral information for those who wish to seek additional assistance includes the following:

Philip J Bosha or Roberta L Millard or Douglas F Aukerman
Penn State | Hershey Orthopaedics - State College
1850 East Park Ave, Suite 112
State College PA 16803
814-865-3566

Penn State University Health Services
Student Health Center
University Park PA 16802
814-863-0774

9. **Voluntary participation:** Your decision to be in this research is voluntary. You can stop at any time. You do not have to answer any questions you do not want to answer. Refusal to take part in or withdrawing from this study will involve no penalty or loss of benefits you would receive otherwise. You may be removed from this research study by investigators in the event of your inability to complete testing procedures. Parental consent is required for any individual under
the age of 18 participating in the study.

10. Injury Clause: In the unlikely event you become injured as a result of your participation in this study, medical care is available. It is the policy of this institution to provide neither financial compensation nor free medical treatment for research-related injury. By signing this document, you are not waiving any rights that you have against The Pennsylvania State University for injury resulting from negligence of the University or its investigators.

11. Abnormal Test Results: In the event that abnormal test results are obtained, you will be made aware of the results in three days and recommended to contact your private medical provider for follow-up.

You must be 18 years of age or older to take part in this research study. If you are under the age of 18 years old, your parent or legal guardian must also agree to your participation in this research study. If you agree to take part in this research study and the information outlined above, please sign your name and indicate the date below.

You will be given a copy of this signed and dated consent form for your records.

______________________________________________
Participant Signature Date

______________________________________________
Person Obtaining Consent Date

**********IN THE EVENT OF A MINOR, THE SECTION BELOW MUST BE COMPLETED**********

Verification of Explanation: I certify to have carefully explained the purpose and nature of this research study to ______________________________ in age appropriate language. He or she has had the opportunity to discuss the research study in detail. I have answered all questions and provide affirmative agreement (i.e. assent) to participate in this research study.
Parental/Guardian Certification: I understand the information supplied to me concerning the nature of this research study and have had the opportunity to ask questions. Therefore, I agree to the participation of my child in this research study.

Parent/Guardian Name (Print)

Parent/Guardian Signature Date
APPENDIX I

Participant ID _____________________ Date____________

Based on your preference rank the following therapeutic taping methods from most effective (1) to least effective (3).

McConnell Tape ____________________

Knee Spider™ _____________________

Hip Spider™ and Knee Spider™ ____________
APPENDIX K

Baseline Measures of Pain using the VAS
Normal - 95% CI

VAS_Base_I

VAS_Base_U

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VAS_Base_I</td>
<td></td>
<td>Mean</td>
<td>1.954</td>
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<tr>
<td></td>
<td></td>
<td>StdDev</td>
<td>0.9125</td>
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<tr>
<td></td>
<td></td>
<td>N</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AD</td>
<td>0.270</td>
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<td></td>
<td></td>
<td>P-Value</td>
<td>0.614</td>
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<tr>
<td>VAS_Base_U</td>
<td></td>
<td>Mean</td>
<td>0.06923</td>
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<tr>
<td></td>
<td></td>
<td>StdDev</td>
<td>0.1251</td>
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<td>N</td>
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<tr>
<td></td>
<td></td>
<td>AD</td>
<td>2.136</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P-Value</td>
<td>&lt;0.005</td>
</tr>
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Baseline Measures of SEMG During the SEBT

Normal - 95% CI

<table>
<thead>
<tr>
<th>SEMG_Base_I</th>
<th>SEMG_Base_U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 22.29</td>
<td>Mean 26.53</td>
</tr>
<tr>
<td>StDev 9.461</td>
<td>StDev 11.30</td>
</tr>
<tr>
<td>N 13</td>
<td>N 13</td>
</tr>
<tr>
<td>AD 0.329</td>
<td>AD 0.214</td>
</tr>
<tr>
<td>P-Value 0.467</td>
<td>P-Value 0.809</td>
</tr>
</tbody>
</table>
Before applying the brace tear all of the perforations

1. Before applying the brace tear all of the perforations. With the knee in a bent position, approximately 90 degrees, peel off half of section 1 and apply to the knee just below the knee cap. Once half of section 1 is applied, tear off the remaining backing of section 1 and apply. Gently rub over top of the tape to activate the glue.

2. As you peel the backing of the inside arm of section 2, apply the tape with a mild amount of stretch around the inside border of the knee cap, crossing the thigh above the knee cap and ending up on the outside border of the thigh.
3. As you peel back the backing on the outside arm of section 2, apply the tape with a mild amount of stretch around the outside border of the knee cap, crossing the thigh above the knee cap and ending up on the inside border of the thigh.

4. With the knee straight and the leg adducted, peel off the backing of the inside arm of section 3 and apply along the inside border of the thigh, with no tension on the tape, ending at the lateral border of the brace.

5. With the knee straight and the leg adducted, peel the backing off the outside arm of section 3 and apply along the lateral border of the thigh, with no tension on the tape, ending at the outside border of the brace.

Once the brace is applied, gently rub over top of the tape to activate the glue.

For complete instructions visit www.nucapmedical.com

Patents and design patents pending - FOR PROFESSIONAL USE ONLY

The original Kinesiology Tape from Japan

[Brand Logos]
APPENDIX N

**ENGINERED for MOVEMENT**

**spider tech**

Pre-cut application instructions

**HIP spider**

Before applying the brace tear all of the perforations

1. With the client lying on their side, remove the backing of the tape in section 1 and stretch the tape in either direction approximately 1 inch longer than resting length and apply over the bony prominence on the side of the hip. Gently rub over top of the tape to activate the glue.

2. With the client still lying on their side, bring their knee towards their chest and let the leg relax in front of the body. Start peeling off the backing of the lower arm of section 2 as you let the tape adhere to the skin in the direction of the centre of the back without any stretch in the tape.

3. In the same position, remove the backing of the upper arm of section 2 as you let the tape adhere to the skin towards the centre of the back without any stretch in the tape.
4. With the client's leg stretched behind the body and lying in back of the bottom leg, start peeling off the backing of section 3 and apply the tape with no stretch along the side of the leg until the remainder of the tape is applied.

5. Once applied, gently rub over the tape to activate the glue.

For complete instructions visit www.nucapmedical.com

Patents and design patents pending - FOR PROFESSIONAL USE ONLY

The original Kinesiology Tape from Japan

NITTO DENKO
ACADEMIC VITA of Zachary T. Boss

Zachary T. Boss
10 Shady Dr. West
Pittsburgh, PA 15228
ztb5013@psu.edu

Education:
Bachelor of Science Degree in Movement Science, Penn State University,
Spring 2012
Honors in Kinesiology
Thesis Title: Effects of Different Patellofemoral Joint Taping Techniques
on Perceived Pain and Knee Neuromuscular Performance in
Patellofemoral Joint Dysfunction Patients
Thesis Supervisor: Dr. S. John Miller

Related Experience:
Internship with Keystone Physical Therapy
Supervisor: Dr. Joseph Brence
Summer 2009 and 2010

Awards:
Werden Family Memorial Scholarship recipient
National Scholars Honor Society Member
National Society of Collegiate Scholars Member

Activities:
Penn State Kinesiology Club Member
Best Buddies Penn State Member