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The Effects of Kinesio Taping on VMO and VL EMG Activities during Stair Ascent and Descent by Persons with Patellofemoral Pain: a Preliminary Study

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Abstract. [Purpose] This study aimed to find out the effects of Kinesio taping (KT) on the vastus medialis oblique (VMO) and vastus lateralis (VL) EMG activities of patellofemoral pain syndrome (PFPS) patients. [Subjects and Methods] Fifteen PFPS patients (mean age: 23 yr, mean height: 155 cm, mean weight: 71.47 kg) participated in this study. KT was attached to all subjects from the tibial tuberosity, following VMO and VL paths, up to 1/3 of the proximal thigh. Subjects' pain was measured using a VAS scale with and without KT. A digital dynamometer (Power Track II, JTECH medical, USA) was used to measure maximal voluntary isometric contraction (MVIC), and a surface EMG (MP150 BIOPAC System Inc. CA. USA) was used to measure the VMO and VL EMG activities. [Results] KT was found to significantly reduce pain and to increase MVIC. The VMO and VL EMG activities during stair ascent and descent decreased to a significant degree. [Conclusion] The study results suggest that KT is effective for pain relief, increase MVIC and decrease EMG activity of PFPS patients. Accordingly, KT applied around knee joints seems to help PFPS patients during stair ascent and descent and with activities of daily living including walking.

Key words: Kinesio taping, EMG activity, Patellofemoral pain syndrome

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INTRODUCTION

Patellofemoral pain syndrome (PFPS) occurs due to mal-tracking arising at the patellofemoral joint. PFPS is a common disease found in one fourth of the total population[1]. PFPS develops when vastus medialis oblique (VMO) activity decreases, allowing increased lateral deviation of the patellar. VMO serves as a dynamic medial stabilizer for the patellar and plays an important functional role in positioning the patellar in the trochlear of the patellofemoral joint[2]. Many investigators have tried using a range of therapeutic exercises or externally appled apparatus such as tapes or braces in an attempt to get the patellofemoral joint gliding back to normal, so as to reduce pain and to improve the functionality of the patellofemoral joint[3–7].

Since McConnell published a report about patellar taping in 1986, lots of investigators have used taping to treat PFPS patients. Interestingly, almost all studies using taping have reported pain relief regardless of the taping method[2,3,6,8].

In contrast, when it comes to muscle strength and muscle activity, previous reports are inconsistent. That is, some studies have reported that taping does not influence maximal muscle strength[2,7], while others have found muscle strength decreases[9,10] or increases[8,11–13]. Some studies have reported that the activity of VMO and VL (vastus lateralis) increases[2,11,14] or decreases[9,15], while others have reported no changes[3,16].

What has caused the differences in previous findings? Multiple causes and variables may exist, but we suspect that the different ways of taping may have resulted in the different findings. Hence, we reviewed prior study results and found that most of taping methods applied to PFPS patients were patellar medial or lateral gliding methods which used non-elastic tapes as suggested by McConnell.

Consequently, we hypothesized that, unlike McConnell's tape, an elastic Kinesio tape fixed not to the patellar medial or lateral side but to the patellar and up to VMO and VL would generate different results.

Kinesio taping (KT) was developed in 1996 by Kenzo Kase and is a thin and elastic adhesive tape, which is characterized by 120–140% elasticity, leading to less dynamic restraint compared to non-elastic tapes. Applied to muscles or joints, Kinesio tape varies in pulling forces on the skin, allowing joints to move to a certain extent[17].

The rationale given for the effects of KT is that it increases circulation of blood, lymph and tissue fluids through space created between skin and muscles. This space expands when the skin is pulled up by the tape when the joint returns to its

Table 1. Inclusion and exclusion criteria of this study

Inclusion criteria	Exclusion criteria
1. Anterior or retropatellar pain, insidious in nature, was aggravated by at least two of the following common functional activities of daily life at least 3 months duration: running, prolonged sitting, stair climbing, squatting, kneeling, hopping/jumping. 2. Never received treatment prior to this study 3. Completed consent form	1. Signs of secondary osteoarthritis in the knee joint 2. History of surgery in the knee joint 3. Dislocation or subluxation in the PFJ 4. Meniscus and ligament injury in the knee joint 5. Referred pain due to spinal cord problems 6. Patellar tendinitis or anterior knee pain

original position as a result of the tape being fixed to the skin and the muscle being maximally extended[18].

The tactile sensation added to the skin by the tape affects the excitatory attributes of the central nervous system, interacting with motor control[19], and serves to sufficiently change muscular power[14]. If this hypothesis were true, it could be inferred that KT has an effect on pain and muscular strength and activities in PFPS patients.

Accordingly, in this study, we applied KT to PFPS patients as suggested by Kase et al.[18] Specifically, we attached the tape without extension to VMO and VL with the knee joint in flexion to find out its effects on pain, muscle strength and the EMG activities of VMO and VL while subjects ascended and descended the stairs.

SUBJECTS AND METHODS

Fifteen male subjects with PFPS (mean age: 23 yr, mean height: 155 cm, mean weight: 71.47 kg) were selected based on criteria based on previous studies[2,3,9].

Inclusion criteria were: those who had felt pain increasing behind the patella in daily activities for at least 3 months duration; those who felt it hard to run for more than 5 minutes; and those who felt anterior or posterior knee pain when sitting long hours, or ascending or descending the stairs, or squatting or running, or kneeling or jumping, as well as those who had never received any treatment prior to this study. Those who had osteoarthritis and received surgery within three months of this trial, and those who had dislocation or subluxation of the patellar, meniscus injury, ligament injuries, referred pain due to spinal cord problems, the patellar tendinitis or other anterior knee pain were excluded (Table 1).

Among those who met the above conditions, 15 subjects were selected based on positive results from the patellar compression test. All subjects signed on informed consent form before participating in this study.

The procedure for this study was as follows. First, surface EMG electrodes were attached to VMO and VL of all subjects to measure MVIC of the knee extensors using a digital dynamometer. Second, the surface EMG activities of the two muscles were measured while subjects ascended and descended 4 stairs of 15 cm step height. Third, pain score was recorded. Then, the 3 steps described above were repeated after application of KT to VMO and VL.

The maximal voluntary isometric contraction (MVIC) was measured using a digital dynamometer (Power Track II, JTECH medical, USA). Subjects sat on the therapeutic table with their knees flexed approximately at 60 degrees. The investigator fixed one hand on the distal femur and the other on the digital dynamometer applied to the top side of the subject's foot to induce maximal knee extension. The mean values of MVIC measured for 5 seconds for each subject were recorded.

The electromyographic activities of VMO and VL during stair ascent and descent were measured with surface EMG (MP150 BIOPAC System Inc. CA. USA). TSD 150B EMG electrodes with an inter-electrode distance of 20 mm were used. The electrode for VMO was placed over the muscle belly 4 cm superior to and 3 cm medial to the superomedial patella border and was oriented 55° to the vertical. The electrode for VL was placed 10 cm superior and 6 to 8 cm lateral to the superior border of the patella and oriented 15° to the vertical. The ground electrode was placed over the tibial tubercle[2,3]. Prior to electrode placement, the skin was shaved, swabbed with alcohol, and gently abraded with sandpaper to reduce the electrical impedance to less than 5 kΩ. To remove noise that might arise due to electrode movements while ascending and descending the stairs, the electrodes were fixed with sticking plaster.

With EMG electrodes attached to VMO and VL, and upon being told to "go," subjects performed a total of 5 repetitions of 3-meter walking followed by ascent and descent of 4 15-cm steps. Subjects were asked to use the affected leg first when ascending the stairs, and the sound leg first when descending. Subjects practiced once before the main measurement began. The first and the last values of the measured values of the stair ascent and descent repeated 5 times were discarded and the mean values of the remaining 3 measurements were used for statistical analyses.

The EMG sampling rate, band-pass filter and the notch filter were set to 1,000 Hz, 30 Hz–500 Hz and 60 Hz, respectively. For normalization, the mean values of muscle activity measured during stair descent and ascent were converted to percentages of the mean values of MVIC measured prior to KT application,

A 10-cm visual analogue scale (VAS) was used after each test to record subjects' perceived pain. The VAS has been proven to be a reliable method of assessing pain[20].

While subjects were taking long sitting positions with their affected knees flexed at about 90 degrees, a 2.5-cm-wide KT was applied first to the tibial tuberosity, the patellar, VMO and up to 1/3 of the proximal thigh. Then, KT was applied to the path of VL in the same way.

To test the statistical significance of differences between with and without KT we conducted the paired t-test (SPSS

Table 2. Significant differences in pain, MVIC and mean values of VMO and VL during stair ascent and descent after the application of KT

	Without tape	With tape	% Change
	Mean ± SE	Mean ± SE	
Pain	5.2 ± 0.7	4.1 ± 0.6	153*
MVIC(lb)	87.9 ± 6.3	97.7 ± 5.9	90**
Stair ascent			
VL(%)	71.2 ± 7.4	49.7 ± 4.6	76**
VMO(%)	95.1 ± 7.1	45.6 ± 5.8	52**
Stair descent			
VL(%)	56.3 ± 6.5	39.4 ± 4.3	79*
VMO(%)	50.2 ± 5.9	35.5 ± 3.5	78*

VL: vastus lateralis; VMO: vastus medialis oblique. *<0.05, **<0.01

v14.oK for Windows). Statistical significance was accepted at values of $p<0.05$.

RESULTS

As shown in Table 2, pain decreased significantly after taping ($p<0.05$), whereas the maximum muscle strength increased significantly ($p<0.05$). The EMG activities of VMO and VL during stair ascent and descent decreased significantly ($p<0.05$).

DISCUSSION

In this study, KT was applied to VMO and VL of PFPS patients and pain, MVIC, and EMG activities of VMO and VL were measured. In short, KT significantly reduced pain, significantly increased MVIC, and significantly decreased EMG activities of VMO and VL during stair ascent and descent.

The findings here that KT around the patellar of PFPS patients lessened pain agree with those of other studies[2,3,6,8]. Why is KT effective for pain relief? Prior reports and the present findings suggest the following rationales. First, according to gate control theory, the tactile stimulus of KT applied to the patellar in pain would activate the function of the substantia gelatinosa cell, blocking pain from passing through the spinal cord, thereby removing (or relieving) the pain[2,16]. Second, Kase asserted that as the tape is applied when the muscle is maximally elongated, wrinkles on the skin are seen when the tape returns to its normal length. Thus, the fascia below the skin is separated from the skin, allowing blood or lymph circulation to increase within the inner space, which would allow the quick removal of pain-inducing substances[18]. Third, the tape causes the patellar to be relocated between the patellar and the femoral trochlear, changing the contact force and joint reaction force of the patellar while decreasing the load and stress as well as pain occurring at the joint[21,22].

As mentioned above, the findings here show that MVIC increased whereas the EMG activity of VMO and VL during stair ascent and descent significantly decreased. This finding is supported by a previous study, in which Herrington[8] applied a medial glide tape fixation to 14 PFPS female patients aged 20–29, as suggested by McConnell[6], and used an isokinetic apparatus to measure the maximal torque values of the eccentric and concentric quadriceps femoral muscle. He found that angular velocities of 60°/s and 180°/s led to significant increases in the maximal torque values after taping. Also, Keet et al.[15] applied taping to the patellar of 14 PFPS patients and reported that the EMG activity of VMO during stair ascent and descent significantly decreased. Further, Parsons and Gilleard[23] reported that tape application contributed to a significant decrease in muscle activity of VMO and VL during stair ascent and descent.

What are the reasons for KT increasing the MVIC of the knee extensors? First, non-elastic materials were used by McConnell, or sports taping, and most previous studies applied taping in a way that the patellar was wrapped[3,6,8,15], with the tape running over the patellar[2]. In contrast, we applied elastic KT following the paths of VMO and VL. Consequently, the MVIC increased in this study, and this seems to attributable to the its assistive action on both muscles. Second, the MVIC of the knee extensors seems to increase because the knee-joint internal moment arm lengthens[8,9,11–13]. Third, MVIC increased because of pain relief. Pain hinders a strong contraction through muscle guarding. With less pain, a stronger the voluntary contraction would have been possible contributing to a higher MVIC.

Lastly, what caused the EMG activity to decrease during stair ascent and descent? In the present study, KT was applied with the knee bent, first to the patellar, and then up to the VMO and VL paths, which would have reduced the pressure on the skin and the patellar, and lengthened the moment arm of the quadriceps femoral muscle passing through the knee joint, resulting in greater maximum muscle contraction and less neuromuscular recruitment for functional activities during stair ascent and descent.

This study is limited in that it was a trial which measured pain, muscle strength and EMG activity of VMO and VL with and without KT, not a long-term longitudinal study of KT. Therefore, longitudinal studies are needed on how long the effects of KT last. Also, as it is predictable that taping has an effect on endurance as it reduces the EMG activity, further studies are required on how taping works in improving endurance.

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