ELASTIC TAPING APPLIED TO THE RECTUS FEMORIS MUSCLE ALTERS INSTEP KICKING KINEMATICS IN SOCCER

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We aimed to clarify the immediate effect of an elastic taping application on the kinematics of soccer instep kicking. Fourteen male university recreational soccer players performed maximal instep kicking with and without an elastic taping applied to the rectus femoris muscle, and their kicking motions were captured using a motion capture system at 500Hz. Prior to the kicking session, the thickness of the rectus femoris muscle was measured using an ultrasound scanner. The elastic taping application significantly increased the thickness of the rectus femoris muscle. Alongside this change, initial ball velocity, peak hip flexion angular velocity, and foot linear velocities increased significantly, whereas knee extension angular velocity and hip linear velocity did not change. It is considered that the elastic taping application may enhance the function of the rectus femoris muscle, thereby inducing these kinematic changes during kicking. These findings suggested that an elastic taping application may be an effective tool to improve the performance of soccer instep kicking.

KEYWORDS: Kinesio taping, rectus femoris muscle, kicking.

INTRODUCTION: Elastic taping is an intervention commonly used to manage pain and other clinical conditions, however, it is also used to improve athletic performance in a variety of sports. The primary goal of elastic taping application is to reduce congestion by exerting a pulling force on the skin surfaces, increasing the distance between the fascia and soft tissues beneath the applied area, and improving the flow of blood and lymph fluid (Yoshida & Kahanov, 2007).
The effects of elastic taping on muscle function have been reported in several studies. It has been reported that muscle tones significantly increased after an elastic taping application (Słupik et al., 2007) and that muscle activities are facilitated during baseball pitching (Hsu et al., 2009). On the other hand, a systematic review examining the effects of elastic taping application concluded that there is currently insufficient evidence to support the use of elastic taping (Morris et al., 2013). Thus, to date, the efficacy of the elastic taping application is assumed to be inconclusive, in particular for sports motions.
Soccer instep kicking motion includes a proximal to distal sequential joint motion to increase final foot velocity. Among muscles regarding this sequential motion, the rectus femoris was found to be highly activated during the instep kicking (Yadav, 2019). In the present study, therefore, we aimed to emphasize the rectus femoris muscle function during soccer instep kicking using an elastic taping application. Since the rectus femoris muscle is a bi-articular muscle, which contributes to both hip flexion and knee extension motions, it can be assumed that this muscle plays an essential role in executing proximal to distal sequential joint motions generally seen in skilled soccer instep kicking. If the elastic taping application enhances the function of the rectus femoris muscle during kicking, the motion of the instep kicking would be reinforced, thereby increasing initial ball velocity.
Thus, the purpose of the present study was to clarify the effect of elastic taping application to the rectus femoris muscle during soccer instep kicking. In conjunction with the aim, it was hypothesised that the elastic taping application to the rectus femoris muscle would immediately alter its thickness, thereby reinforcing sequential joint motion to improve resultant performance of the instep kicking.

METHODS: The participants were fourteen male university recreational soccer players who had 10.6 ±3.1 years of playing experience. All participants preferred to kick the ball using their right leg. A University Research Ethics Committee approved the experimental procedure of the present study. Written informed consent was obtained from each participant before commencement of the experiment.

Spherical markers (15-mm diameter) were attached to 16 body landmarks, as defined in the plug-in gait lower body marker set (Vicon Motion Systems) and to the right fifth metatarsal. After practicing ten submaximal kicks as a warm-up, all participants performed maximum effort instep kicks using their right leg with and without an elastic taping application. Their kicking motions were captured using a 10-camera motion capture system (Vicon Nexus, Vicon Motion Systems) sampled at 500 Hz. A radar gun (Sports Radar Ltd, SRA 3000) was used to measure the initial ball velocity. All participants performed five consecutive trials in each condition.

In the taping condition, a standardised elastic taping application for the right rectus femoris muscle that ended at the anterior superior iliac spine and the upper edge of the patella with Y-shaped Kinesio tape (NICHIBAN, JAPAN) was used (Figure 1). The available tension length was approximately 50%. The tape was directly attached to the skin surface. An experienced physical therapist applied the tape for all participants.

The thickness of the rectus femoris muscle was measured in two conditions using an ultrasound scanner with a 14-Hz probe. In the taping condition, the probe was placed on the longitudinal slit of the Y-shaped tape (Figure 1). The probe position was marked directly on the skin to measure muscle thickness at precisely the same position in the two conditions. In the taping condition, after the taping application, the muscle thickness was measured just before the kicking trial. In the non-taping condition, the measurement was conducted just before the kicking trial. Each participant completed the trials in the two conditions in a random order with enough intervals to avoid the effect of fatigue.

Of five kicks, one kick with the fastest initial ball velocity was selected for each participant for further analysis. The second metatarsal marker during the kicking trial was reconstructed from a local reference frame defined by lateral malleolus, calcaneous, and fifth metatarsal markers in standing trials. Hip and knee joint angular velocities were calculated using local reference framed fixed to the shank, thigh, and pelvis segments defined using three markers on each segment. Linear velocities of the foot centre of gravity and hip joint centre were computed. These data were not filtered because the time series of the curves were visually confirmed to be apparently smooth trajectories for all parameters. The peak values of these kinematic parameters were extracted from the analysed portion from the moment of toe-off of the kicking leg to ball impact.

The Shapiro-Wilk test was used to ensure the normal distribution of data and statistical differences in the average values between the conditions were examined using paired t-tests. The correlation between the initial ball velocity and foot linear velocity was examined using Pearson’s coefficient of correlation. The significance level was set at $p < 0.05$. For the kinematic parameters, the method of Holm (Holm, 1979) was used to adjust the statistical significance level for multiple applications of the paired t-tests.

Figure 1: Tape application and probe position to measure the thickness of the muscle.

RESULTS: As shown in Table 1, the thickness of the rectus femoris muscle increased significantly in the taping condition than that of the non-taping condition ($p < 0.05$). Alongside of this change, the final foot linear velocity ($p < 0.05$) and initial ball velocity increased significantly in the taping condition ($p < 0.01$). There was a significant, high correlation between the final foot velocity and the initial ball velocity ($r = 0.800$, $p < 0.01$).

Peak hip flexion angular velocity become significantly higher in the taping condition than that of the non-taping condition ($p < 0.05$), whereas there was no significant difference in peak knee extension angular velocity between the two conditions (Figure 2, Table 1). There was no significant difference in the hip linear velocity at ball impact between the two conditions.

Table 1. Mean ± SD of the rectus femoris muscle thickness, initial ball velocity, foot and hip velocities, and, knee extension and hip flexion angular velocities.

	Non-taping	Taping	Effect size (d)	*p* value
Rectus femoris muscle thickness (mm)	14.0 ± 2.3	15.7 ± 3.8	0.56	*p* = 0.015
Initial ball velocity (m/s)	25.7 ± 1.8	26.5 ± 2.3	0.38	*p* = 0.008
Final foot linear velocity (m/s)	18.4 ± 1.2	18.8 ± 1.4	0.34	*p* = 0.012
Hip linear velocity at ball impact (m/s)	4.2 ± 0.5	4.3 ± 0.6	0.29	NS
Max. knee extension angular velocity (deg/s)	1919.2 ± 237.6	1983.5 ± 241.9	0.27	NS
Max. hip flexion angular velocity (deg/s)	694.9 ± 99.7	774.0 ± 120.5	0.72	*p* = 0.015

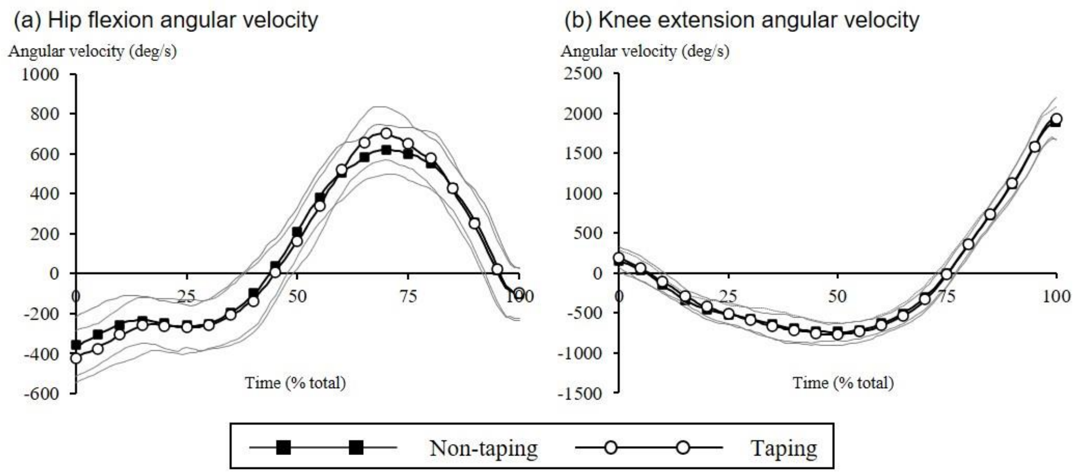

Figure 2. Time-series changes in mean hip flexion and knee extension angular velocities.

DISCUSSION: In the present study, an attempt was made to clarify the effect of an elastic taping applied to the skin surface of the rectus femoris muscle on soccer instep kicking kinematics. It was found that the application of the elastic taping increased the thickness of the rectus femoris muscle and resulted in an increase in the final foot linear velocity and the initial ball velocity. Likewise, hip flexion angular velocity increased significantly while there was no change in knee extension angular velocity. These findings, supported the hypothesis in most part. An application of elastic taping to the rectus femoris muscle would immediately improve the muscle function, thereby reinforcing kicking leg kinematics (except knee extension) to achieve improved performance of the instep kicking.
Velocities measured using a radar gun might be affected by the position and orientation of a radar gun. However, in the present study, the initial ball velocity was highly correlated with foot CG velocity ($r = 0.800$) as previously found (Nunome et al., 2006). This finding would grantee the given initial ball velocity was measured in an appropriate or at least consistent way.
Pamuk and Yucesoy (2015) examined the morphotropic change of a muscle under an elastic taping application using MRI images. They found that the muscle deformed immediately after the elastic taping application. Our findings on the increased thickness of the rectus femoris muscle agreed with this previous finding. It was reported that there was a linear relationship between contraction strength and blood flow response (Corcondilas et al., 1964). Although the background mechanism of this change is still unclear, it can be assumed that the increased muscle thickness might have caused an increased blood flow of the muscle, thereby improving the function of the rectus femoris muscle during the instep kicking.

Regarding kicking motion kinematics, we found hip linear velocity at ball impact had no change, indicating that there was no difference in the run-up velocity between the taping and non-taping conditions. Also, the significant high correlation between the final foot velocity and initial ball velocity over the two conditions confirms the manner of ball impact had little influence on the initial ball velocity regardless the taping or non-taping trials. Therefore, it was reasonable to assume that the increased final foot linear velocity was due to the emphasised angular motions of the kicking leg in the taping condition. Among two joint motions engaged by the rectus femoris muscle, the elastic taping application improved only the peak hip flexion angular velocity while the peak knee extension angular velocity did not change. In soccer kicking, it has been shown that the moment due to motion-dependent interaction, rather than the knee extension muscle moment, played a dominant role in the continuous increase in the knee extension angular velocity during the final phase of kicking (Nunome et al., 2006). This finding: knee muscle moment does not substantially contribute to knee extension motion during the final phase of the instep kicking, may explain why the elastic taping application on the rectus femoris muscle did not alter the peak knee extension angular velocity during kicking. In addition, the rectus femoris muscle is not only one muscle responsible for knee extension velocity, which may explain why knee extension angular velocity did not change after the rectus femoris muscle was thickened by an elastic taping application.
A few limitations were associated with the present findings. First, the immediate effect of elastic taping application was solely assessed in the present study. Long-term effects should be examined in further studies. Also, since the activation level of the rectus femoris muscle during kicking may vary depending on the athlete's training level and experience, further studies include highly trained athletes should be warranted in the future.

CONCLUSION: The present study succeeded in determining the effect of elastic taping application on the skin surface of the rectus femoris muscle on soccer instep kicking kinematics. Our major findings were that an elastic taping application to the rectus femoris muscle increased the thickness of the muscle and the peak hip flexion angular velocity of the kicking leg. These changes resulted in increased foot linear velocity and initial ball velocity. On the other hand, the peak knee extension angular velocity did not change even when the thickness of the rectus femoris muscle was increased. From these findings, it was suggested that an elastic taping application may improve the performance of soccer instep kicking.

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