Original research

The effects of two therapeutic patellofemoral taping techniques on strength, endurance, and pain responses

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Abstract

Objective: To compare the effects of taping techniques on clinical measures in patellofemoral pain syndrome (PFPS) patients.

Design: Crossover experimental design.

Setting: Controlled laboratory.

Participants: Twenty physically active PFPS patients.

Main outcome measures: Isokinetic strength and endurance, and perceived pain.

Results: Bilateral baseline differences existed for strength (involved = 1.8 ± 0.5 Nm/kg; uninvolved = 2.1 ± 0.5 Nm/kg; p = 0.001) and endurance (involved = 35.6 ± 14.0 J/kg; uninvolved = 40.2 ± 12.9 J/kg; p = 0.013). Strength (McConnell = 2.1 ± 0.6 Nm/kg, 95% SCI = (1.1, 4.2); Spider = 2.1 ± 0.5 Nm/kg, 95% SCI = (0.9, 4.0)) and endurance (McConnell = 42.9 ± 13.8 J/kg, 95% SCI = (2.9, 11.6); Spider = 42.5 ± 11.9 J/kg, 95% SCI = (2.6, –11.3)) increased when taped compared to baseline. Pain decreased during strength (baseline = 3.0 ± 2.2 cm; McConnell = 1.9 ± 1.7 cm, 95% SCI = (–1.8, –0.4); Spider = 1.6 ± 2.0 cm, 95% SCI = (–2.0, –0.5)) and endurance (baseline = 2.5 ± 2.0 cm; McConnell = 1.5 ± 1.8 cm, 95% SCI = (–1.6, –0.4); Spider = 1.1 ± 0.8 cm, 95% SCI = (–1.7, –0.5)) measurements when taped. Differences between taping techniques were insignificant.

Conclusions: Taping improved clinical measures in PFPS patients. No differences existed between Spider and McConnell techniques.

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1. Introduction

Patellofemoral pain syndrome (PFPS) is the most prevalent cause of knee pain diagnosed by sports medicine physicians (McConnell, 1986; Powers, 1998). The condition is characterized by pain and discomfort on the anterior aspect of the knee, primarily along the medial border of the patella, and it accounts for 25% of all knee injuries seen in athletes in sports medicine clinics (Earl & Hoch, 2011; Overington, Goddard, & Hing, 2006). Pain associated with PFPS is exacerbated by activities, such as squatting, running, or ascending and descending stairs that yield considerable forces on the joint (Levine, 1979; Powers, 1998). The exact cause of PFPS is unknown, but it has been linked to an abnormal lateral tracking of the patella (McConnell, 1986; Powers, 1998). Several factors contribute to lateral tracking, including a stiff iliotibial band, weak quadriceps muscle, especially the oblique fibers of the vastus medialis (VMO), a large Q-angle, patellar tilting, and neurological dysfunction (Caylor, Fites, & Worrell, 1993; Herrington, 2001; Puniello, 1993). Traditional treatments for PFPS have included patellar taping, stretching, various strengthening exercises, activity modification, bracing, ultrasound, and foot orthoses (Earl & Hoch, 2011).

One proposed intervention for patients suffering from PFPS is the McConnell taping technique. The goal of the McConnell taping technique is to correct abnormal lateral tracking of the patella and to align the patella medially within the trochlear groove in order to diminish pain for patients while they perform therapeutic exercises (McConnell, 1986). Several studies have reported potential benefits of this intervention for perceived pain reduction (Aminaka & Gribble,
2008; Christou, 2004; Whittingham, Palmer, & Macmillan, 2004), but the exact mechanism for this phenomenon is still undefined. For instance, Christou (2004), Handfield and Kramer (2000), and Herrington (2001) concluded that the results observed with the McConnell taping technique were due to pain modulation via cutaneous stimulation, rather than the changing of patellar positioning, as proposed by McConnell (1986). Other studies have also found that taping over the skin can stimulate cutaneous mechanoreceptors and boost afferent signals to the central nervous system (CNS) for improved proprioception (Chen, Hong, Huang, & Hsu, 2007; Hang, Chou, Lin, & Wang, 2010; Tunay et al., 2008). This outcome is commonly referred to as the nociceptive effect, which elicits neural inhibition by facilitating large afferent fiber input. According to these studies, changes in neural input through afferent receptors, such as cutaneous mechanoreceptors and Messner corpuscles, from the patellar taping application may be enough to block nociceptive input and cause neural inhibition via the large afferent fibers (Aminaka & Gribble, 2008; Chen et al., 2007; Hang et al., 2010; Tunay et al., 2008).

More recently, a new form of therapeutic tape called kinesiology tape®, developed by Dr. Kenso Kase and colleagues in Japan (Kase, Wallis, & Kase, 2003), has been suggested for the treatment of PFPS (Chen et al., 2007). Research states that the use of kinesiology tape® provides additional benefits of improved circulation with reduced inflammation compared to other types of tape (Cowan, Bennett, & Hodges, 2002; Kase et al., 2003; Kinzey & Armstrong, 1998). Some of the characteristics of kinesiology tape®, including its similarity to the thickness of human skin, its ability to be stretched up to 120–140% of its length, and its capacity to be worn continuously for 3–4 days (Chen et al., 2007; Hang et al., 2010; Osterhues, 2004; Tunay et al., 2008). This tape has embedded elastic fibers that allow it to recoil when placed on the skin. It also allows for partial to full joint range of motion (Edin, 2004). The elastic recoil in the tape is proposed to lift the skin and increase space between the skin and muscle, and, thus, provide the central nervous system with a large influx of afferent sensory input via mechanoreceptors (Kase et al., 2003). Kinesiology tape® is proposed to increase proprioception by providing constant cutaneous afferent stimulation. By way of this mechanism, the tape leads to an increase in muscle activation (Kinzey & Armstrong, 1998) and a decrease in pain through neurological suppression (Cowan et al., 2002).

Quadriiceps muscle performance is one parameter that has been closely linked to PFPS (Alaca, Yılmaz, Göktepe, Mohur, & Kalyon, 2002; Goharpey, Shaterzadeh, Emrani, & Khalesi, 2007; Handfield & Kramer, 2000; Herrington, 2001). Several studies have shown that patients suffering from PFPS tend to have weaker quadriceps muscle strength than those who are healthy. However, there have been contradictory results with respect to the efficacy of the McConnell taping technique on strength as studies found neither decrease in pain nor increase in force production with the tape application (Keet, Kramer, 2000; Herrington, 2001). Keet et al.’s (2006) results revealed that PFPS patients exhibited a significantly lower isokinetic peak torque than healthy subjects. However, the taping interventions had no significant effect on force production for both the PFPS group and the healthy cohort. The authors concluded that a taping technique may not be an appropriate treatment choice for a physically active population. Instead, they hypothesized that knee muscle strength and endurance would be significantly greater on the uninvolved leg compared to the involved leg, prior to the taping intervention. After the two taping techniques are applied, it was hypothesized that there would be a significant increase in muscle strength and endurance, and a decrease in perceived pain, for the involved leg, compared to the baseline condition. This study will, therefore, help examine the efficacy of the McConnell and Spider® tapping techniques as well as provide information that can be clinically applicable for practitioners treating symptoms of PFPS.

2. Methods

2.1. Participants

Twenty participants (7 men, 13 women) were recruited for the present study. Their mean age, height, body mass, and body mass index were 21.2 ± 2.9 years, 169.2 ± 16.8 cm, 68.1 ± 11.6 kg, and
24.5 ± 7.0 kg/m², respectively. Participation in the study was voluntary, and patients were recruited by means of informational flyers and verbal scripts. The inclusion criteria were as follows: (1) recreationally active (defined as individuals who engage in physical activity with a minimum frequency of three days per week and 30 min in duration each day, over a six-month period), (2) boys and girls (16–17 years of age) as well as men and women (18–35 years of age), (3) diagnosed with unilateral PFPS by a physician up to 6 months prior to participation in the study, and (4) PFPS patients who have not followed a formal rehabilitation protocol under a physical therapist or an athletic trainer. Participants were excluded if they showed signs or symptoms of any of the following: (1) associated musculotendinous, capsuloligamentous, or meniscal pathology to the involved knee, (2) history of traumatic injury to the hip or ankle of the involved extremity or the contralateral lower extremity, (3) history of systemic or metabolic dysfunction impairing sensorimotor capabilities, or (4) cerebral concussion sustained within the preceding six months.

2.2. Procedure

The present study was divided into three sessions, each of these separated by 72 h. The purpose of the first session was to collect the participants’ baseline measurements. Therefore, participants completed strength and endurance tests without any taping intervention for the uninjured and the involved legs. The purpose of the second and third sessions was to collect the participants’ measurements with the taping interventions. Thus, participants completed the same strength and endurance tests with the tape application for the involved leg only.

Upon arrival to the lab for the first session, all participants read and signed an informed consent form approved by East Stroudsburg University Office of the Provost and The Pennsylvania State University Office for Research Protections and Institutional Review Board. They were then asked to complete the health screening questionnaire, the Kujala Questionnaire, and the Tegner Activity Scale. Patients also had their height and mass recorded in centimeters and kilograms, respectively. Afterward, participants started their warm-up, which consisted of a walk on a treadmill at a standardized velocity of 1.2 m/s for 5 min. The testing order of the involved and the uninjured leg (in Session 1) as well as that of the taping techniques (McConnell or Spider⁶, used in Sessions 2 and 3) were randomized among participants by generating random permutations via Minitab Statistical Software (Minitab Inc., State College, PA).

All tests and data collection were performed in the Penn State Athletic Training Research Laboratory. A Biodex System 2 Dynamometer equipped with Biodex Advantage Software v4.6 (Biodex Medical Inc., Shirley, NY) was used to record all isokinetic data. Research by Feiring, Ellenbecker, and Derscheid (1990) has 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, thus these were the angular velocities used in the present study. Test-retest reliability measures [ICC 3, k] for the isokinetic measures used in our study were 0.84 and 0.86, respectively, as established via prior pilot testing with 15 participants. Perceived pain was quantified using a 10 cm visual analog scale (VAS). Patients were also given a 13-question Kujala Questionnaire in order to evaluate subjective symptoms and functional limitations of their patellofemoral disorders (Kujala, Jaakkola, Koskinen, Taimela, Hurme, & Nelimekka, 1993). The questionnaire is scored from 0 to 100 and a patient’s score indicates his or her level of function as a percentage (i.e., a score of 85 means that a patient is at 85% of their full functional capacity).

The interventions in this study consisted of a medial glide McConnell taping technique (McConnell,1986) and a NUCAP Medical Upper Knee Spider⁶ kinesiology taping technique. For the McConnell taping technique, the first step was to apply a strip of cover-roll tape directly onto the skin over the involved knee. Then, a piece of leukotape was applied on top of the cover-roll starting from the lateral patellar border and ending at the posterior-medial aspect of the knee, anchoring the patella in a medialized position. The Spider⁶ taping technique consisted of a pre-cut kinesiology tape, which provides active and dynamic therapeutic support for the patella and the muscles around the knee joint. This taping technique has several components for its application. The first strip of tape was applied to the knee just below the patella, without placing any tension on the tape. Then, two strips that began where the first one ended crossed the thigh in opposite directions passing over the borders of the patella and ending on the outside and inside borders of the thigh. At this step, the tape was applied with a mild amount of stretch. The last strips began where the previous ones ended and were placed down the inside and outside borders of the thigh, without placing any tension on the tape. The taping of patients was exclusively conducted by the same athletic trainer, with a decade of clinical experience, and who was skilled in the use of McConnell and kinesiology tape⁶ taping techniques. Fig. 1 displays the McConnell and Spider⁶ taping techniques used in this study.

After completing the warm-up, participants were seated on the Biodex in an upright position, and they were secured using pelvic, shoulder, and thigh straps. In order to restrict upper body movements, they were asked to cross their arms across their chest. Before starting the testing protocol, participants completed an exercise to help them familiarize themselves with the procedure and the equipment. The familiarization exercise consisted of three repetitions of knee extension/flexion in an arc of 90° (from 90° of flexion to 0° of extension) at 50% of perceived maximal effort at an angular velocity of 60°/s, followed by three repetitions at 75% of perceived maximal effort at an angular velocity of 60°/s. A 1-min rest interval separated both parts of the familiarization exercise. Participants were then given a 2-min rest period before completing the actual strength test. For this test, patients performed three repetitions of knee extension/flexion in an arc of 90° at their maximally perceived effort at an angular velocity of 60°/s. Afterward, patients were administered a VAS scale and were asked to assess their pain levels while performing the strength test.

After a subsequent 2-min rest period, participants proceeded to the endurance test. Endurance testing was preceded by a familiarization exercise, which consisted of 5 repetitions at the participant’s self-selected effort, at an angular velocity of 240°/s. Endurance measurements were recorded while the participant completed as many full range of motion repetitions as possible during a 45-s time interval at an angular velocity of 240°/s. Upon completion of the endurance test, participants ranked their perceived pain while completing the test on a VAS scale. When the strength and endurance tests were completed for the first leg, participants then repeated the same protocol on the contralateral leg. This concluded Session 1. Participants were then asked to return to the lab for Sessions 2 and 3 (each separated by 72 h) to repeat the strength and endurance tests with the corresponding taping technique (McConnell or Spider⁶), according to the randomization. Fig. 2 displays the experimental design used in this study.

2.3. Data analysis

Based on the data analyses conducted by previous researchers, the present study examined three dependent variables: perceived pain, the strength measure of peak moment, and the endurance measure of total work. As mentioned in the Procedure section, perceived pain data were obtained by means of a standardized VAS scale.
VAS, while strength (peak moment) and endurance (total work) measures were obtained by means of isokinetic dynamometry.

Group means and standard deviations (SDs) for the dependent variables were computed. Paired-samples t tests were conducted to analyze statistically significant differences between the involved leg and the uninvolved leg at baseline for the dependent variables. Probability plots were calculated to verify that the data met the assumptions for t test analyses. A one-way analysis of variance

(ANOVA) was conducted to determine statistically significant differences among conditions (baseline, McConnell, and Spider®) on the involved leg for each dependent variable. A Tukey’s Honestly Significant Difference (HSD) test was conducted as a post-hoc analysis for the ANOVA to assess pairwise differences via the 95% simultaneous confidence interval (SCI). Residual analyses were conducted to verify that the data met the assumptions for ANOVA (that the data were normally distributed, that they were independent, and that they had constant variance). An alpha level of ≤0.05 was set a priori to denote statistical significance. In addition, Cohen’s d effect sizes were calculated for perceived pain responses as well as strength and endurance measurements during all experimental conditions. The strength of effect sizes was interpreted using the guidelines described by Cohen (1988), with values less than 0.4 interpreted as weak, values from 0.4 to 0.7 as moderate, and values larger than 0.7 as strong.

3. Results

3.1. Activity level

Results of the Tegner Activity Scale displayed a statistically significant difference between activity level before and activity level after PFPS symptoms presented themselves (p = 0.001). The activity level results are displayed in Table 1.

3.2. Perceived pain

During strength testing, as measured by the standardized VAS, a statistically significant difference was found among conditions (baseline, McConnell, Spider®) with the involved leg for perceived pain (p = 0.001). Tukey’s HSD post-hoc analysis revealed that statistically significant differences existed between the baseline and the McConnell medial glide (95% SCI –1.8, –0.4; effect size 0.269) as well as between the baseline and the NUCAP Medical Upper Knee Spider® (95% SCI –2.0, –0.5; effect size 0.316), each with affiliated weak effect sizes. However, there was no statistically significant difference between the McConnell medial glide and the NUCAP Medical Upper Knee Spider® (95% SCI –0.9, 0.5; effect size 0.080).

During endurance testing, as measured by the standardized VAS, a statistically significant difference was found between conditions (baseline, McConnell, Spider®) with the involved leg for perceived pain (p = 0.001). Tukey’s HSD post-hoc analysis revealed a statistically significant difference between the baseline and the McConnell medial glide (95% SCI –1.6, –0.4; effect size 0.254), associated with a weak effect size. A statistically significant difference was also found between the baseline and the NUCAP Medical Upper Knee Spider® (95% SCI –1.7, –0.5; effect size 0.417). In this case, the effect size affiliated with this difference was moderate. Nonetheless, no statistically significant difference was displayed between the McConnell medial glide and the NUCAP Medical Upper Knee Spider® (95% SCI –0.7, 0.5; effect size 0.142). Table 2 exhibits the perceived pain responses during strength and endurance testing for the involved leg.

3.3. Isokinetic knee extensor strength and endurance measurements (uninvolved leg vs. involved leg)

Regarding the strength measure of normalized peak moment, as measured by isokinetic dynamometry, a statistically significant difference was found between the uninvolved leg and the involved leg at the baseline, associated with a weak effect size (p = 0.001, effect size 0.287). Regarding the endurance measure of normalized total work, as measured by isokinetic dynamometry, a statistically significant difference was found between the uninvolved leg and the involved leg at the baseline, affiliated with a weak effect size (p = 0.013, effect size 0.168). The results for bilateral knee extensor strength and endurance measurements are presented in Table 3.

3.4. Isokinetic knee extensor strength and endurance measurements (involved leg)

With respect to the strength measure of normalized peak moment, as measured by isokinetic dynamometry, a statistically significant difference was found among conditions (baseline, McConnell, Spider®) with the involved leg (p = 0.001). Tukey’s HSD post-hoc analysis revealed that statistically significant differences existed between the baseline and the McConnell medial glide (95% SCI 1.1, 4.2; effect size 0.262) as well as between the baseline and the NUCAP Medical Upper Knee Spider® (95% SCI 0.9, 4.0; effect size 0.287), each of these associated with a weak effect size. However, no statistically significant difference was displayed between the McConnell medial glide and the NUCAP Medical Upper Knee Spider® (95% SCI –1.7, 1.4; effect size 0).

Concerning the endurance measure of normalized total work, as measured by isokinetic dynamometry, a statistically significant difference was found among conditions (baseline, McConnell, Spider®) with the involved leg (p = 0.001). Tukey’s HSD post-hoc analysis revealed that a statistically significant difference existed between

Table 1
Participant activity level.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Mean ± SD</th>
<th>p Value</th>
<th>Effect size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before PFPS</td>
<td>7.6 ± 1.1</td>
<td>0.001*</td>
<td>0.475</td>
</tr>
<tr>
<td>After PFPS</td>
<td>6.3 ± 1.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| * Denotes statistical significance.

Table 2
Perceived pain responses during strength and endurance testing for the involved leg.

<table>
<thead>
<tr>
<th>Condition</th>
<th>VAS score (cm) (mean ± SD)</th>
<th>95% SCI (lower, upper)</th>
<th>Effect size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involved-baseline</td>
<td>3.0 ± 2.2</td>
<td>(–1.8, –0.4)*</td>
<td>0.269</td>
</tr>
<tr>
<td>vs. McConnell</td>
<td>1.9 ± 1.7</td>
<td>(–2.0, –0.5)*</td>
<td>0.316</td>
</tr>
<tr>
<td>vs. Spider®</td>
<td>1.6 ± 2.0</td>
<td>(–0.9, 0.5)</td>
<td>0.080</td>
</tr>
<tr>
<td>McConnell vs. Spider®</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involved-baseline</td>
<td>2.5 ± 2.0</td>
<td>(–1.6, –0.4)*</td>
<td>0.254</td>
</tr>
<tr>
<td>vs. McConnell</td>
<td>1.5 ± 1.8</td>
<td>(–1.7, –0.5)*</td>
<td>0.417</td>
</tr>
<tr>
<td>vs. Spider®</td>
<td>1.1 ± 0.8</td>
<td>(–0.7, 0.5)</td>
<td>0.142</td>
</tr>
</tbody>
</table>

| * Denotes statistical significance (p < 0.05).

Table 3
Bilateral knee extensor strength and endurance measurements.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Peak moment (Nm/kg) (mean ± SD)</th>
<th>p Value</th>
<th>Effect size (Cohen’s d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strength</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninvolved</td>
<td>2.1 ± 0.5</td>
<td>0.001*</td>
<td>0.287</td>
</tr>
<tr>
<td>vs. Involved-baseline</td>
<td>1.8 ± 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uninvolved</td>
<td>40.2 ± 12.5</td>
<td>0.013*</td>
<td>0.168</td>
</tr>
<tr>
<td>vs. Involved-baseline</td>
<td>35.6 ± 14.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| * Denotes statistical significance.
between the baseline and the McConnell medial glide, affiliated with a weak effect size (95% SCI 2.9, 11.6; effect size 0.254). A statistically significant difference was also found between the baseline and the NUCAP Medical Upper Knee Spider®, this time associated with a moderate effect size (95% SCI 2.6, −11.3; effect size 0.548). Nonetheless, no statistically significant difference was displayed between the McConnell medial glide and the NUCAP Medical Upper Knee Spider® (95% SCI −4.7, 4.0; effect size 0.016). Table 4 shows the results for the knee extensor strength and endurance measurements for the involved leg.

4. Discussion

4.1. Perceived pain

The results of the present study showed that patients exhibited significantly lower levels of perceived pain in the two taping conditions (McConnell and Spider®), when each of these was compared to the baseline condition. The reduction in perceived pain level reported in the present study, as quantified by the VAS after tape application, is consistent with previous findings (Aminaka & Gribble, 2008; Earl & Hoch, 2011; Herrington, 2001). Pain reduction has been attributed to the correction of patellar lateral tracking by stabilizing it medially with tape (Aminaka & Gribble, 2008; Christou, 2004; Whittingham et al., 2004), yet several radiographic studies (Derasari, Brindle, Alter, & Sheehan, 2010; Herrington, 2001; Pfeiffer, DeBeliso, Shea, Kelley, Irmscher, & Harris, 2004) have found no significant patellar anatomical differences after exercising with patellar tape. Moreover, Aminaka and Gribble (2008) found that the application of McConnell tape decreased participants’ perceived pain. However, no kinematic alterations were noted after tape application. This led the researchers to conclude that decreased perceived pain may be caused by other factors. Specifically, they suggested that the application of therapeutic tape may lead to a change in afferent signals (increased mechanoreceptor input), leading to the inhibition (gating) of nociceptor input.

Just as previous researchers have suggested a neurosensory mechanism associated with McConnell tape (Aminaka & Gribble, 2008; Christou, 2004; Herrington, 2001), kinesiology tape® is proposed to provide the central nervous system with greater afferent input through mechanoreceptors (Kase et al., 2003). In this capacity, kinesiology tape® may increase muscle activation leading to decreased pain through neurological suppression (Chen et al., 2007; Cowan et al., 2002; Hang et al., 2010; Tunay et al., 2008).

In the present study, this rationale seems to be the most plausible mechanism of pain reduction because we could not conclusively verify if patellar positioning was altered as a result of taping. However, it is also possible that the reduced perceived pain that participants reported in the taping conditions was the result of the placebo effect of the therapeutic taping techniques. Because we did not include a placebo tape condition in our study, we are unable to draw a firm conclusion between these two possibilities. Nevertheless, on the one hand, previous research has shown that therapeutic tape is more effective on pain reduction and functional improvement than placebo tape or control conditions (Cowan et al., 2002; Ernst et al., 1999; Riemann, 2002; Whittingham et al., 2004). On the other hand, several investigators have reported no significant differences between therapeutic and placebo taping techniques on perceived pain and neuromuscular activity (Christou, 2004; Ng & Cheng, 2002; Wilson et al., 2003). Based on both of these findings, we are inclined to consider the first possibility (i.e., changes in neural input) as the most plausible explanation for reduced perceived pain in our study. However, further research is warranted to assess the influence of potential placebo effects from these therapeutic taping techniques.

Turning to the comparison between the two therapeutic taping techniques used in this study (i.e., McConnell and Spider®), our results showed no statistically significant differences in terms of perceived pain during isokinetic testing. It is, however, worth noting that the effect size of the comparison between the baseline condition and the Spider® condition was larger than that of the baseline condition and the McConnell condition in both the strength test (baseline vs. McConnell = 0.269, baseline vs. Spider® = 0.316) and the endurance test (baseline vs. McConnell = 0.254, baseline vs. Spider® = 0.417). These results suggest that the Spider® taping technique may be more effective in reducing perceived pain than the McConnell taping technique. This difference could be influenced by the fact that the amount of tape utilized and, thus, the amount of skin covered, with the Spider® taping technique was greater overall than the amount of tape used with the McConnell taping technique. Because a larger amount of skin is covered, there may consequently be greater changes in neural input. Once again, additional research is necessary in order to confirm this possibility.

4.2. Isokinetic peak moment

The present study revealed that the application of tape had an effect on the participants’ ability to generate a greater peak moment with an angular velocity of 60°/s. This is consistent with previous research that has found that a decreased level of pain is correlated with increased peak moment generation (Handfield & Kramer, 2000; Herrington, 2001; Salsich, Brechter, Farwell, & Powers, 2002). However, Tunay et al. (2008) found that the McConnell taping technique reduced performance in patients with PFPS. This shows a direct contrast with our findings, which displayed an increase in strength performance after the McConnell taping intervention. Tunay et al. also found an improvement in performance after the kinesiology tape® application, but only with healthy matched controls when compared with PFPS patients. These results also differ from the findings of the present study, where PFPS patients revealed an improvement in the peak moment measure under the kinesiology tape® condition.

The differences between our results and Tunay et al.’s results may be due to several methodological reasons. First, in the present study, the therapeutic taping techniques were tested with an open kinetic chain exercise, as opposed to Tunay et al.’s study, which used closed kinetic chain exercises. In addition, Tunay et al. had different clinicians performing the taping procedures. In this study, variability was controlled by having only one clinician tape all the participants. Moreover, Tunay et al.’s study compared PFPS patients to healthy matched controls while in the present study patients served as their own control condition. The results of the present
study are more readily convergent with those obtained by Murray (2003), who also used open kinetic chain exercises and found that kinesiology tape applied to the anterior thigh increased quadriceps activity compared to athletic tape, which showed little or no difference in quadriceps measurements.

4.3. Isokinetic total work

This study revealed an increase in total work output after the therapeutic patellar taping interventions were applied, compared to the baseline condition. It is possible that the reduction in pain contributed to the increase in isokinetic work performed, but no previous studies have examined the effectiveness of McConnell or kinesiology tape tapping techniques on knee muscular endurance. However, significant pain reduction and performance improvement in low-resistant activities, such as stair ambulation, have been detected by previous studies (Cowan et al., 2002; Salsich et al., 2002). In the present study, patients experiencing less pain would have less quadriceps inhibition and would be expected to increase work output, especially when the protocol involved 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 less force is placed on the knee joint, symptoms of PFPS are less severe and decrease perceived pain (Levine, 1979; Powers, 1998). The conclusions reached in previous studies concur with those of the present study, indicating that the McConnell and Spider tape tapping techniques may be an effective way to reduce pain during repetitive low force tasks. This study represents an original investigation to look at the effect of patellar tape on isokinetic measures with an angular velocity of 240°/s. Previous studies had used angular velocities of 60°/s, 120°/s, or 180°/s and they used peak moment as a measure of muscular strength. As hypothesized, work output increased significantly in PFPS participants with the application of therapeutic tape. The participants performed similarly in the endurance test under the McConnell and Spider tape conditions.

Focusing on the two therapeutic taping techniques used in this study (i.e., McConnell and Spider), our results showed no statistically significant differences regarding isokinetic total work. Nonetheless, the effect size of the comparison between the baseline condition and the Spider tape condition was larger than that of the baseline condition and the McConnell condition (0.548 and 0.254, respectively). While the first comparison (baseline vs. Spider tape) reached a moderate effect size, the second one (baseline vs. McConnell) exhibited a weak effect size. As mentioned above with the perceived pain measure, this difference in effect size may hint at the idea that kinesiology tape is more effective in improving performance compared to McConnell tape. Still, additional research is necessary to corroborate this.

The finding that therapeutic patellar taping techniques increased endurance performance may have important clinical applications. Previous research has demonstrated that low-resistance activities, such as stair-stepping, are benefited by a taping technique (Cowan et al., 2002; Salsich et al., 2002). Other authors (English, Brannock, Wan, Eastwood, & Uhl, 2006) have established that lower extremity isokinetic work is correlated to a single-leg functional hop test, meaning that increases in endurance measures enhance functional abilities.

4.4. Limitations and future directions

One limitation of this study was that all PFPS patients only received a standardized McConnell medial glide taping technique. This technique was shown to be beneficial, but there may have been some participants who did not receive the full benefit of patellar taping. For example, the medial glide technique only addresses abnormal lateral tracking of the patella. In a true clinical setting, additional modifications of the technique can be performed in order to address other issues, such as patellar tilt, patellar rotation, or fat pad unloading. Another limitation to consider is that the participants consisted strictly of participants with acute cases of PFPS. This limits any longitudinal conclusions that are proposed, especially related to the endurance results. Patients with chronic PFPS are more likely to be bothered by prolonged low-resistance endurance-based activities. This participant group remains to be examined in future studies. The final limitation of this study involved the kinesiology taping technique. We used the NUCAP Medical Upper Knee Spider tap technique and, as with the McConnell technique, there are several available modifications for using the kinesiology tape with patients with PFPS, depending on the specific condition they have.

The following recommendations for further study seem warranted based on the data obtained and the questions that arose throughout the course of this study. Future research should (1) examine the effects of McConnell and Spider tape tapping techniques on endurance measures in patients with chronic PFPS, (2) test participants performing exercises for prolonged periods of time, such as 30–60 min, in order to evaluate non-acute effects of these therapeutic taping techniques, (3) examine if different kinesiology tape techniques affect pain and function, and (4) develop a taping technique that retains its assessed (medial or lateral) tension during and after exercise, therefore, increasing its effectiveness in reducing pain and improving performance.

5. Conclusion

Within the scope and limitations of this investigation, it is reasonable to conclude that: (1) McConnell and Spider tape tapping techniques decrease perceived pain in patients with acute PFPS compared to a baseline condition, (2) McConnell and Spider tape tapping techniques increase quadriceps isokinetic extensor peak moment and total work in patients with acute PFPS compared to a baseline condition, and (3) there are no significant differences between the effects of the McConnell taping technique and the Spider tape taping technique in patients with acute PFPS who perform isokinetic strength and endurance tests.

Conflict of interest

None declared.

Ethical approval

The participating subjects signed a consent form, and the study protocol was approved by the East Stroudsburg University Office of the Provost and The Pennsylvania State University Office for Research Protections and Institutional Review Board.

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