



Modulation in Pain and EMG Activities with Rigid- and Kinesio-Taping in Athletes with Jumper's Knee

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Abstract

Purpose: To investigate whether taping could modulate intensity of pain and electromyography activities of vasti muscles in the athletes with jumper's knee.

Subjects and Methods: Thirteen subjects with jumper's knee participated (mean age 24.3±5.8 years). All subjects performed single-leg decline squat and counter-movement jump under 3 taping conditions (rigid, Kinesio and placebo tapes). Changes in visual analogue pain score, knee joint angles during the 2 tested movements, and the electromyography amplitudes of vasti muscles prior to landing from the counter-movement jump were measured.

Results: Analyses of variance revealed that only rigid taping had resulted in significant pain reduction during decline squat (by 22%, $p=0.05$), while both rigid and Kinesio taping could reduce pain associated with landing from counter-movement jump (by 65-72%, all $p < 0.05$) when compared with un-tapped condition. All 3 taping conditions increased the maximum knee flexion during the 2 tested movements (all $p < 0.05$). Application of the tapes, however, did not alter the amplitude of the muscle activities of the vastis muscles in preparation for landing ($p > 0.05$).

Conclusion: Rigid tape reduced pain during decline squat, while both rigid and Kinesio taping reduced pain on landing from counter-movement jumps in athletes with jumper's knee. The application of tape increased knee flexion during decline squat and on landing from counter-movement jump, but were not associated with changes in electromyography amplitude of the vasti muscles.

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Keywords: Jumper's knee; Pain; Kinesio taping

Introduction

Jumper's knee or patellar tendinopathy is one of the common problems among athletes. It is characterized by localized pain of the patellar tendon at its origin on the inferior pole of patella and exacerbated by repetitive and forceful quadriceps muscle contractions [1]. The overall prevalence of jumper's knee in an athletic population has been reported to be 14% with highest prevalence in volleyball and basketball [2]. These two sports are characterized by high demands of speed and power of leg extensors and would impose high loading on the patellar tendon during jumping and landing activities. Despite the current treatment options, the symptoms do not resolve quickly and most subjects with jumper's knee would have the symptoms lasting for 32 +/- 25 months. A 15 year prospective follow-up study reported that 53% of athletes were affected to such a degree that they had to quit their athletic career [3].

Although the mechanism of jumper's knee are not fully understood, excessive tendon loading during taking-off or landing and the resultant micro-tears of the tendon has been suggested to be one of the causes [4,5]. A recent study with computer simulation of patella-patellar tendon complex has found that an increase in tensile strain rather than compressive force was associated with knee joint flexion angles and such findings were further confirmed on a cadaver testing [6]. Indeed, similar findings have been reported from dynamic and static magnetic resonance imaging of patellar tendinitis in an open-configuration system [7]. Basing on this tensile-overload theory of the pathophysiology of patella tendinopathy, to de-load the affected tendon is therefore one of the conservative treatments for jumper's knee [8,9].

Rigid taping is one of the commonly used methods to de-load affected tendons [10] which resulted in decreased pain during activities and improve sport performance in patients with patellofemoral pain syndrome [11-14] and tennis elbow [15]. Briem et al. [16] also reported that

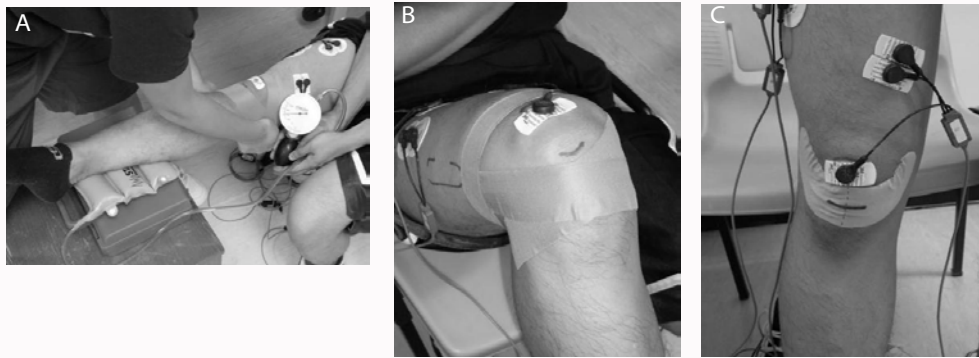


Figure 1: Illustration of taping methods. 1(a) rigid taping. 1(b) placebo tape. 1(c). Kinesio tape with mechanical correction technique.

non-elastic athletic tape may enhance muscle response of the fibularis longus by maintaining greater levels of muscle activation. However, rigid tape has its drawback that the effect of rigid tape is not long-lasting, with most overflows continuing only about 15-30 minutes after cessation [17]. In this connection, Kinesio taping (KT) as proposed by Kenzo Kase in 1996 [18,19], has gained popularity in the field of sport medicine with its unique characteristics of being durable and stretchable thus offering little hindrance to movements. It aims to give free range of motion in order to allow the body's muscular system to heal itself bio-mechanically [19]. However, Briem et al. [16] reported that elastic tape, such as KT, with respect to prevention of inversion ankle sprains via effect on the muscle activation of the fibularis longus, is unsubstantiated. Fu et al. [20] said that KT did not enhance nor inhibit muscle strength when applied to the thigh and knees of healthy athletes. Firth et al. [21] reported that KT had no effect on hop distance, pain, or motoneuronal excitability in people with Achilles tendinopathy. On the contrary, research reported that there is a change in timing to generate the knee extension peak torque [22], and improve the ratio of VMO/VL. In addition, recent studies reported that KT has the ability to mitigate pain [23]. In view of the controversies in response of the frequent use of taping in controlling pain in athletes, this study was undertaken to investigate the effects on pain modulation and muscle activities of rigid and Kinesio taping in athletes with jumper's knee. Our hypotheses were (1) rigid and Kinesio taping could decrease pain intensity in athletes with jumper's knee, and (2) both taping could modulate muscle activities on landing from counter-movement jumps.

Subjects and Methods

This was a single-group repeated measures design. Athletes were recruited from basketball and volleyball teams as well as athletic teams in our geographic region. Subjects were recruited if they suffered from moderate or severe local tenderness on palpation at the inferior pole of patella and/or proximal patellar tendon with Victorian Institute of Sport Assessment (VISA) score less than 80 [24]. The symptoms could be reproduced on jumping, squatting and/or stepping located at the patellar tendon. Patients with history of knee surgery (including surgery to the tendon), patello-femoral joint pain (differentiated by deep pain on the peri-patella region and reduced in pain after re-alignment of patella by taping or manual assistance), fat pad impingement, as well as having corticosteroid injection into the tendon in recent 6 months were excluded from this study. If both knees were affected, the more seriously affected side claimed by the subject was tested. Ethical approval was obtained from the ethics review committee of the Hong Kong Polytechnic University prior to

the study. All subjects participated on a voluntary basis and gave their informed consents prior to participation in this study.

The tests were conducted in the laboratories of the Hong Kong Polytechnic University and a sports hospital. General information on training intensity, pain profile and VISA score were obtained. After 5 minutes of warm-up exercises on a resistance-free exercise bike, each subject performed single-leg decline squat test (DST) and counter movement-jumps (CMJ).

The DST was performed on a 25° decline board as this angle would lessen the contribution from the calf and it has the best ability to discriminate a change in pain scores [25]. Subjects were to keep the trunk vertical (to minimize gluteal participation), heels in contact with the board and squat to the point when pain started. During the process, subjects were not allowed to stabilize their bodies onto any external support. Each subject performed 3 trials under each taping condition.

The CMJ was performed with subjects standing in shoulder-width standing with both feet on the floor and their palms on their pelvis. They were instructed to jump as fast and as high as possible and land for 3 times. A foot switch consisting of a pressure-sensitive lamina (Overlamina, 3M Health Care, Germany) which detected the pressure between the foot and the ground was secured to the calcaneus and to the first ray on the plantar surface of the foot of tested limb with zine oxide tape. The switch was connected to the Noraxon Telemyo System (Noraxon USA Inc, Scottsdale, Arizona) and synchronized with the EMG signals.

Each subject performed the above tests untapped as well as under 3 taping conditions: (1) rigid taping, (2) placebo (control) taping, and (3) Kinesio taping. For rigid taping, the "unloading tape" method suggested by Macdonald [10] was utilized. Rigid tapes of 25 mm wide for anchor strip and 38 mm for cross strip were used. The tapes were applied with the knee in full extension. The first tape was pull obliquely downward from medial thigh just above the knee joint to the lateral side with the top edge of the tape passing just under the inferior pole of the patellar. The second tape was repeated from lateral to medial ending up a V-shaped compression under the inferior pole of patella. The tape was repeated twice (Figure 1a). Placebo taping was applied when the knee was flexed at 90° to minimize the "un-loading" effects (Figure 1b). For Kinesio taping (KT), the taping started with an extended knee with middle of the KT strip placed over the inferior pole of patella so that 1/3 of the tape width was covering the pole. A downward pressure using 25-50% of available tension was applied to the tape. The subject was told to move his knee into full flexion and

Table 1: Visual analog score and range of knee flexion during decline squat and counter-movement jump tests.

		No Tape	Rigid	Placebo	Kinesio
DST	Pain Intensity (VAS)	5.1 ± 2.0	4.0 ± 1.8	4.1 ± 1.7	4.3 ± 1.8
	Knee Angle (°)	37.9 ± 8.2	47.0 ± 2.9	44.6 ± 8.7	45.4 ± 10.7
CMJ	Pain Intensity (VAS)	1.8 ± 2.4	0.6 ± 0.8	0.5 ± 1.4	0.5 ± 0.9
	Knee Angle (°)	58.0 ± 14.9	65.7 ± 14.3	68.0 ± 14.0	64.4 ± 11.1

Values are mean ± SD (standard deviation).

DST: Decline Squat Test; VAS: Visual Analogue Scale; CMJ: Counter-movement Jump

the tails of the strip with paper-off tension was applied towards the vastus medialis obliquus and vastus lateralis muscles (Figure 1c) [12]. To standardize the tension of the Kinesio tape, a 3 cm horizontal strip was marked on the centre of a piece of cut Kinesio tape prior to use. It was verified that an elongation from 3 cm to 4 cm approximated 50% tension of the tape.

The order of taping was randomized by drawing cards indicating which condition was to be tested and 15 minutes rest was allowed between each testing condition.

Subjective pain perceived during DST as well as at the instant of landing from the CMJ was measured with a visual analogue scale (VAS). This tool has been proven to be a valid and reliable measure for both the intensity and unpleasantness of pain perception [26]. All subjects were asked to indicate on a 10 cm line that represents the continuum of pain from no pain on one end to extreme pain on the other end.

An electrogoniometer (Noraxon USA Inc, Scottsdale, Arizona) was used to measure the degree of knee flexion when pain was perceived during DST and on landing from CMJ. The electrogoniometer was positioned along a line passing through the greater trochanter, lateral femoral condyle, and the lateral malleolus. The position of the electrogoniometer was marked by water-resistant pen to ensure identical positioning upon change of taping. Subjects were instructed to stand upright to set zero of the goniometer.

Surface muscle EMG was collected using the Noraxon Telemetry System from the vastus medialis obliquus (VMO), vastus lateralis (VL) and rectus femoris (RF) muscles to study the amplitude of muscle activities on landing from CMJ movements. Self-adhesive Ag/AgCl bipolar electrodes (2223, 3M Health Care, Korea) were placed with an inter-electrode distance of 20 mm. The surface electrodes were placed on the corresponding muscles according to the following references. (1) RF: 50% on the line from the anterior superior iliac spine (ASIS) to the superior part of the patella in the direction of the line. (2) VMO: 80% on the line between ASIS and the joint space in front of the anterior border of the medial ligament in the direction perpendicular to the line. (3) VL: 2/3 on the line from the ASIS to the lateral side of patella in the direction of muscle fibers [27]. The common reference electrode was placed on the patella. Skin preparation was done prior to placement of electrodes with washing, shaving, wiping and gentle abrading and electrical impedance was checked to make sure it was not more than 5k Ohms.

The analogue data from the electrogoniometer, surface electrodes and force sensors were passed through a single-ended amplifier (gain 500) to an 8-channel FM transmitter. The telemetry signals were transmitted to a receiver, amplified (gain 500) and filtered (15-500 Hz Band Pass Butterworth filter, common mode rejection ratio of 130 db). The analog signal was converted to digital data via a PCM16S/12 (16-channel, 12-bit) analog/digital board (Computer Boards,

Middleboro, Mass) at a rate of 1000 Hz.

Raw EMG data were processed with the LabView 7.0 customized software (National Instruments, Austin, Texas) to calculate the root-mean-square (RMS) of the EMG signals of a time window of 200 ms before and after landing from CMJ. The instant of landing was determined by a sudden change in pressure value of the foot switch placed inside the shoe.

Data collected were computed and analyzed using the Statistical Package for Social Sciences (SPSS) version 16. Statistical normality of the mean values of the last 2 measurements from DST and CMJ were assessed by one-sample Kolmogorov-Smirnov test. Normally distributed data were analyzed by multivariate analysis of variance (MANOVA) to test for within-subject effects. Post hoc linear contrasts were performed for significant MANOVA results to identify the data pairs that were different. The alpha level was set at 0.05 for all tests.

Results

Thirteen athletes (7 male and 6 female, mean age 24.3±5.8 years; height: 170.7±11.7 (cm), weight: 70.7±14.7 (kg) were recruited to participate in this study. All of them involved in jumping sports such as basketball, korfbal, volleyball, long jump and high jump. Training intensity ranged between 4 to 36 hours/week. Duration of jump-related pain varied from 0.3 to 6 years with VISA ranged from 51 to 71.

The means (±SD) of pain intensity and pain-free knee flexion for rigid tape, KT and placebo tape during DST are listed in Table 1 (upper 2 rows). The intensity of pain ranged between 1 and 8 from a scale of 0 to 10 when doing single-leg decline squat. All subject except one perceived pain with knee flexion between 28° and 44° (from 0° in stance position). Significant reduction in pain intensity and increased in pain-free knee flexion were found in decline squat test ($F_{0.55, 72} = 4.56, p=0.001$). Post hoc linear contrasts revealed that rigid tape had significantly reduced pain (by 22%, $p=0.012$) when compared with un-taped condition. Insignificant reduction in pain were observed with placebo and Kinesio tapes (by 20%, $p=0.063$; and 16%, $p=0.103$ with placebo and Kinesio tape, respectively). The range of pain-free knee flexion was significantly increased with taping (from 18-20%, all $p < 0.05$) when compared with un-taped squat.

Seven subjects perceived pain on landing from CMJ. The intensity of pain ranged between 1 and 7.5 with a mean score of 3.3 ($n=7$) (Table 1). Analysis on these 7 subjects revealed significant reduction in pain with rigid (by 65%, $p=0.045$) and Kinesio (by 72%, $p=0.02$) taping when compared with un-taped landing. Significant increased in maximum knee flexion on landing was observed with rigid (from 58.0° to 65.7°, $p=0.004$) and placebo taping (from 58.0° to 68.0°, $p=0.004$); as well as a strong trend in increased in maximum knee flexion with Kinesio taping (from 58° to 64.4°, $p=0.062$).

Table 2: EMG Activity (root mean square) under different taping conditions.

Variable		No Tape	Rigid Tape	Placebo Tape	Kinesio Tape
Decline squat	VMO	458.9 ± 123.5	466.6 ± 203.9	449.0 ± 149.9	459.7 ± 159.1
	RF	359.3 ± 153.0	320.2 ± 133.3	320.0 ± 127.7	323.8 ± 134.2
	VL	330.1 ± 94.5	340.6 ± 119.3	333.7 ± 126.2	348.8 ± 131.5

Values are mean ± SD (standard deviation).

VMO: Vastus Medialis Obliquus; RF: Rectus Femoris; VL: Vastus Lateralis

Table 2 shows the muscle activities of the thigh muscles in preparation and on landing from CMJ. Insignificant differences in muscle activities were observed in the 200 ms time window before landing in all the 3 muscles ($p > 0.05$) among the 4 conditions.

Discussion

Taping is commonly used to control the intensity of pain during sports training and competition. Results of this study suggest in athletes with jumper's knee, rigid taping significantly decrease pain in DST and CMJ when compared with un-tape condition. The result supported previous finding of Briem et al. [16] which reported that non-elastic taping may enhance muscle response of the fibularis longus. A possible explanation is strain modulation by rigid tape. The rigid taping used in this study adopted a cross-strip fashion so that the tape might act like a "second tendon" to diverge the tensile strain which originally pulled on the patella tendon, thereby decreasing the disruption on the tendon. In this connection, kinematics studies on basketball players with jumper's knee during CMJ revealed a decrease of knee acceleration and a stiffer landing strategy from the ankle [28]. The failure to absorb shock from the knee and ankle complex might induce extra strain on the patella tendon and induce pain. The application of rigid tape may have taken certain load off the knee thereby reducing the intensity of pain. Further study with the use of optic fiber sensors as mentioned by Dillon et al. [29] on taping would be useful to verify any change in tendon loading. Motion analysis could also be conducted to observe any change in knee and ankle motion with the application of taping. Further research may need to enhance stronger clinical application by lengthening the taping effect in response to rigid taping, as the effect of this taping application last about 15-30 minutes after removal [16].

KT is a relatively new type of adhesive taping which serves 3 functions of muscle facilitation, inhibition and mechanical correction [19]. There are, however, very limited numbers of studies examining the effectiveness of KT. Our study is in agreement with the recent researches of Thelen et al. [23] and Garcia-Muro et al. [30] which reported a decrease of pain in response to KT application. In addition, Osterhues [18] also reported decreasing pain, enhancing quadriceps activity and weight bearing stability during functional activities on a subject with patellar dislocation. However, it is a single case study where only descriptive statistics were reported. In the present study, we have chosen the "mechanical correction" technique of KT taping based on the etiology of jumper's knee which was believed to be strain-related. Such a taping technique uses 50-75% of the available tension of the KT aiming at exerting a moderate to severe stretch and downward pressure to the inferior pole of patella [19]. This stretch is believed to be capable of creating a strong cutaneous stimulation for the mechanoreceptors over the skin and deeper tissue to perceive, which in turn inhibits or alters the pain sensation via stimulation of the larger afferent fiber input. Significant pain reduction after application of KT on landing from jump in the current study probably supports one of the proposed mechanisms of KT, that is

decreasing pain through neurological suppression [19]. Interestingly, its effect on pain modulation reaches a significant level on landing from jump but not during decline squat. Note that landing from jump induce a faster deceleration to the knee joint when compared with the slower movement during decline squat, the cutaneous stimulation for the mechanoreceptors over the skin and deeper tissue would be stronger and thereby induce greater effect on pain modulation. Our next step will be to determine more accurately the relation between tension of the Kinesio tape and pain modulation during decline squat and on landing from counter movement jump. Another interesting observation is that the positive finding of this study did not agree with the negative finding from Fu et al. [20]. This can be explained by the fact that tactile input generated by KT may not be strong enough to modulate muscle power of healthy athletes in the study conducted by Fu et al. [20]. Similarly, the positive finding in our study is opposite to that of Firth et al. [21], which could be explained by the different muscles selected for the studies.

Although the mechanism for the symptomatic reduction in pain with taping remains unknown, our results concur with the findings from many previous studies in which pain reduction is a strong clinical observation with taping [11-15]. Results from this study also suggested that placebo taping would reduce pain during squat and landing, even though the changes were not statistically significant. Such observation suggests that pain modulation might due to factors other than mechanical influences. Aminaka et al. [12] proposed that taping can create a higher level of motivation to perform the tasks and enhance the sense of mechanical stability of the joint. In addition, cutaneous input by taping has been commonly suggested by investigators to account for the clinical effect of patellar taping in patients suffering from patellofemoral joint pain [11-14]. Nevertheless, results from this study proved that the effects of rigid and Kinesio tapes have better effects on pain modulation when compared with placebo tape.

Our results of muscle activities revealed insignificant changes in thigh muscle activities with taping when compared with un-tape condition during decline squat. This finding is contrast to the report by Fu et al. [20] in which the authors observed an increase in VMO EMG activities with a significant increase of VMO/VL ratio with the application of KT in subjects with patello-femoral joint pain. The validity of their findings was threatened, however, by the fragmented information in the methodology. In the present study, application of either rigid tape or KT in athletes with jumper's knee did not demonstrate changes on the muscle activity of thigh muscles in DST.

In clinical practice, application of tape provides a choice of instant pain relief in athletes suffering from musculoskeletal pain. Findings from this study demonstrated that taping (either rigid or KT tape) could relieve pain associated with jumper's knee. More specifically, rigid tape is more effective in relieving pain in squatting and jumping activity while the use of KT is more desirable in decreasing pain in jumping performance. This may suggest that the type of tape being

chosen to alleviate pain associated with jumper's knee depends on which activity is being affected most.

Conclusion

We conclude that rigid tape serves to reduce pain during decline squat, while both rigid and Kinesio taping are effective in reducing pain on landing from counter-movement jumps, in athletes with jumper's knee. The application of tape increases knee flexion during decline squat and on landing from counter-movement jump, but such changes are not associated with changes in EMG amplitude of the vasti muscle.

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