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Original research

Effects of femoral rotational taping on pain, lower extremity kinematics, and muscle activation in female patients with patellofemoral pain

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ABSTRACT

Objectives: To explore the hip and knee joint kinematics as well as muscle activation between participants with patellofemoral pain syndrome (PFPS) and controls, and to investigate the immediate effect of proximal femoral rotational taping on pain, joint kinematics, and muscle activation during single-leg squat (SLS).

Design: Cross-sectional study.

Methods: Sixteen female participants with PFPS, and eight healthy female controls participated. Three-dimensional hip and patellar kinematics measured by electromagnetic tracking system, hip (gluteus maximus and gluteus medius) and thigh (rectus femoris) muscle activation measured by EMG, and subjective report of pain were recorded during SLS in three randomized conditions of no tape, sham taping, and femoral rotational taping with kinesiotape.

Results: Without taping, compared with controls, PFPS group had increased hip adduction angle ($23.5 \pm 11.3^\circ$ vs. $15.8 \pm 7.3^\circ$) during SLS. Additionally, PFPS group exhibited lesser rectus femoris activity during the initial 0–15° of SLS. Application of both femoral rotational and sham tapes reduced pain for PFPS group. Compared with no tape or sham tape, femoral rotational tape significantly shifted the patella into more posterior (1.59 ± 0.83 cm in no tape vs. 1.54 ± 0.87 cm in sham tape vs. 1.32 ± 0.72 cm in femoral rotational tape) and distal (-2.49 ± 0.95 cm vs. -2.64 ± 0.80 cm vs. -3.11 ± 0.77 cm) positions in the PFPS group.

Conclusions: Femoral rotational taping could alter patellofemoral kinematics and decrease pain in treatment of young female participants with PFPS.

1. Introduction

Patellofemoral pain syndrome (PFPS) is the most common complaint affecting the knee,[1] characterized by retropatellar and/or peripatellar pain associated with activities involving lower limb loading. A variety of lower extremity patho-mechanical factors may contribute to PFPS and successful intervention should focus on addressing these underlying etiological factors.[2]

In addition to the local factor of suboptimal patellar alignment/tracking, PFPS may be influenced by the proximal and/or distal factors, such as the hip and/or ankle joints and the segments of femur and/or tibia.[2] Evidence in recent years suggest that proximal hip weakness and poor functional control of the femur are associated with this dysfunction.[2,3] Compared to controls, females with PFPS were more likely to have decreased strength in hip abductor, external rotator and extensor muscles[3,4] as well as greater hip adduction and internal rotation during demanding tasks of single-leg squat (SLS),[5–7] single leg step downs,[8] running, and jumping.[6,8] Considering that poor muscle performance in hip abductor and external rotator may lead to dynamic knee valgus during SLS,[9–11] the one major reason for "medial collapse" is compromised proximal control resulting in excessive hip adduction, internal rotation, and knee valgus observed during weight bearing activities.[2,3]

Biomechanically, abnormal femoral kinematics can potentially alter the normal mechanics of the patellofemoral joint.[7,12–14] Results from magnetic resonance imaging (MRI) and cadaveric studies have demonstrated that excessive femoral internal rotation

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underneath a fixed stable patella was associated with increased lateral patellar tilt and translation[7,12] and elevated patellofemoral contract pressure.[13] A recent MRI study in healthy participants confirmed simulated "medial collapse" movement patterns in SLS resulted in greater tibial external rotation coupled with increased lateral patellar translation.[14]

In light of the deleterious effects of poor femoral control on patellofemoral mechanics, studies have examined the efficacy of hip-targeted therapeutic exercises on pain reduction and functional improvement in patients with PFPS.[15–17] Using movement pattern modification via verbal instruction to correct dynamic knee valgus during SLS in female patients, Salsich et al.[18] found pain reduction may be associated with a correction of faulty hip transverse plane kinematics. Recently, application of an external strap to facilitate hip external rotation reduced pain and brought about a significant reduction in knee valgus angle during unilateral squat and step landing in female patients by a single camera 2-dimensional analysis.[19] This 2-D video analysis method, however, lacks sensitivity to small changes in knee valgus angle.[20] Additionally, the transverse-plane motion components of the medial collapse would require 3-D motion analysis.

Taping is a quick and simple practice to provide external support, motion control, proprioceptive input, kinesthetic reminder, or stress re-distribution. Kinesiotape, has some advantages over the traditional strapping tape (i.e., Leukotape). It is known that the stretchable cotton material works ideally with the skin's natural elasticity. With low allergic adhesive, Kinesiotape could be well tolerated by the skin even in the long-term treatment. In theory, taping the femur into a more externally rotated position may not only restrict hip internal rotation and associated knee valgus, but also provide kinesthetic reminder or proprioceptive input to facilitate femoral external rotation during lower limb loading. To our best knowledge, no study has investigated the benefit of external femoral taping in the treatment of subjects with PFPS. This intervention, directed towards a specific underlying abnormality that cause patients' symptoms, may isolate the effect of proximal hip control on clinical outcomes and patellofemoral kinematics.

The purposes of this study were (1) to compare the hip and knee joint kinematics as well as muscle activation between PFPS participants and controls and (2) to investigate the immediate effect of proximal femoral rotational taping on pain, joint kinematics, and muscle activation during single leg squat (SLS). We hypothesized, during SLS, participants with PFPS would demonstrate greater knee valgus as well as diminished gluteal and rectus muscle activation compared with healthy controls and that femoral rotational taping would reduce pain and knee valgus with changes of muscle activation during SLS.

2. Methods

Sixteen female participants with PFPS and eight healthy controls were recruited from local community by the advertisement. We only included female participants due to gender differences in the PFPS incidence rate and in lower-extremity kinematics.[21] All participants signed informed consent prior to participation. The study protocol was approved by the ethics committee of the National Taiwan University Hospital.

The inclusion criteria of participants with PFPS were (1) experience of knee pain during at least 2 of the following activities: prolonged sitting, stair climbing, squatting, running, kneeling, hopping and jumping, and deep knee flexing; (2) gradual onset of symptoms unrelated to a traumatic accident; (3) pain at least a 3 on a 10-cm visual analog scale (VAS) during the previous week; (4) pain lasting for >1 month; (5) presence of a positive medial collapse during a SLS test (defined and described in the screening exam procedures below). The exclusion criteria were evident of pronated foot, knee ligament instability, patellar tendinitis, knee effusion, or patella dislocation, or having previous knee trauma or surgery as screened and interviewed by a licensed physiotherapist. The selection criterion of the control group was no prior knee pain or trauma to the lower extremity. Healthy subjects were matched with participants with PFPS according to age, height, and weight. All participants had no prior experience of kinesiotaping and had a normal body mass index (BMI < 24 kg/m^2) to minimize the cofounding factor of fatty tissue on the taping effect.

All participants reported to the laboratory for a single testing session. The testing leg was chosen as the most symptomatic leg of each participant, and the dominant leg (foot used to kick a ball) of each control. Basic demographic data were collected and the Anterior Knee Pain Scale completed.[22] The frontal plane projection angle (FPPA) of the knee, formed by the intersection of the line from proximal thigh to mid tibiofemoral joint, and the line from mid tibiofemoral joint to mid ankle mortise,[11] was measured to quantify the severity of medial collapse during the SLS test.

Under each of the three randomized taping conditions (no tape, tape, and sham tape), barefoot participants performed three trials of non-consecutive SLS with their arms crossed over their chest. Squat movements from full knee extension to 45° flexion were paced by a digital metronome at the velocity of 30 deg/s. Participants rested for 30 s between each trial. Foot placement was recorded by marked reference points so that the foot could be repositioned in the same place across the testing conditions. A 10-cm VAS was administered by a physiotherapist to record each participant's perceived pain level on the testing leg. Three practice trials were given prior to the official testing. Participants were told to initiate the SLS according to the therapist's instruction of start, and to return to the start position after the instruction of stop. Knee-flexion angle was checked during practice trials using a standard goniometer. A reference marker was then made aside on the wall for the therapist to ensure that participants reached the target angle during the testing trials.

Kinesiotape (Kinesio Tex Tape; Kinesio Holding Corporation, Albuquerque, NM) allows a partial to full range of motion for the applied muscles and joints with different pulling forces to the skin. First, the participant was asked to maximally rotate her femur externally and maintain this position in standing. Second, the therapist applied a piece of I-shaped kinesiotape anchoring at the inferior-medial aspect of the thigh. Third, the therapist pulled the tape superiorly and laterally, spiraling up the thigh and diagonally crossing the buttock; then anchored the base of the I-tape at the ipsilateral PSIS (Supplement Fig. 1). To standardize the rotational pulling force, moderate tape tension (approximately 20% stretch) was provided. For the sham taping, the tape was applied onto the thigh without tension as the participant maintained neutral stance. All taping was performed by the same physiotherapist experienced in the application of this kind of taping technique.

Supplementary material related to this article can be found, in the online version, at doi:10.1016/j.jsams.2014.07.009.

Kinematic measurements were taken using the Fastrak electromagnetic tracking system (Polhemu Inc., Colchester, VT, USA) at a sampling rate of 40 Hz. The Fastrak system is well established in biomechanics literature assessing hip and knee joint kinematics.[23,24] The system specifications regarding measurement accuracy are 0.8-mm and 0.15-deg for position and orientation, respectively, according to the manufacturers. Four electromagnetic sensors were attached to the sacrum, lateral thigh, lateral shank, and patellar clamp of the testing leg with adhesive tape while the participant stood upright with feet shoulder-width apart. Palpable landmarks consisted of the lateral and medial malleoli, lateral and medial femoral epicondyles, greater trochanter (GT), anterior and posterior superior iliac spines (ASIS and PSIS). The landmarks were