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RESEARCH ARTICLE

EFFECT OF KINESIO TAPING ON ISOKINETIC PARAMETERS OF ANKLE JOINT

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ABSTRACT

The popularity of application of kinesio tape (KT) during the rehabilitation process, and the need for empirical evidence on the effect of kinesio tape are compelling reasons to perform further researches on KT**.** This study was conducted to explore the changes that may occur in the peak torque (PT) of ankle evertors and invertors as well as the ankle strength ratios (EV_{CON}/INV_{ECC} and EV_{ECC}/INV_{CON}) as a result of applying different taping modes. The examined taping modes were; No tape, athletic tape (AT) and kinesio tape (KT). The study was conducted on thirty healthy volunteers of both sexes. Isokinetic concentric and eccentric PT assessments have been done for both ankle evertors and invertors using the Biodex 3 isokinetic dynamometer. All subjects were tested with the different taping modes at 30º/sec and 120º/sec. Repeated measures MANOVA revealed significant increase in the concentric and eccentric evertor PT, the EV_{ECC}/INV_{CON} strength ratio at both of the tested velocities (30º/sec and 120º/sec) and the eccentric invertor PT at 120º/sec ($P < 0.025$) when using KT. It was concluded that, KT has an impact on PT of ankle evertors and invertors as well as ankle strength ratio.

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INTRODUCTION

The primary function of the ankle and foot is to absorb shock and impact thrust to the body during walking. While walking and running, the foot must be pliable enough to absorb the impact of millions of contacts throughout a life-time. Pliability also allows the foot to conform to countless spatial configurations between it and the ground. Walking and running also require that the foot be relatively rigid to withstand the large propulsive thrusts created at the push-off phase of walking (Neumann, 2002). As the ankle and foot participate in locomotion they sustain very large loads that may contribute to some of the clinical complaints reported by patients (Oatis, 2004). A sprained ankle is one of the most common orthopedic injuries. Ankle sprains occur in both athletes and those with sedentary lifestyles, and they can occur during sports or when walking to carry out daily activities (De Noronha and Junior, 2004). Injuries to the lateral ligamentous complex of the ankle result in more time lost from participation than any other single sports-related injury. After an ankle injury, residual symptoms can also affect activities of daily life; about 33% of patients with a lateral ankle sprain have persistent residual symptoms 2 years after the initial injury (Fox *et al.,* 2008). Twenty to forty percent of the acute ankle sprains develop into chronic ankle instability if rehabilitation is inadequate. Chronic ankle instability represents a typical sports injury which can mostly be seen in basketball, soccer and other high risk sports (Mckay *et al.,* 2001). Prevention and treatment programs for ankle injuries can be time and costly consuming (Kaminski *et al.,* 1999). In first-time lateral ankle sprains, although both immobilization and early mobilization prevent late residual symptoms and ankle instability, early mobilization allows earlier return to work (54% versus 13%) and may be more comfortable for patients (Eiff *et al.,* 1994). Prophylactic ankle taping has been considered the mainstay of ankle injury prevention. It has been used at all levels of competitive football (Mickel *et al.,* 2006). Ankle taping protects ankle from excessive range of motion, increase proprioception input, increase peroneal muscle activity, and ankle motion deceleration (Riemann *et al.,* 2002).The most commonly used tape applications are done with non stretch tape. The rationale is to provide protection and support to a joint or a muscle (Alexander *et al.,* 2003). Abian *et al.* (2009) recommend the use of elastic tape (ET) as the first choice for prophylactic ankle taping. Because it produces the same restriction in the ROM as the inelastic tape (IT) but with less taping fatigue, and is perceived as more comfortable and less restrictive by the users.

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In recent years, the use of Kinesio Tape (KT) has become increasingly popular. KT was designed to mimic the qualities of human skin. It has roughly the same thickness as the epidermis (Kase *et al.,* 2003). Kinesio tape differs from traditional white athletic tape in the sense that it is elastic and can be stretched to 140% of its original length before being applied to the skin. It subsequently provides a constant pulling (shear) force to the skin over which it is applied unlike traditional white athletic tape. The fabric of this specialized tape is air permeable and water resistant and can be worn for repetitive days. Kinesio tape is currently being used immediately following injury and during the rehabilitation process (Halseth *et al.,* 2004). The proposed mechanisms by which Kinesio tape works are different than those underlying traditional ankle taping. Rather than being structurally supportive, like white athletic tape, Kinesio tape is therapeutic in nature. According to Kenzo Kase, the creator of Kinesio tape, these proposed mechanisms may include: (1) correcting muscle function through a sensorimotor mechanism (2) improving circulation of blood and lymph by eliminating tissue fluid or bleeding beneath the skin by moving the muscle, (3) decreasing pain through neurological suppression, and (4) repositioning sublaxed joints by relieving abnormal muscle tension, helping to return the function of fascia and muscle (Kase *et al.,* 2003). A fifth mechanism has been suggested by Murray and Husk (2001) who examined the effect of kinesio taping on ankle proprioception. They concluded that kinesio taping for a lateral ankle sprain improved proprioceptive abilities through increased stimulation to cutaneous mechanoreceptors in non-weight bearing positions in the midrange of ankle motion.

Physicians and other clinicians frequently use reciprocal muscle-group ratios in determining return-to-play status and establishing rehabilitation goals. The reciprocal contraction-mode ratios may provide important clinical information, especially in the ankle (Hartsell, 1999). In the ankle region, these ratios are typically expressed as Eversion $_{CON}$/ Inversion $_{ECC}$ (EV_{CON}/INV_{ECC}) and Eversion $_{ECC}$/Inversion $_{CON}$ (EV_{ECC}/INV_{CON}). The more traditional expression of the muscle action-mode ratios is that of EV_{CON}/INV_{ECC}. Perhaps this ratio expresses the “traditional” viewpoint of the invertors acting eccentrically to slow the lateral displacement of the tibia in a closed kinetic chain. It also gives some credence to the need to examine invertor strength deficits in those with chronic ankle instability (CAI) (Perrin, 1993). The opposite ratio expression involving EV_{ECC}/INV_{CON} has also recently been explored. This more “functional” expression of the ratio describes how the peroneal muscles may react eccentrically to slow the rate of inversion in an open kinetic chain (Kaminski *et al.,* 2001).

A high incidence of inversion ankle sprains occurs in individuals with muscle strength imbalance. There are numerous factors and mechanisms that are thought to prevent increased ankle sprain occurrence. Eccentric evertor muscle strength as well as eccentric evertor/ concentric invertor strength ratio (EV_{ECC}/INV_{CON}) is one of these factors associated with the prevention of inversion trauma. An increase of this ratio is expected for preventing ankle inversion sprain (Yildiz *et al.,* 2003). Moreover, ankle EV/INV ratios may be more physiologic and functionally sound than measuring strength alone in an attempt to prevent ankle injuries (Hsiu Lin *et al.,* 2008). The fact that inversion deficit may exist in those with CAI has led to the more recent examination of eversion-to-inversion (EV/INV) strength ratio. However, few studies have examined the "dynamic strength control" ratios incorporating both concentric and eccentric muscle actions. Additionally, the scientific evidence investigating the effectiveness of kinesio tape is limited. So, this study was conducted to detect the difference between the effect of three taping modes; No tape, athletic tape, and kinesio tape, on the concentric and eccentric peak torque (strength) of ankle evertors and invertors. Furthermore, this study was done to know if there is difference in the EV_{CON}/INV_{ECC} and EV_{ECC}/INV_{CON} strength ratios using the three different taping modes. As, the ankle joint strength ratios may be used in the near future, much like those of the shoulder (abductor/adductor and external rotator/ internal rotator and knee (hamstring/ quadriceps), to detect muscle imbalances in an attempt to prevent injury.

METHODS

Participants

Thirty healthy volunteers of both sexes participated in the study (6 females and 24 males). The included subjects met the following criteria; mean age 21 ± 2.73 years, height 172.5 ±7.64 cm and weight 75 ± 6.20 kg. Participants involved in this study had no previous history of ankle injury or surgery, and/or currently have ankle pathology (i.e. abnormal ligament laxity, congenital deformities, and neurological deficits). None of them was participating in any lower limbs strengthening exercise programs.

Instrumentation

The test was conducted by using the Biodex isokinetic system 3 multi-joint testing and rehabilitation system (Biodex medical system, Shirley, NY, USA). It has been widely used in research, clinical setting and rehabilitation to objectively assess factors of muscle performance that would otherwise be difficult to obtain using manual testing techniques. Calibration of the Biodex dynamometer was performed according to the specifications outlined in the manufacturer’s service manual. In this context, Aydog *et al.,* (2004) investigated the intratester and intertester reliability of isokinetic ankle inversion and eversion-strength measurement in neutral foot position in healthy adults using the Biodex dynamometer. Results showed that the intratester ICCs for ankle inversion in healthy young adults were highly reliable (ICC 0.92–0.96), and for the eversion values ranged from 0.87 to 0.94. Intertester ICCs for ankle inversion and eversion peak torque values demonstrated a value of 0.95. So, it can be concluded that isokinetic tests of ankle inversion and eversion strength in neutral foot position for healthy adults are highly reliable with the Biodex dynamometer. Kinesio tape gold was used in this study; 2 inches (5 cm) width by (5 m) roll was used for ankle taping. Creamer non elastic white athletic tape was also used in this study; 2 inches (5 cm) width by (5 m) roll was used for ankle taping.

Procedures

I. Preparatory phase

The subjects' personal data was collected including name, age, address and telephone number then the height and weight of each subject were recorded from the height and weight scale.

Each subject was informed about the experimental process as well as the significance of the study then he was allowed to ask any question about any part of the study. All questions were answered thus; the idea and the testing procedures of the study became clear for all subjects.

II- Experimental phase

1. Taping techniques

Subjects were taped as in accordance to Kenzo Kase's Kinesio taping Manual (Kase *et al.,* 2003). For taping, each subject's leg was placed in a relaxed position while he sits on a taping table. The skin should be free of oils and lotions, to avoid any thing that may limits the acrylic adhesive's ability to adhere to the skin. So, the subject's skin was cleaned with alcohol prior to tape application. To facilitate muscle function the kinesio "I" strip was applied from the origin to the insertion of the examined muscles (tibialis anterior, tibialis posterior, peroneus longus and peroneus brevis), while the muscle to be taped was put in a stretched position.

- **Positioning of kinesio tape on Tibialis anterior muscle**

Tibialis anterior; I tape was measured from the muscle origin to the insertion while the muscle is stretched. The base of the tape was applied to the origin at the lateral condyle and superior 2/3 of anterolateral surface of tibia. Then the subject was asked to stretch the foot into planter flexion and eversion; taping was then finished toward the insertion at the medial and planter surface of medial cuneiform; base of the first metatarsal (Fig. 1).

Figure 1. Positioning of kinesio tape on Tibialis anterior muscle

- **Positioning of kinesio tape on Tibialis posterior muscle**

The same steps were followed to tape tibialis posterior from its origin at lateral portion of posterior, proximal tibia to its insertion at 2-4 metatarsals. The base of the tape was adhered to the origin then the foot was moved to dorsiflexion and eversion and the tape was let to run behind the medial malleolus to the inner side of the foot and then to the insertion (Fig. 2).

Figure 2. Positioning of kinesio tape on Tibialis posterior muscle

- **Positioning of kinesio tape on Peroneus longus and brevis muscle**

Similarly, Peroneus longus and brevis were taped from the origin to the insertion. The base of the tape was applied at the beginning of the muscles at the head and proximal 1/2 to 2/3 of lateral side of fibula. Then the foot was moved to inversion. The tape was then passed behind the lateral malleolus and crossed the planter surface of foot to be attached to the lateral sides of medial (1st) cuniform and 1st metatarsal (Fig. 3).

KT was applied 20 min prior to testing to allow the glue to become fully activated before the subject can become physically active. If activity occurs before this time, the tape may come off. Three colored kinesio tape rolls were used (red for tibialis posterior muscle, blue for peroneus longus and brevis muscles and black for tibialis anterior muscle).The examined muscles were also taped using the white athletic tape in the same manner as in kinesio taping.

Figure 3. Positioning of kinesio tape on Peroneus longus and brevis muscle

2- Isokinetic set up and positioning:

The testing chair was rotated to 90 degrees and the seat back tilt was set to 70 degrees. Then the subject was allowed to sit on the adjustable seat of the Biodex isokinetic dynamometer system. The limb support pad was then installed in chair front receiving tube for the side to be tested. Then the pad was placed under the distal aspect of the thigh for the tested leg and secured with strap. The knee of the tested leg was positioned in 80°-110° flexion so the subject's lower leg was kept parallel to the floor. Then the tested dominant foot was securely fastened into the ankle inversion/ eversion footplate attachment using hook and loop closures. A pair of shoulder straps was then placed around the chest to secure the trunk. The untested lower limb was placed in a rest position and secured by strap. Also, the subject was asked to grip the stabilization handles on either side of the chair for adding support, stabilization, and consistent hand positioning during exercise (Fig. 4).

Figure 4. Testing position and stabilization

3- Isokinetic testing procedures

Each subject accomplished three isokinetic tests at the selected velocities (30˚ /sec and 120˚ /sec) with the different taping modes (no tape, athletic tape and kinesio tape) in a random order. The rational for choosing these speeds was based on previous studies in which comparable velocities were used (Wilkerson *et al.,* 1997; Amaral *et al.,* 2004). In addition, high reliability for this testing protocol was also demonstrated in other studies for both peak and average torque measurements (Kaminski and Dover, 2001; Amaral *et al.,* 2004). Moreover, conducting a strength test with faster angular velocities would have greater risk, yield lower ankle torque values, be more difficult to perform, and give rise to more measurement errors (Willems *et al.,* 2002; Munn *et al.,* 2003). Maximum voluntary efforts were recorded through the selected ROM and angular velocities in the eccentric/concentric mode for invertors and evertors. The chosen type of contraction and test repetition were selected from the control panel. Stretch-shortening protocol was chosen because this method of testing was reported to be a more functional isokinetic test than testing eccentric and concentric actions in isolation. At this context, Porter *et al.* (2002) suggested that measuring the stretch-shorting cycle SSC with an isokinetic dynamometer in isolated muscle groups could provide a better indication of how each muscle group performs during functional activities. Functional activities such as walking, running, and jumping are examples of the SSC, in which a continuous series of eccentric and concentric muscle actions occur. Subjects were asked to perform a 5-min stationary bicycle warm-up followed by a series of lower extremity flexibility exercises for joint movements of inversion/eversion and dorsiflexion/ plantarflexion before the test begun. A 1-min rest was given between the warming up and the actual test sequence. Another 1-min rest was given between velocity changes. Before the actual isokinetic testing procedures, each subject performed one practice series of three sub-maximal repetitions of ankle inversion and ankle eversion to allow the subjects to accommodate to the specificity of the Biodex's speed of movement and ROM. Therefore the subjects became familiar with the testing condition and that minimized any practice effect during the actual test. Firstly, the subject was tested at 30º/sec angular velocity. Each subject performed five repetitions of ankle inversion in the eccentric/concentric mode at the selected ROM (45°). Verbal encouragement was given respectively during the test procedures to maximize the voluntary effort from the subjects. This was followed by a rest period of 1min. Secondly, after 1min of rest, each subject performed five maximal ankle inversion efforts at 120º/sec angular velocity following the same procedures of 30º/sec angular velocity test. This was followed by a rest period of two minutes to start the test for ankle evertors. After two minutes of rest, each subject was asked to perform one practice series of five maximal repetitions of ankle eversion in the eccentric/concentric mode at the same ROM. The test was performed firstly at 30º/sec angular velocity and secondly at 120º/sec angular velocity with a rest period of 1min between the velocities. The procedure above was repeated in three separated days for the three different taping modes; No tape, Athletic tape and Kinesio tape. All tests were performed on the dominant ankle while the subjects were barefoot and no information on what kinesio taping would do as an effect was given to the subjects. To avoid any bias resulting from muscle fatigue induced by the previous isokinetic assessments, the inter-assessment intervals were 7 days.

Data analysis

Peak torque data was then collected from the Biodex computer's data chart. Then it was used in the conversion to eversion/inversion (EV/INV) strength ratios under the three testing conditions. The ratios were derived by dividing the concentric eversion value by the eccentric inversion value for the (EV_{CON}/INV_{ECC}) and the eccentric eversion value by the concentric inversion value for the (EV_{ECC}/INV_{CON}) for the peak torque. In this study, the independent variable was the type of taping mode. And two dependent variables were tested. They were the peak torque and the strength ratio. All statistical measures were performed through the Statistical Package for Social Science (SPSS) version 17 for windows. It was intended to compare between the three types of the taping modes for the peak torque (concentric evertors' PT, eccentric evertors' PT, concentric invertors' PT and eccentric invertors' PT) at both of the tested velocities (30˚ /sec and120˚ /sec). Also, it was intended to compare between the three taping modes for the strength ratios of ankle evertors and invertors (EV_{ECC}/INV_{CON} and EV_{CON}/INV_{ECC}) at the examined velocities. Descriptive statistics which consisted of means and standard deviations for the demographic participants' data were conducted. A repeated measure MANOVA was conducted on the tested variables for two times. Initially, it was used to compare the peak torque of ankle evertors and invertors among the three taping modes. Secondly, it was used to compare the ankle strength ratios among the examined taping modes. As the statistical analysis test (Repeated measures MANOVA) was performed on the examined sample two times (one for each dependent variable), the alpha level was adjusted to 0.025 (0.05/2) for each of the conducted statistical tests. Adjustment was performed to avoid alpha inflation and committing type I error.

RESULTS

Peak torque

Considering the concentric and eccentric evertors' PT at 30º/sec and 120º/sec and the eccentric invertor PT at 120º/sec, descriptive statistics showed that the highest mean value (Nm) was recorded when using KT and the lowest one was obtained at the No tape (Fig. 5). Also, repeated measures MANOVA revealed significant difference for the tested variables of interest among the three taping modes ($p<0.025$). In addition, Multiple pairwise comparison tests (Post-hoc tests) showed a significant increase in the tested variables at KT compared with No tape and AT ($p<0.025$). However, the difference between the No tape and AT was not significant ($p>0.025$). On the other hand, for the mean values of the concentric and eccentric invertors' PT at 30º/sec and the concentric invertors' PT at 120º/sec, descriptive statistics showed that they increased when using KT (Fig. 6). Through statistical analysis using repeated measures MANOVA, it was noticed that there was no significant difference for the tested variables of interest among the three taping modes ($p>0.025$).

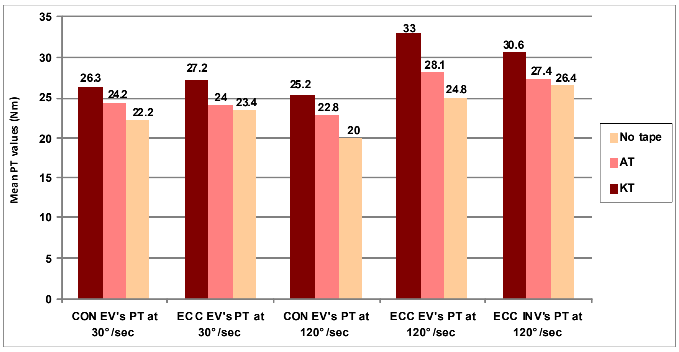

Figure 5. Mean values of the concentric and eccentric evertors' PTat 30º/sec and 120º/sec and the eccentric invertor PT at120º/sec using the three taping modes

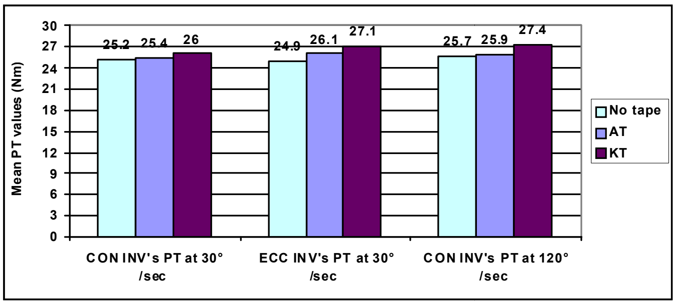

Figure 6. Mean values of the concentric and eccentric invertors' PT at 30º/sec and the concentric invertors' PT at120º/sec using the three taping modes

Strength ratio

Also, descriptive statistics indicated that the highest mean values of the measured strength ratios (EV_{CON}/INV_{ECC} at 30˚ /sec, EV_{CON}/INV_{ECC} at 120˚ /sec, EV_{ECC}/INV_{CON} at 30˚ /sec and EV_{ECC}/INV_{CON} at 120˚ /sec) were obtained when using KT, while the lowest values were recorded for the No tape (Fig. 7 and Fig. 8). Repeated measures MANOVA revealed insignificant difference in the EV_{CON}/INV_{ECC} at 30˚ /sec and 120˚ /sec among the three taping modes ($p>0.025$). However, there was a significant difference in the EV_{ECC}/INV_{CON} strength ratios at 30˚ /sec and 120˚ /sec among the three taping modes ($p<0.025$). Moreover, Multiple pairwise comparison tests showed that there was a significant increase in the EV_{ECC}/INV_{CON} at KT compared with No tape and AT ($p<0.025$). However, the difference between the No tape and the AT was not significant ($P>0.025$).

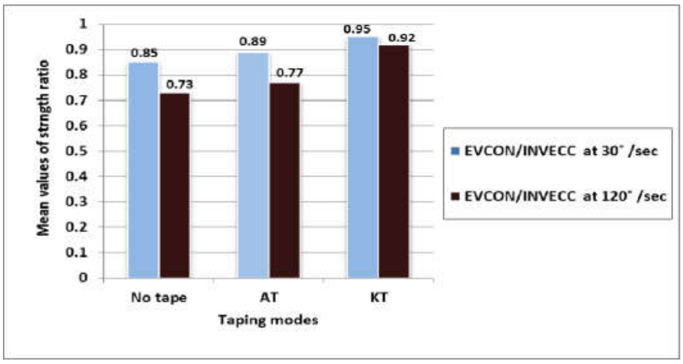

Figure 7. Mean values of EV_{CON}/INV_{ECC} strength ratio at 30˚/secand120˚/sec at the three taping modes

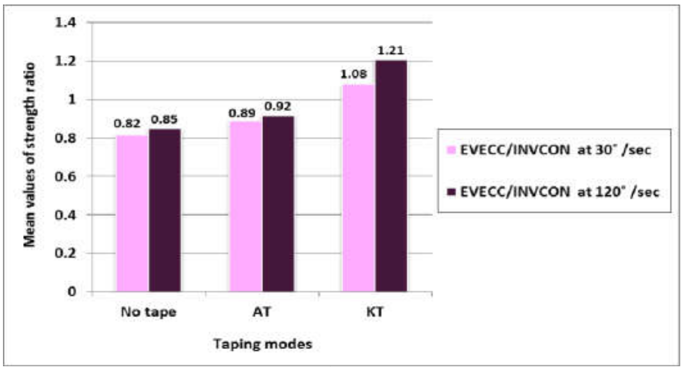

Figure 8. Mean values of EV_{ECC}/INV_{CON} strength ratio at 30˚/secand120˚/sec at the three taping mode

DISCUSSION

KT and peak torque

The results of the current study revealed a significant difference in the eccentric and concentric evertor peak torque (PT) among the three taping modes at 30˚ /sec and 120˚ /sec. Also, statistical analysis showed a significant increase in the concentric and eccentric evertors' PT using KT compared with the other taping modes. In contrast, the difference between the No tape and AT was not significant. On the other hand, the results reflected non significant statistical difference in the eccentric and concentric invertor PT at 30˚ /sec and the concentric invertor PT at 120˚ /sec between the three taping modes. However, the eccentric invertor PT at 120˚ /sec showed significant difference among the examined taping modes. Also, the mean values of the PT of both concentric and eccentric invertor were higher at the KT compared with the other taping modes. The findings of this study indicated an increase in evertors and invertors strength following kinesio taping. The effect of KT on muscle strength has been a content of research with controversial results. The results of this study were similar to the reports by a number of other researchers. For example, Vithoulk *et al.* (2010) studied the effect of KT on quadriceps strength on twenty healthy non-athletes women. Peak torque of dominant knee extensors was measured using

an isokinetic dynamometer. The test protocol include (CON/ CON) mode at 60°/s and 240°/s. and (CON/ECC) mode at 60°/ s. Three different quadriceps taping modes were used (no taping, placebo taping and kinesio taping). Statistical analysis revealed significant difference in the quadriceps ECC torque during both of the CON and ECC modes. Similarly, Murray (2000) has shown a significant improvement in both the active range of motion of knee and the EMG measurements of the quadriceps with KT application, applied for patients after ACL repair. However, no difference was noted in either the range of motion or the EMG activities between the no tape and the athletic tape conditions. In addition, subjects commented that they felt a stronger muscle contraction when KT was applied.
Also, Hsu *et al.* (2009) established that both of the activity and the strength of the lower trapezius muscle were significantly increased with KT application in patients with shoulder impingement syndrome. Three-dimensional scapular motion was assisted by using the Liberty electromagnetic tracking system. Telemetric EMG system was used to record the activity of the upper and lower trapezius muscles as well as serratus anterior. A hand-held dynamometer was used to test the muscle strength of the lower trapizues. All subjects received two taping sessions, one for the KT and the other for placebo-taping with three days of separation between them.
These findings were confirmed by Schneider *et al.* (2010) who examined the effect of kinesio tape on the strength of the forearm extensors in fourteen healthy tennis athletes. The authors asked subjects to hit the tennis ball until fatigue. They used Micro FET2 to assess the strength of forearm extensors at three conditions (pre-test, mid-test and post-test) for both backhands and forehands performed by each player. Their results showed a significant decrease of muscle strength in the control group when compared with the kinesio tape group.

Additionally, Aktas and Baltaci (2011) reported that KT application was more effective in terms of muscular strength and jump performance than knee brace and KT plus knee brace. Their study was conducted to twenty healthy subjects with no previous history of lower extremity injuries. Muscular strength, and jump performance were tested with knee brace, kinesio taping and both applications. They recorded a significant increase in hop distance and in isokinetic knee extension peak torque at 180°/sec with KT application. The same results were shown in Firth's *et al.* (2010) study. They investigated the effect of kinesiotape on calf muscle and hop distance in healthy people and people with Achilles tendinopathy (AT). Twenty six healthy people and 29 people with AT participated in the study. Kinesio tape was applied over the Achilles tendon. The single-leg hop test was done with and without the tape. Results revealed that calf muscles were facilitated with Kinesio tape applied to the Achilles tendon which affect the hop distance. Moreover, Yu Huang *et al.* (2011) recorded an increase in EMG activity of medial gastrocnemius and vertical ground reaction force in Kinesio tape group when compared with athletic tape group. Furthermore, Liu *et al.* (2007) showed an improvement in epicondylar muscles sliding during wrist movements in two patients with epicondylalgia after application of the Kinesio Taping technique. In their study, they used a diagnostic ultrasound image of the epicondylar muscles. On the other hand, the results above are contradictory with the findings of Fu *et al.* (2008). They examined the possible immediate and delayed effects of Kinesio taping on muscle strength in quadriceps and hamstring when taping is applied to the anterior thigh of healthy young athletes. Muscle strength of the subject was assessed by the isokinetic dynamometer under three conditions: (1) without taping; (2) immediately after taping; (3) 12 h after taping. The result revealed no significant difference in muscle power among the three conditions. They concluded that, Kinesio taping on the anterior thigh neither decreased nor increased muscle strength in healthy non-injured young athletes. This contradiction might be due to the different way of application of KT as they applied KT while the muscle to be taped was not in a stretched position. Because during KT application the subjects lay in the supine position with the hip flexed at 30◦, in contrast the hip should be kept at extended position to put rectus femoris in stretched position which could have affected the action of KT on the muscle function. Also, they applied KT only to rectus femoris and ignored vastus medialis and vastus lateralis. Additionally, the small number of participants (14 subjects) may result in insufficient power for statistical analysis of some outcome variables.

KT and strength ratio

The second purpose of this study was to examine the possible effect of different taping modes on the strength ratios of ankle evertors and invertors (EV_{ECC}/INV_{CON} and EV_{CON}/INV_{ECC}). The results obtained revealed a significant difference in EV_{ECC}/INV_{CON} strength ratio at 30° /sec and 120° /sec between the three taping modes. Moreover, statistical analysis showed that KT produced a significant increase in the EV_{ECC}/INV_{CON} strength ratio when compared with the other taping modes at both of the tested velocities. Controversy, the results of this study reflected non significant statistical difference in EV_{CON}/INV_{ECC} strength ratio between the three taping modes at 30°/sec and 120°/sec. However, the mean values of EV_{CON}/INV_{ECC} strength ratio were higher at the KT compared with the other taping modes at the tested velocities. Neither of the previous researchers studied the effect of KT on strength ratio. Only Chen *et al.* (2007) investigated the effect of Kinesio taping on the timing and ratio of VMO and vastus lateralis (VL) for subjects with patellofemoral pain syndrome (PFPS). Fifteen patients participated in the study. Ten normal subjects were recruited as a control group. Subjects were taped according to Kinesio taping manual (Kase *et al.,* 2003), and a white athletic tape was used in the same manner as a placebo condition. EMG activity of VMO and VL were recorded. Subjects completed a stair stepping task during ascend and descend for five consecutive trials. The timing and EMG activity ratio of VMO and VL were calculated for no tape, placebo tape, and kinesio tape conditions for PFPS and control groups. The results showed that the onset of VMO activity occurred earlier in Kinesio tape condition compared with no tape condition, but there was no difference between placebo tape and no tape condition. The earlier activation of the VMO should allow for a more optimal positioning of the patella into the trochlea, which may improve the timing of force distribution and decrease the pressure placed on a particular portion of the articular cartilage. Therefore it can be concluded that Kinesio tape would change the timing of VMO and improve the VMO/VL ratio.

When the ECC/CON ratio increases, this meant either the eccentric force has increased compared with the concentric force or the concentric torque has decreased compared with the eccentric torque. The significant increase in the EV_{ECC}/INV_{CON} ratio when using KT compared with No tape and AT may be attributed to that KT produced a significant increase in the eccentric evertors PT when compared with the other taping modes. Although there was no significant difference in the EV_{CON}/INV_{ECC} strength ratio between the three taping modes, the mean values of EV_{CON}/INV_{ECC} strength ratios were higher at the KT compared with the other taping modes. That may be due to the highest value of the concentric evertor PT which was recorded with KT. Inspite of the significant difference in both of the eccentric and concentric evertor PT between the three taping modes, the difference in the EV_{ECC}/INV_{CON} strength ratios was significant while the difference in the EV_{CON}/INV_{ECC} strength ratios was not significant. The significant difference in the EV_{ECC}/INV_{CON} strength ratio may be due to; firstly, the more pronounced effect of KT on eccentric PT than concentric PT. Secondly, the more obvious effect of KT on the strength of evertors more than invertors; because the mean value of the eccentric evertor PT was increased from 23.4 for No tape to 27.2 for KT at 30˚ /sec and from 24.8 for No tape to 33 for KT at120˚ /sec. While the mean value of the concentric invertor was increased from 25.2 at No tape to 26 at KT for 30˚ /sec and from 25.7 at No tape to 27.4 at KT for120˚ /sec.

These findings lead to a significantly greater eccentric evertor torques without concomitant concentric invertor torque gains. On the other hand, the insignificant difference in the EV_{CON}/INV_{ECC} strength ratio may be due to a less significant increase in concentric evertor torque with concomitant eccentric invertor torque gain. Because, the mean value of the concentric evertor PT was increased from 22.2 for No tape to 26.3 for KT at 30˚ /sec and from 20 for No tape to 25.3 for KT at 120˚ /sec. While the mean value of the eccentric invertor was increased from 24.9 at No tape to 27.1 at KT for 30˚ /sec and from 26.4 at No tape to 30.6 at KT for120˚ /sec.

Effect of kinesio tape versus athletic tape on peak torque and strength ratio

The results of the current study showed insignificant difference between the No tape and AT in the peak torque as well as the strength ratios recorded at the tested velocities. That may be due to that the AT has no significant differences with regard to its benefit on muscle activities. In the same context, Christou (2004) stated that, the only benefits have been associated with the non-elastic tape is the support and reduction of pain. Also, Murray (2000) compared the effect of kinesio tape versus athletic tape on muscle strength of the quadriceps femoris, in individuals with recurrent ACL reconstruction. No difference was noted in either the range of motion or the EMG activities between the no tape and the athletic tape conditions. However, under the KT condition, there was a significant improvement in both of the active range of motion and the EMG measurements compared to the other two conditions. Similarly, Yu Huang *et al.* (2011) found that VGRF was increased after Kinesio taping, while all muscle activities were not changed during jumping after the athletic taping. They suggested that the pattern of muscle activity after taping may be due to different specialized waves and viscosity of KT.

Additionally, Cool *et al.* (2002) proved that, taping for the shoulder impingement syndrome (a rigid tape across the muscle belly of the upper trapezius and along the lower trapezius) seemed to reduce pain and improve range of motion of the shoulder. However, it produced no significant alteration on the electromyographic activities of the two muscles. Moreover, Ackermann *et al.* (2002) used a rigid tape for the professional violinists and found negative effects on the upper trapezius activity and violin performance. They explained that the rigid tape and correctional tape techniques might have caused movement restriction and skin irritation and thus were disadvantageous for fine movement control of the upper extremity.

Clinical relevance

Subjects with functional instability (FI) demonstrated a significant increased inversion, decreased pre- initial contact (IC) peroneus longus EMG activity. It could help to explain why subjects with FI may suffer from inversion injury to their ankle joint when subjected to an unanticipated ground contact (Delahunt *et al.,* 2006). Baumhauer *et al.* (1995) prospectively investigated risk factors associated with susceptibility to lateral ankle sprain. Generalized joint laxity, anatomical measurements of the foot and ankle, anatomical alignment, and ankle-ligament stability were not found to be significant risk factors leading to ankle injury. However, evertor-to-invertor and plantar flexor-to-dorsiflexor strength ratios were affected in the experimental group, indicating that altered antagonist strength relationships may be responsible for the long-term disability. Furthermore, Aagaard *et al.* (1998) reported that the eccentric/ concentric ratio describes functional capacity more accurately than the agonist concentric/ antagonist concentric or agonist eccentric/ antagonist eccentric muscle strength ratios. This is because normal gait and athletic activities involve interaction between eccentric and concentric agonist and antagonist activity.

There are numerous factors and mechanisms that are thought to prevent increased ankle sprain occurrence. The eccentric evertor/ concentric invertor strength ratio (EV_{ECC}/INV_{CON}) is one of these factors associated with the prevention of inversion trauma. An increase of this ratio is expected for preventing ankle inversion sprain (Yildiz *et al.,* 2003). The results of the current study revealed that, KT produced a highly significant increase in the EV_{ECC}/INV_{CON} strength ratio at 120˚ /sec (P=0.00). Based on these results, KT application is effective in terms of muscular strength and ankle strength ratio. So it can be determined as a mechanism which prevents lateral ankle sprain injury especially for subjects with functional instability. Additionally, physical therapists and athletic trainers may apply KT to a patient during or after treatment and rehabilitation to support ankle musculature. Finally, the results of this study would be beneficial for healthy athletes not only for injury prevention but also for enhancing their performance.

Conclusion

To our knowledge this is the first study to investigate the effects of kinesio taping on the muscle strength and strength ratios of the ankle joint. This research indicates that Kinesio taping of ankle evertors and invertors in healthy volunteers is associated with an immediate improvement in both concentric and eccentric peak torque of ankle evertors and invertors at 30º/sec and 120º/sec. Similarly, the results of the study showed significant increase in the EV_{ECC}/INV_{CON} strength ratio at 30º/sec and 120º/sec using KT. On the contrary, the difference in EV_{CON}/INV_{ECC} strength ratio at 30º/sec and 120º/sec was not significant between the three examined taping modes. It was noted that, KT produced the highest impact at angular velocity 120º/sec on both of the eccentric evertor PT and EV_{ECC}/INV_{CON}. These results suggested that kinesio taping could be a useful therapeutic and prophylactic assistance in the rehabilitation process.

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