The Effects of Therapeutic Taping on Pain, Range of Motion, Power, Balance, and Strength in Physically Active Individuals with Patellar Tendinopathy

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Abstract

Patellar tendinopathy is a common injury found among active populations. Typically, tendon pain and tenderness are the most prevalent symptoms associated with patellar tendinopathy and can range from mild to severe. This can be detrimental for active individuals, considering that the presence of these symptoms can also negatively affect range of motion (ROM), power, balance, and strength. Currently, there is much discrepancy within the literature regarding the effectiveness of conservative treatments like Kinesio tape (KT) or Leukotape (LT). Consequently, it is unknown which type of therapeutic tape is beneficial for decreasing the common symptoms of this injury when compared to no tape (NT) or placebo tape (PT). Therefore, the purpose of this Master's thesis study was to examine the effects of therapeutic taping on pain, ROM, power, balance, and strength in physically active male and female adults between the ages of 18 and 45, with patellar tendinopathy.

Using purposive sampling, ten participants were recruited (M = 25 years; SD = 8.0). Participants committed to four test sessions, each separated by at least one day of rest. One session was allocated to each of the following conditions: NT, PT, LT, and KT. The baseline testing session involved NT and the subsequent taping sessions were randomized for each participant. During the initial NT session, participants were informally interviewed about his/her injury. The participant's pain level was then measured and the testing sequence was implemented as follows: ROM of the knee joint, strength, power, and balance measures. Pain levels were also measured once again after the participant performed the balance task. To analyze the differences in perception of pain across the different tapes and times of administration, a 4 x 2 (Tape [KT, LT, NT, PT] x Time [Pre, Post]) repeated measures factorial ANOVA was conducted. To examine the potential effects of different taping conditions on

ROM, power, balance, and strength, a one-way ANOVA, with taping condition as a repeated measures factor was used.

There were no substantial differences found regarding pain, ROM, and power, indicating the effectiveness of therapeutic tape is context specific. From a clinical perspective, therapeutic tape had a tendency to reduce further pain and increase ROM when compared to NT and PT. Strength and balance performances were also substantially improved with the KT application. These results carry several clinical implications that may supplement current rehabilitation procedures for physically active individuals recovering from this injury. The application of KT could be the treatment of choice for health care providers who are considering therapeutic taping as a potential treatment intervention. Future research should consider incorporating more sophisticated laboratory equipment (e.g., EMG) in order to determine the underlying effects associated with therapeutic tape in pathological populations.

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List of Abbreviations and Terms

EMG – Electromyography

KAT – Kinesthetic ability trainer

KT – Kinesio tape

LT – Leukotape

NT – No tape

NPRS – Numeric pain rating scale

PFPS – Patellofemoral pain syndrome

PT – Placebo tape

ROM – Range of motion

SEBT – Star Excursion Balance Test

VAS – Visual Analog Scale

Power: The muscles ability to perform a task in the least amount of time (Durfee & Iaizzo, 2006).

Range of Motion: The capability of a joint to move through its predetermined motion (American College of Sports Medicine, 2009).

Strength: Typically generated by the muscle(s) needed to carry out a particular task (Durfee & Iaizzo, 2006).

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Introduction

Patellar tendinopathy is a common musculoskeletal injury found in individuals who have active lifestyles (Kountouris & Cook, 2007; Magra & Maffulli, 2008; Renström & Woo, 2007). Nearly 10% of all hospital visits are related to tendinopathies and their growing prevalence among active individuals is concerning (Garau, Rittweger, Mallarias, Longo, & Maffulli, 2008; Murtaugh & Ihm, 2013; Renström & Woo, 2007). It is believed that repetitive tasks like jumping, squatting, and running, compromise and degenerate the tendon, leading to adverse effects (Garau et al., 2008; Murtaugh & Ihm, 2013; Peers & Lysens, 2005). If unattended, these effects can negatively influence quality of life, activities of daily living, and further participation in activity (Murtaugh & Ihm, 2013; Cook & Khan, 2007). The literature has identified many successful treatment options for patellar tendinopathy in high-level athletes (Gaida & Cook, 2011), but little research exists involving less elite populations and non-athletes. Therefore, it remains unclear if conservative treatments like therapeutic taping will be beneficial to these individuals.

Patellar Tendinopathy

The term patellar tendinopathy is often used interchangeably with patellar tendinitis, or jumper's knee, to identify tendon deficits (Cook & Purdam, 2013; Hale, 2005). However, there is much discrepancy between these terms because the exact etiology is still unknown (Gaida, Cook, Bass, Austen, & Kiss, 2004; Hale, 2005; Renström & Woo, 2007). It is believed that patellar tendinopathy produces inflammatory symptoms surrounding the patellar tendon (Murtaugh & Ihm, 2013; Rees, Maffulli, & Cook, 2009), thus, the term patellar tendinitis was introduced as a descriptor. Currently, the literature suggests that the injury is more degenerative than inflammatory and the term tendinopathy or tendinosis should be used over tendinitis

(Dimitrios, Pantelis, & Kalliopi, 2012; Larsson, Käll, & Nilsson-Helander, 2012; Murtaugh & Ihm, 2013).

Patellar Tendon

The patellar ligament or patellar tendon, are often used interchangeably within the literature. For the purposes of this document, the term patellar tendon will be used. The patellar tendon originates on the base of the patella and inserts onto the tibial tuberosity (Peers & Lysens, 2005). Although relatively small in length, the patellar tendon acts as an extension of the quadriceps tendon, which is comprised of the four-quadriceps muscles (rectus femoris, vastus medialis, vastus intermedius, and vastus lateralis) (Hale, 2005; Peers & Lysens, 2005; Xu & Murrell, 2008). Researchers believe the average length of the patellar tendon is approximately 3 cm and the average thickness is approximately 3-4 mm (Hale, 2005; Peers & Lysens, 2005).

Structure and function. The structure of the patellar tendon is quite complex. Thick collagen fibers, ground substances, lipids, and proteoglycans are the tendons essential elements (Hale, 2005; Kountouris & Cook, 2007; Peers & Lysens, 2005; Wilson & Best, 2005). It is believed that overused tendons do not follow a normal soft tissue healing response since the structural changes that occur during injury also occur during healing (Kountouris & Cook, 2007; Peers & Lysens, 2005; Tan & Chan, 2008). This is often regarded as a failed healing response (Kountouris & Cook, 2007; Peers & Lysens, 2005; Tan & Chan, 2008). Ultimately, the tendon is more susceptible to injury due to changes in the underlying structures. This compromises the function of the tendon and its ability to absorb repeated force loads (Kountouris & Cook, 2007). The patellar tendon helps connect the quadriceps muscles to the tibial tuberosity and facilitates knee flexion and extension (Xu & Murrell, 2008). During tasks like jumping or squatting, the tendon is susceptible to large amounts of force throughout the joints primary movements (Gaida

& Cook, 2011; Hale, 2005; Kountouris & Cook, 2007). In some cases, these forces can exceed approximately 10 times an individual's body weight (Hale, 2005; Kountouris & Cook, 2007). If tendinopathy is present, these repeated forces might lead to adverse effects like pain or tenderness and potentially limit the frequency and quality of involvement in physical activity (Kountouris & Cook, 2007; Kulig et al., 2013; Xu & Murrell, 2008).

Intrinsic and Extrinsic Factors

There are many intrinsic factors related to the onset of patellar tendinopathy. These factors are determined by an individual's genetic expression and include age, gender, biomechanics, muscular imbalances, and leg length discrepancies (Kountouris & Cook, 2007; Rees et al., 2009; Tan & Chan, 2008; Witvrouw, Bellemans, Lysens, Danneels, Cambier, 2001). Instances of patellar tendinopathy can be found in individuals upwards of 30 to 55 years of age (Renström & Woo, 2007). With increasing age, the tendon structure may become rigid; causing decreased healing responses (Cook & Khan, 2007; Hale, 2005; Rees et al., 2009). Cook and Khan (2007) reported that when individuals age, symptoms of the injury may increase despite no changes in exercise intensity. This is contrary to younger adults whose symptoms often only arise during continuous high-intensity loading (Cook & Khan, 2007). Extrinsic factors have also been associated with the development of patellar tendinopathy and include variations in activity frequency, intensity of the activity, the type of training surfaces, and the type of footwear (Hale, 2005; Kountouris & Cook, 2007; Peers & Lysens, 2005).

Symptoms and Diagnosis

Individual differences will lead to varying symptoms and degrees of patellar tendinopathy. In both acute and chronic cases, symptoms may occur only after activity or repetitive use of the knee joint (Bains & Porter, 2006; Kaux, Forthomme, Le Goff, Crielaard, Croisier, 2011; Peers & Lysens, 2005). In severe circumstances, symptoms may occur before and after activity, with pain reported directly over the tendon area (Bains & Porter, 2006; Peers & Lysens, 2005). During the assessment, palpation of the knee joint and surrounding structures helps to determine the severity of the tendinopathy (Hale, 2005; Kountouris & Cook, 2007). Since the primary motions of this joint include flexion and extension, the ability to perform these movements may be limited due to pain (Renström & Woo, 2007). The amount of discomfort could also negatively affect the amount of power produced when rapidly bending the knee, the strength of both the flexors and extensors, and dynamic balance.

Like most musculoskeletal injuries, patellar tendinopathy must be properly diagnosed and assessed by a certified health care provider. The patient's history and clinical presentation are the most common factors considered (Hale, 2005; Renström & Woo, 2007). Sophisticated clinical tests like magnetic resonance imaging or ultrasonography may be used in conjunction with history and palpation to confirm diagnosis (Renström & Woo, 2007). Depending on symptom duration, two forms of patellar tendinopathy may exist. Acute patellar tendinopathy occurs when symptoms last approximately less than three months; when the symptoms last longer than three months, the disorder may be classified as chronic patellar tendinopathy (Maffulli, Wong, & Almekinders, 2003; Rutland et al., 2010).

Therapeutic Taping

Early intervention is needed in physically active individuals, as recovering from patellar tendinopathy can take upwards of eight months (Renström & Woo, 2007). If left untreated, the tendon could potentially rupture or structural damage can occur in the knee joint (Renström & Woo, 2007; Scott & Chang, 2008). Therapeutic taping is commonly used in rehabilitation programs because of its beneficial properties. In clinical practice, there are several taping techniques available to treat knee conditions; the two most common include the McConnell taping technique and the Kinesio taping methods (Campolo, Babu, Dmochowska, Scariah, & Varughese, 2013).

McConnell taping technique. Jenny McConnell was the developer of the McConnell taping technique (McConnell, 1986). This technique uses Leukotape (LT), which is a non-elastic adhesive that can be used to treat a variety of injuries/conditions, and may reduce the many symptoms associated with patellar tendinopathy (Briem et al., 2011; Campolo et al., 2013). Traditionally, varying quadriceps angles (Q-angle) and muscular imbalances have been primary sources of patellar malalignment and contribute to tendon pain (McConnell, 1986). The adhesive properties of the tape allow health care providers to mechanically realign the patella into its normal position and stimulate the quadriceps muscles (Campolo et al., 2013; McConnell, 1986). This will allow for optimal force distribution and elimination of any muscular imbalances or pain present (Campolo et al., 2013; McConnell, 1986).

Kinesio taping methods. Another common prophylactic treatment used in the treatment of various musculoskeletal disorders is Kinesio tape (KT). Developed by Japanese chiropractor Kenso Kase in 1973, the tape first gained popularity during the 1988 Seoul Olympics where high profile athletes used the tape during competition (Kase, Wallis, & Kase, 2013; Moore, 2012). Since then, desired effects like reduced pain and swelling, and increased joint mobility have been reported with the use of KT (Ujino, Eberman, Kahanov, Renner, & Demchak, 2013). Unlike LT, KT is unique because it is flexible, supportive, and versatile to the applicant (Kase et al., 2013). It was designed for fluid reduction in underlying tissues by imitating the elastic qualities of human skin (Kase et al., 2013). Its flexible characteristics allow it to gently lift the skin and as it retracts, dissipating the underlying fluid (Kase et al., 2013).

Similar to the mechanical correction proposed by the McConnell taping technique, the Kinesio taping methods are also able to correct tendon and ligament alignment (Kase et al., 2013). The traditional pitchfork technique has been specifically designed for patellar tendinopathy and offers numerous health benefits like increased joint proprioception and decreased pain and inflammation (Kase et al., 2013). Therefore, KT may be an appropriate intervention to help individuals recover from patellar tendinopathy, since it will be flexible to allow normal motion of the knee joint, dissipate any swelling that may be present, and decrease pain.

Effectiveness of Therapeutic Taping

As the use of therapeutic taping becomes more common in sport and clinical settings, research is continuously being conducted examining its effectiveness regarding pain (Campolo et al., 2013; Keet, Gray, Harley, & Lambert, 2007), ROM (González Iglesias, Fernández-de-Las-Peñas, Cleland, Huijbregts, & Del Rosario Gutiérrez-Vega, 2009; Huang, Hsieh, Lu, & Su, 2011; McConnell & McIntosh, 2009; Sanzo, Zerpa, Przysucha, & Vasiliu, 2014; Yoshida & Kahanov, 2007; Witvrouw et al., 2001; Ujino et al., 2013), lower body power (Hsu, Chen, Lin, Wang, & Shih, 2009; Nakajima & Baldridge, 2013), balance (Aminaka & Gribble, 2008; Bicici, Karatus, & Baltaci, 2012; Briem et al., 2011; Fayson, Needle, & Kaminski, 2013), and leg strength (Aktas & Baltaci, 2011; Kaya et al., 2010; Sanzo et al., 2014). Given the structural characteristics of both LT and KT, each tape and taping technique/method could serve as potential treatments for patellar tendinopathy.

Pain. The exact relationship between pain and tendinopathy is not fully understood (Cook & Purdam, 2013); however, research has been conducted examining the effects of therapeutic tape as a potential treatment option. Campolo et al. (2013) investigated the effectiveness of therapeutic taping on anterior knee pain. A total of 20 participants took part in the study (15 female, 5 male) with a mean age of 24 ± 3 years. Each participant reported unilateral knee pain secondary to patellofemoral pain syndrome (PFPS). The study implemented a pretest-posttest design comparing KT, LT, and no tape (NT) conditions. Each participant performed two activities, stair climbing and a squat lift under all three taping conditions. Pain was measured using the Numeric Pain Rating Scale (NPRS) before and after activity. Participants reported higher pain levels when performing the squat lift using NT when compared to LT and KT. During the stair climbing activity, higher pain levels were reported with NT when compared to LT and KT, respectively. Statistically significant differences were found only between the NT and KT conditions indicating that KT could be an effective treatment option to reduce pain during stair climbing activities or similar tasks (Campolo et al., 2013).

A similar study conducted by Osorio et al. (2013) examined the effectiveness of two therapeutic patellofemoral taping techniques on strength, endurance, and pain. A total of 20 physically active participants participated in the study (13 female, 7 male) with a mean age of 21.2 ± 2.9 years. Each participant presented with unilateral knee pain secondary to PFPS. A crossover experimental design was implemented for this study comparing LT to KT. The results of the study revealed significant improvements ($p < .05$) in pain, strength, and endurance tests with both types of tape. Therefore, the results suggest that therapeutic tape is beneficial for the reduction of knee pain in symptomatic individuals (Osorio et al., 2013) and it is possible that similar effects may be experienced in individuals with patellar tendinopathy.

Range of motion. Maintaining adequate flexibility is imperative in the prevention of patellar tendinopathy (Cook & Khan, 2007). Typically, normal ROM values for knee flexion are approximately 130° and 0° for knee extension (Roach & Miles, 1991; Shah, 2008). Research conducted by Witvrouw et al. (2001) showed that decreased knee ROM is present and associated with tendon pain. Furthermore, a study conducted by González Iglesias et al. (2009) revealed improvements in cervical spine ROM with KT led to decreased pain symptoms. Currently, little research exists examining the effects of therapeutic taping on knee ROM in pathological populations. Conversely, several studies have been designed examining the effects of therapeutic taping in normal, healthy populations (Sanzo et al., 2014; Ujino et al., 2013; Yoshida & Kahanov, 2007). A study conducted by Yoshida and Kahanov (2007) examined the effects of KT on lower trunk ROM. A total of 30 healthy participants participated in the study (15 female, 15 male) with a mean age of 26.9 ± 5.9 for the women and 20.9 ± 12.1 for the men. The study examined the effects of KT on trunk flexion, extension, and lateral flexion using a static stretching procedure. The authors suggested that trunk ROM may be improved when using KT but that future research should focus on applying the tape to pathological populations (Yoshida & Kahanov, 2007). The authors discussed that KT may have increased ROM by promoting blood flow to the taped area and triggering various underlying mechanisms (e.g., mechanoreceptors). Although a different body segment was used, it is possible that similar effects may occur in active individuals suffering from patellar tendinopathy, as the developers of the tape advocated the effectiveness of tape at improving ROM (Kase et al., 2013).

A study conducted by Sanzo et al. (2014) examined the effectiveness of therapeutic tape on lower quadrant ROM and strength in healthy university students. A total of 10 participants (4 female, 6 male) with a mean age of 24 ± 7.1 years participated in the study. Testing was conducted over four sessions, with each test session completed with a randomly allocated taping condition (e.g., KT, LT, placebo tape (PT), NT). The participant's dominant leg was evaluated for hip, knee, and ankle ROM, using a universal goniometer. In terms of knee ROM, the study found that LT significantly decreased knee flexion and extension when compared across taping conditions. The McConnell taping technique used in this study was originally designed to improve muscular imbalances in individuals suffering from knee pain (McConnell, 1996). These symptoms were absent in the population used by Sanzo et al. (2014) and may explain why participants experienced decreased ROM with the LT application.

Although LT decreased ROM in healthy individuals, the researchers reported that these results were valuable from a clinician's perspective, as it may determine which type of therapeutic tape to apply in certain contexts (Sanzo et al., 2014). For example, the application of LT may not be beneficial for healthy individuals who require full ROM of the knee to carry out specific task demands or activities of daily living (Sanzo et al., 2014). Therefore, KT may be a preferred option for clinicians, as the tape's flexible characteristics may not inhibit knee ROM (Sanzo et al., 2014). Although this study focused on therapeutic taping in healthy university students, it remains plausible that the effects of therapeutic tape will be more robust and beneficial using physically active individuals who are experiencing other knee pathologies like patellar tendinopathy.

Power. Lower body power is imperative to jumping performance (Chen-Yu, Tsung-Hsun, Szu-Ching, & Fong-Chin, 2011; Knežević & Mirkov, 2011). Power is the ability of a muscle, or group of muscles, to produce force in order to overcome minimal resistance in a short period of time (Durfee & Iazzo, 2006; Knežević & Mirkov, 2011). Nakajima and Baldridge (2013) examined the effectiveness of KT on vertical jump height and dynamic postural control measured using the Star Excursion Balance Test (SEBT). A total of 52 healthy individuals (24 females, 28 males) with a mean age of 22.12 ± 2.08 years participated in this study. The results revealed no significant differences between taping conditions in vertical jump height and dynamic postural control for the SEBT. This was contrary to the results for female participants who demonstrated significant improvements in two directional movements of the SEBT (posteromedial $p = .01$ and medial $p = .02$), respectively. The researchers concluded that KT might have an effect on dynamic postural control in healthy female participants (Nakajima & Baldridge, 2013). Although the results reported by Nakajima and Baldridge (2013) were not statistically significant, they were expected given the population was injury free and not experiencing a knee injury like patellar tendinopathy.

Since 2000, there have been few studies that effectively examined the effects of the McConnell taping method on knee power. Huang et al. (2011) compared the use of KT to PT and examined the effects of tape on muscle activity and vertical jump performance in healthy inactive individuals. A total of 30 healthy adults participated in the study (12 female, 19 male) with a mean age of 25.3 ± 3.8 years. Each participant completed three trials in this pretest/posttest repeated measures design. The results revealed no statistical differences ($p = .86$) in jump height with KT; however, statistically significant decreases ($p < .05$) in jump height were found with the application of PT. In terms of electromyography (EMG), the researchers found significant increases in the medial gastrocnemius with the application of KT. Huang et al. (2011) reported that the elastic properties of KT allowed for greater muscular activation and resulted in full ROM in the ankle joint when performing the vertical jump task. The researchers speculated that KT might be an appropriate intervention for the facilitation of increased muscular activity (Huang et al., 2011). Considering Huang et al. (2011) measured these results in a healthy inactive population, the effects on knee pathologies like patellar tendinopathy, might be more profound. This could potentially lead to greater power production in the lower quadrant.

Balance. Maintaining dynamic balance is imperative to sport performance and the completion of everyday tasks. During gross movements such as jumping, the knee joint is constantly adapting to varying force loads. These variations are known as dynamic restraints (Fayson et al., 2013; Gutierrez, Kaminski, & Douex, 2009). Athletes suffering from patellar tendinopathy may have difficulty in maintaining adequate balance since the structure and function of the patella has been compromised. Currently, research examining the effectiveness of therapeutic taping on balance in athletes suffering from patellar tendinopathy remains limited. A study conducted by Bicici et al. (2012) examined the effect of athletic taping and KT on functional performance in basketball players with chronic inversion ankle sprains. A total of 15 male basketball players, between the ages of 18 and 22 participated in the study. To test functional performance (agility, endurance, balance, and coordination), a hopping test, single limb hurdle (Amanda, Buchanan, & Carrie, 2008), and standing heel raise were implemented. These tasks, in conjunction with vertical jump height, SEBT, and kinesthetic ability trainer (KAT), were all tested four times at one-week intervals. No significant differences were observed using the four different types of tape for SEBT or KAT; however, during the single limb hurdle, faster performance times were achieved with the application of KT and standard athletic tape, when compared to the other taping conditions. Additionally, during the heel rise and vertical jump tests, standard athletic taping resulted in decreased vertical jump height and participants reported increased fatigue when compared to the NT condition. The authors concluded that KT had no negative effects on functional performance during each of the tasks when compared to the other types of tape. These results must be interpreted cautiously, however, due to the small sample size and male-only population (Bicici et al., 2012).

A study conducted by Aminaka and Gribble (2008) examined the effects of medial patellar taping on lower extremity kinematics and dynamic postural control in individuals with and without PFPS. A total of 40 participants participated in the study, 20 with PFPS (12 females, 8 males) and 20 without PFPS (12 females, 8 males). For participants with PFPS, the testing leg and the tape being applied was randomly selected. Once formal testing was completed, the remaining taping condition was applied to the opposite leg and the participant replicated the testing procedures. This was then matched for the participants without PFPS. The results from the SEBT revealed greater reach distances in the control group when compared to those with PFPS. In terms of intra-group comparisons, significant differences were found between LT and NT for both groups; however, LT significantly increased reach distance for those with PFPS and decreased performances for those in the control group. Ultimately, LT was more beneficial for balance, as it allowed participants with PFPS to reach further in the anterior direction.

Strength. Knee strength is generated by the quadriceps and hamstring muscles and can be quantified by the amount of force these muscles are able to produce when presented with an external resistance (Durfee & Iaizzo, 2006; Knežević & Mirkov, 2011; Richards, 2008). To date, few studies have been conducted examining the effectiveness of therapeutic taping on knee strength (Atkas & Baltaci, 2011; Sanzo et al., 2014). Aktas and Baltaci (2011) compared the effectiveness of KT and knee bracing on knee strength during jumping performance. A total of 20 healthy individuals (11 females, 9 males) participated in the study with a mean age of 23.8 years. Knee strength was measured using the Isomed 2000 isokinetic dynamometer and jumping performance was measured using a vertical jump procedure and one-leg hop test. Significant results were seen in isokinetic knee extension torque (p = 0.03) at 180°/sec using KT and in the hop distance with both legs (p = 0.01). The researchers concluded that the application of KT might serve as an effective intervention to enhance muscular strength in the knee joint (Aktas & Baltaci, 2011).

In a study conducted by Sanzo et al. (2014), the effects of therapeutic taping were also measured on lower quadrant strength. Using a Baseline Manual Muscle Tester, they found that therapeutic tape had no significant effects on knee flexion or extension strength when compared to the NT and PT conditions. The researchers attributed the lack of statistical findings to the population being measured, as participants were healthy and free from knee pathology. They suggested that future research should consider a pathological population in order to measure the effectiveness of therapeutic taping on knee strength.

Despite the growing trend of using KT and LT in high-level sports and as part of rehabilitation programs, few comparative studies have examined the effectiveness of different types of tape to NT and/or the application of PT. Consequently, there is limited evidence supporting the beneficial claims associated with therapeutic taping, especially in pathological populations (Aminaka, & Gribble, 2008; Bicici et al., 2012; Briem et al., 2011; Campolo et al., 2013; González Iglesias et al. 2009; Kaya et al., 2013; Nakajima & Baldridge, 2013; Osorio et al., 2013; Yoshida & Kahanov, 2007). Since patellar tendinopathy remains a common overuse injury in high-level sport and active lifestyles (Garau et al., 2008; Murtaugh & Ihm, 2013; Renström & Woo, 2007), it is unknown which type of therapeutic tape, if any, is most beneficial for decreasing the common symptoms associated with this injury. Therefore, the purpose of this preliminary investigation was to determine an effective methodology for assessing pain, ROM, power, balance, and strength in varsity athletes with acute patellar tendinopathy and to determine the effectiveness of therapeutic taping on these constraints. It was hypothesized that therapeutic tape (KT and LT) would be effective at reducing pain and improving knee ROM (flexion and extension), power, balance, and strength (flexion and extension) when compared to the NT condition in the affected athletes. Furthermore, no change was expected between or within the comparison group consisting of healthy non-athletes.

Pilot Study

Participants

Purposive sampling was implemented (Trochim, 2005). Following ethical approval from the institution, the participants were recruited from the varsity basketball and volleyball teams and general student population. A team practice was attended to distribute recruitment letters to athletes (Appendix A), whereas the comparison group was recruited via posters distributed around the university. To be included in the affected group, participants had to be at least 18 years of age and diagnosed with acute patellar tendinopathy by a health care provider. The comparison group consisted of male and female non-athletes, who were at least 18 years of age, and not currently diagnosed with a musculoskeletal injury. Participants were excluded if they were experiencing any additional lower quadrant injuries or conditions, had chronic knee pain, or allergies to athletic tape, received corticosteroid injections in the lower quadrant within the past year, or had knee surgery within the past five years. A total of eight participants were recruited, three diagnosed with acute patellar tendinopathy (3 females, age 20.0 ± 1.0 years, height 191.0 ± 20.0 cm, weight 69.4 ± 10.8 kg) and five without the condition (3 males and 2 females, age 22.8 ± 1.3 years, height 173.8 ± 9.0 cm, weight 79.5 ± 18.6 kg).

Procedure

After informed consent was obtained (Appendix B), participants committed to three, 30-minute testing sessions with at least one day of rest between them. One session was allocated to each of the following conditions: NT, KT, and LT. The baseline testing session involved NT and the subsequent taping sessions were randomized for each participant. All testing was conducted in the laboratory at the respective institution by the primary researcher who has extensive training in the use of therapeutic taping (Appendix C).

During the initial NT session, participants were informally interviewed about his/her injury (Appendix D). Following the interview, the participant's pain level was measured using the Numeric Pain Rating Scale (NPRS). After this was completed, the testing sequence was implemented as follows: ROM of the knee joint, strength, power, and balance measures. Pain levels were also measured once again after the participant performed the balance task. Once all the tasks were performed, the participant was asked to return their next scheduled day to continue with subsequent testing. During the KT and LT sessions, application of the tape commenced after the initial pain level was recorded. The participant then followed the same procedures as the initial session and the tape was removed at the end of each session. To determine the testing leg of those without the condition, a coin was flipped with heads indicating the right leg and tails indicating the left leg.

Measures

The perception of pain was measured using the NPRS (Hawker, Mian, Kendzerska, & French, 2011) which consists of an 11-point scale with zero indicating "no pain", one to three indicating "low pain," four to six indicating "moderate pain," and seven to ten indicating "severe pain" (Appendix E). Knee ROM (°) was assessed with a standard goniometer following the procedures adapted from Reese and Bandy (2010). All measurements were taken in a supine position (Appendix F). For knee flexion, the goniometer axis was aligned on the lateral epicondyle of the femur. The proximal arm of the goniometer was placed along the long axis of the femur and pointed towards the greater trochanter. The distal arm was placed along the long axis of the fibula and pointed towards the lateral malleolus. With the hip and knee flexed, the participant was instructed to move the heel toward the buttock until the measurement was recorded (Appendix G). This process was repeated for knee extension, but the participant was instructed to move the heel forward, straightening the knee. The mean of three trials was used in the subsequent analysis, for each taping condition.

Power was measured using a counter movement vertical jump procedure (Markovic, Dizdar, Jukic, & Cardinale, 2008). Before performing the jump, the participant's body mass was measured using a weight scale. The participant stood with his/her dominant arm facing the wall with both feet flat on the ground. A piece of tape was then wrapped around the participant's third and fourth finger. He/she then extended the dominant hand as high as possible and touched the wall using these two fingers. The tape was adhered to the wall marking the highest point reached by the participant. Once the reach height was recorded, the participant was instructed in the proper jumping technique and was given one practice trial. The participant was cued to jump as high as possible and the highest point touched on the wall was recorded with another piece of tape, replicating the previous taping procedure. The participant was asked to use countermovement of the arms to project the body upwards. The mean value of three formal trials (cm) was used to determine peak leg power (Watts) as calculated by the equation used in previous research by Bicici et al. (2012) and Sayers, Haracjiewicz, Harman, Frykman, and Rosenstein (1999):

$$[60.7 \times (\text{Jump Ht. cm.})] + [45.3 \times (\text{Body Mass kg.})] - 2055$$

The SEBT was used to measure dynamic balance (Gribble, Hertel, & Plisky, 2012). Participants stood with his/her affected or test leg over the center of a grid (Appendix H). The grid had eight lines and each of these lines extended at 45° increments in anterior, anterolateral, anteromedial, posteromedial, posterior, posterolateral, medial, and lateral directions. Before the formal testing was completed, the participant's leg length was measured to account for inter-individual differences. Once the affected leg was placed over the center mark, the participant was asked to extend the opposite leg as far as possible on each line following a clockwise direction. In order to complete the trial, the participant had to touch the ground with the toe of the reaching leg. A total of 24 attempts were carried out, with three reaches in each of the eight directions. A coloured piece of tape was placed at the point of contact between the toe and the ground. After each reach, a 30-second break was allotted to measure the distance between the center mark and tape. This value was then divided by the participant's leg length and the mean of the three trials (%) was used for the subsequent analysis.

Lastly, knee strength was measured using a Baseline Electronic Hydraulic Push-Pull Dynamometer (Bohannon, 2005) according to procedures outlined by Andrews, Thomas, and Bohannon (1996). Measurements were obtained while the participant was in a seated position with the knee flexed to 90° (Appendix I). The dynamometer was placed on the anterior surface of the distal end of the leg. When prompted, the participant attempted to extend the knee while receiving counter pressure from the dynamometer. After five seconds of counter pressure, the peak strength was recorded. This process was repeated for knee flexion, but the dynamometer was placed on the posterior surface of the distal end of the lower leg. Three formal trials (lbs) for each movement were carried out, with one minute of rest between them, and the mean was used in the subsequent statistical analysis.

Taping Procedure

Application of the LT followed the McConnell taping technique (McConnell, 1996). The Hypafix tape was measured and applied over the anterior aspect of the patella (Appendix J).

Small portions of the Hypafix tape extended past the medial and lateral side of the patella and were firmly anchored to the skin. Once this procedure was completed, the LT was applied to the central portion of the patella. The tape was then tensioned, tilting the patella in a medial direction. The remainder of the tape was then laid down medially over the surrounding tissues. In order to correct the glide of the patella, tape was held with tension in one hand while the other hand glided the patella medially. The tissues surrounding the knee were gathered upwards and the remainder of the LT was applied.

Application of the KT replicated the U-Strip technique outlined by Pope, Baker, and Grindstaff (2010) and Kase et al. (2013). The length of the tape required was measured using the distance from the medial to lateral portion of the patella (Appendix K). With the participant in a supine position with the knee fully extended, the KT was applied over the base of the patella. Roughly half of the tape's full tension was applied to the participant's knee. A downward pressure was used when placing the KT over the lower portion of the patella. This tension was determined by stretching the KT until the wave pattern and spaces between the tape's fibers emerged. Once the tape was placed over the patella, the participant flexed his/her knee to a 90° position. As the participant flexed the knee, the remainder of the KT was laid down around the patella with slight tension.

Design and Analysis

A group (affected vs. comparison) x condition (KT; LT; NT) mixed factorial design, with repeated measures on the second factor was implemented. A Wilcoxon Signed Ranks was conducted to examine intra-group differences across the conditions, whereas a Mann-Whitney U Test was used to examine inter-group differences. The alpha level was set at .05.

Results

Pain

In terms of intra-group comparisons (Table 1), the affected group showed no statistically significant differences in pre-pain levels when KT and LT (Z = -4.7, p = .65), KT and NT (Z = -1.34, p = .10), and LT and NT conditions were compared (Z = -1.3, p = .18). The same was true for the comparison group regarding KT and LT (Z = -1.0, p = .31), KT and NT (Z = -1.0, p = .31), and LT and NT comparisons (Z = -1.0, p = .31). With regards to post-pain levels, the affected group once again revealed no statistical differences between KT and LT (Z = -4.7, p = .65), KT and NT (Z = -1.6, p = .10), or LT and NT conditions (Z = -1.6, p = .10). Also, no differences were found for the comparison group when KT and LT (Z = -1.0, p = .31), KT and NT (Z = -.47, p = .65), or LT and NT (Z = -1.3, p = .18) were compared. In terms of inter-group differences, particularly at the post-test condition, the differences between the groups were significant for all three taping conditions (KT (U = .50, p = .02); LT (U = 0, p = .01); NT (U = 0, p = .02).

Table 1

Pre and Post Pain Levels in Comparison (1-5) and Affected (6-8) Participants with Different Taping Conditions

	Pre			Post		
Participant	KT	LT	NT	KT	LT	NT
1	0	0	0	0	0	0
2	0	0	2	0	0	3
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	2	0	0	0	1	1
M *(SD)*	0.4 *(0.8)*	-	0.4 *(0.8)*	-	0.2 *(0)*	0.8 *(1.3)*
6	4	5	6	4	4	6
7	3	1	4	3	1	6
8	2	2	2	2	3	5
M *(SD)*	3.0 *(1.0)*	2.6 *(2.0)*	4.0 *(2.0)*	3.0 *(1.1)*	2.6 *(1.5)*	5.6 *(0.5)*

Note. KT = Kinesio tape; LT = Leukotape; NT = No tape

Range of Motion

For the purpose of inferential analysis, the data obtained from participants 5 and 6 was removed, as performances were three standard deviations below the group mean. The intra-group analyses of knee flexion revealed no significant differences in the affected group when ROM was compared between KT and LT ($Z = -.44$, $p = .65$), KT and NT ($Z = -1.3$, $p = .18$), and LT and NT conditions ($Z = -.44$, $p = .65$) (Table 2). Similar results were found within the comparison group, as no significant differences were revealed when KT and LT ($Z = -1.4$, $p = .14$), KT and NT ($Z = -.36$, $p = .75$), and LT and NT conditions ($Z = -1.8$, $p = .06$) were compared. The analysis of inter-group comparisons once again showed no significant differences between groups for KT ($U = 2.0$, $p = .53$), LT ($U = 2.5$, $p = .53$), and NT conditions ($U = 3.0$, $p = .80$).

With regards to knee extension, the analyses of intra-group comparisons showed that the affected group exhibited no significant differences between KT and LT ($Z = -.44$, $p = .65$), KT and NT ($Z = -1.4$, $p = .15$), or LT and NT conditions ($Z = -.44$, $p = .65$). The comparison group also exhibited no significant differences between KT and NT ($Z = -1.6$, $p = .10$), KT and LT ($Z = -1.8$, $p = .06$), or LT and NT ($Z = -.44$, $p = .65$) conditions. With respect to inter-group comparisons for knee flexion, no statistically significant differences were found between the groups for KT ($U = 1.5$, $p = .23$), LT ($U = .5$, $p = .10$), and NT conditions ($U = 0$, $p = .13$).

Table 2

Contrast of Knee Range of Motion (°) Performances in Comparison (1-5) and Affected (6-8) Participants with Different Taping Conditions

	Flexion			Extension		
Participant	KT	LT	NT	KT	LT	NT
1	126.0	120.6	126.6	6.0	7.3	8.6
2	128.3	126.0	128.6	4.0	4.6	4.0
3	148.3	132.3	143.0	6.0	4.6	6.6
4	119.3	120.3	120.6	3.6	4.0	9.0
M	130.4	124.8	129.7	4.9	6.8	7.0
(SD)	*(12.4)*	*(5.6)*	*(9.4)*	*(1.2)*	*(1.8)*	*(2.2)*
7	139.3	120.6	128.0	3.0	4.6	2.3
8	140.6	145.3	138.3	4.0	2.6	3.3
M	139.9	132.9	133.1	3.5	3.6	2.8
(SD)	*(0.9)*	*(17.4)*	*(7.2)*	*(0.7)*	*(1.4)*	*(0.7)*

Note. KT = Kinesio tape; LT = Leukotape; NT = No tape

Power

The intra-group analyses revealed no significant differences in the affected group when power was compared between KT and LT ($Z = -.81$, $p = .41$), KT and NT ($Z = -.53$, $p = .59$), or LT and NT conditions ($Z = -.44$, $p = .65$) (Table 3). Similar results were found for the comparison group as no significant differences were found between KT and LT ($Z = -1.8$, $p = .06$), KT and NT ($Z = -1.4$, $p = .13$), or LT and NT ($Z = -.13$, $p = .89$). In terms of inter-group comparisons, the analysis revealed no statistical differences between groups for KT ($U = 4.0$, $p = .39$), LT ($U = 5.0$, $p = .57$), and NT ($U = 5.0$, $p = .45$).

Table 3

The Amount of Power (Watts) Produced in Comparison (1-5) and Affected (6-8) Participants with Different Taping Conditions

Participant	KT	LT	NT
1	3109.3	3006.1	2723.2
2	4559.6	4559.6	4717.4
3	3680.4	3601.5	3486. 7
4	6064.7	5801.7	5862.4
5	4584.9	4342.1	4463.5
M *(SD)*	4399.7 *(1119.6)*	4262.2 *(1058.2)*	4441.6 *(1297.1)*
6	4363.9	4242.5	4339.6
7	3594.7	3716.1	3655.4
8	3376.3	3194.2	3194.2
M *(SD)*	3778.3 *(518.7)*	3717.6 *(524.1)*	3729.7 *(576.3)*

Note. KT = Kinesio tape; LT = Leukotape; NT = No tape

Balance

In terms of the affected group, no intra-group differences were evident in the balance domain (p = .10 - 1.0) when each of the eight directions were compared for the KT, LT, and NT conditions (Table 4). The same was true for the comparison group as no significant differences were found across directions and taping conditions (p = .06 – 1.0). In regards to inter-group comparisons, statistically significant differences were found in the anterior, anterolateral, anteromedial, posterolateral, and lateral directions with KT (U = 0, p = .02). Similar results were found with LT when the anterior, anterolateral, anteromedial, posteromedial, medial, lateral (U = 0, p = .02) and posterior directions (U = 0.5, p = .03) were examined. The analysis of the NT condition revealed significant differences between groups in the posterior, posterolateral, medial, and lateral directions (U = 0, p = .02).

Table 4

Contrast of Taping Conditions on Balance with Comparison and Affected Groups

	Condition					
	KT		LT		NT	
	M	*SD*	M	*SD*	M	*SD*
Balance (%)						
Comparison						
A	124.7	*9.6*	125.2	*9.6*	120.4	*7.9*
AL	121.6	*14.1*	119.8	*14.1*	117.1	*12.5*
AM	127.0	*5.7*	127.4	*7.9*	119.0	*12.8*
PM	117.0	*9.0*	116.7	*7.0*	115.1	*8.9*
P	109.6	*7.8*	112.1	*5.1*	110.1	*6.9*
PL	105.9	*11.1*	103.6	*8.9*	102.2	*11.6*
M	125.9	*8.2*	126.4	*7.5*	128.9	*4.9*
L	102.0	*22.6*	98.5	*21.0*	104.4	*24.2*
Affected						
A	91.3	*18.3*	90.8	*16.9*	90.8	*17.6*
AL	80.4	*17.3*	80.6	*13.4*	81.3	*16.6*
AM	91.8	*17.6*	91.3	*16.7*	89.5	*17.5*
PM	94.9	*18.8*	96.6	*14.9*	94.8	*15.3*
P	94.2	*9.0*	90.4	*12.8*	83.9	*13.7*
PL	72.1	*31.4*	81.4	*14.9*	75.9	*14.3*
M	97.3	*19.9*	74.1	*36.1*	92.9	*23.2*
L	60.4	*6.6*	62.3	*10.0*	58.6	*10.2*

Note. KT = Kinesio tape; LT = Leukotape; NT = No tape; A = Anterior; AL = Anterolateral; AM = Anteromedial; PM = Posteromedial; P = Posterior; PL = Posterolateral; M = Medial; L = Lateral

Strength

The intra-group analyses of flexor strength revealed no significant differences within the affected group when KT and LT (Z = -1.0, p = .59), KT and NT (Z = -.53, p = .59), or LT and NT conditions (Z = 0, p =1.0) were compared (Table 5). The same scenario was true for the comparison group, as no significant differences were found between KT and LT (Z = -.94, p = .34), KT and NT (Z = -.67, p = .50), or LT and NT conditions (Z = -3.6, p = .46). In terms of inter-group comparisons, once again, statistical analysis revealed no differences for any of the conditions (KT (U = 2.0, p = .10); LT (U = 2.0, p = .10); NT (U = 4.0, p = .29)).

Intra-group analyses of extensor strength revealed no statistical differences in the affected group between KT and LT (*Z* = -.53, *p* = .59), KT and NT (*Z* = -1.6, *p* = .10), or LT and NT conditions (*Z* = -1.0, *p* = .28) (Table 5). Similarly, no statistical differences were found between KT and LT (*Z* = -.94, *p* = .34), KT and NT (*Z* = -1.8, *p* = .06), or LT and NT (*Z* = -.40, *p* = .68) for the comparison group. In terms of inter-group comparisons, also no differences in strength were found with KT (*U* = 3.0, *p* = .18), LT (*U* = 3.0, *p* = .25), or NT (*U* = -1.2, *p* = .22) conditions.

Table 5

Contrast of Knee Strength Performances (lbs) in Comparison (1-5) and Affected (6-8) Participants with Different Taping Conditions

	Flexion			Extension		
Participant	KT	LT	NT	KT	LT	NT
1	31.6	28.2	30.8	30.2	24.1	29.9
2	51.5	51.7	33.5	46.5	47.2	38.7
3	39.8	42.7	45.8	41.7	43.4	44.3
4	59.3	61.4	51.6	55.5	49.8	37.9
5	57.2	59.4	60.4	57.2	59.0	67.8
M	47.8	48.7	44.4	46.2	44.7	43.7
(SD)	*(11.8)*	*(13.6)*	*(12.3)*	*(10.9)*	*(12.8)*	*(14.4)*
6	28.2	23.0	18.5	34.4	33.3	24.4
7	38.3	32.5	33.6	38.6	37.1	38.3
8	34.9	36.8	39.7	41.2	40.5	32.2
M	33.8	30.7	30.6	38.0	36.9	31.6
(SD)	*(5.1)*	*(7.0)*	*(10.9)*	*(3.4)*	*(3.6)*	*(6.9)*

Note. KT = Kinesio tape; LT = Leukotape NT = No tape

Discussion

Pain

Pain is considered to be the primary symptom of acute patellar tendinopathy (Rio et al., 2014; Williams, Whatman, Hume, & Sheerin, 2012) and previous research has shown that therapeutic tape may serve as a potential treatment when applied to the knee (Campolo et al., 2013). The results of the current study did not confirm this finding, as no substantial differences were found within the affected and comparison groups regarding pre- and post-pain levels, across the taping conditions (Table 1). This may be attributed to the fact that participants were experiencing little to no pain at the initial level of assessment, thus, leaving minimal opportunity for improvement. Although pain did not decrease within the affected group, it should be noted that it was also not enhanced despite the fact that participants were engaged in several ballistic tasks. Thus, it appears that both therapeutic tapes may reduce further pain, which could possibly stem from the tapes' structural characteristics and the different methods of application (Farrar, Portenoy, Berlin, Kinman, & Strom, 2000; Kase et al., 2013; McConnell, 1996; Williams et al., 2012). For example, the McConnell taping technique implemented a mechanical correction to medially glide and tilt the patella, equalizing the force distribution within the quadriceps muscles (McConnell, 1996). On the other hand, the application of KT incorporated a tendon correction, which is believed to decrease pressure over the taped area (Kase et al., 2013). From a clinical standpoint, the fact that both tapes reduced further pain represents a valuable outcome. This may be beneficial for an individual who is competing in sport or attempting to rehabilitate through a set of active exercises. As for the comparison group, few participants were experiencing knee pain; therefore, the lack of statistical differences is intuitively pleasing. Regarding inter-group comparisons, substantial differences in pain were measured across the taping conditions. These findings were expected, as only one group was experiencing pain. Ultimately, it appears that therapeutic tape does not substantially decrease pain in varsity athletes with acute patellar tendinopathy. However, both tapes may be beneficial for the limitation of further pain when multiple tasks are being performed.

Range of Motion

The application of therapeutic tape had minimal effect on knee flexor ROM within the affected group (Table 2). These results are partially consistent with Sanzo et al. (2014) who found no improvements with KT, but observed decreased knee flexion with LT. The authors believed that the structural rigidity of LT prevented the participants from achieving maximal knee flexion range (Sanzo et al., 2014). It is likely that the discrepancies between the past and current results are attributed to the population demographics, as Sanzo et al. (2014) incorporated healthy as opposed to a pathological population. Furthermore, it is believed that individuals with acute patellar tendinopathy experience reduced ROM as a result of pain influences (Renström & Woo, 2007). Within the current study, only low to moderate pain levels were reported among the affected participants. It is possible that these low measures of pain did not appear to reduce knee mobility and could explain why participants were able to achieve optimal ROM during each of the taping conditions. Within this domain, optimal knee flexion is approximately 130° (Roach & Miles, 1991; Shah, 2008).

In terms of the comparison group, it was expected that therapeutic tape would have little effect on ROM, based on the absence of pathology. The results of the current study confirmed this hypothesis and these findings are not consistent with Sanzo et al. (2014), where the application of LT substantially decreased ROM. The inconsistent results between the current study and Sanzo et al. (2014) may be attributed to the age and number of male and female participants included within the samples. Furthermore, differences in knee flexion were expected between the comparison and affected groups. This was also not the case, as performances were comparable across the taping conditions. These results may be attributed to the low pain levels reported within the affected group, as they may have not been enough to substantially reduce knee flexion. As for knee extensor range (Table 2), no substantial differences were found across the taping conditions within the affected group and these results are consistent with previous findings (Sanzo et al., 2014). Thus, even in the presence of pathology, participants were able to approach full knee extension across the taping conditions (Roach & Miles, 1991; Shah, 2008). It is plausible that less tensile strain is acting on the patellar tendon when performing knee extension versus knee flexion movements (Almekinders, Vellema, & Weinhold, 2002). The presence of pain or tenderness may be absent when performing the extension movement because the tendon is not in a fully stretched position. Therefore, it is difficult to infer how or if therapeutic tape has any effects on knee extensor range. With regards to the comparison group, no substantial differences were found. These results were expected based on the absence of pathology and are consistent with the previous findings (Sanzo et al., 2014).

Power

Therapeutic tape does not appear to increase power within the affected and comparison groups, as performances were comparable across the taping conditions (Table 3). These findings are consistent to those previously reported by Nunes, De Noronha, Cunha, Ruschel, and Borges (2013), who believed that the effects of therapeutic tape are not sufficient enough to elicit an underlying sensory response, which includes the stimulation of the mechanoreceptors and Golgi tendon organs underlying the taped skin (Kase et al., 2013). Moreover, trends within the comparison and affected groups revealed decreases in performance with LT when compared to the baseline NT condition. It is possible that the structural characteristics of the tape contributed to these findings, as the rigidness of LT may have prevented the participants from forcefully flexing the knee (Sanzo et al., 2014) during the jumping maneuver. From a clinical standpoint, if therapeutic taping were to be implemented as a treatment intervention for athletes with acute patellar tendinopathy, KT may be the optimal selection when considering that the two affected participants (6 and 8) generated greater power with its application. The elastic properties of KT allow it to be supportive to the knee's primary movements (Kase et al., 2013), while positively influencing the amount of power being produced. Furthermore, no substantial differences were found across conditions regarding inter-group comparisons. These results are surprising when considering that members of the comparison group were injury free and did not have any limitations in amount of power being produced at the knee. Overall, it appears that therapeutic tapes have limited effect on power production. Health care providers that are considering therapeutic tape as a supplementary tool or treatment option, should consider the tapes structural characteristics before applying it to the knee.

Balance

The status of balance control, as inferred from the SEBT, remained unchanged in both groups when therapeutic tape was applied to the knee (Table 4). These findings were unexpected for those within the affected group, given that the application of therapeutic tape was intended to increase support at the knee and potentially stimulate underlying sensory systems when performing the directional movements (Kase et al., 2013; McConnell, 1996). Similar to power, it is plausible that the effects of therapeutic tape are not robust enough to elicit an underlying sensory response and may explain why no substantial increases in balance performances were revealed (Nunes et al., 2013). In terms of previous research, the study's current findings are in-line with Bicici et al. (2012) who measured the effects of KT on inversion ankle sprains. Using the SEBT, they found no substantial differences in reach distance when NT, PT, athletic tape, and KT were applied. Thus, it appears that regardless of the joint or condition measured, taping may not affect balance performances when measured in physically active individuals with patellar tendinopathy.

In terms of inter-group comparisons, substantial differences were found for the majority of directions with therapeutic tape. These findings were expected, considering that only one group was symptomatic and experiencing movement impairments in the lower quadrant. The results emerging here are not in line with Nakajima and Baldridge (2013) who found no considerable differences in balance performances during the SEBT between an experimental and control group. The experimental group consisted of healthy participants who received KT with applied tension on the ankle joint. Those in the control group also received KT but with no tension. The discrepancies between the current study and Nakajima and Baldridge (2013) are likely attributed to the lack of a comparison group consisting of a pathological population and the taping techniques measured. Therefore, it appears that regardless of the population (e.g., healthy versus pathological), therapeutic tape has no effect on balance and the differences between the groups are likely attributed to movement restrictions within the affected group.

Strength

When observing the effects of therapeutic taping on muscular strength, no substantial differences were found within the affected group (Table 5). At the group and individual level of analyses, greater knee flexor (6 and 7) and extensor strength (6-8) was generated with KT when compared across the taping conditions. The group findings do not support those previously reported by Osorio et al. (2013) who found significant improvements in strength with therapeutic tape. The inconsistencies from the current study are likely attributed to the method of assessing strength, as the latter study examined isokinetic and not isometric knee strength. Isometric strength is generated through static movements whereas isokinetic strength is generated through dynamic movements (Fahey, Insel, Roth, & Wong, 2007). Therefore, the application of therapeutic tape may have a different effect on strength when performing dynamic versus static tasks. Also, the presence of swelling within the tendon area may have contributed to the current findings.

Swelling is a reported symptom of acute patellar tendinopathy and has been reported to inhibit muscular contraction at the knee (Renström & Woo, 2007; Spencer, Hayes, & Alexander, 1984). Decreased muscular contraction results in less strength being produced (Spencer et al., 1984). All three affected participants were experiencing swelling at the time of testing; however, levels were more moderate for participant 6. This may explain why participants 7 and 8 generated greater strength when compared to participant 6. When LT was applied, the presence of swelling may have reduced the overall effectiveness of the McConnell taping technique, by inhibiting muscular contraction at the knee (McConnell, 1996). Additionally, the U-strip technique with KT may not have been sufficient to reduce the amount of pressure surrounding the taped area preventing any underlying fluid from dissipating (Kase et al., 2013). In terms of the comparison group, it was hypothesized that therapeutic tape would have minimal effect on strength due to the absence of knee pathology. This was confirmed by the data where knee flexor and extensor strength were comparable across taping conditions (Table 5), and this is consistent with previous research (Sanzo et al., 2014). Similar results were also found regarding inter-group comparisons, as minimal differences in performance were found across the taping conditions. These results are surprising when considering that participants in the comparison group generated approximately 10 lbs more strength than those in the affected group. The presence of symptoms (e.g., pain, tenderness, or swelling) within the affected group may have reduced muscular contraction when performing the resisted isometric flexion and extension movements (Renström & Woo, 2007; Spencer et al., 1984). Thus, the implementation of additional sophisticated laboratory equipment may be needed to detect the effects of therapeutic taping on muscular strength, as previous research has reported substantial findings using a Biodex system (Osorio et al., 2013).

Conclusion

The purpose of this preliminary investigation was to determine the effectiveness of therapeutic taping on pain, ROM, power, balance, and strength in individuals with and without acute patellar tendinopathy. The overall results of the present study revealed no substantial differences on the measured constraints when therapeutic tape was applied to the knee for those with and without the condition. It should be noted that participants in the affected group were still receiving therapeutic treatment from their health care provider throughout the course of the study. This may have created both positive and negative residual effects on the day of testing, which may have influenced performance. Moreover, small sample sizes make the generalizability of the findings limited. It appears both KT and LT may be beneficial for the reduction of further pain for some individuals. However, future research should consider the implementation of a placebo condition in order to make any definitive conclusions regarding the effectiveness of the therapeutic tape.

Main Study

Based on the results from the pilot study, it appeared that individuals with lower physical activity levels could experience greater improvements with the use of therapeutic tape compared to varsity level athletes. More specifically, it is plausible that the effect of the tape(s) was magnified in populations who suffered from patellar tendinopathy but who were not physically active. Since patellar tendinopathy remains a common overuse injury in active populations

(Murtaugh & Ihm, 2013; Cook & Khan, 2007), their quality of life may be negatively affected by the common symptoms of this injury.

Therefore, the purpose of this research was to examine the effects of therapeutic taping on knee pain, ROM, power, balance, and strength, in physically active male and female adults between the ages of 18 and 45 years, with patellar tendinopathy. It was hypothesized that therapeutic taping (KT and LT) would be effective at reducing pain and increasing knee ROM (flexion and extension), power, balance, and strength (flexor and extensor) when compared to NT and the application of PT in physically active individuals with patellar tendinopathy. It was also hypothesized that KT would be more effective than LT for all dependent measures.

Method

Participants

Participants were recruited through purposive sampling (Trochim, 2005). After obtaining ethical approval, poster advertisements (Appendix L) were placed in Thunder Bay health clinics that provided injury rehabilitation services. Each intended facility was contacted by phone or in-person to obtain advertisement permission (e.g., Thunder Bay Physiotherapy Centre, Victoriaville Physiotherapy Centre, Fairway Physiotherapy, Lakehead University Sports Medicine Clinic, Walser Physiotherapy, Northern Physiotherapy, Fanti Physiotherapy, Partners in Rehab, CBI Physiotherapy and Rehabilitation Centre, and Active Rehabilitation and Fitness). Health care providers (e.g., physicians, physiotherapists, athletic therapists, chiropractors) within these centers were also contacted directly (phone or email) and were provided with recruitment letters (Appendix M) to give to potential participants. Poster advertisements were also placed in local fitness centers for the purpose of recruitment (e.g., Push Fitness, Synergee Fitness, Movati Athletic, Chase Fitness, Unleashed Fighting Fitness, Southside Fitness, Canada Games Complex, Fit 4 Less, Anytime Fitness, Lakehead University Wolves Den, and Confederation College Fitness Centre). Social media (i.e., Facebook and Twitter) was also utilized for recruitment. The primary researcher obtained permission from the School of Kinesiology at Lakehead University to display a recruitment poster (Appendix N) on the school's Facebook page and Twitter account. This poster was shared publicly and those interested were instructed to contact the primary researcher via email.

Participants for this study included physically active men and women with patellar tendinopathy who were between the ages of 18 and 45 (M = 25 years; SD = 8.0). To be considered physically active, the participant must have engaged in at least 150 minutes of moderate to vigorous exercise (e.g., brisk walking, cycling, or jogging) per week as recommended by the American College of Sports Medicine [ACSM] (2009) and the Canadian Society for Exercise Physiology [CSEP] (2011). Also, each participant had to be diagnosed with acute or chronic patellar tendinopathy from a certified health care provider (e.g., physician, physiotherapist, athletic therapist, or chiropractor), at the time of the study. Participants were excluded from the study if he/she participated in excess of 300 minutes of moderate to vigorous exercise a week, had undergone any knee surgery within the past five years, or were currently experiencing any additional lower body injuries or conditions. Also, those who received corticosteroid injections in the knee within the past year or were allergic to adhesives such as athletic tape or Tuf-Skin®, were excluded. A total of 10 participants were recruited.

Procedure

After informed consent was obtained (Appendix O), the majority of testing procedures and measures were replicated from the pilot study (e.g., informal interview, pain, ROM, power, balance, and strength measures, and the LT procedure). For the purpose of this study, a placebo

(PT) condition was incorporated to control for placebo effects (Appendix O). Also, for the purpose of this study, the taping procedure used for the KT consisted of the Pitchfork Technique as opposed to the original U-Strip technique (Appendix Q). Additionally, a Lafayette Manual Muscle Tester was used in place of a Baseline Electronic Hydraulic Push-Pull Dynamometer, in order to measure more reliably the degree of strength (Appendix R).

Taping Procedure

Prior to the application of KT, LT, and PT, a topical adhesive spray known as Tuf-Skin® was applied to the participant's knee, directly over the taping area. The PT application procedure consisted of a piece of Hypafix applied over the anterior aspect of the patella without any tension or compression (Constantinou, 2010). Furthermore, KT was applied using the Pitchfork Technique outlined by Kase et al. (2013) and Pope et al. (2010). The length of the tape was determined by measuring the distance from the medial to the lateral portion of the patella and was cut to length accordingly. Each corner of the tape was rounded in order to maximize tape adhesion to the skin. The participant was then asked to lie in a supine position with the affected knee fully extended. Once comfortable, the KT was applied over the base of the patella. Roughly 50% paper off tension was applied to the participant's knee with a downward and inward pressure. This tension was determined by stretching the KT until the wave pattern and spaces between the tape's fibers emerged. Once the tape was placed over the base of the patella, the participant slowly flexed his/her knee to a 90˚ position. During this motion, the remainder of the KT was placed around the patella with approximately 15 to 25% paper off tension.

A second strip of KT was then placed vertically over the knee. With the participant's leg flexed, the KT was anchored approximately 7 cm inferior to the tibial tuberosity with no tension.

Once adhered, the tape was slightly tensioned (15 to 25% paper off tension) and applied over the superior aspect of the knee to approximately 12 cm above the top portion of the patella.

Design and Analysis

A repeated measures factorial design was implemented in this study. To analyze the differences in perception of pain across the different tapes and times of administration, a 4 x 2 (Tape [KT, LT, NT, PT] x Time [Pre, Post]) repeated measures factorial ANOVA was conducted. To examine the potential effects of different taping conditions on ROM, power, balance, and strength, a one-way ANOVA, with taping condition as a repeated measure factor was used. A Huynh-Feldt correction was also implemented if the assumption of sphericity had been violated. Also to infer the amount of variance explained an eta square was implemented for the ANOVA analyses, whereas the meaningfulness of the differences between the means was inferred from Cohen's *d* when the dependent samples t-test were performed. The alpha level was set at .05.

Dependent Variables

The dependent variables for this study included measures of pain, ROM, power, balance, and strength. Since the variables implemented here were consistent with those used for the pilot study, please refer to pages 15 to 18 for their detailed description.

Results

Morphological Characteristics and Subjective Information

Two female (mean age 27.0 ± 11.3 years, height 173.0 ± 7.0 cm, and weight 65.3 ± 4.3 kg) and 8 male participants were recruited (mean age 24.5 ± 8.4 years, height 182.5 ± 5.3 cm, and weight 91.1 ± 17.7kg). Across the group, participants reported that repeated and forceful bending of the knee was the most common aggravating factor for their condition (Appendix S).

This movement was typically experienced during activities like running and playing basketball, soccer, and volleyball. Some of the primary symptoms of the injury included pain, stiffness, tenderness on palpation, and the presence of minimal swelling. Seven participants (1, 3, and 5-9) were able to participate in activity despite the presence of knee discomfort, whereas the rest (2, 4, and 10) did not participate in certain sports due to the presence of pain or additional symptoms. Of the ten participants, three (1, 3 and 5) were experiencing acute symptoms. The remaining participants were experiencing chronic symptoms. None of the participants were currently receiving treatment from a health care provider and only four participants (2, 5, 7, and 8) were applying self-treatment methods, when needed. These included non-steroidal anti-inflammatory medications, cryotherapy, or thermotherapy.

Pain

The results from the repeated measures factorial ANOVA revealed no significant interaction (F (3, 36) = 0.73, p = .53, η^2 = 0.58) or main effects for Time (F (1, 36) = 0.20, p = .65, η^2 = .006), as well as Taping Condition (F (3, 36) = .49, p = .68, η^2 = .04) (Figure 1).

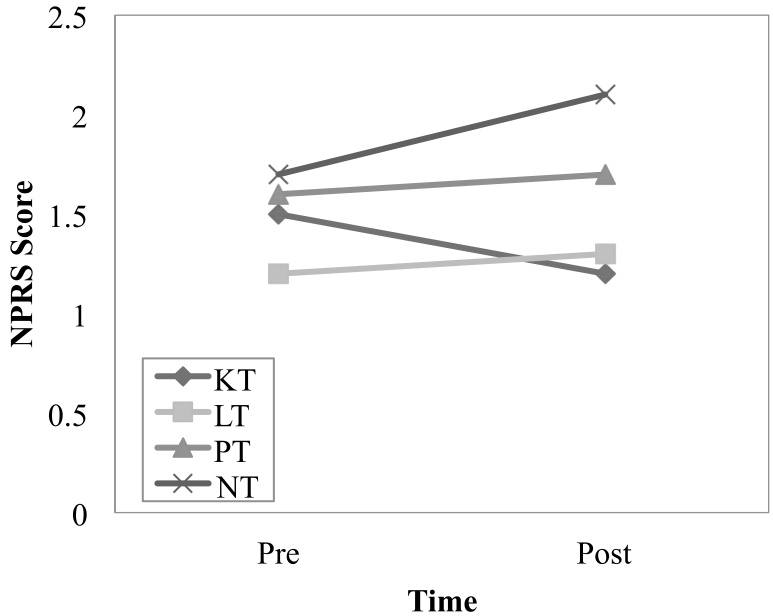

Figure 1. **Mean pain scores experienced across the different taping conditions during pre- and post-treatment measurements.**

The lack of differences at the group level was further confirmed at the individual level of analysis (Table 6). There were two participants (1 and 5) who reported lower pain scores post-treatment with KT. However, this was not the case with NT, as three participants (2, 8, and 10) reported higher pain scores post-session. In terms of LT, only participant 6 reported a lower pain score post-session. Lastly, pain scores remained unchanged with the PT condition. Also as evident from the individual scores, none of the participants exhibited a high perception of pain to begin with, across the different conditions, at pre-test. These pre-test scores were also to a large degree consistent for each participant across the different conditions indicating that low perception of pain was a stable trait.

Table 6

Participant Pre- and Post-Pain Scores with Different Taping Conditions

	Pre				Post			
Participant	KT	LT	PT	NT	KT	LT	PT	NT
1	4	2	3	5	2	2	3	3
2	0	0	2	0	1	0	1	2
3	4	2	3	2	3	2	3	2
4	0	0	0	0	0	0	0	0
5	3	2	3	4	1	2	3	4
6	0	2	0	1	1	1	0	1
7	1	2	3	3	1	2	2	2
8	3	0	0	3	3	1	3	5
9	0	2	2	0	0	2	2	0
10	0	0	0	0	0	1	0	2
M	1.5	1.2	1.6	1.8	1.2	1.3	1.7	2.1
(SD)	*(1.8)*	*(1.0)*	*(1.4)*	*(1.8)*	*(1.3)*	*(0.8)*	*(1.3)*	*(1.6)*

Note. KT = Kinesio tape; LT = Leukotape; PT = Placebo tape; NT = No tape

Range of Motion

In terms of ROM (Table 7), the results from the repeated measures ANOVA revealed no significant differences in performance between the taping conditions for knee flexion (F (3, 27) = 1.86, p = .16, η^2 = .17). Regarding individual performances, six participants (2, 4-7, and 10) generated greater knee flexion with KT when compared to NT and PT. In terms of LT, only participant 1 generated greater knee flexion when compared to NT and PT. Comparisons between KT and LT revealed that nine participants (2-10) generated greater knee flexion with KT when compared to LT. Performances were also relatively stable under the KT and LT conditions, indicating that the effects associated with KT and LT were consistent among the participants. Similar results were also revealed when therapeutic tape was compared to the NT condition. Lastly, the effects pertaining to the PT application were relatively inconsistent among participants when compared across the taping conditions.

Knee extension performances revealed no significant differences between the taping conditions (F (3, 27) = 1.0, p = .45, η^2 = .10) (Table 7). There were four participants (3-6) that generated greater knee extension with therapeutic tape when compared to NT and PT. Of these four participants, three (4-6) generated greater knee extension with LT. When LT was compared to KT, six participants (2, 4-7, and 10) generated greater knee extension with LT. There were also two participants (1 and 8) that generated the same range with LT and KT. Additionally, the effects pertaining to the KT and LT applications were relatively stable among the participants. Similar consistencies were also revealed when therapeutic tape was compared to the effects of NT and PT.

Table 7

Participants Range of Motion (°) Performance with Different Taping Conditions

	Flexion				Extension			
Participant	KT	LT	PT	NT	KT	LT	PT	NT
1	131.7	133.3	131.0	130.7	5.7	5.7	4.3	4.0
2	135.7	131.7	85.7	130.0	1.0	-0.7	-5.3	0.7
3	126.3	109.3	129.3	131.6	4.3	5.3	5.3	6.3
4	136.0	132.7	135.6	135.6	3.3	2.0	3.0	2.7
5	141.7	132.0	141.3	142.0	1.0	0.7	1.6	4.0
6	135.7	126.7	130.0	134.7	2.3	-4.0	2.3	0.0
7	133.3	130.7	127.7	126.0	8.7	8.3	9.0	8.3
8	142.3	130.3	143.7	141.0	2.3	2.3	2.3	-1.7
9	146.3	143.3	143.6	149.0	3.7	4.3	3.0	2.3
10	146.6	135.3	141.3	143.6	7.6	5.6	5.3	5.6
M	137.5	130.5	130.9	136.4	4.0	3.0	3.0	3.2
(SD)	*(6.5)*	*(8.6)*	*(17.0)*	*(7.2)*	*(2.6)*	*(3.6)*	*(3.6)*	*(3.0)*

Note. Direction of movement (flexion and extension) does not represent a part of the design. KT = Kinesio tape; LT = Leukotape; PT = Placebo tape; NT = No tape

Power and Strength

The results from the repeated measures ANOVA revealed no significant differences in power between the taping conditions (F (3, 27) = .40, p = .75, η^2 = .04) (Table 8). These results may be attributed to the large intragroup variability found across the taping conditions. There were three participants (1, 5 and 6) that generated greater power with LT when compared to NT and PT. When KT was compared to NT and PT however, none of the participants were able to generate greater power. Comparisons between therapeutic tapes revealed that three participants (4, 7, and 10) generated greater power with KT as opposed to the seven participants (1-3, 5, 6, 8, and 9) with LT. Performances with KT and LT were inconsistent among the participants. This trait was also apparent across the taping conditions, indicating that the performance of the vertical jump task was individualized. Individualized performances were expected considering different morphological characteristics contribute to the vertical jump task and the amount of power being produced.

Table 8

Participant Power Production (Watts) with Different Taping Conditions

Participant	KT	LT	PT	NT
1	5118.3	5138.5	5077.8	4976.6
2	5417.6	5498.5	5498.5	5437.8
3	4140.5	4201.2	4322.6	4407.6
4	4436.5	4396.0	4375.8	4456.7
5	2702.6	2925.2	2682.4	2884.7
6	3899.7	4385.3	4324.6	3312.9
7	5850.0	5769.1	5809.6	5890.5
8	4332.8	4474.4	4454.2	4575.6
9	3869.5	3930.2	4031.4	3889.7
10	4811.4	4544.3	4847.8	5034.0
M	4457.9	4526.2	4542.4	4486.6
(SD)	*(899.1)*	*(811.6)*	*(866.1)*	*(926.7)*

Note. KT = Kinesio tape; LT = Leukotape; PT = Placebo tape; NT = No tape

In regards to knee flexor strength (Table 9), a main effect for therapeutic tape was found (F (3, 27) = 5.04, $p < .05$, $\eta^2 = .32$). The results from the paired samples t-test revealed that there was a significant difference in knee flexor strength when comparing the KT and LT (t (9) = 3.01, $p < .05$), KT and NT (t (9) = 2.84, $p < .05$), and KT and PT conditions (t (9) = 4.05, $p < .05$) conditions. Analysis of individual performances further confirmed this finding as nine participants produced greater strength with KT (1, 3-5, 7, 8, and 10) and LT (2 and 9) when compared to NT and PT. When performances with therapeutic tape were compared, all but participant two generated greater strength with KT. The effects of KT and LT were consistent among participants. This trait was also apparent across the taping conditions, indicating that the differences in performance may be related to therapeutic effects.

With respect to knee extensor strength (Table 9), the results from the repeated measures ANOVA revealed no significant differences between the taping conditions (F (3, 27) = 2.3, p = .07, $\eta^2 = .20$). Regarding individual performances, there were six participants (1, 2, 6-8, and 10) that produced greater strength with KT and two participants (2 and 9) with LT when compared to NT and PT. When KT and LT were compared, eight participants generated greater strength with KT (1, 2-8, and 10). Once again, the effects of KT and LT were stable among the participants. This was also apparent across the taping conditions, indicating uniform performances.

Table 9

Participant Knee Strength Performances (lbs) with Different Taping Conditions

	Flexion				Extension			
Participant	KT	LT	PT	NT	KT	LT	PT	NT
1	57.2	48.1	43.6	35.2	73.0	61.4	48.1	34.1
2	85.5	90.8	85.7	71.2	89.5	96.7	92.7	91.9
3	41.2	27.6	31.1	27.0	56.9	53.0	46.5	47.0
4	66.7	51.7	60.2	52.2	70.9	67.5	64.6	75.3
5	44.1	42.9	41.2	50.2	42.6	38.6	35.8	46.4
6	55.1	45.2	51.6	55.9	65.6	65.1	61.6	64.2
7	53.3	50.4	46.1	43.8	88.6	77.1	87.2	80.2
8	39.0	33.2	35.6	34.0	52.1	50.8	50.5	43.8
9	40.7	41.2	33.9	38.7	51.3	55.1	41.7	49.0
10	69.8	57.3	69.1	67.3	94.6	76.7	80.6	92.9
M	55.2	48.8	49.8	47.5	68.5	64.2	60.9	62.4
(SD)	*(15.1)*	*(17.1)*	*(17.3)*	*(14.5)*	*(18.0)*	*(16.4)*	*(19.3)*	*(21.3)*

Note. Direction of movement (flexion and extension) does not represent a part of the design. KT = Kinesio tape; LT = Leukotape; PT = Placebo tape; NT = No tape

Balance

In terms of balance (Table 10), no significant effect was found when the therapeutic tapes were compared in the anterior (F (3,27) = .96, p = .42, η^2 = .97), anterolateral (F (3,27) = 1.0, p = .37, η^2 = .10), medial (F (3,27) = .86, p = .47, η^2 = .08), posterior (F (3,27) = 2.7, p = .06, η^2 = .23), and posteromedial (F (3,27) = 1.5, p = .22, η^2 = .14) directions. A significant effect was found between the taping conditions in the anteromedial (F (3,27) = 2.96, p < .05, η^2 = .25), lateral (F (3,27) = 7.2, p < .05, η^2 = .44), and posterolateral (F (3,27) = 3.8, p < .05, η^2 = .30) directions. During the SEBT, greater performances are associated with greater reach distances. The results from the paired samples t-test revealed that reach distances were greater with KT when compared to NT in the anteromedial (t (9) = 3.39, p < .05) and posterolateral (t (9) = 2.57, p < .05) directions. As for the lateral direction, significant differences in performance were found between KT and NT (t (9) = 3.89, p < .05), LT and NT (t (9) = 4.55, p < .05), and NT and

PT (t (9) = -2.69, $p < .05$) conditions. The effects pertaining to KT and LT were relatively consistent among the participants and the directional movements being performed. Similar consistencies were also revealed across the taping conditions, indicating that the substantial differences in performance may be related to the effects of the condition applied.

Table 10

Balance Performances (%) as Inferred by Reach Distance Divided by Leg Length with Different Taping Conditions

	Condition							
	KT		LT		PT		NT	
	M	*SD*	M	*SD*	M	*SD*	M	*SD*
Balance (%)								
A	88.6	*19.9*	85.4	*17.6*	86.9	*18.7*	84.6	*14.9*
AL	80.6	*15.1*	76.7	*14.1*	78.1	*16.3*	75.8	*14.5*
AM	91.8	*16.7*	88.5	*17.8*	91.1	*21.1*	85.5	*13.8*
PM	94.4	*12.5*	93.0	14.8	93.0	*14.8*	88.3	*14.6*
P	94.9	*13.6*	92.2	*13.7*	92.9	*16.8*	88.4	*14.8*
PL	87.2	*14.9*	85.5	*13.8*	84.0	*14.9*	80.4	*13.1*
M	88.7	*18.0*	87.3	*19.9*	88.4	*20.4*	84.0	*16.0*
L	74.6	*14.9*	71.9	*14.6*	71.0	*15.7*	64.5	*12.0*

Note. KT = Kinesio tape; LT = Leukotape; PT = Placebo tape; NT = No tape; A = Anterior; AL = Anterolateral; AM = Anteromedial; PM = Posteromedial; P = Posterior; PL = Posterolateral; M = Medial; L = Lateral

Discussion

Pain

Pain is a symptom of patellar tendinopathy and research regarding its etiology remains inconclusive (Cook & Khan, 2007; Rio et al., 2014; Williams et al., 2012). The present results showed that the application of therapeutic taping (LT or KT) did not substantially decrease pain when applied to physically active individuals with patellar tendinopathy. However, despite the lack of statistically significant changes in the pain levels across the different experimental conditions, clinically significant findings were found regarding the individual profiles (Table 6).

From a clinical standpoint, a difference in pain is defined as a two-level fluctuation in the NPRS score (Farrar et al., 2000). When therapeutic tape (LT and KT) was compared, three participants (2, 8, and 10) pain levels remained unchanged, post-treatment. During the NT condition, these participants experienced a clinically significant increase in pain. It is plausible that both KT and LT may be beneficial for preventing an increase in further pain when applied to the knee if the participant performs similar tasks to those tested in the current study. The current findings partially support the initial hypothesis where KT would be more effective at reducing pain when compared to LT. There were two participants (1 and 5) who experienced clinically significant decreases in pain post-treatment with KT. Both of these participants were in the acute phase of their injury and their pain levels were highest during the NT condition. The application of KT and the taping methods involved may be more effective at preventing further pain when the initial pain levels are at a more moderate level. Ultimately, the application of therapeutic tape may have more of a preventive effect when applied to physically active individuals with acute patellar tendinopathy.

As previously mentioned, few studies have examined the effectiveness of therapeutic taping on pain in physically active individuals with patellar tendinopathy. The results of the current study are not in-line with those previously reported on other knee pathologies (e.g., PFPS). For example, Campolo et al. (2013) examined the effects of two taping techniques (KT and LT) on anterior knee pain in individuals with patellofemoral pain syndrome (PFPS). The taping methods involved with LT were consistent with the current study and Campolo et al. (2013) applied KT to the knee using a quadriceps facilitation method. During a stair-climbing task, application of KT resulted in a substantial decrease in pain when compared to LT. The researchers also found that when a lower body squat was performed, pain levels remained unchanged with therapeutic tape. This indicates that the effectiveness of therapeutic tape may be task specific. Additionally, Campolo et al. (2013) applied KT using a quadriceps facilitation method and not a Pitchfork technique. Thus, the effects of therapeutic tape on pain may be specific to certain tasks, injuries, and taping methods, which can be further supported by additional research.

Osorio et al. (2013) also examined the effects of two taping techniques (KT and LT) on pain in physically active individuals with PFPS. They found that the application of both KT and LT significantly decreased pain when applied to the knee. Osorio et al. (2013) reported that when therapeutic tape was implemented, the mechanoreceptors underlying the taped skin might have decreased the transmission of pain (Aminaka & Gribble, 2008; Kase et al., 2013; Osorio et al., 2013). Additionally, Osorio et al. (2013) speculated that the pain reduction associated with KT might also be attributed to the amount of tape applied to the knee, as more tape was required with KT than with the LT technique. The increase in tape might have further influenced the underlying sensory receptors, ultimately decreasing pain symptoms (Osorio et al., 2013). Although the results from Osorio et al. (2013) showed substantial decreases in pain with KT and LT, this cannot be confirmed within the current study. Only two participants (1 and 5) experienced clinically significant decreases in pain with the KT application. Based on the previous research, it appears that the effects of KT and LT on pain are constrained by the type of injury, population, and the tasks being performed. Although positive effects were observed in some participants (i.e., 1 and 5); overall, KT and/or LT have no effects on pain for physically active individuals with patellar tendinopathy.

Range of Motion

Individuals suffering from patellar tendinopathy often experience pain, which restricts knee range of motion (Williams et al., 2012; Witvrouw et al., 2001; Yoshida & Kahanov, 2007). It was hypothesized that therapeutic tape would increase ROM during knee flexion and extension. This was not confirmed, as both KT and LT did not improve knee flexion or knee extension in physically active individuals with patellar tendinopathy (Table 7). At the group level, optimal knee flexion (approximately 130°) was achieved across the taping conditions (Roach & Miles, 1991; Shah, 2008). It is possible that the amount of pain the participants were experiencing was not substantial enough to limit knee flexor ROM. Perhaps individuals suffering from patellar tendinopathy only experience deficits in range when subjective pain levels are at a more severe level. The effects of therapeutic tape may be more substantial in this regard and could lead to improved ROM. Despite minimal differences across the taping conditions, clinically significant findings were observed regarding individual performances (Table 7).

It has been reported that a 4˚ difference in lower extremity ROM is necessary for a clinically significant change (Boone et al., 1978). When KT was compared NT and PT, only two participants (2 and 7) experienced a clinically significant increase in knee flexion. With regards to the LT application, almost half of the participants (3, 5, 8, and 10) experienced a clinical reduction in knee flexion when compared to NT and PT. Similar findings were also revealed when LT was compared to KT, where over half of the participants (2, 3, 5, 6, 8, and 10) demonstrated deficits in knee flexion (approximately 10.3˚) with LT. These results partially support the initial hypothesis where KT would be more beneficial to knee flexion when compared to LT. The reduced knee flexion with LT may be attributed to the elasticity present within the tapes, as LT is more rigid than KT (Sanzo et al., 2014). From a clinical standpoint, this poses several implications for health care providers considering therapeutic tape as a potential treatment option. Restricted knee mobility may not benefit an individual who performs tasks that require full ROM and excursion in the use of the joints primary movements (e.g., jumping or squatting; Sanzo et al., 2014). In this specific context, the application of KT may be more beneficial than LT, given KT is more elastic and has the potential to elicit other therapeutic effects (e.g., preventing further pain; Kase et al., 2013). In the acute stages or if pain or discomfort is present at the end of range of knee flexion, the goal of the health care provider may be to reduce knee mobility. This will prevent the individual from moving into this painful range that further tensions the patellar tendon. Therefore, in this clinical example, a more rigid tape like LT would be suitable. Overall, it appears that neither KT nor LT may improve knee flexion; however, the elasticity present within the tapes may be appropriate in certain contexts (e.g., decreasing knee flexor ROM).

The effects of therapeutic tape across the taping conditions is partially consistent with Sanzo et al. (2014) who examined the effects of KT, LT, PT, and NT on knee ROM in healthy university students. The taping methods involved with LT were consistent with the current study and Sanzo et al. (2014) found that LT substantially decreased knee flexion when compared to NT and KT. The researchers believed that the rigidness of LT contributed to these results. With respect to the current study, it appears that the lack of substantial findings stems from type of injury measured, as Sanzo et al. (2014) observed decreased knee flexion in a healthy population and not physically active individuals with patellar tendinopathy.

In regards to knee extension, it was believed that the application of therapeutic tape would allow individuals to increase ROM and that KT would be more beneficial than LT. The results revealed that both KT and LT did not substantially improve performances, thus, failing to support the initial hypotheses. This is due to the fact that all 10 participants were able to approach or exceed optimal knee extension (approximately 0°) with and without the tape (Roach & Miles, 1991; Shah, 2008). Similar to knee flexion, it is likely that the presence of pain was not substantial enough to reduce mobility. Thus, the effects of therapeutic tape on ROM are unclear but may be specific to certain populations, body segments, and goals of the health care provider. Given the limited results, it is difficult to infer the appropriateness of therapeutic tape on knee extension. In essence, the application of therapeutic tape does not appear to improve ROM in physically active individuals with patellar tendinopathy.

Power

Activation of the quadriceps muscles is a fundamental component to the vertical jump task, where greater contraction contributes to increased power production (Durfee& Iaizzo, 2006; Sayers et al., 1999). The application of therapeutic tape is believed to generate greater muscular contraction when applied to the knee (Kase et al., 2013; McConnell, 1996). Therefore, it was hypothesized that therapeutic tape would increase power when applied to the knee and that the application of KT would be more effective than LT. The results failed to support these hypotheses, as no substantial changes in power were revealed across the taping conditions (Table 8). Although the amount of power produced remained unchanged across the different experimental conditions, a trend at the individual level revealed seven participants (1-3, 5, 6, 8, and 9) generating greater power with LT (approximately 153.1 Watts) when compared to KT. Therefore, it is possible that the taping methods involved may have contributed to these results. The McConnell taping technique incorporates a mechanical correction that realigns the patella into the trochlear groove (McConnell, 1996). It is believed that this realignment increases the activation of the quadriceps muscles, relieving any potential joint compression (Crossley, Cowan, Bennell, & McConnell, 2000; McConnell, 1996). This could also explain why almost half of the participants (1, 5, 6, and 8) were able to generate greater power with the LT application (approximately 80.9 Watts) when compared to KT and PT. Unlike the McConnell taping technique, the taping method implemented with KT incorporates a tendon correction (Kase et al., 2013). This method is believed to reduce pressure surrounding the patellar tendon and increase mechanoreceptor (sensory) activity underlying the taped area (Kase et al., 2013). Only two participants (4 and 7) generated greater power with KT when compared to PT and LT. Therefore, the KT taping method may not be effective for power production when applied to the knee in physically active individuals with patellar tendinopathy. The application of LT may be more beneficial for power production, as the mechanical correction appears to generate greater power at the individual level when compared to KT.

Vertical jump height is an indirect measure of lower body power (Sayers et al., 1999). Generally, greater power production contributes to a greater jump height (Markovic & Jaric, 2007). The results of the current study are partially supported by Nakajima and Baldridge (2013) who examined the effects of KT on vertical jump height and dynamic postural control (SEBT) in healthy individuals. Using a true experimental design, the analysis revealed that the application of KT to the ankle had no effect when the jump heights of either group were compared (Nakajima & Baldridge, 2013). The researchers believed that the lack of statistical differences might be attributed to the KT application, as it failed to stimulate the mechanoreceptors underlying the taped skin (Nakajima & Baldridge, 2013; Simoneau, Degner, Kramper, & Kittleson, 1997; Yoshida & Kahanov, 2007). This may have reduced the participant’s ability to generate greater muscular contraction when performing the vertical jump procedure (Nakajima &

Baldridge, 2013; Simoneau et al., 1997; Yoshida & Kahanov, 2007). Thus, the taping methods implemented with KT do not appear to elicit a strong enough sensory response when performing a vertical jump task.

With respect to the current study, it is possible that a mechanical correction implemented with LT may be necessary to generate greater power at the knee. The generation of greater power may be useful for individuals performing therapeutic exercises in the clinical setting. Therefore, this information may be beneficial from a clinical perspective, as the application of LT could be an effective treatment intervention for physically active individuals suffering from patellar tendinopathy.

Balance

During sport or recreational activity, the knee joint is continuously adapting to various dynamic constraints (Fayson et al., 2013; Gutierrez et al., 2009). These constraints may further stress the patellar tendon (Cook & Khan, 2007) and potentially compromise the individual's ability to maintain balance during dynamic tasks. It was hypothesized that therapeutic tape would substantially improve balance performances (i.e., reaching distance) across all eight directions of the SEBT. It was also believed that KT would be more effective at improving balance when compared to LT. The results of the current study revealed that performances were substantially greater with KT in the anteromedial, lateral, and posterolateral directions partially supporting the initial hypotheses (Table 10). It is possible that performances during the SEBT may be enhanced when individuals are able to achieve full knee ROM (Hertel, Miller, & Denegar, 2000). The elastic and supportive characteristics of KT did not appear to restrict knee ROM, which could explain why participants were able to improve performances by reaching further in the anteromedial, lateral, and posterolateral directions. Since the primary objective of the SEBT is to maintain postural control while reaching with the non-supported leg as far as possible without losing balance, underlying sensory systems (e.g., somatosensory) are believed to be active when performing the directional movements (Hertel et al., 2000). The Pitchfork technique applied with KT has been reported to heighten mechanoreceptor activity underlying the taped skin (Kase et al., 2013). It is possible that the tape may be activating the somatosensory system when the participants are performing the directional movements. Nevertheless, the application of KT increases balance performances in the anteromedial, lateral, and posterolateral directions. The elastic properties of KT may allow for greater ROM and stimulation of the mechanoreceptors underlying the taped area. Further research is required, however, to determine any definitive effects.

To date, there have been few studies that have compared the effectiveness of both KT and LT on patellar tendinopathy, especially during the performance of the SEBT. Aminaka and Gribble (2008) examined the effects of LT and NT on dynamic postural control in individuals with and without PFPS. Measuring only the anterior direction of the SEBT, the results revealed that individuals with PFPS improved balance performances with the application of LT when compared to NT. Those without PFPS experienced no substantial improvements with LT. Aminaka and Gribble (2008) incorporated similar taping methods to the current study with LT. Additionally, participants in the previous study were also suffering from PFPS and not patellar tendinopathy. Thus, it appears that the effectiveness of LT on balance performance may be injury specific.

Bicici et al. (2012) examined the effects of athletic tape and KT on functional tasks consisting of the SEBT, KAT, single limb hurdle, hop-test, vertical jump test, and the standing heel raise test. The study included male basketball players with chronic inversion ankle sprains and revealed that the application of KT had no substantial effects on balance performances during the administration of the SEBT. The KT was applied to the peroneus longus, peroneus brevis, and anterior talofibular ligament of the ankle. Given the positive results from the current research and lack of statistical findings from the previous study, it appears that the effectiveness of KT, as related to balance, can be joint specific. Hence, it may have a different therapeutic effect when applied to the ankle as opposed to the knee. In the context of the current study, health care providers should give special consideration to KT, as it may improve balance during specific directional movements. This may be beneficial for individuals that require adequate balance when performing certain dynamic movements.

Strength

Individuals suffering with patellar tendinopathy often reduce activity levels in order to decrease or prevent further pain associated with this injury (Cook & Purdam, 2013). Consequently, decreased activity levels due to pain may lead to strength impairments in the lower quadrant. Additionally, the presence of swelling or edema within the knee joint has been reported to inhibit muscular strength (Spencer et al., 1984). The results of the current study revealed that KT increased knee flexor strength, when compared to NT, PT, and LT (Table 9), partially supporting the initial hypotheses. There were eight participants (1, 3-8, and 10) that generated greater strength with KT (approximately 8.7 lbs) when compared to LT. The Pitchfork technique applied with KT incorporated a tilting effect over the lower portion of the patella. This tilting effect is believed to create an area of decreased pressure, which may alleviate symptoms of pain and/or swelling (Kase et al., 2013). It is possible that the application of KT may have dissipated any swelling within the knee, ultimately heightening underlying motor neuron activity and greater muscular contraction (Kase et al., 2013; Spencer et al., 1984). In terms of LT, the

McConnell taping technique incorporated a mechanical correction that realigns the patella into the trochlear groove (McConnell, 1996). The realignment of the patella along with the direction of the tape's application may not be sufficient enough to reduce swelling within the knee and generate greater muscular contraction. Ultimately, it appears that KT may be more beneficial to the improvement of knee flexor strength in physically active individuals with patellar tendinopathy.

In terms of knee extensor strength, no substantial improvements were found across the taping conditions, failing to support the initial hypotheses. It is believed that the patellar tendon is less taut when performing knee extension versus knee flexion movements (Almekinders et al., 2002). It is possible that the common symptoms of patellar tendinopathy (e.g., pain) may not be as severe during the knee extension movement. The absence of symptoms may have allowed participants to maintain adequate strength. This is contrary to knee flexion where the presence of symptoms (e.g., swelling) appear to reduce strength at the knee by inhibiting muscular contraction (Spencer et al., 1984). However, the application of KT appears to dissipate swelling within the knee and prevent muscular inhibition. Therefore, only the application of KT may be beneficial for knee flexor strength in physically active individuals with patellar tendinopathy.

With regards to the previous literature, Sanzo et al. (2014) examined the effectiveness of therapeutic tape on isometric knee strength in healthy individuals. They reported that the application of LT and KT had no significant effects on knee flexor and extensor strength when compared to the application of PT or NT. Sanzo et al. (2014) believed that the lack of statistical findings was related to the absence of knee pathology. Within the present study, participants were suffering from patellar tendinopathy and the application of KT substantially increased knee flexor strength while using similar strength testing procedures as Sanzo et al. (2014). Therefore, it appears that the effects of KT may be more effective in pathological populations that are experiencing strength impairments. In the context of the current study, the effects of KT appear to improve knee flexor strength. The application of LT, however, has no substantial effect on knee flexor or extensor strength in physically active individuals suffering from patellar tendinopathy.

Conclusion

The present study integrated common clinical methods used to measure pain, ROM, power, balance, and strength in physically active individuals with patellar tendinopathy. It also remains one of the few studies to compare LT and KT to NT and PT within the design. The purpose of this research was to examine the effects of therapeutic taping on knee pain, ROM, power, balance, and strength in physically active male and female adults between the ages of 18 and 45 years, with patellar tendinopathy. The results showed that certain aspects of motor functioning, such as knee flexor strength and balance (anteromedial, lateral, and posterolateral), would benefit from the application of KT. This was not the case with LT, as it appears to be limited to certain contexts (e.g., decreasing ROM). Clinically significant improvements were revealed in terms of pain and ROM with the application of KT. Despite these improvements, the differences between therapeutic tapes were marginal across the dependent measures. Limitations to the current study included a relatively low sample size, an uneven ratio of participants with acute versus chronic patellar tendinopathy, and a male dominant population. These limitations make generalizability of the findings limited and conservative. Participants were also asked to attend a total of four test sessions in order to complete the study. Four test sessions appeared challenging for participant’s from a time commitment perspective and may have contributed to the small sample size

Clinical Implications

To date, there is an increasing trend incorporating therapeutic tape into the clinical setting. Surprisingly, few studies have been conducted examining the effectiveness of the tapes using pathological populations (e.g., Aminaka, & Gribble, 2008; Bicici et al., 2012; Briem et al., 2011) and even fewer have compared therapeutic tape to NT and PT conditions (e.g., Sanzo et al., 2014). A pilot study was conducted in order to examine the effects of therapeutic taping on pain, ROM, power, balance, and strength in athletes and non-athletes with and without acute patellar tendinopathy. The results revealed that the effects of therapeutic tape are context specific, indicating that the appropriateness of therapeutic tape may be dependent on the population and the presence of pathology. In addition to the population and presence of pathology, the main study determined that certain circumstances might also include the type of injury, the goal of the health care provider, and the taping characteristics and methods incorporated with therapeutic tape.

In the clinical setting, the results of the current study may supply health care providers with valuable information pertaining to the effects of therapeutic taping on the common symptoms of patellar tendinopathy. For physically active individuals with this injury, KT appears to improve knee flexor strength and balance control during specific directional movements. Although common clinical methods were incorporated within the current study, future research should consider more sophisticated laboratory equipment (e.g., EMG) in order to help determine the underling effects of therapeutic tape. Additional research should also compare the effectiveness of therapeutic tape in participants with acute versus chronic symptoms of patellar tendinopathy. As evident within the current study, there is a potential that therapeutic tape may have a distinctive effect on pain when symptoms are in the acute stage of the injury. In order to make any definitive conclusions, a larger study with an equal ratio of participants is needed. This information obtained from these studies may supplement current care practices for individuals suffering from patellar tendinopathy and potentially determine the appropriateness of therapeutic tape in acute versus chronic cases.

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Appendix A

**** ON LAKEHEAD UNIVERSITY LETTERHEAD****

Recruitment Letter for Participants

Dear Potential Participant,

My name is Michael Massei and I am conducting a pilot study entitled "The Effects of Therapeutic Taping on Pain, Range of Motion, Power, Balance, and Strength in Varsity Athletes with Acute Patellar Tendonitis" under the supervision of Dr. Eryk Przysucha and Dr. Paolo Sanzo. This research will determine if different types of taping techniques improve the common symptoms associated with acute patellar tendonitis.

Athletes suffering from patellar tendonitis have a difficult time performing at an optimal level. Typically, decreased range of motion, power, balance, strength and increased pain levels are the most common symptoms of this condition. Currently, it is unclear which type of tape is most beneficial for this injury in varsity athletes. Leukotape tape (LT) and Kinesio tape (KT) have been reported to reduce these symptoms and prevent decreased sport performance. However, no research has been conducted that compares these types of tape to a placebo tape (PT) during functional tasks in varsity athletes. As a result, the aim of this preliminary investigation is to encompass tasks and instruments that measure lower body strength, range of motion, balance, and power to mimic the movements used during practice or games. Pain levels will also be measured to help determine the most effective taping method. The results gained will provide you and health care providers information about the potential effectiveness of therapeutic tape.

You are able to participate in this study if you are currently diagnosed with acute patellar tendonitis by a certified health care provider and are male or female over the age of 18. If this condition is preventing your involvement in practice or games, you are still able to participate in this study. You are not eligible to participate in this study if you have undergone any knee surgery within the past five years, are currently nursing any additional lower body injuries, have received corticosteroid injections in the lower body within the past year, have been experiencing knee pain for more than three months, and have any allergies to adhesives such as athletic tape.

A total of four sessions will be needed to complete this study. Three testing sessions will be allocated to taping conditions and one for a baseline "no tape" condition. Each session will be 30 minutes in duration with at least one day of rest between each session. During the initial session, you will be interviewed about your injury (e.g., mechanism of injury, signs and symptoms of your injury, treatment techniques). You may choose not to answer any of the questions during this process or during subsequent testing. Following this procedure, you will be asked to complete a questionnaire called the Numeric Pain Rating Scale that will help identify your current pain levels. Upon completion, you will be asked to perform a number of tasks without tape. In the subsequent sessions, Michael Massei, who is certified in athletic taping, will apply KT, LT, or a PT to your affected knee. After the tape has been applied and your pain level has been established, you will be asked to complete a series of tasks.

The first task will measure your range of motion. It will involve you lying down on a medical bed while flexing and extending your affected leg. A measuring instrument known as a goniometer will be used to measure your knee range of motion three times. Strength testing will commence after the completion of this procedure. This will require you to be in a seated position while a strength gauge is positioned on the posterior and anterior surface of your lower leg. This gauge is known as a strength dynamometer. When cued, you will either flex or extend your affected leg while the researcher provides counter-pressure. Your peak strength after five seconds will be recorded and three trials will be carried out.

The vertical jump test will be implemented next. Your standing reach height will be recorded and three maximal jumps will be performed. To determine your standing reach height, you will be required to reach as high as possible beside a wall. A piece of tape will be wrapped around your third and fourth finger. When cued, you will raise your dominant arm as high as possible and touch the wall allowing the tape to adhere. After your standing reach height is determined, another piece of tape will be wrapped around the same fingers. When cued, you will be asked to jump as high as possible and touch the wall allowing the tape to adhere. This will be performed three times. Your maximum jump height will be marked and subtracted from your standing reach height. This value will be put into an equation to determine your lower body power. Your body weight will also be measured.

To determine your ability to maintain balance, The Star Excursion Balance Test will be used. This test requires you to balance only on your affected leg while reaching in eight different directions with your other leg. The distances reached in each direction will be calculated. Your pain levels will also be re-examined following the completion of this final task. This is to determine if your pain levels have fluctuated since the initial recording.

Potential risks for participation in this study are minimal. The tasks may lead to temporary discomfort or you may have an adverse reaction to the tape, which may include irritation, itching, or redness of the skin. If you feel uncomfortable or unsafe, you may stop performing any of the tasks or completely withdraw from the study at any time.

All testing will take place at Lakehead University in the Multipurpose Assessment Lab, SB-1016. The researcher will arrange the date and time of testing. Only I, Dr. Eryk Przysucha, and Dr. Paolo Sanzo, will have access to the recorded data and personal information. All information will be securely stored in Dr. Eryk Przysucha's office at Lakehead University for a period of five years.

The results of this study may be submitted to a research journal for publication or be presented at a conference. Full anonymity and confidentiality will be assured during the course of the research, in the final report, and in the presentation of the results. You will not be identified in any way, as your name will be replaced with a number. Upon completion of the study, the results can be provided if requested.

If you agree to participate in this study or have any questions, please feel free to contact me by email at mmassei@lakeheadu.ca. This research has been approved by the Lakehead University Research Ethics Board but should any further questions arise then Dr. Eryk Przysucha may also be contacted at 807-343-8189.

Thank you for your consideration and cooperation.

Sincerely,

Michael Massei HBK
Lakehead University

Appendix B

****On Lakehead University Letterhead****
CONSENT FORM

I,, agree to participate in a study titled "The Effects of Therapeutic Taping on Pain, Range of Motion, Power, Balance, and Strength In Varsity Athletes with Acute Patellar Tendonitis." This study is being conducted by Michael Massei, a Masters student in Kinesiology at Lakehead University and supervised by Dr. Eryk Przysucha and Dr. Paolo Sanzo, Assistant Professors in the School of Kinesiology.

- I have read and understood the participant recruitment letter and I understand that during the initial session, I will be interviewed about my injury

- I recognize that different types of tape will be applied to my knee over the course of three half-hour sessions, with one session allocated to a no-tape condition. These types of tape will consist of Kinesio tape, and Leukotape. After the tape is applied, I will be guided through a series of tasks that focus on assessing the strength, range of motion, power, and balance of my knee

- I recognize the potential risks involved in participation, as they may exacerbate the injury temporarily or possibly lead to an adverse reaction to the tape, which may include irritation, itching, or redness of the skin

- I understand that my participation in this study is voluntary and that I may withdraw at any time.

- I recognize that my identity will remain anonymous and all data will be kept strictly confidential. Only Michael Massei, Dr. Eryk Przysucha, and Dr. Paolo Sanzo will have access to this data. No identifiable characteristics will be used in the final report in the presentation of the results. The data will be securely stored in the office of Dr. Eryk Przysucha for a period of five years.

- I understand that I will be provided with a copy of my results at the completion of the study, if requested.

______________________________ ________________________

Participant Signature Date

______________________________ ________________________

E-mail Address Phone #

If you wish to receive a copy of your results upon completion of the study. Please check the box below and provide a mailing address.

☐ ____

Appendix C

Certification

Figure 1. Athletic Wrapping and Taping Certification.

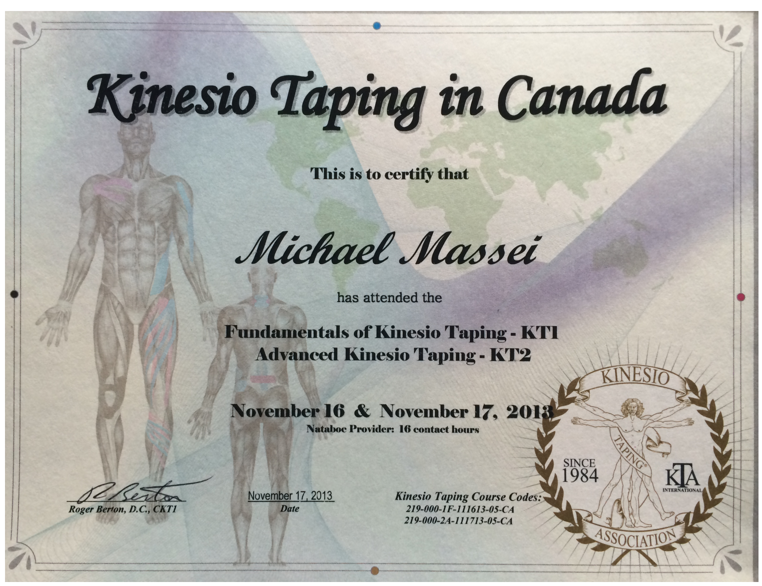

Figure 2. Kinesio Taping Certification.

Appendix D

Interview Questions

Name:………………………………………

Mechanism of Injury

How long ago did you start experiencing these symptoms?

What activities or movements led you to start experiencing these symptoms?

How often do you practice or train during a typical week?

Who diagnosed your injury?

When were you formally diagnosed with your injury?

Signs and Symptoms

What do you believe are the most common symptoms of your injury?

Do your symptoms affect the way you train or exercise?

Are you able to train despite the discomfort?

Do you experience locking in the knee?

Do you experience swelling in the knee?

Does your knee give way?

Treatment

Are you currently receiving any treatment from a health care provider?

If so, how long have you been receiving treatment?

If so, what does this treatment consist of?

Are you currently taking any medication for your knee? If so, which ones and what are these for?

Are you applying any of your own treatment methods? If so, what kind?

Appendix E

The Numeric Pain Rating Scale

0 1 2 3 4 5 6 7 8 9 10

Low Moderate Severe

Appendix F

Figure 1. The instrument that will be used for ROM testing.

Figure 2. Goniometer's positioning for the measurement of knee extension (in degrees).

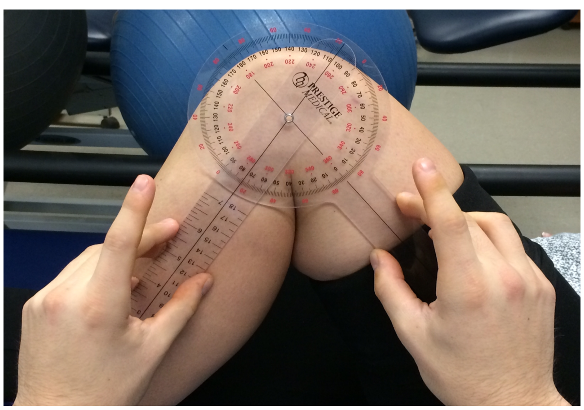

Figure 3. Goniometer's positioning for the measurement of knee flexion (in degrees).

Appendix G

Measurement Sheet

Participant Name:…………………………………….

Age:……….   Weight (kg):………….   Gender:………..

Height (cm):………..Leg length (cm):…………

		Session 1	Session 2	Session 3	Session 4
Condition		No Tape			
Pre Pain Level					
R.O.M (degrees)					
Peak Strength (Kg)					
Max Vertical Jump (cm)					
Balance (%)	A				
	AL				
	AM				
	PM				
	P				
	PL				
	M				
	L				
Post Pain Level					
Power (Watts)					

Appendix H

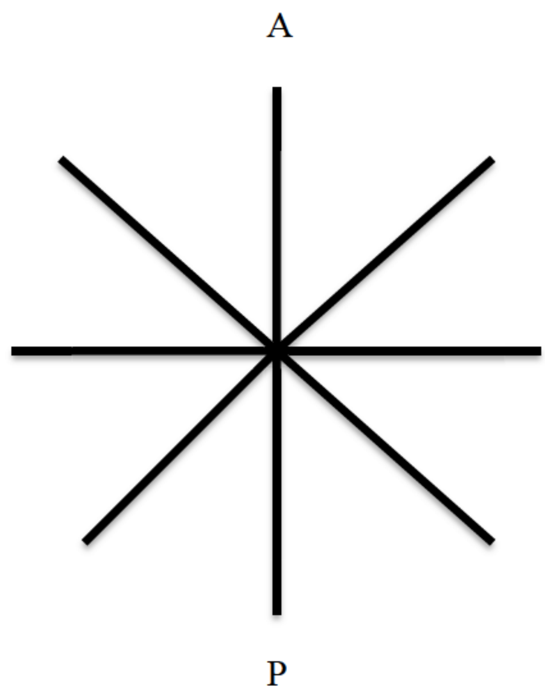

Figure 1. The Star Excursion Balance Test. This figure illustrates the grid used during the application of this test. Note that the lateral and medial directions will be dependent on the stance leg that is used.

Figure 2. The Star Excursion Balance Test. This figure illustrates the participants positioning during the application of this test.

Appendix I

*Figure 1.*The instrument that will be used for strength testing.

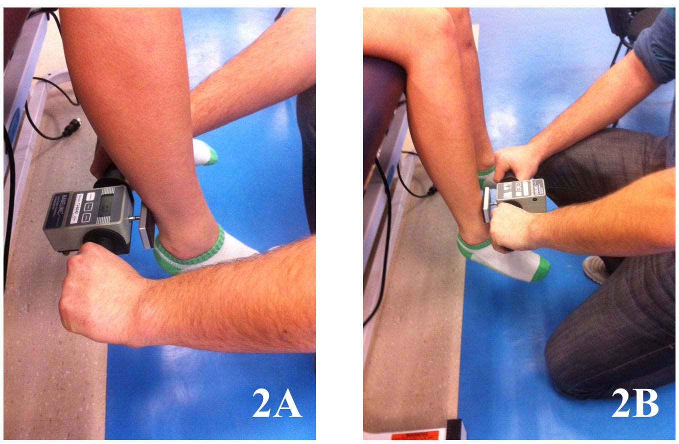

Figure 2- (A) This represents the posterior position of the dynamometer over the distal portion of the affected leg. (B) This represents the anterior position of the dynamometer over the distal portion of the affected leg.

Appendix J

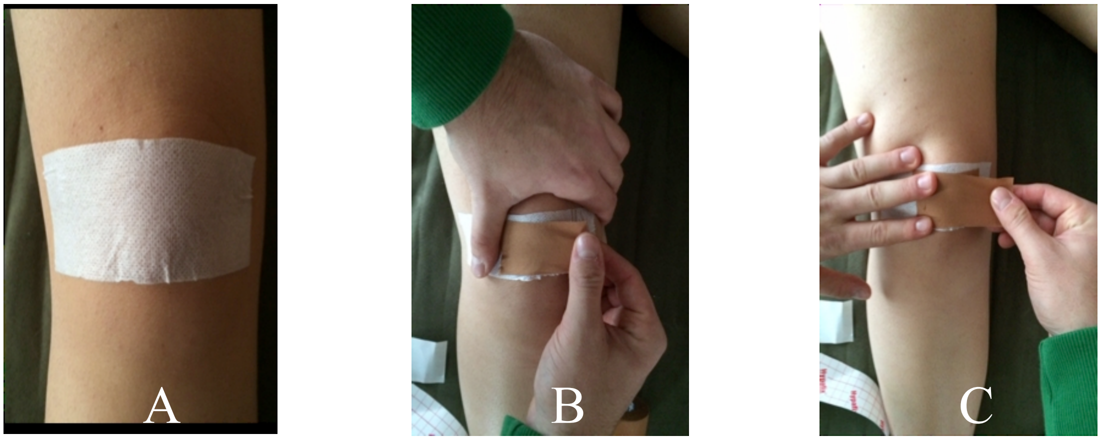

Figure 1. McConnell Taping Technique. (A) Prior to the LT application, a dressing known, as Hypafix will be measured. The primary researcher will place the Hypafix horizontally over the affected knee. Small portions of the Hypafix will extend past the medial and lateral boarders of the patella. (B) On the middle portion of the patella, one piece of LT will be applied. The primary researcher will generate slight tension to tilt the patella in the medial direction while gathering the surrounding medial tissues upward. Once gathered, the remainder of the LT will be applied over the knee in the medial direction. (C) To correct the glide of the patella, a second piece of LT will be applied. During this application, the primary researcher will tension the tape with one hand while the other will be used to position the patella in the medial direction. The surrounding medial tissues will also be gathered during this process and positioned upwards as the tape is applied (Constantinou, 2010; Perrin, 2012).

Appendix K

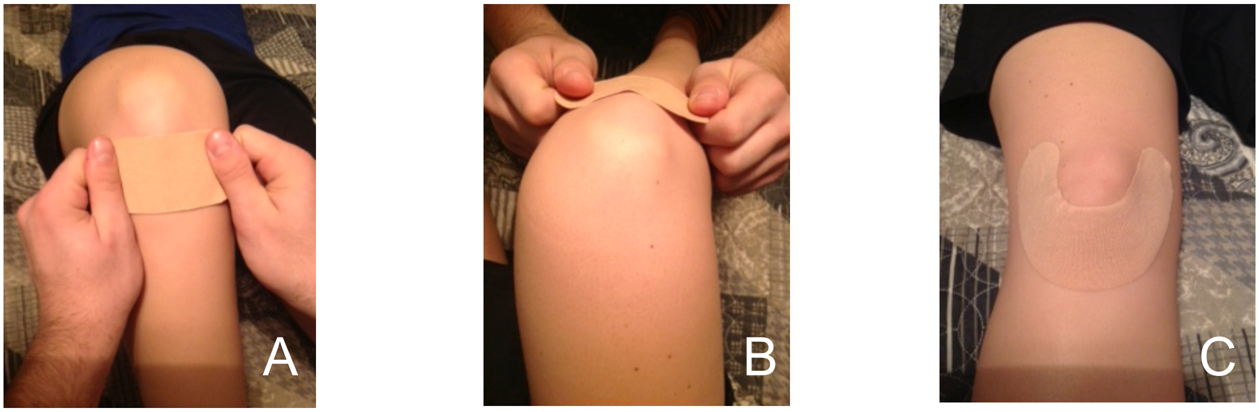

Figure 1. U-Strip Technique. (A) Prior to application, the participant will be asked to lie in a supine position with the affected knee fully extended. The Kinesio tape (KT) will be measured from the medial to lateral portion of the knee. (B) Once the measurement has been established, the primary researcher will expose the adhesive of the KT. Only the middle of the adhesive will be exposed. With approximately half the tapes tension, the researcher will apply the middle portion of the KT over the base of the patella. (C) Once the KT has been applied, the participant will be asked to flex the knee to about 90 degrees. During the flexion motion, the remainder of the tape will be applied around the medial and lateral portions of the knee with approximately a quarter tension (Pope et al., 2010).

Appendix L

Lakehead UNIVERSITY

PARTICIPANTS WANTED FOR RESEARCH STUDY

ARE YOU BETWEEN THE AGES OF 18 & 45 AND PHYSICALLY ACTIVE?

HAVE YOU BEEN DIAGNOSED WITH PATELLAR TENDINOPATHY OR TENDONITIS?

IF YES,

A RESEARCH STUDY IS BEING CONDUCTED THAT EXAMINES THE EFFECTS OF DIFFERENT TYPES OF THERAPEUTIC TAPE ON KNEE PAIN, RANGE OF MOTION, POWER, STRENGTH, AND BALANCE!

IF YOU WOULD BE WILLING TO PARTICIPATE IN THIS MASTER OF SCIENCE RESEARCH STUDY

CONTACT ME TODAY!!

Michael Massei
mmassei@lakeheadu.ca

Michael Massei
mmassei@lakeheadu.ca
Michael Massei
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Appendix M

**** On Lakehead University Letterhead****

Recruitment Letter for Participants

Dear Potential Participant,

My name is Michael Massei and I am conducting a research study entitled "The Effects of Therapeutic Taping on Pain, Range of Motion (ROM), Power, Balance, and Strength in Physically Active Individuals With Patellar Tendinopathy" under the supervision of Dr. Eryk Przysucha and Dr. Paolo Sanzo. This research will determine if different types of taping techniques improve the common symptoms associated with patellar tendinopathy.

Individuals suffering from patellar tendinopathy have a difficult time performing daily tasks at an optimal level. Typically, decreased range of motion, power, balance, strength, and increased pain levels are the most common symptoms of this condition. Currently, it is unclear which type of tape is most beneficial for this injury. Leukotape (LT) and Kinesio tape (KT) have been reported to reduce these symptoms and prevent decreased physical activity. As a result, the aim of this investigation is to encompass tasks and instruments that measure lower body strength, range of motion, balance, and power to mimic the movements used during everyday tasks. Pain levels will also be measured to help determine the most effective taping method. The results gained will provide you and health care providers information about the potential effectiveness of therapeutic tape.

You are able to participate in this study if you are currently diagnosed with acute or chronic patellar tendinopathy by a certified health care provider (e.g., physician, physiotherapist, chiropractor), are male or female between the ages of 18 and 45, and are participating in 150 to 300 minutes of moderate physical activity (e.g., brisk walking, cycling, or jogging) per week. You are not eligible to participate, if you have undergone any knee surgery within the past five years, are currently nursing any additional lower body injuries, have received corticosteroid injections in your knee within the past year, have been experiencing knee pain for more than three months, and have any allergies to adhesives such as athletic tape or Tuf-Skin®.

A total of four sessions will be needed to complete this study. Three testing sessions will be allocated to taping conditions and one for a baseline "no tape" condition. Each session will be 30 minutes in duration with at least one day of rest between each session. During the initial session, you will be interviewed about your injury (e.g., mechanism of injury, signs and symptoms of your injury, treatment techniques). You may choose not to answer any of the questions during this process or during subsequent testing. Following this procedure, you will be asked to complete a questionnaire called the Numeric Pain Rating Scale that will help rate your current pain level. Upon completion, you will be asked to perform a number of tasks without tape. In the subsequent sessions, a spray adhesive product known as Tuf-Skin® will be applied to your knee. This product helps ensure greater tape adhesion and prevents the tape from loosening during testing. After this is completed, KT, LT, or a PT will be applied to your knee and your pain level will be established. I have undergone extensive training and certification (i.e., Lakehead University Athletic Wrapping and Taping, Fundamentals of Kinesio taping, and Advanced Kinesio taping) to ensure the proper taping techniques are applied to your knee, limiting the chance of injury. Following these procedures, you will be asked to complete a series of tasks.

The first task will measure your range of motion. It will involve you lying down on a medical bed while flexing and extending your affected leg. A measuring instrument known as a goniometer will be used to measure your knee range of motion three times. Strength testing will commence after the completion of this procedure. This will require you to be in a seated position while a strength gauge is positioned on the front and back of your lower leg. This gauge is known as a manual muscle tester. When cued, you will either flex or extend your affected leg while the researcher provides counter-pressure. Your peak strength after five seconds will be recorded and three trials will be carried out.

The vertical jump test will be implemented next. Your standing reach height will be recorded and three maximal jumps will be performed. To determine your standing reach height, you will be required to reach as high as possible beside a wall. A piece of tape will be wrapped around your third and fourth finger. When cued, you will raise your dominant arm as high as possible and touch the wall allowing the tape to adhere. After your standing reach height is determined, another piece of tape will be wrapped around the same fingers. When cued, you will be asked to jump as high as possible and touch the wall allowing the tape to adhere. This will be performed three times. Your maximum jump height will be marked and subtracted from your standing reach height. This value will be put into an equation to determine your lower body power. Your body weight will also be measured.

To determine your ability to maintain balance, the Star Excursion Balance Test will be used. This test requires you to balance only on your affected leg while reaching in eight different directions with your other leg. The distances reached in each direction will be calculated. Your pain levels will also be re-examined following the completion of this final task. This is to determine if your pain levels have fluctuated since the initial recording.

Potential risks for participation in this study are minimal and are comparable to that involved during everyday activity. Minor injury may occur during the performance of any of these physical tasks but will be reduced by giving you clear and concise instructions, adequate rest, and practice. The tasks may lead to temporary discomfort (knee pain or tenderness) or you may have an adverse reaction to the tape, which may include irritation, itching, or redness of the skin. If you feel uncomfortable or unsafe, you may stop performing any of the tasks or completely withdraw from the study at any time.

All testing will take place at Lakehead University in the Multipurpose Assessment Lab, SB-1028, situated in Thunder Bay. The researcher will arrange the date and time of testing. Only I, Dr. Eryk Przysucha, and Dr. Paolo Sanzo, will have access to the recorded data and personal information. All information will be securely stored in Dr. Eryk Przysucha's office at Lakehead University for a period of five years.

The results of this study may be submitted to a research journal for publication or be presented at a conference. Full anonymity and confidentiality will be assured during the course of the research, in the final report, and in the presentation of the results. You will not be identified in any way, as your name will be replaced with a number. Upon completion of the study, the results can be provided if requested.

If you agree to participate in this study or have any questions, please feel free to contact me by email at mmassei@lakeheadu.ca. This research has been approved by the Lakehead University Research Ethics Board but should any further questions arise then Sue Wright may also be contacted at 807-343-8283 or research@lakeheadu.ca.

Thank you for your consideration and cooperation.

Sincerely,

Michael Massei, MSc (c), HBK
Lakehead University
mmassei@lakeheadu.ca

Dr. Eryk Przysucha, PhD
Assistant Professor, School of Kinesiology
Lakehead University
(807) 343-8189
eprzsuc@lakeheadu.ca

Dr. Paolo Sanzo, DScPT
Assistant Professor, School of Kinesiology
Lakehead University
(807) 343-8944
paolo.sanzo@lakeheadu.ca

Appendix N

PARTICIPANTS NEEDED FOR RESEARCH STUDY

ARE YOU BETWEEN THE AGES OF 18 & 45 AND PHYSICALLY ACTIVE?

HAVE YOU BEEN DIAGNOSED WITH PATELLAR TENDINOPATHY OR TENDONITIS?

IF YES,

A RESEARCH STUDY IS BEING CONDUCTED THAT FOCUSES ON DIFFERENT TYPES OF THERAPEUTIC TAPE AND THEIR EFFECTS ON YOUR KNEE PAIN, RANGE OF MOTION, POWER, STRENGTH, AND BALANCE!

IF YOU WOULD BE WILLING TO PARTICIPATE IN THIS MASTER OF SCIENCE RESEARCH STUDY OR HAVE ANY QUESTIONS

PLEASE EMAIL

mmassei@lakeheadu.ca

Appendix O

****On Lakehead University Letterhead****

CONSENT FORM

I, ______________________________ agree to participate in a study titled "The Effects of Therapeutic Taping on Pain, Range of Motion (ROM), Power, Balance, and Strength in Physically Active Individuals With Patellar Tendinopathy." This study is being conducted by Michael Massei, a Masters student in Kinesiology at Lakehead University and supervised by Dr. Eryk Przysucha and Dr. Paolo Sanzo, Assistant Professors in the School of Kinesiology.

- I have read and understood the participant recruitment letter and I understand that during the initial session, I will be interviewed about my injury.
- I recognize that different types of tape will be applied to my knee over the course of four half-hour sessions, with the first session allocated to a no-tape condition. These types of tape will consist of placebo tape, Kinesio tape, and Leukotape that will be applied by Michael Massei who is certified in athletic taping. After the tape is applied, I will be guided through a series of tasks that focus on assessing the strength, range of motion, power, and balance of my knee.
- I recognize potential risks for participation in this study are minimal. Minor injury may occur during the performance of any of these physical tasks but will be reduced through clear and concise instructions, adequate rest and practice.
- I understand these tasks may aggravate my injury temporarily or possibly lead to an adverse reaction to the tape, which may include irritation, itching, or redness of the skin.
- I understand that my participation in this study is voluntary and that I may withdraw at any time.
- I recognize that my identity will remain anonymous and all data will be kept strictly confidential. Only Michael Massei, Dr. Eryk Przysucha, and Dr. Paolo Sanzo will have access to this data. No identifiable characteristics will be used in the final report in the presentation of the results. The data will be securely stored in the locked office of Dr. Eryk Przysucha for a period of five years.
- I understand that I will be provided with a copy of my results at the completion of the study, if requested.

______________________________ ______________________________

Participant Signature Date

______________________________ ______________________________

E-mail Address Phone #

If you wish to receive a copy of your results upon completion of the study. Please check the box below and provide a mailing address.

☐ ____

Appendix P

Figure 1. Placebo Taping Technique. (A) Prior to the LT application, a dressing known, as Hypafix will be measured. The primary researcher will place the Hypafix horizontally over the affected knee. Small portions of the Hypafix will extend past the medial and lateral boarders of the patella (Constantinou, 2010; Perrin, 2012).

Appendix Q

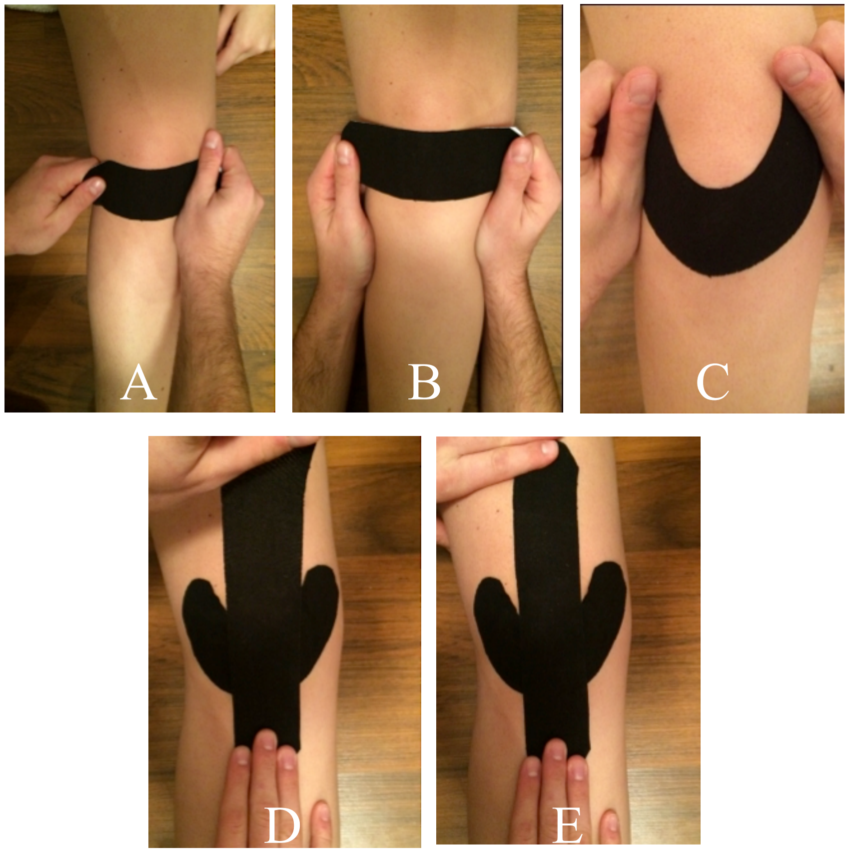

Figure 1. Pitchfork Technique.(A) Prior to application, the participant will be asked to lie in a supine position with the affected knee fully extended. The KT will be measured from the medial to lateral portion of the knee. (B) Once the measurement has been established, the primary researcher will expose the only the middle-third of the adhesive of the KT. With approximately half the tapes tension, the researcher will apply the middle portion of the KT over the base of the patella. (C) Once the KT has been applied, the participant will be asked to flex the knee to about 90 degrees. During the flexion motion, the remainder of the tape will be applied around the medial and lateral portions of the knee with approximately a quarter tension. (D) A second strip of KT will be placed vertically over the knee. With the participant's leg flexed, the KT will be anchored approximately three inches below the tibial tuberosity with no tension. (E) Once adhered, the tape will be slightly tensioned and applied over the knee to approximately five inches above the top portion of the patella (Kase et al., 2013; Pope et al., 2010)

Appendix R

Figure 1. The instrument that will be used for strength testing.

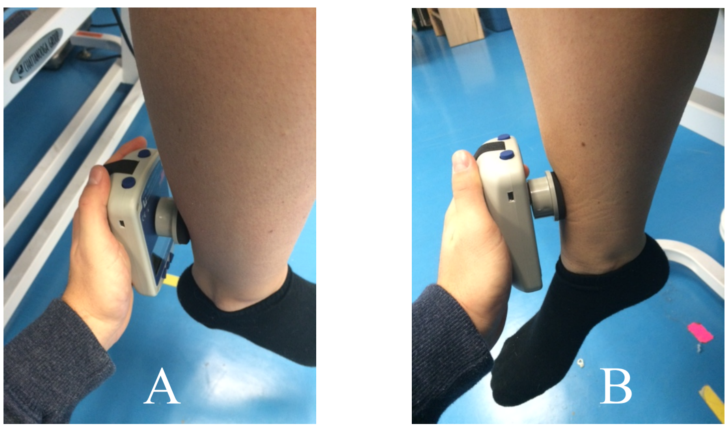

Figure 2. (A) This represents the posterior position of the manual muscle tester over the distal portion of the affected leg. (B) This represents the anterior position of the manual muscle tester over the distal portion of the affected leg.

Appendix S

Participant Information

Participant	Gender	Age (years)	Weight (kg)	Height (cm)	Mechanism of Injury	Signs and Symptoms	Current Treatment Techniques
1	Male	18	105.2	185	Sports (e.g., soccer)	Acute pain and stiffness when bending at the knee (~1 month)	None
2	Male	21	106.0	181.5	Sports (e.g., track & field)	Chronic pain and minor swelling when bending at the knee (~ 1 year)	Cryotherapy when needed
3	Male	44	87.1	177.8	Kneeling	Acute pain and tenderness on palpation (~3 weeks)	None
4	Male	23	80.1	186	Sports (e.g. soccer, basketball)	Chronic soreness after activity (~8 years)	None
5	Female	35	68.4	168	Running	Acute pain and tenderness on palpation (~ 1 week)	Cryotherapy after activity
6	Male	22	71.6	180	Sports (e.g., track & field)	Chronic pain and tenderness on palpation (~5 years)	None
7	Male	28	121.8	178	Sports (e.g., soccer), sitting, and walking	Chronic pain, tenderness on palpation, and swelling (~ 2 years)	Advil when needed
8	Male	23	75.8	175	General activity	Chronic pain, tenderness on palpation, and aching (~3 years)	Advil and thermotherapy when needed
9	Female	19	62.3	178	Jumping, stair climbing	Chronic pain after activity (~1.5 years)	None
10	Male	18	81.9	191	Running	Chronic pain (~ 7 months)	None