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Effects of Kinesio Taping over Abdominal Muscles with Different Tensions on the Lumbopelvic Complex Components in Men with Increased Anterior Pelvic Tilt

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ABSTRACT

Introduction: This study aimed to investigate the immediate effect of kinesio taping (KT) over abdominal muscles with different tensions on the components of the lumbopelvic complex.

Materials and Methods: This is a single-blind randomized controlled clinical trial. Participants were 44 healthy male athletes aged 18-30 years with increased anterior pelvic tilt (PT). Three intervention groups underwent 15 minutes of KT over rectus abdominis and external oblique muscles with tensions of 100, 115, and 140%, respectively, and one group was considered as the control group with no KT. The PT and lumbar lordosis angles and iliopsoas and hamstring muscle lengths were measured before and after the KT. Repeated measures ANOVA was used to compare the means in the study groups before and after the intervention.

Results: The mean of right and left PT and lumbar lordosis angles in groups with 115 and 140% tensions before and after the intervention were statistically different ($P<0.05$). Moreover, the mean of right and left PT and lumbar lordosis angles showed a significant difference between the groups after the intervention ($P<0.05$). There was a significant difference in active and passive hamstring lengths on both sides in the group received KT with 140% tension before and after the intervention ($P<0.05$).

Conclusion: Kinesio taping with high tension on rectus abdominis and external oblique muscles can reduce their PT angle and lumbar lordosis and increase hamstring muscle length in men with increased anterior PT. This issue should be considered in lumbopelvic complex physiotherapy.

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1. Introduction

The pelvis connects the spine to the lower limbs and is a key structure for maintaining balance. Therefore, any change in its alignment can change the distribution of body weight and cause pain in the spine, hip, and knee [1, 2]. pelvic tilt (PT) is an angle that shows the tendency of the pelvis to the horizon in the sagittal plane [3, 4]. Its changes affect the lumbar lordosis [5] and may cause low back pain [6]. The natural curvature of the lumbar lordosis is essential for proper weighting and increasing the efficiency of the muscles around the spine [7, 8]. The degree of lumbar lordosis increases in standing position due to the increase in PT angle [9], which can lead to an increase in lumbosacral angle. It has been reported as one of the risk factors for low back pain [10, 11]. In fact, this increased lumbar lordosis is the primary cause of different types of low back pain, including postural pain, radiculopathy, and facet joint syndrome [12]. There is a significant relationship between changes in PT angle and lumbar lordosis in standing position [9], and the effect of floor muscle training on lumbar lordosis and flexibility of spinal erectors has been shown in previous studies [13]. The abdominal muscles and hip extensors work together as a force-couple to produce posterior PT, and the lumbar muscles and hip flexors work as a force-couple to create anterior PT [14].

Kinesio Tape is a therapeutic elastic tape used to prevent and treat sports injuries during movement and training [15]. Many studies have described the application of kinesio taping (KT) on the skin surface to stimulate mechanical receptors and increase the transmission of sensory information to the central nervous system [16]. Therapists use KT technique to stimulate or inhibit muscles, reduce pain and fatigue, prevent injury, improve blood flow and lymphatic drainage, and improve joint/fascia alignment and range of motion [17-21]. Some studies have shown the effect of KT on increasing the strength and endurance of the abdominal muscles and reducing the time to create maximum muscle torque [22, 23].

Any change in the strength, length, or flexibility of the muscles attached to the pelvis and lumbar vertebrae can cause changes in the natural angles of the lumbar–pelvic complex in the long term. The hamstring and iliopsoas muscles can affect the PT angle according to their attachments; the shortness of iliopsoas muscles can increase anterior PT, while the shortness of hamstring muscles can decrease anterior PT [14]. There is a relationship between abdominal muscle function and PT angle; better function of these muscles can reduce the PT angle, while their poor function increase the angle [24]. KT can affect muscle function. Most of the previous studies have examined the effect of PT taping on lumbar lordosis when KT is applied to the erector spinae and internal oblique muscles [25]. However, its effect when KT is applied to the rectus abdominis and external oblique muscles has less been studied. Furthermore, in the conducted studies, the KT has been done with 100% tension and no control group has been used. Therefore, the present study aims to evaluate the immediate effect of KT over abdominal muscle with 100%, 115% and 140% tensions on PT and lumbar lordosis angles and iliopsoas and hamstring muscle length in healthy young men with increased anterior PT.

2. Materials and Methods

Study design and participants

This is a single-blind randomized controlled clinical trial conducted in the school of Rehabilitation Sciences, Tehran University of Medical Sciences, in 2019. The study population included healthy semi-professional male athletes aged 18-30 years with increased anterior PT. Inclusion criteria were: Being a healthy semi-professional male athlete, age 18-30 years, exercising for at least three and half hours per week with increased anterior PT (>15 degrees), no history of low back pain in the past six months, no history of spinal surgery, no orthopedic disorders in the lower extremities, no history of neurological diseases, no iliopsoas and hamstring muscle damage (strain, spasm, tendinopathy) in the past six months, and no pathological abnormalities in the spine such as scoliosis, etc. Subjects who could not continue their participation or had willingness to leave the study and those with any type of skin allergy or sensitivity to KT during the intervention were excluded from the study. In this regard, 44 eligible healthy men were selected using the non-probability sampling method. For determining the sample size, the effect size was first calculated based on a pilot study. First, we calculated the intragroup and intergroup dispersions which were obtained 3.82 and 2.18, respectively. After dividing intergroup dispersion by intragroup dispersion, the effect size was obtained 0.57. With 95% confidence interval and 80% test power, the number of samples in each group was determined 11.

All participants were explained about the study procedure, and signed the informed consent form. Subjects were then randomly assigned into four groups; three intervention groups (groups 1, 2 and 3) that received KT with 100%, 115%, and 140% tensions and one control group (group 4) that did not receive KT intervention. In

order to allocate the samples, the numbers 1,2,3,4 were written on four cards in different orders (1234, 2134, 3214, 4321). Then, the first participant was asked to pick one of cards; he was placed in the group based on the first number written on the selected card. The group of next three samples was determined in the same way. Demographic information and medical history were first recorded. Then, height and weight were measured and recorded in the general information form. Before applying the KT, without any warm-up, the lordosis angle, the right and left PT angles, as well as the length of iliopsoas and hamstring muscles in active and passive conditions were randomly measured and recorded for both lower limbs.

Assessments

The right and left PT angles were measured using a palpation meter (Varzeshpajohane Emruz Co., Iran) in standing position with legs parallel to each other and shoulder-width apart. The palpation meter arms were placed between the anterior superior iliac spine and the posterior superior iliac spine to measure the PT angle [26]. This measurement was performed three times, and the average degree was considered as the PT angle.

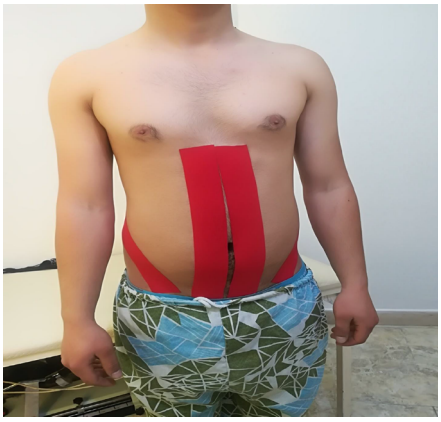
For measuring the lordosis angle, two bone indices were used: spinous process of T12 as the starting point and spinous process of S2 as the endpoint of lumbar curvature [27]. In order to find these two points, the lower edge of each posterior superior iliac spine was identified and the two points were connected. This line passes over the sacrum of the S2 spinous process [28]. After finding the S2, there was the spinous process of L5 higher than S1 with a width of examiner's index finger. By touching and counting the spinous processes of the lumbar vertebrae from the bottom up, the spinous process of the T12 vertebra was located. The target points were marked. The subjects were then asked to spread their legs shoulder-width apart while standing. They were given two minutes to be in their normal standing position. Then, a flexible ruler (Varzeshpajohane Emruz Co., Iran) was placed in the waist area. After the ruler was fixed to the contours of the spinal curve, it was removed carefully. Then, it was carefully placed on a white sheet, and the curvature was drawn. Next, the points T12 and S2 were connected with a straight line (L), and another line was drawn perpendicular to the midpoint of curvature (H). The angle was calculated according to the formula [29]. This measurement was performed three times, and the average value was considered as the lordosis angle.

The modified Thomas test was used to measure the length of iliopsoas muscle [3]. The participant was asked to sit on the edge of the bed with both hands on the left hip, and lay down gently on the bed with the help of the examiner. The left hip was bent to the extent that the lumbar curve was fully placed on the bed, and the right hip was allowed to extend freely off the bed without support. The hip was checked to make sure it was not in the abduction position, because it indicates the shortness of the tensor fasciae latae muscle. When the final position was reached, a goniometer (Varzeshpajohane Emruz Co., Iran) was placed on the outer part of the greater trochanter. The proximal arm was aligned with the outside of the midline of the pelvis, and the distal arm was aligned with the lateral midline of the femur (using the lateral epicondyle). The hip angle was recorded 0° when the hip was in the horizontal position, and was recorded with a negative number when the hip was above the horizontal line. When the hip was lower than the horizontal line, the angle was recorded with a positive number [3]. The test was repeated three times and the average of the obtained numbers was considered as the length of iliopsoas muscle. Then, the test was performed in the same way for the left limb, and the data were recorded.

For measuring the length of hamstring muscle, 90-90 active knee extension and passive knee extension tests were used for both lower limbs [3]. For this purpose, the subject was in a supine position and straightened the lower left limb. The limb was fastened to the bed with a strap (Novin Co., Iran). The hip joint and the knee of the right lower limb were held at 90 degrees. Then, the subject extended the right knee actively as far as possible, and the knee angle was measured with a goniometer. Next, the right knee was extended passively, and the knee angle was measured. The test procedure was repeated in a same way for the left lower limb. The scoring criterion for hamstring muscle length included the highest number read on the goniometer at the highest level of knee extension. The ankle was also in a plantarflexion position during the test to prevent nerve tension. For each limb, measurements were performed three times, and the average of the three obtained numbers was considered as the hamstring muscle length.

Intervention

For the KT intervention, a red color Kinesio Tape (ATEX, Atex Co., South Korea) was used for all muscles. The Kinesio Tape was attached from the pubic bone to the xiphoid process on the right abdominal muscle and from the lateral third of the inguinal liga-



JMR

Figure 1. Kinesio taping of rectus abdominis and left and right external oblique muscles

ment and the anterior one-third of the iliac crest to the lower edge of the posterior one-third of rib 11 for external abdominal oblique muscle, bilaterally (Figure 1) [5, 17]. After 15 minutes, the PT angle, lumbar lordosis angle, and hamstring and iliopsoas muscles' length were re-recorded for all subjects. The examiner was unaware of the percentage of tension used for each participant.

Statistical analysis

SPSS v. 22 was used for statistical tests. A P<0.05 was statistically significant. Kolmogorov-Smirnov test was used to evaluate the normality of data distribution. one-way analysis of covariance was used to compare the demographic variables between the groups. To compare the mean PT angle, mean lumbar lordosis angle, mean hamstring muscle length, and mean iliopsoas muscle length between groups before and after KT application, repeated measures ANOVA was used. When necessary, Tukey's post hoc test with adjusted significance level was used.

3. Results

Kolmogorov-Smirnov test results showed the normal distribution of the data (P>0.05). Demographics characteristics of subjects including age, height, weight, and body mass index are presented in Table 1. There was no significant difference between different groups in terms of demographics factors (P>0.05).

The mean values of right PT angle, lumbar lordosis angle, active and passive length of right hamstring, active and passive lengths of left hamstring, and right and left iliopsoas lengths were not significantly different among the groups before applying KT (P>0.05) (Tables 2, 3, 4). The mean values of right and left PT angles and lumbar lordosis angle were significantly different in groups with 115% and 140% tensions before and after KT (P<0.05) (Tables 2, 3, 4). Furthermore, the mean values of right and left PT angles and lumbar lordosis angle were significantly different between groups after KT application (P<0.05). The mean active and passive lengths of the right and left hamstring and the lengths of right and left iliopsoas were not significantly different between the groups (P>0.05). The mean length of the passive left hamstring showed a significant difference in groups with 140% and 115% tensions before and after the intervention (P<0.05). The mean active length of left hamstring and the mean active and passive lengths of right hamstring were significantly different only in group with 140% tension before and after the intervention (P<0.05). The results of Tukey post hoc test showed that the mean right and left PT angles and the mean lumbar lordosis angle in the group with 140% tension were lower than in other groups (P=0.0125).

Table 1. Demographic characteristics of the participants in each group

Characteristics	Mean±SD			
	Group 1 (n=11)	Group 2 (n=11)	Group 3 (n=11)	Group 4 (n=11)
Age (y)	23.63±2.69	24.54±3.32	22.72±3.52	24.00±2.40
Weight (kg)	67.18±7.98	70.186.49	67.90±9.26	71.45±11.05
Height (cm)	171.27±4.58	171.63±2.80	172.00±2.00	172.36±2.24
Body mass index (kg/m²)	22.86±2.51	23.89±2.64	22.95±2.86	24.02±3.31

Group1: KT with 100% tension, Group 2: KT with 115% tension, Group 3: KT with 140% tension, Group 4: No KT

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Table 2. Comparison of right PT angle (degree) in study groups before and after intervention

Time	Mean±SD				Effect Size	Sig.
	1	2	3	4		
Before	17.17±2.07	15.90±1.20	17.41±1.40	16.60±1.29	0.39	0.113
After	17.14±2.49	14.96±1.86	12.41±1.99	16.57±1.14	0.99	0.000
Sig.	0.873	0.037	0.000	0.813		

JMR

Group1: KT with 100% tension, Group 2: KT with 115% tension, Group 3: KT with 140% tension, Group 4: No KT; SD= Standard deviation

4. Discussion

The present study was conducted to evaluate the immediate effect of KT over abdominal muscle with different percentages of tension on PT, lumbar lordosis angle, and hamstring and iliopsoas muscle lengths in healthy men with increased anterior PT. The results showed that both PT and lumbar lordosis angles decreased only after applying KT with 115% and 140% tensions. This issue indicates that KT over abdominal muscles can cause a favorable change in PT and lumbar lordosis angle which depends on the percentage of tension. There are theories about improvement in muscle function by KT. KT increases peripheral blood circulation and lymphatic drainage by lifting the target area [30, 31]. It stimulates the autonomic nervous system, causes arterial vasodilation, and ultimately improves muscle function. Another theory states that, by stimulating the cutaneous mechanoreceptors by KT, the reflexive contraction of muscle spindles and the excitability of the motor units are improved [32], and the bioelectrical activity of the muscle is increased [33]. Moreover, there are theories about the effect of KT on regulating the muscle length-tension relationship and improving their function [34]. Considering that, in our study, the abdominal muscles were subjected to KT intervention and these muscles can cause posterior PT with their contraction, the present study results can be explained.

According to studies by Mostert-Wentzel et al., Peixoto et al., and Mohammadi et al. on subjects with good muscle function and athletes [35-37], more tension in applying KT leads to desirable results. Since samples in our study were healthy young athletes, the greater effect of KT with higher percentages of tension can be explained. It is possible that low tensions of KT do not increase the use of motor units and the stimulation of motor reflexes properly [36]. Consistent changes in PT and lumbar lordosis angles in our study may be because the two structures are skeletally related. Previous studies have shown a significant relationship between PT angle and lumbar lordosis angle in standing position; the degree of lumbar lordosis in standing position increases due to the increase in PT angle, and the decrease in anterior PT angle and reduce the degree of lumbar lordosis [9, 38]. This result is consistent with the results of Lee et al. Lee and Yoo, and Peixoto et al. [25, 36, 39, 40]. Lee et al. [25] examined the immediate effect of KT over erector spinae and internal abdominal oblique muscles on the PT angle. A significant increase in anterior PT angle was observed after applying KT with 15-25% tensions. As mentioned before, KT can improve muscle function; since erector spinae muscles are connected to the sacrum and pelvis, they can cause anterior PT and increase lumbar lordosis angle [41]. Moreover, when the chest is fixed, the superior–inferior fibers of the internal oblique muscles can cause anterior PT [14]. As a result, the KT of target

Table 3. Comparison of left PT angle (degree) in the study groups before and after the intervention

Time	Mean±SD				Effect Size	Sig.
	1	2	3	4		
Before	17.96±2.76	16.78±2.07	18.33±1.82	16.20±1.45	0.43	0.042
After	17.54±3.06	15.63±1.97	12.93±2.34	16.20±1.39	0.77	0.000
Sig.	0.182	0.008	0.000	0.990		

Group 1: KT with 100% tension, Group 2: KT with 115% tension, Group 3: KT with 140% tension, Group 4: No KT JMR

Table 4. Comparison of lumbar lordosis angle (degree) in the study groups before and after the intervention

Time	Mean±SD				Effect Size	Sig.
	1	2	3	4		
Before	45.08±3.07	45.73±3.31	46.40±2.41	45.12±3.31	0.18	0.713
After	45.17±3.37	43.36±3.03	39.16±3.75	45.06±3.45	0.74	0.000
Sig.	0.786	0.017	0.000	0.576		

Group 1: KT with 100% tension, Group 2: KT with 115% tension, Group 3: KT with 140% tension, Group 4: No KT

muscles leads to a change in the direction of the lumbopelvic-hip complex in accordance with the function of the same muscles. In 2014, Lee et al. [39] used KT to reduce anterior PT in women with sacroiliac pain. In their study, similar to our study, KT was applied over the rectus abdominis and external oblique muscles. The amount of tension was 50%. In addition to these muscles, KT was performed from the anterior superior iliac crest to the posterior superior iliac crest for mechanical correction with 75% tension. KT immediately reduced anterior PT in the patients, which lasted for 24 hours [39]. Since the KT in their study was used for both muscle facilitation and mechanical correction, it is unclear which component had the greatest effect. Lee and Yoo in a case report study used KT similar to the method of the previous study with about 30-40% tension to reduce lumbar lordosis and anterior PT in a 20-year-old woman with increased anterior PT and lumbar lordosis. The results showed that both angles were reduced after the intervention [40]. Their intervention was performed for two weeks, six days per week, which was longer compared to similar studies. However, their results are not generalizable because only one person was examined. Bozorgmehr et al. [42] reported a reduction in lumbar lordosis following one-week application of KT with a method similar to Lee's method and with 50-75% tension in people with non-specific chronic low back pain with increased lordosis, which is consistent with the present study. Furthermore, the thickness of external and internal obliques and transverse abdominal increased during contraction after the intervention in their study, indicating that the KT may have increased the function and strength of these muscles. In addition to the reasons mentioned earlier, another factor in increasing muscle function and strength can be the effect of KT on maintaining the continuity of muscle tension and improving their function by increasing stability [43]. Peixoto et al. examined the effect of KT over gluteus maximus muscle on PT angle in 26 women and reported significant increase in the posterior PT in two groups of KT with 30% and 60% tensions [36]. It should be noted that in their study, the range of PT angle with 60% tension was more than with 30% tension, which is consistent with our study; in both studies, young people with good muscle function were evaluated. Correction of severe lumbar lordosis using KT was also evaluated by Shirazi et al. [45], but there was one difference; KT was performed on the rectus abdominis and external oblique muscles in one group and on the hamstring muscles in the other group. The tension was 30% in both groups. They found no significant difference in lumbar lordosis angle before and after KT application, which may be due to the small sample size in their study or because the sensory afferents created by the KT are not strong enough to cause short-term stimulation [44]. However, after 24 hours, the lumbar lordosis angle decreased in both groups, which was greater in the group where the KT was applied to the abdominal muscles [45], which may indicate that the improvement in muscle function by the KT requires at least one day and, as reported by Lee et al. [39], higher tensions should be used for mechanical correction to see immediate effects.

Regarding the effect of tension amount of KT over the abdominal muscle on the PT and lumbar lordosis angles, no similar study was found. However, there are studies used KT over other body areas with different tensions. For example, Mohammadi et al. reported that 115% and 140% tensions of KT compared to 100% tension could reduce passive/active joint repositioning error at 60-degree angle [37]. Furthermore, consistent with the present study, the high percentage of tension was more effective than zero tension. However, in a study, KT over the extensor muscles of the wrist and fingers with higher tensions (25% and 50%) did not show a different degree of motor-sensory synchrony perception compared to the group without tension [46]. The discrepancy in the results may be due to the different nature of the anatomical region and the study variables.

In the present study, the length of iliopsoas and hamstring muscles were actively and passively examined on both sides. It was reported that the length of right and left iliopsoas muscles before and after KT with different tensions were not significantly different. This may be due

to insufficiency of immediate abdominal muscle taping in increasing iliopsoas muscle flexibility. Regarding the effect of abdominal muscle taping on hamstring muscle length, it seems that high tension (140%) can cause an immediate increase in the muscle length on both sides, which is consistent with the results of Han et al. who showed an immediate increase in the length of pectoralis minor with 35-40% tension compared to zero tension [47]. This can be explained by the mechanical correction created by the KT. Ozer et al. also found that the length of pectoralis minor increased immediately after 72 hours of KT application with 50-75% tension, indicating that a higher percentage of tension can have long-term effects in addition to short-term effects [48].

Limitations of the present study included: No assessment of the long-term effects of KT, lack of a follow-up period to investigate the persistence of KT's immediate effects, and no female participants.

5. Conclusion

Application of KT with 115% and 140% tensions for 15 minutes on rectus abdominis and external oblique muscles in men with increased anterior PT can reduce their lumbar lordosis and PT angles. This method can be used if there is a need to change the angle of PT and lumbar lordosis in physiotherapy of the lumbopelvic area. Higher tensions of KT over the abdominal muscles can also be used to influence the length of hamstring muscle. For further assessment of mechanical or neurophysiological effects of KT, more studies are recommended. Moreover, neurophysiological components such as muscle position sense and joint position sense can be used in addition to biomechanical components to differentiate the effects. Studies using long-term KT on female subjects are also recommended.

Ethical Considerations

Compliance with ethical guidelines

All study procedures were in accordance with the guidelines of the Scientific Board and Ethics Committee of Tehran University of Medical Science (Code: IR.TUMS.FNM.REC.1397.130).

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Authors' contributions

Conceptualization and design: Adel Soleimani, Nastaran Ghotbi, Azadeh Shadmehr, Kazem Malmir; Acquisition of data: Adel Soleimani; Analysis and interpretation of data: All authors; Drafting of the manuscript: Adel Soleimani, Alireza Tahmasbi; Critical revision of the manuscript for important intellectual content: Nastaran Ghotbi, Alireza Tahmasbi; Supervision: Nastaran Ghotbi

Conflict of interest

The authors declared no conflicts of interest.

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