THE PENNSYLVANIA STATE UNIVERSITY
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DEPARTMENT OF KINESIOLOGY

THE EFFECTS OF A THERAPEUTIC PATELLOFEMORAL TAPING TECHNIQUE ON OPEN KINETIC CHAIN KNEE MUSCULAR PERFORMANCE AND PERCEIVED PAIN

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Abstract

The Effects of a Therapeutic Patellofemoral Taping Technique on Open Kinetic Chain Knee Muscular Performance and Perceived Pain

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Context: Patellofemoral taping techniques are utilized in clinical orthopaedics for patellofemoral pain syndrome (PFPS) patients. However, limited evidence demonstrates efficacy of this treatment on musculature performance. Objective: To investigate the effects of patellofemoral taping on muscular performance and perceived pain performing an open kinetic chain exercise. It was hypothesized taping would increase strength and endurance as well as decrease pain.

Design: Pretest-posttest control group true experimental design. Setting: Controlled laboratory environment. Patients or Other Participants: Twenty (12 men, 8 women) patients diagnosed with acute unilateral PFPS by a sports medicine physician (age = 21.9 ± 4.0 years, height = 171.5 ± 10.1 cm, mass = 67.4 ± 8.7 kg, BMI 22.9 ± 1.5, Kujala score 80.3 ± 9.3) and twenty (12 men, 8 women) healthy matched controls (age = 21.5 ± 2.7 years, height = 171.4 ± 10.7 cm, mass = 69.0 ± 11.7 kg, BMI 23.3 ± 1.7). Participants with prior traumatic lower extremity injury were excluded. Interventions: The independent variable was a patellofemoral taping technique. Participants performed knee extension and flexion via isokinetic dynamometry. Strength and endurance were assessed at 60 °/s and 240 °/s respectively. Pain was measured using a visual analogue scale. Separate dependent and independent t-tests were calculated to determine within patient and between participant differences. Analyses were made amongst: involved to uninvolved patient knee; pre-tape involved to post-tape involved patient knee; patient post-tape involved to healthy matched control knee.

Main Outcome Measures: Pre and post-tape measures were recorded for patients. A 48-hour rest period separated pre and post-tape testing. Randomization was applied to prevent an order effect. Controls performed one testing session. Dependent variables included extensor strength (peak moment, time to peak moment, angle of peak moment, peak moment at 0.2 s) and endurance (work) normalized to body weight (%BW).

Results: Patients demonstrated significant deficits in the involved (201.4 ± 71.1 %BW) compared to uninvolved (217.4 ± 71.8 %BW) knee for peak moment (P=0.039). Total work increased post-tape (113.9 ± 33.9 %) compared to pre-tape (100.7 ± 28.6 %) for the involved knee (P=0.008). Patients demonstrated reduced pain post-tape (0.8 ± 1.0 cm) compared to pre-tape (2.0 ± 1.7 cm) for the involved knee (P=0.0002). No differences in time to peak moment were noted among all conditions. Conclusions: Our findings confirmed patients exhibited an extensor strength deficit in the involved compared to the uninvolved knee. Tape did not affect peak moment, time to peak moment, peak moment at 0.2 s or angle of peak moment. However, post-tape increased endurance as well as decreased pain compared to pre-tape for the involved knee. Further research is warranted to investigate taping effects on muscular performance for acute PFPS patients. Word Count: 442
Acknowledgements

This thesis would not have been possible without the support of many people. I would like to express my gratitude towards my supervisor, Dr. Nicole McBrier who was abundantly helpful and offered invaluable assistance, support and guidance. Deepest gratitude is also due to John Vairo, without whose countless hours of help in the lab, knowledge and assistance this study would not have been successful. A special thanks is needed for all of the undergraduates who helped in the completion of this research, particularly my research-partner Jeremy Baumgarten. Finally, I would like to express much love and gratitude to my entire family especially my parents. Their ongoing support and encouragement inspired me to become the person I am today.
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CHAPTER 1: INTRODUCTION

Patellofemoral Pain Syndrome (PFPS) is the most prevalent cause of knee pain diagnosed by sports medicine physicians.\textsuperscript{1,2} Characterized by pain and discomfort on the anterior portion of the knee, primarily along the medial border of the patella, PFPS is estimated to affect one fourth of the entire population.\textsuperscript{3,4} Pain is exacerbated by activities that put a large force on the joint such as squatting, running or ascending/descending stairs.\textsuperscript{4,5} The exact cause of PFPS is unknown but it has been linked to an abnormal lateral tracking of the patella. Several factors contribute to lateral tracking including a tight illiotibial band, weak quadriceps musculature, especially the vastus medialis oblique (VMO), a large Q-angle, patellar tilting and even neurological dysfunction.\textsuperscript{6-8}

Traditional treatments for PFPS have included patellar taping, stretching, various strengthening exercises, activity modification, bracing, ultrasound and foot orthoses.\textsuperscript{1} One proposed intervention for patients suffering from PFPS is the McConnell taping technique. The goal of the McConnell technique is to correct abnormal lateral tracking of the patella and align it medially within the trochlear groove in order to diminish pain for patients while they perform therapeutic exercises.\textsuperscript{3} Several studies have reported potential benefits of this intervention for perceived pain reduction,\textsuperscript{8-18} but the mechanism for this phenomenon is still undetermined.

Peak quadriceps force output is one parameter that has been closely linked to PFPS.\textsuperscript{8,19-22} Several studies have shown that patients suffering from PFPS tend to have weaker quadriceps musculature than those people who are healthy; however, efficacy of a McConnell technique on strength has provided some contradictory results.\textsuperscript{8,20-22} Herrington et al\textsuperscript{8} investigated the effects of taping on quadriceps strength and perceived pain of 14 participants with PFPS. These authors found that all participants showed a significant increase in strength and decrease in pain after the
tape was applied. Although Herrington et al observed a positive correlation between the taping intervention and isokinetic strength, this study did not address the possibility that sensory input from the tape may affect pain and torque measures. Handfield addressed this issue in a study by using a protocol similar to Herrington et al; however with the application of Hypafix tape to the knee during the no-tape testing condition. Hypafix tape was used because it stimulates sensory input without affecting the anatomical position of the patella. The results were comparable to the Herrington et al study in that pain was significantly decreased and torque generated was significantly increased after the application of tape. Keet et al were the first to use placebo taping while looking at isokinetic force production. Fifteen physically active PFPS patients and 20 physically active healthy control participants underwent 3 testing conditions: no-tape, placebo tape and McConnell taping. The results contradicted those of previous studies, as they found no decrease in pain or increase in force production under any of the three conditions.

This study aims to augment previous research by adding internal and external controls. Internal control will be provided by the contralateral healthy knee while external control will come from a cohort of healthy subjects. In addition to strength parameters, this study will be original in examining quadriceps endurance measures of the knee musculature. Information on low-resistance isokinetic performance may prove useful in helping clinicians design more effective therapies for PFPS patients. It is hypothesized that knee muscle strength and endurance will be significantly greater in the unaffected and matched control leg compared to the affected leg prior to the taping intervention. After the tape is applied it is hypothesized that there will be a significant increase in muscle strength and endurance for the affected leg compared to the unaffected leg and that the affected leg measures will be equivalent to those of the matched controls. Results from this study will help investigate the efficacy of the McConnell taping technique as well as provide information that can be clinically applicable for treating symptoms of PFPS.
CHAPTER 2: METHODS

Participants

The 40 participants (Table 1) in this study consisted of 20 patients (21.9 ± 4.0 years, 171.5 ± 10.1 cm, 67.4 ± 8.7 kg, BMI 22.9 ± 1.5, Kujala score 80.3 ± 9) with PFPS and 20 healthy matched control subjects (21.5 ± 2.7 years, 171.4 ± 10.7 cm, 69.0 ± 11.7 kg, BMI 23.3 ± 1.7). All participants volunteered and were recruited to the study via informational flyers and verbal scripts. Prior to the start of the study all participants read and signed an informed consent form approved by The Pennsylvania State University Office for Research Protections and Institutional Review Board. The following is a list of criteria for inclusion of participants:

- Recreationally active (defined as individuals engaging in physical activity with a minimum frequency of three days per week, 30 minutes in duration over a six-month period)
- Boys and girls (16-17 years of age) as well as men and women (18-35 years of age)
- Diagnosed with unilateral patellofemoral pain syndrome by a physician within the last 6 months of participation in the study
- Patellofemoral participants have not followed a formal rehabilitation protocol under a physical therapist or athletic trainer
- Control participants matched by sex, approximate age, body type, physical activity level and have no history of traumatic injury to either lower extremity

Criteria for exclusion of participants included:

- Associated musculotendinous, capsuloligamentous or meniscal pathology to the involved knee
- History of traumatic injury to the hip or ankle of involved extremity or contralateral lower extremity
- History of systemic or metabolic dysfunction impairing sensorimotor capabilities
- Cerebral concussion sustained within the preceding six months
- Non-English speaking

Instrumentation

All tests and data collection were performed in the Penn State Athletic Training Research Laboratory. A Biodex System 2 Dynamometer (Biodex Medical Inc., Shirley, NY) equipped
with Biodex Advantage Software v4.6 (Biodex Medical Inc., Shirley, NY) was used to record all isokinetic data. The research of Feiring et al established that an isokinetic angular velocity of 60°/s provides an accurate assessment of peak quadriceps moment while 240°/s is reliable for determining endurance.

**Intervention**

The intervention in this study was a medial glide McConnell taping technique. A strip of Cover-roll tape was first applied directly onto the skin. Then a piece of Leukotape was applied on top of the Cover-roll starting from the lateral femoral condyle and ending at the posterior-medial aspect of the knee, anchoring the patella in a medialized position. The taping of patients was conducted by a clinical athletic trainer (GLV), who was trained and experienced in the use of McConnell techniques. Only the twenty participants diagnosed with acute PFPS were given the taping intervention. A picture of the medial glide technique can be found in APPENDIX A.

**Outcome Measures**

The outcome measures assessed in this study include perceived pain levels as well as isokinetic knee extensor strength and endurance. Perceived pain was quantified using a 10 cm Visual Analog Scale (VAS) (APPENDIX B). The variables used to quantify extensor and flexor strength were peak moment normalized to body weight (%BW), time to peak moment (ms), moment at 0.2 s and joint angle of peak moment. All strength variables were collected at an isokinetic angular velocity of 60°/sec. The endurance variable of normalized work output was collected at an angular velocity of 240°/sec. Participants diagnosed with acute PFPS were also given a thirteen question Kujala Questionnaire (APPENDIX B) in order to evaluate subjective symptoms and functional limitations of their patellofemoral disorders. The questionnaire is
scored from 0 to 100 and a patient’s score indicates their level of function as a percentage (i.e. a score of 70 means a patient is at 70% of their full functional capacity).

**Testing Protocol**

Upon arrival to the lab for the first session, patients were asked to complete the consent form, health screening questionnaire and Kujala survey (APPENDIX B). Patients then had their height and mass recorded in centimeters and kilograms, respectively (APPENDIX B). Participants then walked on a treadmill at a speed of 1.2 m/s for 5 minutes to warm-up. The order of testing affected or unaffected leg was randomized by having patients flip a coin; “heads” denoted the affected would be tested first while “tails” meant the unaffected would be first.

Knee musculature strength and endurance were tested using the Biodex System 2 Dynamometer (Biodex Medical Inc., Shirley, NY). Participants were seated on the Biodex in an upright position and secured using pelvic, shoulder, and thigh straps. In order to restrict upper body movements they were asked to cross their arms across their chest. The testing protocol for the strength measure was 3 50% max effort warm-up repetitions at 60 °/s, a 30 s break, and 3 75% maximal repetitions at 60 °/s. Participants were then given a one minute rest. The next 3 repetitions were done maximally at 60 °/s and the measurements were collected and recorded. All repetitions involved a full extension and flexion of the knee. After a 2 minute rest period, patients continued with the endurance protocol consisting of 5 warm-up repetitions and 5 50% sub-maximal repetitions at 240°/s Final measurements were recorded while the patient completed as many full repetitions as possible during a 45 s time interval at 240°/s. When the testing on the first leg was completed, the patients then repeated the same protocol on the contralateral leg. Upon completion of the isokinetic testing on their affected leg, patients were administered a VAS sheet and were told to assess their pain levels while performing the exercises. Patients were
then asked to return to the lab 72 hours later to repeat the strength and endurance testing with the McConnell taping technique on only the affected leg. The testing protocols for the match control participants were exactly the same as those for the PFPS patients with only a few minor differences. Control participants only reported for a single testing session because they were only tested on the matched affected leg to their PFPS patient. They did not receive the taping intervention nor did they fill out a VAS sheet.

**Data Analysis**

All collected data was entered into a spreadsheet to calculate groups and condition means as well as standard deviations. Normality plots were produced to assess distribution of data set means. Analysis of the means determined the data to represent a normal distribution, which permits utilization of $t$-tests. Separate paired $t$-tests and two-sample $t$-tests were calculated to determine within (unaffected/affected, no-tape/tape) and between participant (PFPS patients/matched controls) differences respectively. A probability level of $P \leq 0.05$ was accepted to denote statistical significance.
CHAPTER 3: RESULTS

Subject Demographics

<table>
<thead>
<tr>
<th>Table 1. Participant Demographics</th>
<th>PFPS Group</th>
<th>Control Group</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>20</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>12/8</td>
<td>12/8</td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>21.9 ± 4.0</td>
<td>21.5 ± 2.7</td>
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</tr>
<tr>
<td>Height (cm)</td>
<td>171.5 ± 10.1</td>
<td>171.4 ± 10.7</td>
<td>0.731</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>67.4 ± 8.7</td>
<td>69.0 ± 11.7</td>
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</tr>
<tr>
<td>BMI</td>
<td>22.9 ± 1.5</td>
<td>23.3 ± 1.7</td>
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</tr>
<tr>
<td>Kujala Score</td>
<td>80.3 ± 9.3</td>
<td>N/A</td>
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</table>

Values are mean ± standard deviation

Perceived Pain

Patients demonstrated reduced pain post-tape (0.8 ± 1.0 cm) compared to pre-tape (2.0 ± 1.7 cm) for the involved knee (P < 0.001).

Figure 1.

Perceived Pain of PFPS Group

* P ≤ 0.05 denotes statistical significance
Isokinetic Strength Measures

Knee extensor peak moment, time to peak moment, angle of peak moment and moment at 0.2 s did not significantly differ bilaterally, after the taping intervention or between patients and control groups (Table 2). It should be noted that the bilateral difference in normalized peak moment approached significance ($P=0.070$) in PFPS patients. The only significant strength measure for knee flexion was a decrease in time to peak moment comparing post-tape (785.0 ± 405.5 ms) to pre-tape conditions (886.7 ± 378.9 ms) ($P=0.052$) in PFPS patients. This meant that patients exhibited a greater rate of flexion force production with their affected leg after tape application.

Isokinetic Endurance Measure

Patellofemoral Pain Syndrome participants demonstrated a bilateral extensor deficit in work produced. In the pre-tape condition the unaffected leg (348.4 ± 93.2 %) generated a significantly greater amount of work than the affected leg (322.3 ± 109.5 %) ($P=0.050$). The affected leg (322.3 ± 109.5 %) also produced significantly less work compared to the matched control leg compared (402.1 ± 107.7 %) ($P=0.017$) Furthermore, the PFPS group demonstrated a significant increase in work production post-tape (374.4 ± 87.6 %) compared to pre-tape (322.3 ± 109.5 %) ($P=0.002$).

The flexor data reveals a significant greater work output for the matched control group (233.1 ± 67.1 %) compared to the affected leg in both pre-tape (179.3 ± 69.8 %) ($P=0.012$) and post tape conditions (191.2 ± 37.9 %) ($P=0.029$). The McConnell technique was not found to have a significant affect on the patients’ ability to increase flexor muscle work output.
Table 2. Knee Extensor Strength and Endurance Measurements

<table>
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<tr>
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<th>Uninvolved</th>
<th>Involved Pre-Tape</th>
<th>P Value</th>
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<tbody>
<tr>
<td><strong>Strength Measures</strong></td>
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<tr>
<td>Peak Moment (%BW)</td>
<td>21.3 ± 6.6</td>
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<tr>
<td>Time to Peak Moment (ms)</td>
<td>505.8 ± 175.9</td>
<td>462.1 ± 138.2</td>
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<td>Angle of Peak Moment (°)</td>
<td>68.1 ± 10.7</td>
<td>66.3 ± 8.7</td>
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<td>Moment @ .2 sec (Nm)</td>
<td>99.0 ± 51.1</td>
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<td><strong>Endurance Measures</strong></td>
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<tr>
<td>Total Work (%BW)</td>
<td>348.4 ± 93.2</td>
<td>322.3 ± 109.5</td>
<td>0.05*</td>
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<tr>
<td>Peak Moment (%BW)</td>
<td>19.9 ± 7.0</td>
<td>22.2 ± 5.7</td>
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<tr>
<td>Time to Peak Moment (ms)</td>
<td>462.1 ± 138.2</td>
<td>530.0 ± 215.8</td>
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<td>Angle of Peak Moment (°)</td>
<td>66.3 ± 8.7</td>
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<td>Moment @ .2 sec (Nm)</td>
<td>94.8 ± 41.9</td>
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<td><strong>Endurance Measures</strong></td>
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<tr>
<td>Total Work (%BW)</td>
<td>322.3 ± 109.5</td>
<td>402.1 ± 107.7</td>
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<tr>
<td>Peak Moment (%BW)</td>
<td>19.9 ± 7.0</td>
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<td>Time to Peak Moment (ms)</td>
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<td>Angle of Peak Moment (°)</td>
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<td>Moment @ .2 sec (Nm)</td>
<td>94.8 ± 41.9</td>
<td>105.6 ± 62.0</td>
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<td><strong>Endurance Measures</strong></td>
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<tr>
<td>Total Work (%BW)</td>
<td>322.3 ± 109.5</td>
<td>374.4 ± 87.6</td>
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<td>Peak Moment (%BW)</td>
<td>20.4 ± 6.9</td>
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<td>Time to Peak Moment (ms)</td>
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<td>Angle of Peak Moment (°)</td>
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<tr>
<td>Total Work (%BW)</td>
<td>374.4 ± 87.6</td>
<td>402.1 ± 107.7</td>
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* P ≤ 0.05 denotes statistical significance

Values are mean ± standard deviation
Table 3. Knee Flexor Strength and Endurance Measurements

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<td><strong>Strength Measures</strong></td>
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<tr>
<td>Peak Moment (%BW)</td>
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<td>Time to Peak Moment (ms)</td>
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<td>886.7 ± 378.9</td>
<td>858.0 ± 106.0</td>
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<td>Angle of Peak Moment (°)</td>
<td>67.5 ± 18.5</td>
<td>66.3 ± 20.5</td>
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<td>Moment @ .2 sec (Nm)</td>
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<tr>
<td>Total Work (%BW)</td>
<td>183.0 ± 46.9</td>
<td>179.3 ± 69.8</td>
<td>191.2 ± 37.9</td>
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<td><strong>Strength Measures</strong></td>
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<tr>
<td>Peak Moment (%BW)</td>
<td>10.9 ± 3.7</td>
<td>11.4 ± 3.6</td>
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<tr>
<td>Time to Peak Moment (ms)</td>
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<td>Angle of Peak Moment (°)</td>
<td>66.3 ± 20.5</td>
<td>64.0 ± 22.4</td>
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<tr>
<td>Moment @ .2 sec (Nm)</td>
<td>37.3 ± 24.5</td>
<td>48.8 ± 33.2</td>
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<tr>
<td>Total Work (%BW)</td>
<td>179.3 ± 69.8</td>
<td>233.1 ± 67.1</td>
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* P ≤ 0.05 denotes statistical significance
Values are mean ± standard deviation
CHAPTER 4: DISCUSSION

Perceived Pain

The reduction in perceived pain level on a VAS after tape application is consistent with previous findings.\textsuperscript{8-10,12-18,21} It is possible that the reduction in pain contributed to the increase in isokinetic work produced, but no previous studies have examined the effectiveness of a McConnell technique on knee musculature endurance. However, significant pain reduction and performance increase in low-resistance activities such as stair stepping brought upon by a taping intervention have been demonstrated in previous studies.\textsuperscript{15-16} These studies, along with the results from our research, suggest that a McConnell technique may be an effective way to reduce pain during repetitive low force tasks.

It has been thought that pain reduction may be due to the placebo effect of patellar taping. Some studies\textsuperscript{12,16} have found that therapeutic taping was more effective than a placebo taping, however a study by Christou\textsuperscript{14} found that therapeutic taping was as effective as a placebo taping in reducing pain. Additional research is warranted to investigate the influence of a possible placebo effect on patellar taping. Another possible mechanism for the reduction in pain is that the lateral glide of the patella is corrected and pulled medially by the tape. However, several radiographic studies\textsuperscript{25-28} have demonstrated no significant anatomical differences after an application of a patellar taping, especially following a bout of exercise, signifying that there must be another reason for the reduction in pain. Previous research has suggested that the application of tape changes cutaneous afferent input. Changing the afferent input would cause neural inhibition therefore reducing perceived pain in the participant. We feel that this is the most plausible mechanism of pain reduction. If taping does not change the anatomical position of the
patella, it means that changes in neural pathways are the most likely cause of a decrease in perceived pain.

**Isokinetic Strength Measures**

Our results conflict with previous research that has shown there to be a significant decrease in peak quadriceps moment amongst unilateral PFPS patients when comparing the affected leg to the unaffected leg and the leg of a matched control.\(^{29-30}\) This could be due to the fact that our study was limited to only those patients with acute PFPS, whereas the previous studies\(^{29-30}\) were not. Patients suffering from acute PFPS are less likely to demonstrate significant decreases in strength output because the duration of their symptoms has been less than six months.

We found that application of tape had no effect on the patients’ ability to generate a greater moment at 60°/s. This is conflicting with other research\(^ {8,11,15,21}\) that has shown a McConnell taping technique to be effective in increasing isokinetic quadriceps strength. Discrepancies in the literature may be attributed to the fact that the other studies lacked randomization\(^ {8,11,15}\) or only included those patients who experienced a 50% reduction in pain after tape was applied.\(^ {8}\) Our study controlled for these limitations so we propose that the lack of increased peak quadriceps moment was due to the testing protocol. We know from previous studies\(^ {25-28}\) that a medial glide taping technique does not alter anatomical positioning of the patella after exercise. The strength testing protocol we used involved 3 isokinetic repetitions at high resistance that was most likely sufficient to negate any medial pull the tape initially established. This means that the biomechanics of the knee extensors were unaffected by tape application and therefore could not produce an increase in peak moment via patellar repositioning.
A unique aspect of this study was that following a taping intervention we found no increase in isokinetic strength measures yet the patients demonstrated a significant decrease in perceived pain. All the previous research we found involving patellar taping and knee extensor isokinetic strength exhibited a strong correlation between perceived pain and peak moment generation. Studies that found a decreased level of pain also demonstrated increased isokinetic strength\textsuperscript{8,11,15,21} while the study that found no change in pain did not find an increase in isokinetic strength\textsuperscript{22}. This discrepancy with previous research may due to the fact that only a single VAS was administered to the patients directly after the endurance isokinetic protocol. The VAS, therefore, may not be reliable in assessing the patient’s pain during the isokinetic strength testing as they were probably more influenced by the endurance portion of the testing.

**Isokinetic Endurance Measure**

This study represents an original investigation to look at the effect of patellar tape on isokinetic measures at 240°/s. Previous studies had used angular velocities of 60°/s, 120°/s or 180°/s and looked at peak moment as a measure of muscular strength. The outcome we recorded in this study was work output which is a measure of muscular endurance. The major difference between these variables is the testing protocol. The studies\textsuperscript{8,11,15,19-22} that measured peak moment had their participants complete no more than 5 repetitions at high isokinetic resistance during the data collection trial. For the endurance protocol our participants performed anywhere between 27 and 45 repetitions at low isokinetic resistance during a 45 s time interval. As hypothesized, work output increased significantly in PFPS patients with the application of tape. With the McConnell technique applied to their knees, the patients performed just as well in the endurance testing as their healthy matched controls. One proposed explanation for this increase in performance is that it is a result of the decrease in pain due to the taping. Stokes\textsuperscript{31} found there to be possible
quadriceps reflex inhibition with the presence of anterior knee pain. Therefore patients experiencing less pain have less quadriceps inhibition and would be expected to increase work output, especially when the protocol involved 45 s of continuous low resistance exercise. Another possible explanation for the increased performance is the fact that testing was done at a high angular velocity. The force-velocity relationship of muscle indicates that higher angular velocities result in lower loads placed on the joint. When smaller force is placed on the knee joint symptoms of PFPS are less severe and decrease perceived pain. As previously stated, a decrease in perceived pain decreases reflex quadriceps inhibition and performance would expectedly increase.

Our findings that patellar taping increased endurance performance may have clinical applications. Previous research has demonstrated that low-resistance activities such as stair-stepping are benefited by a taping technique. English et al established that lower extremity isokinetic work is correlated to a single-leg functional hop test, meaning that increases in endurance measures increase functional abilities. It seems that the populations who stand to benefit the most from a patellar taping treatment are those whose PFPS is associated with simple activities of daily living such as walking, stair ambulation, or squatting. High-resistance explosive tasks may not be affected by the tape as seen by the results of our strength testing.

Limitations

One limitation in this study was that PFPS patients only received a medial glide McConnell technique. As a representative group, this technique proved to be beneficial but there may have been some participants who did not receive the full benefit of patellar taping. The medial glide technique only addresses patients who suffer from lateral tracking of the patella. In a clinical setting, alterations of the technique can be performed in order to other issues such as
Another limitation to consider is that the patient group consisted strictly of participants with acute cases of PFPS. This limits any conclusions we make, especially those about our endurance results. Patients with chronic PFPS are more likely to be bothered by the low-resistance activities we propose can be alleviated by a patellar taping. The final limitation to this study involved our administration of the VAS. Using only a single VAS at the end of isokinetic testing may not be specific enough because the strength protocol was always first and the endurance protocol was always second. A better assessment of perceived pain would have resulted if we administered a VAS after the strength protocol and then another one after the endurance protocol.
CHAPTER 5: CONCLUSION

We are the first to investigate the effects of a McConnell technique on knee musculature endurance. Our results suggest that a McConnell technique increases quadriceps isokinetic work output and reduces pain in patients with PFPS; however, we did not find it to have an effect on strength outcomes. It is proposed that the results from our endurance data have clinical significance especially in those populations who suffer from symptoms of acute PFPS during low-resistance activities. Future research is warranted to examine the effects of a McConnell technique on endurance measures in patients with chronic PFPS.
REFERENCES


LITERATURE REVIEW

Introduction

The purpose of this literature review is to provide an evaluation of the current literature pertaining to the effects of a patellofemoral taping technique on muscular performance and perceived pain in patients suffering from Patellofemoral Pain Syndrome (PFPS). This review will include: a description of PFPS including prevalence, symptoms and etiology of the condition, as well as the McConnell Medial Glide Technique and its effects on perceived pain and muscular performance.

Patellofemoral Pain Syndrome

Patellofemoral Pain Syndrome, also known as Patellofemoral Joint Dysfunction, is the most common cause of anterior knee pain affecting mostly young active individuals and the elderly population.\textsuperscript{1,2} Several studies have estimated that PFPS is responsible for 25-40\% of knee problems presented in orthopaedic clinics\textsuperscript{33-35} and McConnell reports that one fourth of the entire population is affected.\textsuperscript{3} Fairbanks et al\textsuperscript{36} took a random sample of children aged 13-19 and found that 30\% of them had experienced anterior knee pain within the previous year. In terms of incidence among genders, it occurs more frequently in females than males 2 to 1, however when looking exclusively at athletes men see the largest incidence.\textsuperscript{4,5} The major symptom of patellofemoral pain syndrome is pain originating at the anterior portion of the patella especially along the medial border of the patella, though pain experienced retro-patellar and laterally is common as well.\textsuperscript{4} Activities that facilitate pain are usually high impact and cause elevated compressive forces on the knee joint such as running, ascending and descending stairs, and squatting.\textsuperscript{4,5} Unfortunately, this means that the quality of life for activities of daily living is often
diminished in PFPS patients as daily activities and exercises are unable to be performed pain free.

PFPS is thought to be caused by an abnormal lateral tracking of the patella within the trochlear groove. There are several hypotheses as to why this happens including a tight iliotibial band, weak quadriceps musculature, especially the vastus medialis oblique (VMO), a large Q-angle, patellar tilting and even neurological dysfunction. There is no known cure for PFPS but symptoms can often be managed through treatments such as stretching, strengthening, ultrasound and taping.  

The McConnell Medial Glide Technique

In 1986 a landmark study was conducted by Jenny McConnell about managing pain in patients with PFPS. She suggested that one way to address the lateral tracking of the patella was to apply a taping technique that would correct this lateral translation and hold the patella in the trochlear groove. McConnell’s rationale was that if she could reduce pain in flexion and extension, patients would be better able to strengthen their VMO and ultimately compensate for the weaknesses that caused the original lateral drift. The clinical trial consisted of 35 patients with PFPS, 20 of them female and 15 of them male. The average duration of symptoms in the patients was 4.9 years with a range of one month to 19 years. All patients received the same treatment which involved a medial glide patellar taping and a bout of exercises aimed at specifically strengthening the VMO. In order for the tape to be appropriately applied, McConnell had to assess three components of the patellar alignment; glide, tilt, and the rotation. Once completed, she could align the patella so that it was in an ideal tracking position for the exercises. Her results were significant in that 29 of the subjects reported no pain after only 8 treatments. Another 3 patients reported a decrease in pain and only one patient said that the
treatment did not relieve any pain. The McConnell technique is an effective way to reduce pain and several studies\textsuperscript{8-22, 25-29} have stemmed from this one in an attempt to find out exactly why and how it produces these results.

**The McConnell Taping Technique and Effects on Perceived Pain**

Numerous studies have followed up on the idea that the taping technique leads to a decrease in pain for patients with PFPS.\textsuperscript{8-18, 21} Clark et al\textsuperscript{9} conducted a randomized control trial (RCT) on 81 patients with PFPS and randomly assigned them into four groups of treatment. The first group had exercise, taping, and education, the second group had exercise and education, the third group had taping and education, and the fourth group only had education. At 3 and 12 months the subjects’ satisfaction was assessed as well as several other measures including the visual analog scale for pain (VAS), the Western Ontario and McMaster University (WOMAC) lower limb function scores, and the Hospital Anxiety and Depression Scale. The results showed with 99% confidence that the subjects in groups one and two (those that incorporated exercise) were more satisfied than the other groups at the 3 month period, although all four groups improved post-test VAS, WOMAC lower limb function scores, or the Hospital Anxiety and Depression Scale. It also showed that taping alone compared to the non-tape groups had no effect on satisfaction. The outcomes of this study highlight the success of a combined exercise and taping regimen. Though the medial glide taping technique proved to be ineffective in increasing satisfaction when used by itself, other variations do exist. In a clinical setting, alterations of the technique can be performed in order to improve patellar tilt, patellar rotation, or for fat pad unloading. Future research needs to be done in order to see how varying taping techniques affect pain and function.
Harrison et al\textsuperscript{10} examined the effect of professional guidance, biofeedback and taping on PFPS pain management. One hundred and thirteen PFPS patients were randomly allocated into three groups. The first group was assigned a home strengthening and flexibility exercise program. The second group participated in a similar exercise program but they completed it in a clinical setting while being monitored 3 times a week by a physical therapist over the course of one month. The third and final group had a physiotherapist-directed program including exercise similar to the other two groups, a McConnell technique patellar taping, and biofeedback 3 times a week for 1 month. At one, three, six and twelve month intervals, subjects were assessed based on a Functional Index Questionnaire, a visual analog scale (VAS) for pain, a patellofemoral scale, and a step test. Results showed that at the end of one month group three saw a significant difference from only group two in decreased pain and pain threshold during a step test. Harrison therefore could only conclude that biofeedback and the McConnell taping was beneficial strictly for short-term pain relief as opposed to long-term pain relief. In the long term, however, they thought that a home exercise program with regular follow-ups may be just as effective in the treatment of PFPS as more time and resource intensive interventions.

Ng\textsuperscript{13} examined the effects of patellar taping on pain and the EMG activity ratio of vastus medialis oblique (VMO) to vastus lateralis (VL) during exercise. Fifteen subjects diagnosed with PFPS performed single-legged semi-squats with 20\% of extra body weight loading exercises both with and without tape. After application of tape, subjects demonstrated a significant decrease in pain performing the semi-squats according to a VAS; however, they also found a decrease in the relative activity of VMO post-tape. Ng concluded that it may not be appropriate to supplement a VMO specific strength training program with a patellar taping.
Christou\textsuperscript{14} examined the effect of patellar tape on knee extensor force production in addition to perceived pain and muscle activity of VMO and VL. Thirty female participants, fifteen of which had been diagnosed with PFPS, performed maximal isokinetic leg presses at 30°/sec under no-tape, placebo, and medial and lateral-glade taping conditions. During the test perceived pain, force, and EMG of the VMO and VL, were recorded. It was found that the placebo and medial-glide conditions significantly reduced pain in the fifteen PFPS subjects (70-80%). Contradictory to Ng’s\textsuperscript{18} results, Christou found that VMO activity increased in response to the medial taping technique. Since the medial glide and placebo taping conditions had similar effects, it was proposed that the benefits of a McConnell technique are not due to a change in patellar position but rather due to pain modulation via cutaneous stimulation.

Salsich et al\textsuperscript{15} wanted to determine the effects of patellar taping on perceived pain, knee kinetics, kinematics, and VL activity during stair ambulation in individuals with PFPS. Ten subjects each diagnosed with PFPS were used, five male and five female. Each subject ascended and descended stairs under taped and un-taped conditions while lower extremity kinematics, ground reaction forces, and VL EMG were obtained. The results showed that on average the subjects had 93% less pain following the tape application during stair ambulation. Increases in knee flexion angles and knee extensor torques were noted under the taped condition for both stair ascent and descent; however, no difference in VL activity was found. It was suggested that this phenomenon may be caused by increased efficiency in extensor force generation due to recruitment of other muscles that cross the patellofemoral joint.

Cowan et al\textsuperscript{16} wanted to determine if patellar taping has an effect on the onset of VMO activation relative to VL. A group consisting of ten PFPS patients and a group of twelve healthy controls each performed a stair stepping task during one of three conditions: no tape, placebo
tape, and medial glide therapeutic tape. Timing of the onset of muscle activity was recorded via EMG as the participants completed the stair task. The results showed that VMO activity onset was earlier than that of VL in the PFPS group under taped conditions, whereas there was no difference in the untapped and placebo conditions. Also, perceived pain was significantly decreased under the taping condition in the PFPS group after the stair stepping task. Interestingly, the taped condition for the control group did not have an effect on VMO/VL timing. This data supports the claim that taping may be a useful addition to therapy in patients suffering from PFPS.

Aminaka and Gribble\textsuperscript{18} examined the effects of patellar taping on perceived pain, lower extremity kinematics and dynamic postural control during a Star Excursion Balance Test (SEBT). Twenty PFPS patients and twenty healthy matched controls were used as participants in the study. Each participant completed three reaches of the SEBT in the anterior direction. While performing the excursions, lower extremity kinematics were assessed using an electromagnetic tracking system. Reach distances were recorded by hand and normalized to the patients’ leg length. Consistent with previous research,\textsuperscript{12-17} Aminaka found the tape to significantly decrease pain in the PFPS participants. Furthermore, the results showed an increase in reach distance after application of tape and no significant change in joint kinematics. Aminaka therefore concluded that even though a McConnell technique reduced pain and improved SEBT reach distances, the exact mechanisms of these phenomena could not be explained by her study. Further research is needed on the effect of patellar taping on neuromuscular control during dynamic postural control.

In order to further investigate the efficacy of a McConnell taping technique, a study needed to be done involving placebo control. Whittingham et al\textsuperscript{12} were the first to do this in 2004
when they took twenty-four men and six women with PFPS and assigned them randomly and evenly to one of three groups. The first group performed a standardized exercise program with the application of a patellar taping, the second group performed that same exercise program but with a placebo taping technique and the last group exclusively did the exercise regimen. Each group completed the treatment in a supervised clinic once each day for 4 straight weeks. A VAS and Functional Index questionnaire were administered at the beginning of the study and then once weekly for the 4 subsequent weeks. They found a statistically significant difference between the group with the patellar taping and the other two groups in both the VAS and the Functional Index questionnaire. It was concluded that the 4 week program along with the taping was an effective way to reduce pain in PFPS patients.

Not all follow-up studies found the taping technique to be an effective way of reducing pain. Kowall et al\textsuperscript{11} set out to evaluate the efficacy of patellar taping in the conservative management of patellofemoral pain. Twenty-five PFPS patients were randomly sorted into one of two groups. Both groups underwent the same conservative therapeutic treatments; however one group performed these treatments with a patellar taping. The findings revealed that there was a significant decrease in pain within both groups and an increase in quadriceps isokinetic strength and EMG activity. When comparing the groups to each other there were no significant differences suggesting that it was the therapy instead of the taping that produced the results. This is contradictory to all of the previously mentioned studies but it may have to do with the small sampling size or that the exercise program was effective in strengthening the quadriceps which may have been the cause for reduced pain. A larger prospective study needs to be done on the specific physical therapy used in this study in order to further investigate Kowall’s claim that the McConnell technique is ineffective in reducing pain on its own.
Radiographic Studies Involving the McConnell Technique

The major rationale offered to explain the therapeutic effects of the McConnell taping technique is that it glides the patella medially and places it back in the trochlear groove. In order to test this hypothesis several studies have been conducted that use radiographic images as a way of tracking the anatomical positioning of the patella. Larsen et al performed a study to determine radiographically the effectiveness of the McConnell technique. They took 20 healthy men between the ages of 18 and 35 and exposed them to three bilateral Merchant view x-rays of the knees. The Merchant view is an axial view that is sometimes referred to as a “sunrise” view because the patella resembles the morning sun as it floats over the femur. The first x-ray was taken prior to taping to be used as a baseline. The second x-ray was taken immediately following an application of a patellar taping. After this subjects were put through an exercise regimen that was designed to disturb the taping and associated knee structures and the third x-ray was taken. All radiographic images were taken from the exact same view to keep trials consistent. The results yielded a significant medial glide in the subjects’ knees right after taping. This medial translation was not maintained through the exercise bout and the researchers even found that in the control group there was an excessive lateral glide post-exercise. Based upon these findings Larsen proposed future research into using a patellar taping as a preventative measure against lateral translation.

Another important radiographic study was conducted by Bockrath et al. Unlike Larsen’s study, Bockrath’s 12 subjects all suffered from PFPS and were on patellar taping therapies at the time. The design of the study was to compare Merchant view x-rays of the patellar alignment pre tape and post tape while performing an isometric quadriceps contraction against a 1.36kg weight at 45° flexion. The results found that the taping lead to no significant change in patella rotation,
patellofemoral congruence or the sulcus angle; therefore, they concluded the reduction in pain was not due to the taping. This conclusion could not be generalized because Bockrath only tested a single joint position. Perhaps varying angles of knee flexion would produce different results. Also it was thought that magnetic resonance imaging may reveal more accurate measurements of anatomical positioning.

Pfeiffer\textsuperscript{26} et al addressed some of the voids in the Bockrath research in a 2004 study. Using an MRI machine they obtained 4 different images (0°, 12°, 24°, 36° of flexion) for eighteen healthy females under three conditions, no tape, patellar taping with medial glide, and post-exercise with the same taping technique. Similar to the results of the Larsen study, Pfeiffer found that there was significant medial glide between the control no-tape condition and the taped condition at all joint angles; however after the exercise all medial correction was lost. They concluded that the McConnell technique would be most effective in a controlled environment completing mild to moderately intense rehabilitation exercises. This is the second study to find that the corrective medial glide is lost after bouts of exercise. Perhaps future research could involve developing a taping technique that retains its medial tension during and after exercise, therefore increasing its effectiveness in reducing pain.

In 2006 Herrington\textsuperscript{27} published another study using MRI but instead of healthy subjects he used eight patients with PFPS (five female and three male). Images were taken at 0°, 10° and 20° of flexion both before and after a McConnell technique taping. The variable of interest was lateral patella displacement (LPD) and at all flexion angles the application of tape significantly decreased LPD. They quantified the effect of taping and found that the average reduction of LPD at 0° was .4mm, at 10° it was 1.1 and at 20° it was .7mm. Herrington hypothesized that even those small distances could be important in offering an explanation as to why taping reduces
pain. The void in Herrington’s study is that he did not look at LPD after exercise. Previous studies have shown that LPD increases after an exercise bout but it has not been determined by how much. Using Herrington’s technique and quantifying LPD increase can help practitioners in designing therapy protocols for PFPS patients. Also this study suggested that the McConnell technique may be more or less effective at designated joint angles.

One study by Gigante et al.\textsuperscript{28} opted to use computed tomography (CT) instead of x-ray or MRI in order to examine patellar positioning. Images were taken of sixteen female PFPS patients with and without quadriceps contraction both pre and post patellar taping. Images were also taken at knee flexion angles of 0° and 15°. Patellar displacement was measured as LPD and patellar tilt was measured as lateral patella angle (LPA). During all conditions, Gigante found no significant reduction of LPD or LPA. He acknowledged that patellar taping does produce a decrease in pain; however it cannot be due to medialization of the patella. Instead it is proposed that pain relief may be a result of tape-skin contact invoking a neuroinhibitory mechanism. Further research can be done using a placebo patellar taping in order to determine if this mechanism is plausible.

**Isokinetic Dynamometry**

Isokinetic dynamometry has proven to be a reliable and significant method of testing knee musculature strength and endurance.\textsuperscript{23,37} Feiring et al.\textsuperscript{23} produced a study to determine the testing reliability of isokinetic dynamometry. Nineteen healthy physically active males and females aged 20-35 were tested bilaterally for concentric knee extension and flexion at 60°/sec, 180°/sec, 240°/sec, and 300°/sec, utilizing standard Biodex protocol. The first results were gathered during the pre-test and the second set of results was collected 7 days later during the post-test. Peak torque and single repetition work were the parameters being tested. An intraclass
correlation coefficient (ICC) was calculated for each different speed and it was found that at all speeds the Biodex provided reliable test-retest results for peak torque and repetition work.

Mongomery et al\textsuperscript{37} evaluated the reliability of an isokinetic test for knee muscle strength and endurance. Twenty healthy subjects underwent three testing sessions, anywhere between two and four days apart. The protocol included a velocity spectrum test and a muscle endurance test. Velocity spectrum testing used a 5 repetition test at velocities ranging from 90º/sec to 330º/sec. Muscle endurance testing involved counting the number of contractions performed in a 45 second interval at 180º/sec. Results yielded that reliability was generally higher for lower velocities and also for knee flexion as opposed to extension. After calculating ICC’s it was determined that total work performed and average power were the two reliable measures for muscle endurance. Peak torque was a reliable measure of muscle strength at all velocities examined in the velocity spectrum test.

\textbf{Isokinetic Dynamometry and Patellofemoral Pain Syndrome}

There have been several studies that examine isokinetic dynamometry and patellofemoral knee syndrome. One study done by Goharpey et al\textsuperscript{19} looked at the relationship between functional testing and isokinetic parameters in patients with PFPS. They put 15 healthy subjects and 15 PFPS patients on a dynamometer measuring quadriceps/hamstrings strength at 60º/sec and 120º/sec. After isokinetic testing all subjects performed two functional tests, a step down and semi-squat. As predicted, the patients with PFPS produced less torque in isokinetic testing and lower scores in the functional tests. There was no relationship established between results of the isokinetic parameters and the functional scores suggesting that quadriceps/hamstrings strength does not correlate with functional capacity. This may suggest that isokinetic exercises need to be
used in conjunction with other types of strengthening exercise in order to gain functional benefits.

Alaca\textsuperscript{20} et al conducted a similar study except it incorporated a 6 week therapy program. Both isokinetic parameters and functional test scores were recorded before and after the therapy. Every subject in the study was a PFPS patient and the results showed that all isokinetic parameters significantly improved as well as functional scores. Like Goharpey, Alaca found no correlation between increased strength and functional abilities. A potential follow-up study could look at a longer therapy program. Six weeks may be insufficient time for PFPS patients to make up the strength deficit they are already possessed due to their condition.

One study that yielded positive isokinetic results was done by Handfield et al.\textsuperscript{21} Thirty-six patients referred to physical therapy with a diagnosis of PFPS were included in the study. The inclusion criteria consisted of at least 2 of the following: pain on direct compression of the patella with the knee extended, tenderness with palpation along the posterior surface of the patella, pain with resisted knee extension, and pain during isometric knee extension with suprapatellar resistance. Patients were tested for isokinetic knee extensor peak torque at 60°/sec and 180°/sec under 2 conditions, tape and no-tape. For the no-tape condition, Hypafix tape was wrapped around the knee to control for the possibility that sensory input alone may affect strength and pain measures. A VAS sheet was administered at the end of each test to assess perceived pain. The results revealed that there was a significant increase in peak torque at both 60°/sec and 180°/sec during the taping condition as well as a decrease in perceived pain. With these results Handfield suggested that isokinetic training combined with a McConnell taping technique may be a safe and effective method for strength training in PFPS patients.
Herrington et al\textsuperscript{8} also conducted a study that examined the effect of taping on quadriceps peak torque and it was discovered that taping did have a significant effect on peak torque production. At 60\(^{\circ}\)/sec strength was improved by 20\% and at 180\(^{\circ}\)/sec there was a 20\% improvement as well. A possible explanation for this observation is that the medial glide alters the leverage of the patella and creates more favorable mechanics for the knee joint. Although pain was reduced immediately after the patella was taped, it is questionable whether neurological pathways were immediately restored, allowing the quadriceps to demonstrate improved torque immediately. Another consideration offered for the observed torque increases may be a placebo effect. When the tape was applied, they were more motivated to increase performance.

A study by Keet et al\textsuperscript{22} did use a placebo taping and they found contradictory results to those of Handfield and Herrington. Fifteen physically active patients with PFPS were used as the experimental group and 20 physically active healthy volunteers were used as the control cohort. All participants were subject to 3 interventions applied in a randomized order: (1) with a patellar taping technique; (2) with placebo tape; and (3) with no tape application. Isokinetic testing was done at a speed of 120\(^{\circ}\)/sec because previous research had used 60\(^{\circ}\)/sec and 180\(^{\circ}\)/sec.\textsuperscript{8,19,21} The results revealed that PFPS patients exhibited a significantly lower isokinetic peak torque than the healthy subjects, however the taping interventions had no significant effect on force production in either the PFPS group or healthy cohort. Keet proposed that these contradictory results could be because previous studies lacked randomization or placebo control. Also Keet suggested that a taping technique may not be an appropriate treatment choice for a physically active population. A rehabilitation program designed for improving strength deficits could be more effective. This claim is supported by the research of Kowall which concluded that taping provides no benefit to a strength based rehabilitation program.\textsuperscript{11}
Conclusion

Clearly, there is much more investigation that needs to be done on patellofemoral pain syndrome. The exact etiology is still unknown but we have a pretty good idea of what causes anterior knee pain. A tight illiotibial band, weak quadriceps musculature, especially the vastus medialis oblique (VMO), a large Q-angle, patellar tilting and even neurological dysfunction\textsuperscript{6-8} all contribute to development of systems. McConnell developed a taping technique in an attempt to correct some of the factors. There are many examples in the literature that prove it is an effective way to alleviate pain but no study has been able to explain the reasoning behind the phenomenon. Isokinetic performance has been associated as a key variable in assessing the McConnell technique. Several studies have examined this relationship\textsuperscript{8, 19-22} however there is more research to be done. With a better understanding more effective and successful therapies can be designed that will ultimately improve the quality of life for people suffering from PFPS.
ADDITIONAL REFERENCES


APPENDIX A

Picture 1. Medial Glide McConnell Technique

Picture 2. Participant on Treadmill

Picture 3. Anterior View of Isokinetic testing

Picture 4. Medial View of Isokinetic Testing
APPENDIX B

Health Screening Questionnaire (PFPS Participants)

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

Principal Investigator: Giampietro L Vairo, MS, ATC

Advisor: Nicole M McBrier, PhD, ATC

Other Investigator(s): Philip J Bosha, MD, Roberta L Millard, MD

Research Assistant(s): Jeremy E Baumgarten and Nicholas M DeBellis

Screening Checklist: Patellofemoral Joint Dysfunction Patients

Participant Identification Number: _________________________________________

As a general health screen, you must be able to answer ‘YES’ to the following questions.

1. Are you recreationally active (defined as individuals engaging in physical activity at least three days per week for 30 minutes over the past six-months)? Yes No

2. Are you between 16 to 35 years old? Yes No

3. Have you been diagnosed with unilateral patellofemoral joint dysfunction by your doctor within the past six months? Yes No

4. Do you speak English? Yes No

As a general health screen, you must be able to answer ‘NO’ to the following questions.

5. Have you followed a formal rehabilitation program under supervision of a physical therapist or athletic trainer? Yes No

6. Have you suffered from patellofemoral joint dysfunction for more than six months? Yes No

7. Do you have any further injuries to the involved knee (ligament sprains or tears, meniscus tears)? Yes No
8. Have you sustained traumatic injury to the hip or ankle of the involved leg?  
   Yes  No

9. Have you sustained traumatic injury to the opposite uninvolved leg?  
   Yes  No

10. Are you diabetic or suffer from peripheral neuropathy?  
    Yes  No

11. Have you sustained a concussion within the past six months?  
    Yes  No
Health Screening Questionnaire (Control Participants)

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

Principal Investigator: Giampietro L Vairo, MS, ATC

Advisor: Nicole M McBrier, PhD, ATC

Other Investigator(s): Philip J Bosha, MD, Roberta L Millard, MD

Research Assistant(s): Jeremy E Baumgarten and Nicholas M DeBellis

Screening Checklist: Control Participants

Participant Identification Number: ________________________________

As a general health screen, you must be able to answer ‘YES’ to the following questions.

1. Are you recreationally active (defined as individuals engaging in physical activity at least three days per week for 30 minutes over the past six-months)? Yes No

2. Are you between 16 to 35 years old? Yes No

3. Do you speak English? Yes No

As a general health screen, you must be able to answer ‘NO’ to the following questions.

4. Have you sustained traumatic injury to any joint on either of your legs? Yes No

5. Are you diabetic or suffer from peripheral neuropathy? Yes No

6. Have you sustained a concussion within the past six months? Yes No
PFPS Participant Consent Form

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

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Other Investigator(s): Philip J Bosha, MD and Roberta L Millard, MD
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Research Assistant(s): Jeremy E Baumgarten and Nicholas M DeBellis
Schreyer Honors College Undergraduate Students
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814-865-4303

1. Purpose of the study: The purpose of this research is to study the effects of a taping technique 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. A total of 40 people will be taking part in this study, 20 are patellofemoral (kneecap) joint dysfunction patients and 20 are healthy matched control participants.

2. Procedures to be followed: If you chose to participate in this research study, you will be asked to perform the following tests during two (2) identical sessions. The first session will be testing you without tape application and a second session three (3) days later with 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 Start 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. 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.

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 in three (3) days to complete your second session. For your second session you will only repeat testing procedures C and D. After completing the second 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 two (2) 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. Penn State’s Office for Research Protections, the Biomedical Institutional Review Board and the Office for Human Research Protections may review records related to this research study. 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. Questions about your rights as a research participant may be directed to Penn State University’s Office for Research Protections at (814) 865-1775. Referral information for those who wish to seek additional assistance includes the following:

Philip J Bosha or Roberta L Millard  
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.

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.

______________________________________________ _____________________
Principal Investigator or Faculty Advisor Signature Date

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

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Other Investigator(s): Philip J Bosha, MD and Roberta L Millard, MD
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State College PA 16803
pjb35@psu.edu and rlm8@psu.edu
814-865-3566

1. Purpose of the study: The purpose of this research is to examine the effects of a therapeutic taping technique 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. A total of 40 people will be taking part in this study, 20 are patellofemoral (kneecap) joint dysfunction patients and 20 are healthy matched control participants.

2. Procedures to be followed: If you chose to participate in this research study, you will be asked to undergo the following tests during two (2) identical sessions. The first session will consist of testing without therapeutic tape application and a second session with therapeutic tape application.
Experimental Procedures

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

- 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 cleansed 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 balancing task called the Star Excursion Balance Test. The Star Excursion Balance Test consists of you standing in place on one leg and reaching as far as possible with your other leg in the following directions: front, same-side-front-diagonal, side, same-side-back-diagonal, back, opposite-side-back-diagonal, opposite-side, opposite-side-front-diagonal. A picture of the Star Excursion Balance Test is below for your viewing.

You will be given four (4) practice trials and complete three (3) testing trials. You will be given 15 second rest periods between each trial and a two (2) minute rest period between the practice and test trials. You will be asked to perform the Star Excursion Balance Test separately with both legs. You will be asked to flip a coin to decide which leg is tested first.

- Final assessment includes strength and endurance of your leg muscles (hamstrings, quadriceps and calves) measured by an exercise machine. The exercise machine is an instrument that records muscle strength and endurance by participants exerting force against a set constant resistance. 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 selected 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 selected resistances. Five repetitions are performed at high resistance and as many repetitions as you can complete in 45 seconds at low resistance. You will be given two practice trials before high resistance testing separated by a one (1) minute rest period. You will be given one practice trial before low resistance testing. A two (2) minute rest period is then given before you will complete three testing trials.
period will take place between high and low resistance tests. You will be asked to perform these tests separately with both legs. You will be asked to flip a coin to decide which leg is tested first.

3. **Discomforts and risks:** The discomforts and risks assumed during participation in this type of research study are minimal. The maneuvers measured and the levels of exertion are well within expected ranges for physically-active people. To decrease potential onsets of injury, you will be instructed in all the proper study procedures and only experienced researchers will consistently conduct testing. Possible discomforts may consist of mild skin irritation from application of self-adhesive surface electrodes or mild bruising from the exercise machine stabilizing straps. Additional discomforts may include delayed onset muscle soreness for two to three days following testing, which is typical with various types of physical activity. Furthermore, participation in this research study may potentially aggravate symptoms you usually experience in your patellofemoral (kneecap) joint dysfunction knee. As with any experiment it is possible that harmful effects that are unknown may occur. However, the injury rate in this type of research study is minimal and occurs in less than 1% of participants. Every precaution will be made to monitor and help prevent against any such discomforts and risks.

4. **Benefits:** The benefits to you include potentially learning about knee joint anatomy, the causes of patellofemoral (kneecap) joint dysfunction as well as muscle activity patterns, strength and endurance of your legs with and without therapeutic tape application. However, there may be no direct benefit from your participation in this research study.

The benefits to society include recognizing potential advantages from therapeutic 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 two (2) 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 research questions within this study.

7. **Statement of confidentiality:** You understand that any information about you obtained from this research study including history and physical findings will be kept strictly confidential. Research records pertaining to this study will be available only to those investigators listed on the first page of this document. Penn State’s Office for Research Protections, the Biomedical Institutional Review Board and the Office for Human Research Protections may review records related to this research study. In unusual cases your research records may be inspected by appropriate government agencies or released to an order from a court of law. 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 case number will indicate a participant’s identity on research records. Three years following the end of the 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. Questions about your rights as a research participant may be directed to Penn State University’s Office for Research Protections at (814) 865-1775. Referral information for those who wish
to seek additional assistance includes the following:

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

11. 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 also understand that you may be removed from this research study by investigators in the event of your inability to complete testing procedures.

12. 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.

The Patient Care Advocate for the hospital may be reached by calling 717-531-6311.

13. 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 between 16 and 35 years of age to take part 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

______________________________________________
Witness Name (Print)

______________________________________________ _____________________
Witness Signature Date
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.

______________________________________________ _____________________  
Principal Investigator or Faculty Advisor Signature Date

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
Control Participant Consent Form

Informed Consent Form for Biomedical Research
The Pennsylvania State University
CONTROL PARTICIPANTS

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

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Research Assistant(s): Jeremy E Baumgarten and Nicholas M DeBellis
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1. Purpose of the study: The purpose of this research is to study the effects of a taping technique 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. A total of 40 people will be taking part in this study, 20 are patellofemoral (kneecap) joint dysfunction patients and 20 are healthy matched control participants.

2. **Procedures to be followed:** If you chose to participate in this research study, you will be asked to perform the following tests during one (1) session. This session of testing will be without 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 either your right or left leg length. To record the length of your leg 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. We will ask to place ten (10) self-adhesive surface electrodes on one of your legs 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 leg 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 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 one leg only.

C. Finally we will measure the strength and endurance of your leg’s 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 ankle 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 on one leg only.

3. Discomforts and risks: The discomforts and risks assumed during participation in this type of research study are minimal. The maneuvers measured and the levels of exertion are well within expected ranges for physically-active people. To decrease potential onsets of injury, you will be instructed in all the proper study procedures and only experienced researchers will consistently conduct testing. Possible discomforts may consist of mild skin irritation from application of self-adhesive surface electrodes or mild bruising from the exercise machine stabilizing straps. Additional discomforts may include delayed onset muscle soreness for two to three days following testing, which is typical with various types of physical activity. As with any experiment it is possible that harmful effects that are unknown may occur. However, the injury rate in this type of research study is minimal and occurs in less than 1% of participants. Every precaution will be made to monitor and help prevent against any such 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 one (1) session lasts about thirty minutes. 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. Penn State’s Office for Research Protections, the Biomedical Institutional Review Board and the Office for Human
Research Protections may review records related to this research study. 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. Questions about your rights as a research participant may be directed to Penn State University’s Office for Research Protections at (814) 865-1775. Referral information for those who wish to seek additional assistance includes the following:

Philip J Bosha or Roberta L Millard  
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.

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

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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.

Principal Investigator or Faculty Advisor Signature

Date

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
Control Participant Consent Form (Under the Age of 18)

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

Principal Investigator: Giampietro L Vairo, MS, ATC
PhD Candidate in Kinesiology
Department of Kinesiology
146 Recreation Building
University Park PA 16802
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814-865-2725

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Other Investigator(s): Philip J Bosha, MD and Roberta L Millard, 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 and rlm8@psu.edu
814-865-3566

1. Purpose of the study: The purpose of this research is to examine the effects of a therapeutic taping technique 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. A total of 40 people will be taking part in this study, 20 are patellofemoral (kneecap) joint dysfunction patients and 20 are healthy matched control participants.

2. Procedures to be followed: If you chose to participate in this research study, you will be asked to undergo the following tests during one (1) session. This session will consist of testing without therapeutic tape application.

Experimental Procedures
We will ask to place ten (10) self-adhesive surface electrodes on one 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 cleansed 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 leg will be measured as you perform a balancing task called the Star Excursion Balance Test. The Star Excursion Balance Test consists of you standing in place on one leg and reaching as far as possible with your other leg in the following directions: front, same-side-front-diagonal, side, same-side-back-diagonal, back, opposite-side-back-diagonal, opposite-side, opposite-side-front-diagonal. A picture of the Star Excursion Balance Test is provided for your viewing.

You will be given four (4) practice trials and complete three (3) testing trials. You will be given 15 second rest periods between each trial and a two (2) minute rest period between the practice and test trials. You will be asked to perform the Star Excursion Balance Test on only one leg determined by the investigators.

Final assessment includes strength and endurance of your leg muscles (hamstrings, quadriceps and calves) measured by an exercise machine. The exercise machine is an instrument that records muscle strength and endurance by participants exerting force against a set constant resistance. 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 selected resistances. While seated and secured in the exercise machine you will repeat this type of testing to record force in pointing and raising your ankle against two selected resistances. Five repetitions are performed at high resistance and as many repetitions as you can complete in 45 seconds at low resistance. You will be given two practice trials before high resistance testing separated by a one (1) minute rest period. You will be given one practice trial before low resistance testing. A two (2) minute rest period will take place between high and low resistance testing. You will be asked to perform these strength and endurance tests on only one leg determined by the investigators.

3. Discomforts and risks: The discomforts and risks assumed during participation in this type of research study are minimal. The maneuvers measured and the levels of exertion are well within expected ranges for physically-active people. To decrease potential onsets of injury, you will be instructed in all the proper study procedures and only experienced researchers will consistently conduct testing. Possible discomforts may consist of mild skin irritation from application of self-adhesive surface electrodes or
mild bruising from the exercise machine stabilizing straps. Additional discomforts may include delayed onset muscle soreness for two to three days following testing, which is typical with various types of physical activity. As with any experiment it is possible that harmful effects that are unknown may occur. However, the injury rate in this type of research study is minimal and occurs in less than 1% of participants. Every precaution will be made to monitor and help prevent against any such discomforts and risks.

4. Benefits: The benefits to you include potentially learning about knee joint anatomy, the causes of patellofemoral (kneecap) joint dysfunction as well as muscle activity patterns, strength and endurance of your leg. However, there may be no direct benefit from your participation in this research study.

The benefits to society include recognizing potential advantages from therapeutic 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 one (1) session lasts about thirty minutes. 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: You understand that any information about you obtained from this research study including history and physical findings will be kept strictly confidential. Research records pertaining to this study will be available only to those investigators listed on the first page of this document. Penn State’s Office for Research Protections, the Biomedical Institutional Review Board and the Office for Human Research Protections may review records related to this research study. In unusual cases your research records may be inspected by appropriate government agencies or released to an order from a court of law. 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. Questions about your rights as a research participant may be directed to Penn State University’s Office for Research Protections at (814) 865-1775. Referral information for those who wish to seek additional assistance includes the following:

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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
11. **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 also understand that you may be removed from this research study by investigators in the event of your inability to complete testing procedures.

12. **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. The Patient Care Advocate for the hospital may be reached by calling 717-531-6311.

13. **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 between 16 and 35 years of age to take part 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

__________________________
Witness Name (Print)

__________________________  ____________________
Witness Signature            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
Kujala Questionnaire

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 (5)
(b) Slight or periodical (3)
(c) Constant (0)

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)
Demographics Sheet

Subject: _________________________

Height (cm): ______________________

Weight (kg): ______________________

Leg Length (cm)

   Involved Leg: ______________________

   Uninvolved Leg: ______________________

Leg Dominance:   R       L
Visual Analog Scale (VAS)

Participant Code: ___________ Date: __________
Procedure: _________________

Tape/ No Tape

1. If used as a graphic rating scale, a 10 cm baseline is recommended.
2. A 10 cm baseline is recommended for VAS scales.
APPENDIX C

**Figure 2.** Extensor Work of PFPS Patients at velocity of 240°/s, Bilateral Comparison

*P* ≤ 0.05 denotes statistical significance

*Pre-Tape*  
*Uninvolved*
Figure 3. Extensor Work of PFPS Patients at velocity of 240°/s, Taping Intervention

* $P \leq 0.05$ denotes statistical significance
ACADEMIC VITA of Nicholas DeBellis

Nicholas DeBellis
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Granite Springs, New York 10527
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Education: Bachelor of Science Degree in Kinesiology, Penn State University, Spring 2010
Honors in Kinesiology
Thesis Title: The Effects of a Therapeutic Patellofemoral Taping Technique on
Open Kinetic Chain Knee Muscular Performance and Perceived Pain
Thesis Supervisor: Dr. Nicole M. McBrier

Related Experience:
Undergraduate Teaching Assistant for Functional Anatomy Class
Supervisor: Dr. Cynthia Bartok
Summer and Fall 2008

Awards:
Dean’s List
Walter Cunningham Memorial Scholarship
National Honors Society

Presentations/Activities:
Poster Presentation- NATA Research & Education Foundation, Free Communications Program
Volunteer work in San Pedro Sula, Honduras
Health and Human Development, Jumpstart Program, Leader