The effects of McConnell patellofemoral joint and tibial internal rotation limitation taping techniques in people with Patellofemoral pain syndrome

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Keywords: Patellofemoral pain syndrome (PFPS), McConnell Patellofemoral Joint Taping (PFJT) and Tibial Internal Rotation Limitation Taping (TIRLT) are proposed to be useful adjuncts to the management of PFPS. However, it is unclear if TIRLT offers similar benefits to PFJT, and its effect on pain and lower limb kinematics have not been investigated previously.

ABSTRACT

Background: Taping is frequently used as part of the multi-modal management for patellofemoral pain syndrome (PFPS). McConnell Patellofemoral Joint Taping (PFJT) and Tibial Internal Rotation Limitation Taping (TIRLT) are proposed to be useful adjuncts to the management of PFPS. However, it is unclear if TIRLT offers similar benefits to PFJT, and its effect on pain and lower limb kinematics have not been investigated previously.

Methods: This cross-sectional study compared the effects of TIRLT, PFJT and no taping, on knee pain and lower limb kinematics during two pain-provoking movements in people with PFPS. Participants with PFPS (n = 23) performed a lunge and SLS under three randomised conditions: TIRLT, PFJT and no taping. The Codamotion system captured and analysed lower limb kinematic data in the sagittal, transverse and coronal planes. Peak knee pain intensity during the movement was assessed using the Numerical Rating Scale (NRS).

Results: Participants reported significantly less pain with the TIRLT and PFJT techniques compared with no tape during the lunge (p = 0.005 and p = 0.011, respectively) and SLS (p = 0.002 and p = 0.001, respectively). There was no evidence of altered lower limb kinematics accompanying pain reductions with either taping technique.

Significance: Both forms of taping may be useful adjuncts as the short-term benefit of pain relief may enable participation in more active forms of rehabilitation.

1. Introduction

Patellofemoral pain syndrome (PFPS) is a common musculoskeletal condition with an annual prevalence of 22.7% [1]. It is characterised by anterior knee pain and/or pain in the retropatellar and/or peripatellar region that typically increases with flexion-related activities such as squatting, kneeling, stair climbing and after prolonged sitting [2]. The underlying causes of PFPS are multifactorial and may be associated with biomechanical and/or neurophysiological changes at the pelvis, hip, knee or ankle regions [48]. Numerous factors including a larger quadriceps (Q) angle [3], dynamic knee valgus [4], increased rear-foot eversion on heel strike [5] have been linked to the aetiology of PFPS. Additionally, altered activation of the vastus lateralis (VL) and vastus medialis oblique (VMO) muscles [6], reduced hip abduction strength and deficits in knee extension strength have been observed in people with PFPS compared to healthy controls [7].

Systematic reviews and consensus statements have indicated that effective management of PFPS requires an individually tailored and multimodal approach, with taping suggested to be potentially useful as an adjunct to other rehabilitation and exercise interventions [8–10]. According to expert opinion, taping can have value in early management to gain patient trust and facilitate active engagement in the prescribed rehabilitation programme [8], though approaches to taping in research vary and evidence has been inconsistent [11].

Various taping protocols exist for the management of PFPS, which largely aim to normalise the altered lower limb biomechanics that are thought to cause PFPS [12,13]. The McConnell Patellofemoral Joint Taping (PFJT) technique [14] is a popular method of taping that is...
proposed to correct the excessive lateral glide, tilt and rotation of the patella, commonly observed among people with PFPS [13]. Evidence supports the effectiveness of PFJT in providing short-term pain relief in people with PFPS during a range of functional activities [15]. The McConnell PFJT technique has been shown to move the patella inferiorly within the femoral groove, which may increase the patellofemoral contact area [16]. Redistribution of the load over a larger area is thought to decrease contact stress with a consequent improvement of symptoms. However, this only addresses one potential cause of PFPS, patellar tilt, which may explain why a proportion of individuals are not responsive to this method of taping [45]. It is postulated that targeting other commonly reported biomechanical changes associated with PFPS may provide relief of symptoms for individuals with patellofemoral pain.

According to the 3rd Patellofemoral Pain Consensus Statement changes in lower limb mechanics including tibial rotation can influence PFPS [10]. Evidence suggests that increased internal rotation of the tibia, coupled with greater rear-foot eversion and subtalar pronation are observed in subjects with PFPS [5,17,18]. Indeed research has identified greater shank internal rotation among runners with PFPS compared to controls [46]. Pronation is commonly targeted in treatment plans [19,9] using foot orthoses to alter biomechanics distally by modifying the position of the foot [5] and subsequently reducing excessive tibial internal rotation. An alternate way of limiting excessive internal rotation of the tibia and any associated dynamic knee valgus is the Tibial Internal Rotation Limitation Taping (TIRLT) technique [14], which is a spiral taping technique that utilises a mobilisation with movement principle to reduce excessive internal tibial rotation to a more neutral position [47]. TIRLT proposes to use a proximal solution, by facilitating a more neutral, less internally rotated tibial position at the knee joint [14]. As such, by addressing the biomechanical factors relating to PFPS in a novel manner, TIRLT may offer a new and potentially alternative taping technique to the popular PFJT method. To the authors knowledge, no published literature has evaluated the effectiveness of the TIRLT technique in patients with PFPS, compared to the widely used PFJT method. Thus, it is not clear how this method compares to PFJT with respect to alterations in joint kinematics and pain reduction in people with PFPS. There is also a paucity of published evidence investigating the effect of taping on lower limb kinematics during the lunge, a movement frequently used as an objective marker of strength and motor control deficits and prescribed as part of PFPS rehabilitation programmes [45]. It is postulated that targeting other anatomical landmarks on the participants’ pelvis and lower limb using wands and double-sided adhesive tape in accordance with the manufacturer’s guidelines and published protocols [24] by two researchers trained in this process. Researchers were final year physiotherapy students, who had received training in three-dimensional motion analysis by a postdoctoral researcher who had five years’ experience using the system and set-up in a number of previous studies. Familiarization with marker application and system set-up and five pilot practice trials of the study protocol were completed prior to testing and trial data acquisition.

Data was recorded at a sampling rate of 200 Hz for the duration of each test movement performed. Range of motion at the hip knee and ankle on the sagittal, coronal and transverse planes were reported for each participant during each of the movement tasks under the different taping conditions. Range of motion from the initiation of each movement task from an upright standing position to the return to the start position was recorded and was defined as the maximum less the minimum angle based on previous research [25].

The Numerical Rating Scale (NRS) was used to categorise responders perceived pain intensity on an 11-point scale, with the severity of pain increasing from no pain (0) to ‘the worst pain imaginable’ (10). The NRS has been validated for a number of chronic musculoskeletal disorders [26], and has been used among people with anterior knee pain in various research settings [24].

2.3. Measures

Joint kinematics were recorded using the Cartesian Optoelectronic Dynamic Anthropometer (Codamotion) analysis system mpx64 (Charnwood Dynamics Ltd., Leicestershire, UK). The Codamotion system is a widely used instrument that has proven reliable in research settings to capture the three-dimensional (3D) motion of each participant’s test limb and measure sagittal, transverse and coronal plane ROM [23]. The Codamotion system captured infrared light signals emitted by 22 diodes within a marker box. Each marker was placed on specific anatomical landmarks on the participants’ pelvis and lower limb using wands and double-sided adhesive tape in accordance with the manufacturer’s guidelines and published protocols [24] by two researchers trained in this process. Researchers were final year physiotherapy students, who had received training in three-dimensional motion analysis by a postdoctoral researcher who had five years’ experience using the system and set-up in a number of previous studies. Familiarization with marker application and system set-up and five pilot practice trials of the study protocol were completed prior to testing and trial data acquisition.

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2.4. Procedure

Demographic data were collected via questionnaire and anthropometric data were collected in accordance with guidelines [27]. If symptoms were bilateral, the most provocative knee was chosen. The order of taping and test movements were randomly allocated using sealed envelopes selected by the participant. Three trial conditions were used: no taping, PFJT and TIRLT techniques. Under each of the three randomised taping conditions participants performed a lunge and SLS (order also randomised). With the taping (if applicable) and markers in situ, subjects stood barefoot between two infra-red cameras. For the lunge, participants began the movement with their arms across their chest and lunged forwards leading with the index knee as far as was comfortable before returning to the starting position (Fig. 1). To perform the SLS, participants were asked to squat down on the affected limb as far as comfortably possible and return to the start position in one continuous movement (Fig. 2). Participants were requested to rate their peak pain during the provocative movement using the NRS. To limit risk of aggravating symptoms pain, scores in excess of seven resulted in the cessation of the trial. To minimize the risk of excessive symptom irritation and fatigue, following demonstration and practise only one lunge
or SLS trial per taping condition was performed [13,28]. For a trial to be accepted the participant was required to execute the movement smoothly with arms folded, while maintaining balance throughout (Figs. 1 and 2).

Fig. 1. The Codamotion system set-up during a lunge trial.

Fig. 2. The Codamotion system set-up during a single leg squat trial.

Fig. 3. The application of the McConnell Patellofemoral Joint Taping technique (PFJT).
2.5. Taping

For both taping conditions 3.8 cm width rigid zinc oxide tape with 5 cm hypoallergenic underlay were applied to the symptomatic leg in accordance to guidelines outlined by Constantinou and Brown (2010). To reduce performance bias, one researcher applied the TIRLT technique while another consistently applied PFJT. Both researchers were practised in performing the techniques and were observed and trained in the technique by an expert in the field. The PFJT technique was applied in long sitting with the knee bent to approximately 30 degrees using a standardised cylinder under the selected knee (Fig. 3). Following the application of hypoallergenic underlay over the patella, zinc oxide tape was applied from the middle to the lateral aspect of the patella to tilt it medially. Next, a medial glide was applied with one hand, while gathering the medial tissues of the knee with the other. The tape was anchored from the lateral to the medial aspect of the knee as the medial tissues were released (Fig. 3). The knee was then actively flexed as the researcher applied pressure to each side of the tape to ensure it would be secure during the movement.

The TIRLT technique was applied to the participants’ affected knee in a standing position with the knee in approximately 20 degrees flexion. A strip zinc oxide tape was applied starting approximately two cm medial to tibial tuberosity. The tape was tensioned whilst simultaneously applying an external rotational glide on the tibia up to the neutral rotation position (Fig. 4) and applied obliquely from medial to lateral crossing the knee joint posteriorly, finishing in a laterally directed tension on the superior aspect of the thigh (Fig. 4).

2.6. Data analysis

Data was analysed using IBM SPSS Version 22. Descriptive statistical analysis was performed on the demographic data. Data was assessed for normality using the Shapiro Wilkes Tests. A one-way repeated measures ANOVA was conducted to compare ROM between the different taping conditions (no taping, PFJT, TIRLT) for both the lunge and the SLS. Significance for kinematic data was reported using Wilks’ Lambda. As pain data was not normally distributed, it was analysed non-parametrically using Friedman’s test for K-related samples and using the Wilcoxon Sign Rank Test for post hoc analysis. Significance was set to \( p < 0.05 \) for all values. The above tests were performed, as appropriate, for pain values and ROM (maximum-minimum values) at the hip, knee and ankle during the lunge and squat on the sagittal, transverse and coronal planes. ROM values of all movement data were reported. Mean and standard deviation (SD) were reported; however, where non-parametric tests were used, medians and interquartile range (IQR) were provided, this was the case for the pain variables only.

3. Results

The demographic, anthropometric and baseline data for the participants (n = 23) is summarised in Table 1.

3.1. Pain

During the lunge participants reported a significant reduction in pain with both the TIRLT technique (median NRS = 1, IQR = 2) and the PFJT technique (median NRS = 1, IQR = 2) compared with the no tape condition (median NRS = 2, IQR = 3, \( p = 0.005 \) and \( p = 0.011 \), respectively). Similarly, while performing a SLS participants indicated significantly less pain with TIRLT technique (median NRS = 2, IQR = 3) and PFJT technique (median NRS = 2, IQR = 2) compared with the no tape condition (median NRS = 3, IQR = 3, \( p = 0.002 \) and \( p = 0.001 \) respectively). There was no significant difference in reported pain scores between the two taping conditions for either the lunge (\( p = 0.045 \)) or the SLS (\( p = 0.232 \)).

3.2. Kinematic data

While performing the lunge, participants displayed no differences between taping conditions for any of the sagittal, transverse or coronal plane kinematic data at the hip, knee or ankle. Range of motion angles of the lower limb joints during the lunge are presented in Table 2.

Similarly, during the SLS there was no significant difference between the taping conditions for any of the sagittal, transverse and coronal

Table 1

| Characteristic                                     | Mean (SD) or Median (IQR) |
|----------------------------------------------------|---------------------------|
| Gender, female (%)                                 | 12 (52.2)                 |
| Age, years (mean ± SD)                             | 29.1 ± 10.7               |
| Height, cm (mean ± SD)                             | 175.4 ± 9.5               |
| Weight, kg (mean ± SD)                             | 75.0 ± 11.8               |
| Number of aggravating factors identified (median)   | 4 (2–6)                   |
| Baseline NRS at rest (median, range)               | 0 (0–3)                   |

NRS: numerical rating scale; SD: standard deviation.
The immediate effect of the TIRLT and PFJT techniques on pain in people with PFPS and directly compared the effects. Altered sensory and pain processing pathways have been identified in some individuals with PFPS. Taping could positively influence these factors together with motor re-learning to correct adaptive movement patterns and facilitate recovery.

The pain-relieving effects of taping may be explained by changes in quadriceps muscle activation, specifically the timing of VMO contraction relative to VL. Moderate evidence supports earlier onset of VMO activation with the application of PFJT. It is not known if TIRLT technique produces any alterations in muscle activation. Several studies found comparable levels of pain reduction between taping protocols and sham taping. Patellar taping decreased pain in subjects with PFPS, irrespective of how taping was applied. Pain relief may also be partially attributed to sensory or proprioceptive afferent sensory input. Pain relief may also be partially attributed to sensory or proprioceptive afferent sensory input.

Changes in movement may require consideration of these factors together with motor re-learning to correct adaptive movement patterns and facilitate recovery.

Table 3

| Hip Angle (Degrees) | No tape  | PFJT  | TIRLT  | p-value |
|---------------------|---------|-------|--------|---------|
| Flexion (mean ± SD) | 62.17 ± 14.39 | 60.95 ± 12.33 | 64.01 ± 10.90 | 0.15    |
| Adduction (mean ± SD) | 9.83 ± 5.58 | 9.49 ± 5.48 | 8.77 ± 5.79 | 0.76    |
| Internal rotation (mean ± SD) | 11.08 ± 4.29 | 9.99 ± 3.53 | 11.43 ± 4.51 | 0.32    |
| Ankle Angle (Degrees) |       |       |        |         |
| Dorsiflexion (mean ± SD) | 27.69 ± 9.04 | 27.94 ± 10.42 | 28.26 ± 8.28 | 0.89    |
| Adduction (mean ± SD) | 12.18 ± 3.58 | 12.98 ± 3.48 | 13.72 ± 4.05 | 0.27    |
| Pronation (mean ± SD) | 15.49 ± 8.62 | 13.65 ± 6.26 | 15.71 ± 7.74 | 0.39    |
irrespective of technique, may create an expectation of improvement. The placebo effect is at its height directly after the intervention [41]. It is unclear if the magnitude of the immediate pain reduction changes with repeated application of the tape. Further evaluation of taping effects beyond the short-term is thus recommended [15].

Irrespective of the mechanism of action, the provision of immediate pain relief through both types of taping techniques in this study could provide a valuable tool in order to gain patient trust. Both types of taping techniques used in this study could provide a pain-free opportunity to engage in more active forms of treatment, such as therapeutic exercise. Despite the lack of consensus regarding its mechanisms of action there is good evidence to support various forms of taping as an adjunct to exercise in the management of PFPS [42].

Among the limitations to the study was the possibility of sampling bias. Participants were recruited via convenience sampling from the same university source potentially limiting the generalizability of the study findings to other populations [42]. Blinding participants to the different conditions was not possible due to the nature of the study. The aim of this study was to assess and compare the immediate effects of two different types of taping techniques and thus did not include sham taping. This was to reduce the amount of tape application, number of different conditions was not possible due to the nature of the study. The TIRLT technique aims to correct excessive pronation and internal rotation of the tibia, it may be useful to determine the effectiveness of TIRLT technique in a homogenous sub-group.

TIRLT technique had a similar pain reducing effect to the widely used PFJT technique. While this study did not find evidence of a kinematic effect for either taping technique, it suggests that both PFJT and TIRLT may be a useful adjunct to rehabilitation. This short-term benefit of pain relief may allow therapists the opportunity to engage patients in active forms of intervention with proven long-term effectiveness, such as exercise.

Declaration of Competing Interest

The authors report no declarations of interest.

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