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Original Article

Effects of Kinesiology Taping on Repositioning Error of the Knee Joint after Quadriceps Muscle Fatigue

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Abstract. [Purpose] The purpose of this study was to identify the effects of kinesiology taping on repositioning error of the knee joint after quadriceps muscle fatigue. [Subjects] Thirty healthy adults with no orthopaedic or neurological problems participated in this study. [Methods] The repositioning error of the knee joint was measured using a digital goniometer when the subjects extended their dominant-side knee to a random target angle (30°, 45°, or 60°) with their eyes closed, before and after a quadriceps muscle fatigue protocol, and after application of kinesiology tape. [Results] We found that repositioning errors of the dominant-side knee joint increased after quadriceps fatigue compared with no-fatigue conditions. However, kinesiology taping of the quadriceps muscle and patella after quadriceps fatigue significantly decreased repositioning errors of the knee joint. [Conclusion] These results suggest that quadriceps fatigue increases the repositioning error of the knee joint, whereas application of kinesiology tape decreases fatigue-induced joint repositioning error.
Key words: Joint position sense, Kinesiology tape, Proprioception

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INTRODUCTION

Proprioception consists of a combination of joint position sense, i.e., the ability to detect the movement and position of a limb in space[1)], and the sense of muscular effort and tension[2)]. The joint position sense is a very important contributor to joint coordination, maintenance of muscle stiffness, and the production of natural movements for appropriate task performance. Furthermore, appropriate joint position sense minimizes the risk of joint injury[3)].

Muscle fatigue is an exercise-induced decline in the ability of muscles to produce force or power[4)] and is known to alter proprioception[5)]. Previous studies have shown that muscle fatigue negatively affects the joint position sense during both passive and active examination tests[6)]. Decline in knee proprioception as a result of physical fatigue may be a risk factor for knee ligament injuries[7)]. In sports games, most of the injuries occur near the end of the game because of the fatigued state of the players[8)].

The use of kinesiology taping is gradually increasing in sports competitions, such as the Olympic Games or European football leagues, as well in sports medicine[9)]. Previous studies have shown the effects of kinesiology taping on pain control[10, 11)], joint support[12, 13)], and muscle function[14, 15)]. Therefore, the aim of this study was to determine whether kinesiology taping decreases the repositioning error of the knee joint after quadriceps fatigue and ultimately confirm if kinesiology taping can improve joint position sense.

SUBJECTS AND METHODS

Fifteen male subjects (mean ± SD: age, 21.87 ± 0.83 years; height, 1.75 ± 5.05 m; body weight, 66.33 ± 9.81 kg) and fifteen female subjects (mean ± SD: age, 21.47 ± 0.52 years; height, 1.61 ± 5.07 m; body weight, 54.33 ± 7.21 kg) volunteered for this study. Subjects were excluded if they had any known musculoskeletal disorders of the lower limb, neurological problems, or balance disturbances within the 6 months prior to the start of the study. Before participation, subjects provided written informed consent, which was approved by the Human Ethics Committee of Kyung Sung University.

Three reflective markers were attached to the skin of the greater trochanter, the lateral epicondyle of the femur, and the lateral malleolus using double-sided tape. For measurements of knee range of motion, the axis of a digital goniometer (digital Absolute+Axis™ goniometer; Fabrication Enterprises Inc., White Plains, NY, USA) was placed on the lateral epicondyle of the femur, with the stationary arm along the midline of the femur and the moveable arm at the midline of the lateral malleolus[16)]. Before starting the formal experiment, a physical therapist with more than 10 years of experience practiced taking measurements using a digital

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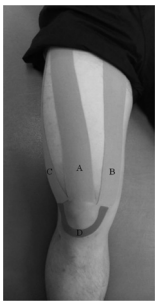

Fig. 1. Application of kinesiology tape on the (A) rectus femoris muscle, (B) vastus medialis muscle, and (C) vastus lateralis muscle and (D) taping for superior elevation of the patella.

goniometer for 1 day in order to reduce measurement error.

Prior to practical testing, participants were given instructions on fatigue-induced exercise, and the examiner with more than 10 years of experience demonstrated the fatigue-induced exercise procedure. Quadriceps muscle fatigue was induced as follows. An assistant set a metronome at 20 beats per minute (BPM), and the participant assumed a squatting position on the floor with the feet shoulder-width apart. The assistant gave a "start" command, and the participant then performed squats (sitting as low as possible without lifting the heels and then returning to the standing position in time with the metronome) while the assistant counted. Three sets of 10 squats were performed with 30 seconds of rest between sets.

Kinesiology tape (BB Tape, WETAPE Inc, Seoul, Korea) was applied by a physical therapist specialized in kinesiology taping methods. Before kinesiology taping, the subjects sat in a relaxed position. The kinesiology tape was applied with approximately 30–40% stretch on the 3 quadriceps muscles. For the rectus femoris muscle, the kinesiology tape was applied from the anterior inferior iliac spine to the superior border of the patella while holding the knee in full flexion (Fig. 1A). For the vastus medialis muscle, the kinesiology tape was applied from the lower part of the intertrochanteric line (the medial lip of the linea aspera of the femur) to the medial superior aspect of the patella (Fig. 1B) while holding the knee in full flexion. For the vastus lateralis muscle, the kinesiology tape was applied from the greater trochanter of the femur to the lateral superior aspect of the patella (Fig. 1C) while holding the knee in full flexion. To enable superior gliding of the patella, kinesiology tape with a width of 2.5 cm was applied from the inferior pole of the patella in the direction of the vastus medialis and vastus lateralis (i.e., stretch of 40–50% in the middle of tape, with no stretch at the ends of the tape), while holding the knee at approximately 50–60° of flexion (Fig. 1D).

The subjects sat comfortably with their eyes closed and wore an eye patch[17]. The examiner randomly performed passive knee extension of the dominant leg from a starting position (knee 90° flexion) to a target angle (30°, 45°, or 60°) determined using a digital goniometer. After holding the target position for 3 seconds, the examiner placed the limb in the starting position[17]. The subjects were then instructed to actively reproduce the same angle that was passively performed by the examiner[17]. The repositioning error of the knee joint was recorded using a digital goniometer for only 1 trial, along with random selection of the target angle, to minimize learning effects. Subsequently, the repositioning error of the knee joint was remeasured immediately after completion of the quadriceps muscle fatigue protocol and also immediately after application of kinesiology tape to the quadriceps and patella without rest after the measurement obtained following muscle fatigue.

Table 1. Comparison of the knee joint repositioning error before and after quadriceps fatigue and with kinesiology taping after quadriceps fatigue

Variable	Mean ± SD (°)		
	Pre-fatigue	Post-fatigue	With taping
Repositioning error	3.41 ± 1.42	4.25 ± 1.67*	2.99 ± 1.24†

* Significant difference ($p<0.05$) between before and after quadriceps fatigue.
† Significant difference ($p<0.05$) between quadriceps fatigue and kinesiology taping after quadriceps fatigue.

Repeated one-way ANOVA was used to analyze changes in repositioning error of the knee joint. Multiple comparisons were examined using Bonferroni's correction. Statistical analysis was performed using SPSS version 19 (SPSS Inc., Chicago, IL, USA). The significance level was set at $p < 0.05$ for all tests.

RESULTS

The results for the knee joint repositioning error of the dominant leg are presented in Table 1. Repositioning error of the knee joint significantly increased after quadriceps fatigue compared with before quadriceps fatigue ($p < 0.05$). However, compared with the knee joint repositioning error obtained after quadriceps fatigue, the knee joint repositioning error obtained after use of kinesiology taping following quadriceps fatigue was significantly lower ($p < 0.05$).

DISCUSSION

Muscle fatigue impairs neuromuscular control in the lower extremities[17]. In addition, local muscular fatigue causes negative effects on joint proprioception[18] by increasing the threshold of muscle spindle discharge, disrupting afferent feedback, and consequently altering conscious knee joint awareness[19]. In line with previous work[7, 20], the current study shows an impaired sense of knee joint position under fatigued conditions. We found that the application of kinesiology tape decreases fatigue-induced repositioning errors. The application of kinesiology tape may affect tactile stimulation[21]. When kinesiology tape is applied with an elasticity of 30–40%, the skin is stretched/deformed by joint movement[22]. Cutaneous mechanoreceptors are stimulated as a result of the skin deformation[23, 24]. Therefore,

the application of kinesiology tape may have decreased the repositioning error by increasing knee joint proprioception through this stimulation of cutaneous mechanoreceptors[23, 25].

Fatigue protocols would presumably have more effect on muscle than joint tissue because a decreased joint position sense is thought to be secondary to a decrease in muscle receptor input[26]. Although the evidence regarding muscle activity is inconsistent[23, 27], recent studies have shown that kinesiology tape application enhances muscle function[14, 15]. The application of kinesiology tape on the rectus femoris, vastus medialis, and vastus lateralis, such as in the current study, increases eccentric muscle strength in healthy subjects[28]. Therefore, application of kinesiology tape to the quadriceps muscles may assist the reduced knee extension function caused by muscle fatigue. In addition, kinesiology taping that elevates the patella, applied with 40–50% tension, may provide external support and assist the function of quadriceps muscles by enhancing the superior glide of the patella[29] throughout various angles of knee extension. However, the mechanism underlying the effects of kinesiology taping on fatigue-induced muscle is beyond the scope of this study, and further study is needed.

This study has several limitations. First, the compensation of the pelvis and trunk during assessment of knee joint angle was not controlled. Second, repositioning errors of the nondominant leg were not compared. Third, we did not evaluate the duration of the effect of kinesiology taping on knee repositioning errors after muscle fatigue. Fourth, the learning effect was not completely eliminated because the repositioning error after kinesiology taping was assessed last. Fifth, the general fatigue level was not assessed. Further studies are required to resolve the limitations of the current study and ascertain the effects of kinesiology taping on muscle fatigue, which was not determined experimentally in this study.

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REFERENCES

1) Aydin T, Yildiz Y, Yanmis I, et al.: Shoulder proprioception: a comparison between the shoulder joint in healthy and surgically repaired shoulders. Arch Orthop Trauma Surg, 2001, 121: 422–425. [Medline] [CrossRef]
2) Proske U, Gandevia SC: The kinaesthetic senses. J Physiol, 2009, 587: 4139–4146. [Medline] [CrossRef]
3) Madhavan S, Shields RK: Influence of age on dynamic position sense: evidence using a sequential movement task. Exp Brain Res, 2005, 164: 18–28. [Medline] [CrossRef]
4) Enoka RM, Duchateau J: Muscle fatigue: what, why and how it influences muscle function. J Physiol, 2008, 586: 11–23. [Medline] [CrossRef]
5) Boucher JA, Abboud J, Descarreaux M: The influence of acute back muscle fatigue and fatigue recovery on trunk sensorimotor control. J Manipulative Physiol Ther, 2012, 35: 662–668. [Medline] [CrossRef]
6) Allen TJ, Ansems GE, Proske U: Effects of muscle conditioning on position sense at the human forearm during loading or fatigue of elbow flexors and the role of the sense of effort. J Physiol, 2007, 580: 423–434. [Medline] [CrossRef]
7) Lattanzio PJ, Petrella RJ, Sproule JR, et al.: Effects of fatigue on knee proprioception. Clin J Sport Med, 1997, 7: 22–27. [Medline] [CrossRef]
8) Rahnama N, Reilly T, Lees A: Injury risk associated with playing actions during competitive soccer. Br J Sports Med, 2002, 36: 354–359. [Medline] [CrossRef]
9) Williams S, Whatman C, Hume PA, et al.: Kinesio taping in treatment and prevention of sports injuries: a meta-analysis of the evidence for its effectiveness. Sports Med, 2012, 42: 153–164. [Medline] [CrossRef]
10) Lee JH, Yoo WG: Treatment of chronic Achilles tendon pain by Kinesio taping in an amateur badminton player. Phys Ther Sport, 2012, 13: 115–119. [Medline] [CrossRef]
11) Hwang-Bo G, Lee JH: Effects of kinesio taping in a physical therapist with acute low back pain due to patient handling: a case report. Int J Occup Med Environ Health, 2011, 24: 320–323. [Medline] [CrossRef]
12) Lee JH, Yoo WG: Effect of scapular elevation taping on scapular depression syndrome: a case report. J Back Musculoskeletal Rehabil, 2012, 25: 187–191. [Medline]
13) Lee JH, Yoo WG: The mechanical effect of anterior pelvic tilt taping on slump sitting by seated workers. Ind Health, 2011, 49: 403–409. [Medline] [CrossRef]
14) Cortesi M, Cattaneo D, Jonsdottir J: Effect of kinesio taping on standing balance in subjects with multiple sclerosis: a pilot study1. NeuroRehabilitation, 2011, 28: 365–372. [Medline]
15) Huang CY, Hsieh TH, Lu SC, et al.: Effect of the Kinesio tape to muscle activity and vertical jump performance in healthy inactive people. Biomed Eng Online, 2011, 10: 70. [Medline] [CrossRef]
16) Norkin CC, White DJ: Measurement of Joint Motion: A Guide to Goniometry, 4th ed. Philadelphia: F.A. Davis Company, 2009.
17) Miura K, Ishibashi Y, Tsuda E, et al.: The effect of local and general fatigue on knee proprioception. Arthroscopy, 2004, 20: 414–418. [Medline] [CrossRef]
18) Baker V, Bennell K, Stillman B, et al.: Abnormal knee joint position sense in individuals with patellofemoral pain syndrome. J Orthop Res, 2002, 20: 208–214. [Medline] [CrossRef]
19) Ribeiro F, Mota J, Oliveira J: Effect of exercise-induced fatigue on position sense of the knee in the elderly. Eur J Appl Physiol, 2007, 99: 379–385. [Medline] [CrossRef]
20) Roberts D, Ageberg E, Andersson G, et al.: Effects of short-term cycling on knee joint proprioception in healthy young persons. Am J Sports Med, 2003, 31: 990–994. [Medline]
21) Yamashiro K, Sato D, Yoshida T, et al.: The effect of taping along forearm on long-latency somatosensory evoked potentials (SEPs): an ERP study. Br J Sports Med, 2011, 45: A9. [CrossRef]
22) Shim JY, Lee HR, Lee DC: The use of elastic adhesive tape to promote lymphatic flow in the rabbit hind leg. Yonsei Med J, 2003, 44: 1045–1052. [Medline]
23) Chang HY, Chou KY, Lin JJ, et al.: Immediate effect of forearm Kinesio taping on maximal grip strength and force sense in healthy collegiate athletes. Phys Ther Sport, 2010, 11: 122–127. [Medline] [CrossRef]
24) Myers TW: Anatomy trains: Myofascial meridians for manual and movement therapists, 2nd ed. Edinburgh: Churchill Livingstone, 2009.
25) Murray H, Husk L: Effect of kinesio taping on proprioception in the ankle. J Orthop Sports Phys Ther, 2001, 31: A–37.
26) Hiemstra LA, Lo IK, Fowler PJ: Effect of fatigue on knee proprioception: implications for dynamic stabilization. J Orthop Sports Phys Ther, 2001, 31: 598–605. [Medline] [CrossRef]
27) Soylu AR, Irmak R, Baltacı G: Acute effects of kinesiotaping on muscular endurance and fatigue by using surface electromyography signals of masseter muscle. Med Sportiva, 2011, 15: 13–16. [CrossRef]
28) Vithoulka I, Beneka A, Malliou P, et al.: The effects of kinesio-taping® on quadriceps strength during isokinetic exercise in healthy non athlete women. Isokinet Exerc Sci, 2010, 18: 1–6.
29) Sebastian D: Prin. of Manual Therapy. New Delhi: Jaypee Brothers Publishers, 2005.