Immediate Effect of Kinesio Taping on Knee Joint Position Sense after Anterior Cruciate Ligament Reconstruction

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Abstract

Introduction: Sprain of the anterior cruciate ligament (ACL) is the most common sports injury. Kinesio-taping (KT) method could be used for rehabilitation after ACL reconstruction (ACLR) surgery. The purpose of this study was to evaluate the immediate effect of KT on the knee joint position sense after ACLR surgery. Observational, descriptive, and comparative study. **Materials and Methods:** Twenty male football players with ACLR surgery, aged 20 to 30 years with matched pre-injury activity level, and 4 months post surgeries were enrolled. The knee joint position sense error rate was assessed before and after taping in injured and uninjured limbs in weight bearing and non-weight bearing positions from flexion to extension and vice versa at angles of 15°, 30° and 60°. Repeated measure ANOVA test was used for data analysis. **Results:** The knee joint position sense error rates were significantly smaller after taping compared to before taping in injured and uninjured control limbs in weight bearing and non-weight bearing positions from flexion to extension and vice versa at repositioning angles mentioned above. The knee joint position sense error rates were significantly lower in control uninjured limbs than injured limbs before taping in all tests. There was no significant difference between the two limbs in knee joint position sense error rates after taping in all tests. **Conclusion:** This study showed that, in people who underwent ACLR surgery, the knee joint position sense in injured limb was impaired after 4 months. Joint position sense error rate after ACLR surgery can be reduced by increasing the sensory inputs through taping.

Keywords: Anterior Cruciate Ligament, Knee Joint Position Sense, Kinesio-Taping, Surgery

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Introduction

There has been a marked increase in anterior cruciate ligament (ACL) injury in normal individuals and athletes (1-3). The highest number of injuries occurs in football players (50% of total injuries). Skiing and gymnastics are high-risk sports that cause spraining or rupturing of the ACL of the knee joint (4-6). In the USA, ACL injuries occur between 100000 and 200000 times each year, thus placing this ligament as one of the body structures prone to injuries (7-9). In the past two decades, surgical techniques for ACL reconstruction (ACLR) and post-surgery rehabilitation have had many developments, helping many patients return to their previous sports activities. However, the period of repair and return to sports activities takes a long time with high physical, psychological and economic impact on these patients. For these reasons, preventing these injuries has become more important in recent years (10). ACL is one of the fundamental components of knee joint stability. There are many diverse views about the fundamental role of this ligament. Evidence shows that ACL injury interferes with control of the position while standing on one or both limbs (11-13). In addition, impaired postural control can be seen after ACLR surgery. The probable reason for impairment is that the amount of sensory information from the position of the damaged leg and sense of movement of the leg decreases after ACLR, so the body sway is greater (13). In addition to being a mechanical constrainer of the knee joint, the ACL can be defined as an important sensorimotor component for postural control (13-17).

Information about the sense of posture and movement depends on the integrity of the input data received by the elements, such as joint capsule, skin, tendon, ligament and muscle receptors (18.) Damage to these elements in the knee disrupts joint position sense and knee proprioception 19. ACL of the knee provides the sense of posture and movement of the knee joint with feedback mechanisms and effect on muscle spindle system. Although the feedback mechanism will disappear after ACL tear of the knee, the reason of restoration of the knee proprioception after ACLR surgery is still unknown (18-20).

Researchers investigating the proprioception after rupture and reconstruction of the ACL of the knee have mainly measured the passive motion detection threshold and repositioning angle of the knee joint (5, 7, 21-23). These researchers have investigated the deep sense of knee flexion and extension at different angles with different instruments. The major error in proprioception has been reported at terminal knee extension in patients with ruptured or reconstructed ACL (5, 7, 21-23). In addition, it has been reported that distinguishing the motion in extension will be impaired more than the flexion. Therefore, the direction and initial state of motion are important to stimulate the joint mechanoreceptors (7).

In patients with reconstruction or rupture of the ACL, assessing the knee joint position sense in the weight bearing position is much more valuable than non-weight bearing position. This is because co-activation of the quadriceps and hamstring muscles during the weight bearing position reduces the stress on the ACL of the knee. In addition, the weight bearing position is very close to functional activities (24).

Evaluation of the knee joint position sense after ACLR, during weight bearing position, provides valuable information for therapists to prepare an appropriate rehabilitation program (19).

Rehabilitation methods, such as Kinesio taping (KT), have been introduced as supplements after the ACLR surgery (25). As the tape remains in direct contact with the skin, it provides strong skin proprioceptive inputs. It may be said that increasing the skin proprioceptors' activity around the joint prevents further damage. Hence, the taping method is easy to use, can improve neuromuscular performance by creating appropriate sensory afferent signals, and can compensate the proprioception deficit partially. It has wide applications in physiotherapy and sports medicine. A few studies have been performed on the effects of KT on the knee joint position sense after ACLR surgery (6, 9, 11, 12, 25). But there is no precise interpretation of its effectiveness yet, and the knee joint position sense has not been evaluated in closed and open chain situations concurrently. Therefore, the purpose of this study was to evaluate the immediate effect of KT on the knee joint position sense after ACLR surgery in weight bearing and non-weight bearing conditions. We assumed that it could help improve the knee joint position sense and its effect would also improve in weight bearing condition.

Materials and Methods

Twenty football players, who underwent a single leg ACLR, participated in this quasi-experimental clinical trial study. This research was approved by the Research Ethics Committee and has IRCT ID: IRCT201306227057N2. Data of ACLR limb were compared with control contralateral knee. The inclusion criteria were only one surgical intervention for a torn ACL, no concomitant tear of the posterior cruciate ligament or other ligaments of both knees, unilateral knee ACLR (right leg) over the last 4 months of surgery, having full range of extension and flexion of the knee, no history of surgery or traumatic injury to the ankle or hip joints on either sides, no complaints concerning instability, ability to walk without assistive device, and all reconstructions done by the same surgeon after acute ACL injury. The exclusion criteria were previous knee injuries on the target side, neurological disease, sprain of other knee ligaments, bilateral ACL sprains, instability or pain at rest in the knee, and sprain of the non-dominant or the left dominant limb. The sample size was determined based on the significance level, power, and magnitude of the difference (effect size) of previous studies (16, 17) by G power software.

Participants read and signed the informed consent form. All recruited patients had undergone the same type of ACLR (arthroscopically assisted central bone-patellar tendon–bone graft). Data were recorded through interviews, examinations, and recording of the joint range of motion. The joint position sense error rate was evaluated in different positions with a standard goniometer. Joint position sense error rate was measured before and after taping in injured (as an experiment group) and contralateral uninjured limbs (as a control group) in weight bearing and non-weight bearing positions from flexion to extension and vice versa at angles of 15°, 30° and 60°.

Test procedures:

All participants in this study were in one group. In this scheme, every person controlled himself, and the joint position sense error rate of the knee joint on moving towards flexion and extension was evaluated in weight bearing and non-weight bearing position on injured and contralateral uninjured control limbs.

A) Moving toward full extension in non-weight bearing position: In the first step, the participant was asked to sit on the chair so that his both limbs were hanging (no contact with the ground). He was asked to move the knee from 90° flexion (initial test position of the joint)

Figure 1

Figure 2

to 60° flexion (final position of the test) with injured limb; this position was maintained for 5 seconds. Then the subject was asked to return to the initial position. In the second step, the person was asked to go to the trained position. This position was retained for 5 seconds and the angle made was measured with a goniometer; the subject was then asked to return to the first position. In third step, KT (production of ARES Company, South Korea) was applied from tibial tuberosity to the lower third of the thigh as anterior- medial, anterior-lateral in the position of 30° flexion of the knee and with the stretch of 60% of the maximum tensile capacity of the tape (Figure 1). For this purpose, firstly distal base of the tape was installed without any tension, then a 10 cm length of the tape was stretched so that its length increased to 16 cm and was attached to the limb. Finally, the proximal base of the tape was placed without stretch. In the fourth step, the second step was repeated. Reconstruction of the 30° and 15° knee flexion angles was done like the steps above. Test order of injured and contralateral uninjured limb was assigned randomly, but the knee flexion angles reconstruction has the same order from 60° toward 15° flexion in all trials.

B) Moving toward the full extension in weight bearing position: In the first step, the participant was asked to stand on his injured limb. He was asked to move the knee from 90° flexion (initial test position of the joint) to 60° flexion (final position of the test), with injured limb. This position was maintained for 5 seconds, and the subject was asked to return to the initial position. In the second step, the person was asked to go to the trained position. He retained this position for 5 seconds, and this angle was measured with goniometer; he was then asked to return to the first position. In the third step, KT was applied from tibial tuberosity to the lower third of the thigh as anterior-medial, anterior-lateral in the position of 30° flexion of the knee and with the stretch of 60% of the maximum tensile capacity of the tape. In the fourth step, the second step was repeated. Reconstruction of the 30° and 15° knee flexion angles was done like the steps above. Test order of injured and contralateral uninjured limb was assigned randomly, but the knee flexion angles reconstruction had the same order from 60° toward 15° flexion in all trials.

C) Moving toward flexion in non-weight bearing position: In the first step, the participant was made to sit on a chair with both limbs hanging (no contact with the ground). He was asked to move the knee from 0° extension of the knee (initial position of the test) to 60° flexion (final position of the test), with injured limb. This position was maintained for 5 seconds. Then the subject was asked to return to initial position. In the second step, the subject was asked to go to the trained position. He

Table 1. Difference between knee joint position sense error of injured and uninjured limb before taping in weight bearing and non-weight bearing position

		Variables	Mean (SD)	95% confidence interval of the difference		*P*-value
				lower	upper	
Non-weight bearing position.	Flexion to Extension	Angle of 15°	1.4 (1.00)	0.34	1.65	0.003
		Angle of 30°	2.34 (2.21)	1.11	3.31	0.001
		Angle of 60°	4.25 (0.8)	3.24	5.25	0.001
	Extension to Flexion	Angle of 15°	0.87 (0.42)	0.35	1.6	0.004
		Angle of 30°	1.96 (0.41)	1.26	2.34	0.001
		Angle of 60°	1.779 (0.43)	0.85	2.27	0.001
Weight bearing position	Flexion to Extension	Angle of 15°	0.93 (0.32)	0.11	0.76	0.004
		Angle of 30°	2.37 (1.84)	1.51	3.23	0.001
		Angle of 60°	2.64 (1.83)	1.78	3.49	0.001
	Extension to Flexion	Angle of 15°	1.02 (0.96)	0.48	1.44	0.001
		Angle of 30°	2.73 (1.92)	1.83	3.63	0.001
		Angle of 60°	2.39 (1.36)	1.75	3.03	0.001

Table 2. Difference of knee joint position sense error of injured limb between before and after taping in weight bearing and non-weight bearing position

		Variables	Mean (SD)	95% confidence interval of the difference		*P*-value
				lower	upper	
Non-weight bearing position.	Flexion to Extension	Angle of 15°	2.33 (1.1)	1.81	2.84	0.001
		Angle of 30°	2.61 (1.47)	1.92	3.29	0.001
		Angle of 60°	4.29 (1.94)	3.37	5.2	0.001
	Extension to Flexion	Angle of 15°	2.15 (1.37)	1.51	2.79	0.001
		Angle of 30°	1.8 (1.05)	1.3	2.29	0.001
		Angle of 60°	1.78 (0.92)	1.35	2.21	0.001
Weight bearing position	Flexion to Extension	Angle of 15°	1.81 (0.78)	1.39	2.22	0.001
		Angle of 30°	3.21 (1.78)	2.38	4.04	0.001
		Angle of 60°	2.9 (1.77)	2.07	3.73	0.001
	Extension to Flexion	Angle of 15°	2.02 (0.72)	1.68	2.35	0.001
		Angle of 30°	2.48 (1.61)	1.72	3.23	0.001
		Angle of 60°	2.3 (1.02)	1.82	2.78	0.001

Table 3. Difference of knee joint position sense error of uninjured limb between before and after taping in weight bearing and non-weight bearing position

		Variables	Mean (SD)	95% confidence interval of the difference		*P*-value
				lower	upper	
Non-weight bearing position	Flexion to Extension	Angle of 15°	1.18 (0.59)	0.9	1.45	0.001
		Angle of 30°	1.03 (0.7)	0.7	1.36	0.001
		Angle of 60°	1.55 (0.8)	1.18	1.92	0.001
	Extension to Flexion	Angle of 15°	0.87 (0.42)	0.67	1.07	0.001
		Angle of 30°	1.96 (0.41)	0.63	1.04	0.001
		Angle of 60°	1.77 (0.43)	0.62	0.98	0.001
Weight bearing position	Flexion to Extension	Angle of 15°	0.79 (0.38)	0.61	0.97	0.001
		Angle of 30°	0.74 (0.48)	0.51	0.96	0.001
		Angle of 60°	0.96 (0.31)	0.81	1.11	0.001
	Extension to Flexion	Angle of 15°	0.85 (0.61)	0.56	1.13	0.001
		Angle of 30°	0.92 (0.51)	0.68	1.16	0.001
		Angle of 60°	0.77 (0.45)	0.55	0.98	0.001

Table 4. Difference between knee joint position sense error of injured and un injured limb after taping in weight bearing and non-weight bearing position

		Variables	Mean (SD)	95% confidence interval of the difference		*P*-value
				lower	upper	
Non-weight bearing position	Flexion to Extension	Angle of 15°	1.03 (0.15)	-0.63	0.33	0.525
		Angle of 30°	1.58 (0.64)	-0.09	1.37	0.086
		Angle of 60°	0.82 (0.25)	-0.21	0.72	0.269
	Extension to Flexion	Angle of 15°	0.82 (0.3)	-0.68	0.08	0.122
		Angle of 30°	1.01 (0.84)	0.36	1.32	0.006
		Angle of 60°	0.95 (0.58)	0.13	1.03	0.053
Weight bearing position	Flexion to Extension	Angle of 15°	0.85 (-0.69)	-1.09	-0.28	0.061
		Angle of 30°	1.15 (-0.09)	-0.63	0.44	0.706
		Angle of 60°	1.52 (0.7)	-0.01	1.41	0.054
	Extension to Flexion	Angle of 15°	0.77 (-0.2)	-0.56	0.15	0.249
		Angle of 30°	1.54 (1.1)	0.45	1.9	0.08
		Angle of 60°	0.96 (0.86)	0.4	1.31	0.072

retained this position for 5 seconds, and this angle was measured with digital goniometer; he was then asked to return to the first position. In the third step, KT was applied from tibial tuberosity to the lower third of the thigh as anterior-medial, anterior-lateral in the position of 30° knee flexion and with the stretch of 60% of the maximum tensile capacity of the tape (Figure 2). In the fourth step, the second step was repeated. Reconstruction of the 30° and 15° knee flexion angles was done like above steps. Test order of injured and contralateral uninjured limb was assigned randomly, but the knee flexion angles reconstruction has the same order from 60° toward 15° flexion in all trials.

D) Moving towards flexion in weight bearing position: In the first step, the participant was asked to stand on his injured limb. He was asked to move the knee from 0° extension (initial test position) to 60° flexion (final test position), with injured limb. This position was maintained for 5 seconds. The subject was then asked to return to the initial position. In the second step, the subject was asked to reconstruct the trained position, which he retained for 5 seconds; this angle was measured with a digital goniometer. He was then asked to return to the first position. In the third step, KT was applied from tibial tuberosity to the lower third of the thigh as anterior-medial, anterior-lateral in the position of 30° knee flexion and with the stretch of 60% of the maximum tensile capacity of the tape. In the fourth step, the second step was repeated. Reconstruction of the 30° and 15° knee flexion angles was performed like the steps above. Test order of injured and contralateral uninjured limb was assigned randomly, but the knee flexion angles reconstruction has the same order from 60° toward 15° flexion in all trials.

Statistical analysis:

The data were analyzed using version 17 of SPSS software. Normal distribution was checked using the Shapiro-Wilk test. Since data were shown to be normally distributed, repeated measure ANOVA was used to determine any difference among baseline, injured and uninjured limbs. Greenhouse-Geisser and paired t tests were used to determine the effect of taping on the knee joint position sense error of the injured and uninjured limbs before and after taping among different knee joint position sense error tests. Statistical significance for all tests was accepted below 0.05.

Results

The mean age (SD), height and weight of participants were 24.4 (1.42) years, 178.4 (3.66) cm, and 75.65 (2.49) kg, respectively. Greenhouse-Geisser test showed significant differences among these three parameters (P=0.001). Then paired t test was used to determine the effect of taping on the knee joint position sense error in different conditions.

There was a significant difference in knee joint position sense error rate of injured and uninjured limbs before taping in the weight bearing and non-weight bearing positions (Table 1). There was a significant difference in knee joint position sense error of injured limb between before and after taping from flexion to extension and extension to flexion in the non-weight bearing and weight bearing positions (Table 2). In addition, there was a significant difference in knee joint position sense error of uninjured limb between before and after taping from flexion to extension and extension to flexion in the non-weight bearing and weight bearing positions (Table 3).

There was no significant difference in knee joint position sense error of injured and uninjured limb after taping in the weight bearing and non-weight bearing positions (Table 4).

Discussion

The main results of this study were as follows: 1-There was a significant difference in joint position sense error rate of injured and contralateral uninjured limbs before taping. 2-There was a significant difference in joint position sense error rate of injured and contralateral uninjured limbs before and after taping. 3-There was no significant difference in joint position sense error rate between injured and contralateral uninjured limbs after taping. The results revealed the beneficial immediate effect of KT on joint position sense of both injured and contralateral uninjured limbs.

Joint position sense as a main part of proprioception has an important role in maintaining joint healthiness. Gardner reported that the ligaments of the knee had a rich sensory innervation that allowed them to act as the first link in the kinetic chain (26). Impulses arising in the ligaments are transmitted through the central nervous system back to the effecter muscles, allowing for maintenance of normal, smooth, and coordinated movement of the joint. Abnormally strong impulses, such as those initiated when a ligament is over-stretched, would result in contraction of allied muscle groups, thereby, protecting from further injury and subluxation of the knee (27).

However, ACL tear affects the directly damaged knee joint position sense. But, changing the normal activities of patient could affect joint position sense of contralateral uninjured knee, although joint position sense of contralateral uninjured knee is close to normal as compared to the injured knee. Therefore, a significant difference in joint position sense error rate of injured and contralateral uninjured limbs before taping is an expected result.

The knee joint position sense error rate after taping in the injured limb was significantly reduced in comparison with before taping in both weight bearing and non-weight-bearing conditions of three evaluating angles of 15°, 30° and 60° toward the flexion and extension.

The results listed above showed that the immediate effect of KT could improve abnormal knee joint position sense. However, the rate of improvement is more significant in limb with greater deficiency (ACLR knee). This can be explained as follows that the possible mechanism for the recovery of joint position sense after KT is proprioception improvement of the knee joint. ACL sprain causes a decrease in the sensory afferent signals from the ACL; therefore, inputs from other healthy tissues come in to maintain joint position sense. Among the most important proprioceptive receptors, cutaneous mechanoreceptors are stimulated by applying pressure and stretching of the skin, and can play an important role in determining the position and the motion of the joint (28, 29). KT, due to its elasticity and skin contact, causes continuous stimulation that facilitates skin mechanoreceptors activity.

The results of this study support the theory of the improvement of the limb position sense after application of taping. The body uses the stretch of the skin caused by taping for predicting limb position (12).

Direct contact of the tape with the skin after KT provides strong skin proprioceptive inputs, and it may increase the skin proprioceptors' activity around the joint and help in decreasing the joint position sense error rate. Hence, KT can improve neuromuscular performance by creating appropriate sensory afferent signals and can compensate the proprioception deficit partially (6, 9, 11, 12). The taping creates a sense of support for the patient's knee, which increases the sense of confidence in prediction of the knee joint position sense 13.

Results of Niknam *et al.* (30) about the effect of taping after ACLR surgery on the knee joint repositioning in weight bearing position is in line with this study. However to reach the desired point in this field, more study is needed.

This study was a single-sex subject such that all of our subjects were male football players. We suggest that the results of studies with double-sex subjects and also among athletes in various sports could be helpful in the treatment of sports injuries.

Conclusion

Based on the results of the present study, in people who undergo ACLR surgery, the knee joint position sense in the injured limb is impaired after 4 months. Joint position sense error rate after ACLR surgery can be reduced by increasing the sensory inputs by KT.

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Conflict of interest:
None

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Authors' contributions:
All authors made substantial contributions to conception, design, acquisition, analysis and interpretation of data.

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