EFFECT OF THE RECTUS FEMORIS KINESIO-TAPING ON MALE ATHLETES DURING THE STOP-JUMP TASK POST-FATIGUE

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This study aimed to investigate the biomechanics of the stop-jump task under the effect of Kinesio-taping (KT) applied on rectus femoris before and after fast-induced fatigue on male athletes. Nine male college athletes served as the subject. Two force plates and ten high-speed cameras were synchronized to capture the stop-jump tasks. The results showed that the jumping height decreased, the vertical ground reaction force (GRF) and the peak proximal tibia anterior shear force increased, and the time to peak vertical GRF was earlier after intervened fatigue in the non-taping group. We also found that the peak proximal tibia anterior shear force did not increase after fatigue when following the application of KT. We recommend that KT is used to intense exercises or competition with repeated jumping.

KEYWORDS: non-contact ACL injury, anterior shear force, injury prevention.

INTRODUCTION: Anterior cruciate ligament (ACL) injury is one of the most common and severe knee injuries related to sports activities. Also, Boden et al. (2000) have reported that 72% of ACL injuries are due to a non-contact mechanism and 28% are due to a contact mechanism. These injuries occur commonly during dynamic activities involving quick deceleration and change in direction such as the stop-jump movement.

The stop-jump movements are often used in athletic sports. This action requires an immediate deceleration and rapid stabilization of the body to facilitate subsequent vertical jumps, thus causing a proximal tibia forward shear force that places a significant strain on the ACL (Chappell et al. 2002).

Fatigue is an extrinsic factor affecting the musculoskeletal and neurologic systems. Fatigue is associated with decreased knee proprioception and increased joint laxity compared to baseline values (Rozzi, Lephart, & Fu, 1999). In sports competition, fatigue is unavoidable, especially after repeated high frequency jumping action, not only to muscle strength decreased but also reduced the proprioception and the balance and increased the error rate of movement (Rodacki, Fowler, & Bennett, 2002). Therefore, how to delay fatigue or support body joints during fatigue are an essential issue to reduce sports injuries.

Kinesio-taping (KT), a kind of elastic tape, was invented by Dr. Kenzo Kase. It is purported to improve local circulation, reduce edema, facilitate or relax the muscle, and improve joint function by enhancing sensory mechanisms. Even though these hypotheses have not been proven so far, KT is being used more in clinical, rehabilitation and orthopedic departments as well as on athletes (Briem et al. 2011; Huang et al. 2011).

In the past, most of the research studied the immediate effect of KT, and few studies related to the effect of KT after fatigue can still maintain efficacy. The purpose of this study was to investigate the effect of KT on male athletes by fatigue intervention, on the stop-jump task. We hypothesized that lower extremity knee kinetics and kinematics during the landing phase of the stop-jump tasks would be altering after muscle fatigue. The use of KT will reduce the lower extremity biomechanics after muscle fatigue.

METHODS: Nine male college athletes recruited as participants. Their mean age, body mass, and height were 20.1±0.8 years, 73.0±5.9 kg, and 177.1±3.9 cm respectively. After the dressing, the length of the subject's limbs were measured and the reflective markers were attached to the following body landmarks: left and right sides of the skull temples and both sides of the skull at the same level, left and right acromioclavicular joint, medial and lateral condyle of the elbow, upper arm and forearm center, the wrist joint inside and outside, the second palm of the hand, the seventh section of the spine, thoracic seventh section, clavicle, xiphoid and right back, the anterior iliac spine and the posterior superior iliac spine, the greater trochanter, the lateral thigh and lateral calf, the medial and lateral condyle of the knee joint and the medial and lateral condyle of the ankle, medial metatarsal head, proximal second metatarsal head, lateral metatarsal head and heel. One certificate athletic trainer applied the Kinesio tape to each subject by taping from the anterior inferior iliac spine to the tibial tuberosity with a total length of 120% tension with two I-shaped stickers to cover the rectus femoris.

Each subject came to the lab twice on two separate days, one for non-taping and one for Kinesio-taping exercise. A 5-minute self-directed warm-up was allowed for each subject. The stop-jump tasks were described and demonstrated to the subject. The stop-jump tasks consisted of a 3-step approach run followed by a 1-footed take-off, a 2-footed landing with each foot on a separate force plate, and a 2-footed take-off for maximum height. Each subject was allowed to practice each task until he felt comfortable performing the task in a pre-fatigue exercise test and immediately after completion of the fatigue protocol for the post-fatigue exercise test. The order of the task was randomized for each subject.

The fatiguing exercise consisted of unlimited repetitions of consecutive vertical jumps for 90 seconds (one jump for one second) and reached a state of volitional exhaustion (Bosco et al., 1983). To maintain the fatigued state, we instructed the subject to perform five consecutive vertical jumps as done previously after every five stop-jump trials during the post-fatigue exercise test.

The stop-jump tasks were collected by a 10-camera Vicon system (250 Hz) and two Kistler force plate (1,500 Hz) respectively. The Visual3D software (C-Motion, Rockville, MD, USA) was used to analyze the data. Kinematic data were low-pass filtered at 10 Hz using 4th order zero-lag Butterworth filters (Yu et al., 1999). Force plate data were low-pass filtered at 50 Hz. Anatomical reference frames for the body segments defined as the positive x-axis (medial/lateral) to the right, the positive y-axis (anterior/posterior) to the forward, and the positive z-axis (superior/inferior) to the upward.

The landing phase was defined as the duration from the time of landing to the time of the maximum knee flexion angle. The take-off phase was defined as the time of the maximum knee flexion angle to the time of take-off.

Statistics were performed with repeated-measure two-way ANOVA using SPSS 23.0.

RESULTS: The subjects had lower jumping height after fatigue in non-taping group ($F(1,17) = 12.951$, $p < .05$). There was no significant difference in jumping performance on non-taping and taping (Table 1). The selected kinematic data for the stop-jump tasks were summarised in Table 2. The only significant difference was lower peak knee valgus angle in post-fatigue for both taping conditions during the landing phase ($F(1,17) = 15.234$, $p < .05$). No significant differences were found in other lower extremity kinematics (Table 2). We found differences in kinetic variables. The peak vertical GRF increased ($F(1,17) = 16.521$, $p < .05$) and the time to peak vertical GRF was earlier ($F(1,17) = 7.617$, $p < .05$) in the post-fatigue group compared with the pre-fatigue stop-jump tasks in non-taping group, significant interaction effect was also found in the peak proximal tibia anterior shear force ($F(1,17) = 7.671$, $p < .05$) (Table 3). The knee extension moment reduced after fatigue in non-taping group ($F(1,17) = 7.175$, $p < .05$) (Table 4)

Table 1: Phase time of landing, take-off and total time, and jumping height.

	Non-taping		Taping	
	Pre-fatigue	Post-fatigue	Pre-fatigue	Post-fatigue
Landing(s)	0.171±.032	0.191±.041	0.172±.035	0.183±.042
Take-off(s)	0.196±.044	0.214±.051	0.191±.046	0.210±.060
Total(s)	0.367±.070	0.405±.088	0.362±.078	0.393±.098
Height(m) [b]	0.508±.080	0.417±.077	0.504±.090	0.449±.072

b Main effect of fatigue.

Table 2: Selected lower extremity kinematics during the landing phase

	Non-taping		Taping	
	Pre-fatigue	Post-fatigue	Pre-fatigue	Post-fatigue
Knee angle at IC(deg)				
Flexion	38.7±15.5	34.4±11.0	35.4±9.1	36.6±12.3
Valgus	1.2±6.5	1.3±6.9	1.0±7.5	0.0±6.5
Internal rotation	6.3±12.9	2.4±13.9	5.6±6.1	5.0±6.2
Peak knee angle(deg)				
Flexion	102.2±15.8	105.6±18.1	101.2±18.6	101.3±18.4
Valgus [b]	11.3±11.2	10.2±11.9	12.1±11.8	9.3±10.9
Internal rotation	24.0±10.8	21.5±8.3	24.0±6.5	24.0±6.3
Knee ROM(deg)				
Flexion	61.2±13.6	69.2±17.4	63.6±15.5	64.8±15.9
Valgus	10.4±6.7	10.3±5.3	11.1±7.2	9.3±4.4
Internal rotation	19.8±13.0	21.9±10.4	19.5±9.4	20.7±8.5
Angular velocity at IC(deg/s)				
Hip flexion	166.9±55.0	155.7±96.7	173.8±58.8	189.7±64.7
Knee flexion	342.6±76.6	328.5±139.7	309.4±103.2	343.2±127.9
Peak angular velocity(deg/s)				
Hip flexion	302.0±87.2	347.1±119.6	322.6±122.2	349.6±115.9
Knee flexion	767.5±94.1	820.5±113.3	813.9±98.2	800.9±108.1
Time to peak angular velocity(s)				
Hip flexion	0.026±0.010	0.027±0.009	0.026±0.008	0.026±0.008
Knee flexion	0.035±0.008	0.035±0.008	0.037±0.008	0.036±0.005

b Main effect of fatigue; IC, initial foot contact with ground; ROM, range of motion.

Table 3: Selected lower extremity kinetics during the landing phase.

	Non-taping		Taping	
	Pre-fatigue	Post-fatigue	Pre-fatigue	Post-fatigue
Peak posterior GRF(BW)	0.86±0.32	0.93±0.39	0.86±0.36	0.80±0.34
Peak vertical GRF(BW) [b]	1.90±0.43	2.38±0.65	1.93±0.64	2.07±0.54
Time to peak P_GRF(s)	0.045±0.010	0.042±0.009	0.044±0.010	0.043±0.014
Time to peak V_GRF(s) [b]	0.032±0.018	0.020±0.007	0.033±0.017	0.026±0.015
Peak proximal tibia anterior shear force(BW) *	11.72±2.41	13.98±2.59	12.09±3.34	11.96±3.80
50 ms P_Impulse(BW*s)	0.022±0.007	0.022±0.007	0.022±0.006	0.019±0.007
50 ms V_Impulse(BW*s)	0.055±0.015	0.063±0.018	0.057±0.020	0.055±0.016

b Main effect of fatigue; P_GRF, posterior GRF; V_GRF, vertical GRF; P_Impulse, posterior impulse; V_Impulse, vertical impulse.
* Interaction.

Table 4: Joint moment in the sagittal plane during the landing phase

	Non-taping		Taping	
	Pre-fatigue	Post-fatigue	Pre-fatigue	Post-fatigue
Hip extension(N*m/kg)	4.38±2.24	5.85±1.99	4.69±2.54	5.20±2.69
Knee extension(N*m/kg) [b]	3.01±0.64	2.59±0.52	2.89±0.60	2.67±0.74
Ankle dorsiflexion(N*m/kg)	1.64±0.55	2.00±0.71	1.79±0.83	1.84±0.78

b Main effect of fatigue.

DISCUSSION: Lower extremity muscle fatigue may increase an athlete's risk for non-contact ACL injury. The results of this study showed that the peak proximal tibia anterior shear force increased for college male athletes in the fatigued state without taping. Previous studies have suggested that proximal tibia anterior shear force may be an indication of increased strain in the ACL. (Chappell et al. 2005) Therefore, the results of this study suggested that ACL strain

might increase when performing the stop-jump tasks with lower extremity fatigue. Rodacki et al. (2002) showed that knee extensor muscle fatigue caused changes in kinematic and kinetic variables. This study found that the peak vertical GRF increase and the time to peak vertical GRF is earlier after intervened fatigue in the non-taping group, which indicated that the body is stiff after intervened fatigue during landing. It may increase the impact force during landing which could be a risk factor for knee injuries.
The tactile input generated by the KT might not be strong enough to alter the instantaneous muscle force output. (Wong, Cheung, & Li, 2012) Previous studies showed that KT could not enhance muscle strength immediately to improve sports performance. (Huang et al. 2011; Chang et al. 2010) The results of this study were consistent with those studies. We found that there is no effective change in jumping height when applying KT. However, we found that the significant interaction between fatigue and taping conditions for the peak proximal anterior shear force, the peak proximal tibia anterior shear force increased after fatigue for non-taping condition; nevertheless, the peak proximal tibia anterior shear force did not increase after fatigue when applied KT. Multiple researchers suggested that the proximal tibia anterior shear force is the major ACL loading mechanism. (Lin et al. 2009; Yu et al. 2006) Therefore, this result indicated that apply KT on rectus femoris may help athletes reduce the ACL loading after the muscle fatigue.

CONCLUSION: In conclusion, lower extremity muscle fatigue significantly decreased the jumping height and increased the impact force and the peak anterior shear force on the proximal tibia of male college athletes during landing. However, the application of KT on the rectus femoris can help male college athletes reduce the proximal tibial shear force for fatigue condition. We suggest male college athletes that applying KT could prevent anterior shear force on the proximal tibia and helps to reduce the ACL injury risk when having intense exercises or competitions with repeated jumping.

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