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Lower-leg Kinesio tape reduces rate of loading in participants with medial tibial stress syndrome

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A B S T R A C T

Context: Medial tibial stress syndrome (MTSS) is an overuse injury occurring among the physically active. Linked to increased strain on the medial tendons of the ankle, studies emphasize controlling medial foot loading in the management of this condition. Kinesio taping (KT) has gained popularity for treating musculoskeletal pathologies; however, its effect on MTSS remains uninvestigated. This study aimed to determine if healthy participants and patients with current or previous history of MTSS differ in the rate of loading, and if KT affects plantar pressures in these participants.

Methods: Twenty healthy participants and 20 participants with current or previous history of MTSS were recruited and walked across a plantar pressure mat prior to KT application, immediately after application, and after 24 h of continued use. Time-to-peak force was measured in 6 foot areas and compared across groups and conditions.

Results: ANOVA revealed a significant interaction between group, condition, and foot area (F = 1.990, p = 0.033). MTSS participants presented with lower medial midfoot time-to-peak force before tape application (95%CI: 0.014–0.160%, p = 0.021) that significantly increased following tape application (p < 0.05).

Conclusions: These results suggest that KT decreases the rate of medial loading in MTSS patients. Future research might assess mechanisms by which this effect is achieved.

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1. Introduction

Medial tibial stress syndrome (MTSS) contributes to 13–17% of all running injuries (Plisky, Raah, Heiderscheit, Underwood, & Tank, 2007; Yates & White, 2004) and up to 35% of all cases of exercise-related leg pain (Moen, Tol, Weir, Steunebrink, & De Winter, 2009). Incidence rates for MTSS have been reported between 4 and 35 percent for military recruits and runners (Andrish, Bergfeld, & Walheim, 1974; Bennett, Reinking, Pleumer, Pentel, Seaton, & Killian, 2001; Yagi, Muneta, & Sekiya, 2013; Yates & White, 2004). This condition is characterized by pain along the posteromedial aspect of the distal two-thirds of the tibia that occurs prior to, during, or after activity (Moen et al., 2009). Patients with MTSS have an increased risk of developing a stress fracture in the area, and recent sports medicine research has emphasized the importance of prevention among physically active populations (Moen et al., 2009; Winters, Eske, Weir, Moen, Backx, & Bakker, 2013).

Various risk factors for MTSS have been identified including type, duration or frequency of activity; improper footwear; and running surface (Willems, Witvrouw, De Cock, & De Clercq, 2007; Yates & White, 2004). While these extrinsic factors may be altered to reduce the risk of MTSS, a number of intrinsic risk factors are also present that may be more difficult to modify. These include an increased navicular drop (where the medial longitudinal arch of the foot between is observed to flatten during weight-bearing), increased pronation during the loading response of the gait cycle (Bandholm, Boysen, Haugaard, Zebis, & Bencke, 2008; Bennett et al., 2001; Delacera, 1980; Moen et al., 2009; Sommer & Valentyne, 1995; Yates & White, 2004), biomechanical alterations in running gait (Tweed, Campbell, & Avil, 2008), higher body mass index (Plisky et al., 2007), lean calf girth (Burne et al., 2004), and increased plantar flexion range-of-motion (Hubbard, Carpenter, & Cordova, 2009). Among these, the greatest amount of evidence

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exists supporting the presence of an increased navicular drop and increased foot pronation during gait as observed in large prospective studies in military recruits (Moen et al., 2009; Yates & White, 2004), recreational athletes and runners (Busseuil, Freychat, Guedj, & Lacour, 1998; Tweed et al., 2008; Willems et al., 2007), dancers (Sommer & Valente, 1995), collegiate athletes (Hubbard et al., 2009; Reinking, 2006), and high school athletes (Bennett et al., 2001); where participants with increased pronation were approximately twice as likely to develop medial tibia stress syndrome. This increase in pronation has been hypothesized to increase the eccentric load on the deep plantar flexors and inverters leading to increased strain applied to the medial aspect of the tibia (Beck, 1998).

Altered kinematics potentially related to excessive pronation during gait may be quantified using a plantar pressure mat (Hafer, Lenhoff, Song, Jordan, Hannan, & Hillstrom, 2013; Lord, Reynolds, & Hughes, 1986; Morrison et al., 2010). While typical force plates measure only forces and moments about the center of pressure, mats and insoles with small force transducers are able to provide increasing information regarding the distribution of forces and pressures in varying areas of the foot. Previous studies have demonstrated significant increases in medial plantar forces pressures in participants with exercise-induced leg pain, although its relative contribution to MTSS specifically has not been assessed (Sharma, Golby, Greeves, & Spears, 2011; Willems, De Clercq, Delbaere, Vanderstraeten, De Cock, & Witvrouw, 2006). Sharma et al. (2011) reported 70% of military recruits who developed MTSS had higher rearfoot plantar pressures and forces, while only 14% of healthy controls had similar plantar pressure measurements. Although not explicitly measured, it has also been hypothesized that increases in peak medial plantar pressures may be tied to an increase in the rate of loading and altered biomechanical patterns (Menz & Morris, 2006).

In order to relieve symptoms related to MTSS, the use of various modalities have been used to treat symptoms, while multiple rehabilitation strategies have been implemented to reduce the intrinsic risk factors leading to this condition. Several modalities, such as the use of non-steroidal anti-inflammatory and ice (Andrish et al., 1974), massage (Johnston et al., 2006), and therapeutic laser and ultrasound (Nissen, Astrvad, & Madsen, 1994) have been used with limited effectiveness. Reports have suggested prevention and treatment of MTSS should be achieved by altering mechanics using techniques such as taping, orthotics use, and strengthening (Moen et al., 2009; Rome, Handoll, & Ashford, 2005). These interventions and treatments may be effective if used in conjunction with each other; however, there were no significant findings to support their individual usage. The only treatment that has consistently proven to be effective is cessation from activity (Moen et al., 2009).

Recently, Kinesio taping (KT) has garnered interest among sports medicine clinicians for treating a variety of musculoskeletal pathologies. Developed in the 1970s, KT involves application of an elastic therapeutic tape intended primarily for the treatment of sport-related injuries (Kase, Wallis, & Kase, 2003). The tape is designed to mimic the properties of skin in its thickness and elasticity; while differing from traditional athletic tape in several ways, including tensile strength and flexibility, as well as the binding agents; which together allow the tape to be worn for several days at a time (Kase et al., 2003). Although some studies have investigated the effects of KT on pain, range-of-motion, strength, and proprioception, very few of these studies have investigated its use among injured populations. A recent meta-analysis of ten studies observed that KT may have a beneficial effect on strength, force sense error, and active range of motion; however, no significant findings were found to support improvements in pain or joint position sense of the lower extremity (Williams, Whatman, Huma, & Sheerin, 2012). Studies that have investigated the effects of KT on injury have found varying results for pain in the foot (Tsai, Chang, & Lee, 2010), knee (Ayta, Ozunu, Surenok, Baltaci, Oztop, & Karatas, 2011; Campolo, Babu, Dmochowska, Scariali, & Varughese, 2013; Osorio et al., 2013) and in the shoulder (Kaya, Zinnurogu, & Tugcu, 2011; Thelen, Dauber, & Stoneman, 2008), and no effect on balance among previously sprained ankles (Shields, Needle, Rose, Swani, & Kaminski, 2013). A recent investigation reported an increase in joint stiffness in the foot and ankle with KT application, although it remains unclear how this would affect patients with joint injury (Fayson, Needle, & Kaminski, 2013).

As the use of KT becomes more widespread among sports medicine and orthopedic clinicians, further investigation is warranted how the tape affects joint mechanics and musculoskeletal pathologies (Williams et al., 2012). The purpose of this research is to examine the differences in rate of loading between healthy participants and those with MTSS and the effects of KT on the rate of loading across all participants with a history of MTSS. We hypothesize that differences in the rate of plantar loading will exist at baseline between healthy and MTSS patients; and that application of KT may reduce this rate of loading.

2. Methods

2.1. Study design

A repeated measures case-control study design with a non-injured comparison group was used to measure changes in time-to-peak force in participants before and after Kinesio tape application. Independent variables included group (MTSS vs. Healthy), tape application, and area of the foot (medial and lateral rearfoot, midfoot, and forefoot). Dependent variables included time-to-peak force.

2.2. Participants

Forty participants were recruited from a university community through posted and classroom announcements over several months. The sample included 20 healthy participants (10 M, 10 F, 173.2 ± 11.7 cm, 76.9 ± 14.4 kg, 20.2 ± 1.5 yrs.) and 20 participants with a previous or current history of MTSS (10 M, 10 F, 172.7 ± 10.4 cm, 74.3 ± 13.4 kg, 20.7 ± 2.0 yrs.). Institution-reviewed informed consent (UDIRB 247899-2) in line with current ethical practices in sports and exercise research was obtained from all participants.

Participants were separated into the two groups using a lower-leg injury questionnaire adapted from Hubbard et al.,(2009), which determined inclusion criteria for the participants in the MTSS group. Participants with no previous history of MTSS and no lower limb injuries within the past 6 months were classified as healthy; while participants who had a current or previous history of MTSS that was diagnosed by a healthcare professional (physician, physical therapist, or athletic trainer) with no other lower limb injuries within the past 6 months were placed in the MTSS group. Participants with both current and previous history of MTSS were included as symptoms may often be transient while biomechanical risk factors may still be present (Rome et al., 2005). Of the 20 participants in the injured group, 8 reported a current diagnosis of MTSS, while 17 reported leg pain during running at the time of testing.

2.3. Procedures

Plantar pressures were measured using a 442 mm × 488 mm Tekscan® pressure mat system (Boston, MA). Prior to testing, the mat was calibrated for each individual’s mass using F-Scan® System.
Research software (Tekscan, Boston, MA). In healthy participants, the test leg was determined randomly through a coin toss. In the participants with MTSS, the test leg was determined by which leg was affected by MTSS or, in the presence of bilateral injury, which leg presented worse symptoms.

Once calibration was completed the individual was asked to walk across the plantar pressure mat under three different conditions: prior to tape application (PRE), immediately following tape application (KT-I), and after 24-hours of continued use (KT-24). Between KT-I and KT-24 trials, participants were allowed to continue normal activities of daily living, including showering, with the tape in place. Walking trials consisted of participants stepping across the mat using a 2-step gait initiation method, ensuring participants started at the same position and landed with the test leg on the mat (Zammit, Menz, & Munteanu, 2010). The 2-step gait initiation method involves landing on the pressure mat on the second step after a constant velocity has been reached and then continuing to walk through the mat for 2 steps. This technique has been shown to have good reliability and repeatability for measuring plantar pressures and forces that are present during normal gait (Zammit et al., 2010). A total of 5 trials were collected, with 2 practice trials provided for each condition, and a rest period of 5-10 s was provided between each trial. Trials were rejected if the participant came to a stop or changed their stride length in order to make contact with the mat.

The taping technique used for this study was a modification of the MTSS technique as outlined by Kase et al. (2003). All taping was applied by the same certified athletic trainer trained in this specific tape application. Prior to KT application, hair was removed from the medial tibia and the area was cleaned with an alcohol swab. Tape adherent was applied to the area to improve tape adhesiveness. A single Y-strip of KT (Kinesio USA, Charlotte, NC) was applied beginning with the tail placed on the proximal third of the medial tibia. Each half of the Y-strip was then applied so that they lay anterior and posterior to the medial malleolus and terminated under the medial longitudinal arch of the foot (Fig. 1). No tension was applied on the proximal and distal ends of the tape, while the remainder of the tape was applied with 75% tension (Kase et al., 2003).

2.4. Data reduction and analysis

Continuous data were collected during each trial using the F-Scan® System Research software. Using an image of the averaged stance phase of gait, the files were manually partitioned into six foot areas (Fig 2): lateral forefoot, medial forefoot, lateral midfoot, medial midfoot, lateral rearfoot, and medial rearfoot. The division of lateral and medial components of the foot was determined by using a straight line to bisect the space between the second and third metatarsals through the foot to the midpoint of the calcaneus. The forefoot and midfoot were separated by the center of the metatarsal heads. The midfoot and rearfoot were then separated by the distal aspect of the calcaneus (Hafer et al., 2013; Lee & Hertel, 2012; Schmidt, Sauer, Lee, Saliba, & Hertel, 2011; Webster, 2010).

Forces in each foot area over time were exported and further analyzed in Custom LabVIEW software (National Instruments, Austin, TX). Time-to-peak force (TTPF; % stance duration) was extracted in each area of the foot by determining the sample at which forces in each area were highest, and was normalized by dividing the sample by the total number of samples the foot was in contact with the mat (Schmidt et al., 2011).

Data were analyzed using SPSS 17.0 (IBM, Chicago, IL). A 3-way analysis of variance (ANOVA) with one between-participants factor (Group, 2 levels), and two within-participants factors (Tape Condition, 3 levels; Foot Area, 6 levels) was used to detect

Fig. 1. Kinesio® tape application used in this study. A single Y-strip was applied with the base at the superomedial tibia, and tails traveling anterior and posterior to the medial malleolus to the arch of the foot.

Fig. 2. Image of averaged plantar pressures across a single trial used to partition the foot into the medial forefoot (MFF), medial midfoot (MMF), medial rearfoot (MRF), lateral forefoot (LFF), lateral midfoot (LMF), and lateral rearfoot (LRF).
significant differences for TTPF. Homogeneity of data was confirmed using Mauchley's test of sphericity. In the case of significant interaction, pairwise comparisons were used to detect where differences occurred across groups and conditions. Ninety-five percent confidence intervals (95% CI) were calculated for the difference between groups and conditions. An a priori level of significance (α) was set at 0.05.

3. Results

Group means for each condition and foot area are presented in Table 1. A significant 3-way interaction effect was observed for condition, foot area and group (F = 1.990, p = 0.033). Pairwise comparisons revealed significantly higher TTPF in the healthy group at the medial midfoot at baseline (PRE) (95% CI: 0.014–0.160%, p = 0.021, ES = 0.76). This difference was not present at KT-I (95% CI: −0.016 to 0.092%, p = 0.542) and KT-24 (95% CI: −0.025 to 0.112%, p = 0.177) measurements, as TTPF significantly increased from PRE among the MTSS group at both KT-I (95% CI: 0.010–0.102%, p = 0.022, ES = 0.46) and KT-24 (95% CI: −0.027 to 0.057%, p = 0.043, ES = 0.35). Furthermore, within the MTSS group, TTPF significantly increased from PRE to KT-I under the lateral forefoot (95% CI: −0.017 to 0.069%, p = 0.031, ES = 0.38), but differences did not remain at KT-24 (95% CI: −0.027 to 0.057%, p = 0.29). The tape was not observed to have any effect on healthy participants.

4. Discussion

The purpose of this study was to investigate the differences in the rate of plantar loading between people with and without medial tibial stress syndrome and the effect of lower-leg KT on the rate of loading in participants with MTSS. Our results support a higher rate of loading in the medial midfoot among MTSS participants at baseline when compared to healthy participants. This increased rate of loading appeared to be corrected following application of the tape. This data supports the hypothesis that Kinesio tape may be used to correct biomechanical factors that may be associated with musculoskeletal pathology.

A higher TTPF (slower rate of medial loading) was observed in healthy participants at baseline as compared to MTSS participants, supporting the presence of biomechanical differences among patients with a history of MTSS. As a lower TTPF indicates a faster rate of loading, our data may suggest that the foot has a faster rate of medial plantar loading in MTSS patients. Furthermore, as this change was noted under the medial midfoot, this may be associated with a faster rate of foot pronation in the stance phase of gait. Previous research has established foot pronation as a risk factor for the development of MTSS. However, these previous studies have investigated the amount of pronation rather than the rate at which it occurs (Bandholm et al., 2008; Bennett et al., 2001; Moen et al., 2009; Sommer & Valentyne, 1995; Yates & White, 2004). While the amount of pronation would increase the amount of strain and eccentric load on the tendons responsible for ankle supination (tibialis anterior, tibialis posterior, flexor hallucis longus and flexor digitorum longus), the rate of strain to these tendons may also present an important risk factor to the etiology of MTSS (Beck, 1998). Our data supports the need to address rate of loading among these patients, rather than just the amount of pronation. Based on the current study design, it is unclear if this finding represents a risk factor for the development and recurrence of MTSS, or an adaptation from the injury.

Furthermore, our study observed an increase in TTPF following KT application in participants with MTSS. This increase was observed in the LFF and MMF following immediate application, and remained increased in the MMF following 24-hours of use. The effects size of the decrease in rate of loading was considered medium at the KT-I and small-to-medium after 24 hours of use at MMF, while only a small-to-medium effect-size was observed in the LFF. We may therefore hypothesize that KT has a moderate effect on rate of loading after initial application that decreases over time. The effect on the LFF was smaller, and may still represent the delay in medial loading as the foot will typically load medially towards the midfoot before the center-of-pressure shifts laterally to push-off (Lord et al., 1986). This supports the use of KT for addressing one potential risk factor in patients with MTSS (Menz & Morris, 2006; Sharma et al., 2011; Willems et al., 2006). A similar effect was not observed in healthy participants, possibly because these participants were demonstrating normal movement patterns that did not require a change.

Although no previous studies have investigated the use of KT in patients with MTSS, the taping has been studied across a range of other joints and variables. Positive effects on joint range-of-motion (Hsu, Chen, & Lin, 2009), joint stiffness (Fayson et al., 2013), and muscle activity (Slupik, Dwornik, Bialoszewski, & Zych, 2007) have all been reported following application of the tape. These previous results, and the results of the present study, support the hypothesis that KT may impact biomechanics. With regard to the specific taping that we used in this study, we speculate the observed effect to have been achieved either through a proprioceptive effect leading to an increase in muscle activation, or from the tape's mechanical properties. Future studies might incorporate electromyographical recordings of ankle supinators to determine the mechanism through which this effect occurred.

The findings from our study support the integration of KT for the lower-leg in the prevention, management and treatment of medial tibial stress syndrome, by reducing a potential risk factor for this condition. However, the current study contains several limitations. First, our data supports a decrease in the rate of pronation during normal gait. While previous studies have found excessive pronation during gait to be a risk factor for development of MTSS, it is unclear what effect the tape may have during more functional activities such as running and jumping (Moen et al., 2009).
5. Conclusions

Our findings demonstrate that Kinesio tape decreased the rate of medial plantar loading among patients with a history of MTSS. We postulate that this decreased rate of loading may be beneficial for potentially slowing pronation and reducing injurious forces in people suffering from MTSS during activity. The difference between groups in TTPF is consistent with previous studies on MTSS. Participants suffering from MTSS during activity. The difference between groups in TTPF is consistent with previous studies on MTSS. Furthermore, a significant limitation of the present study was not including a sham treatment option. Future studies should incorporate a randomized control trial design to address this, or perhaps integrate an alternate taping technique to determine if changes were specifically from the tape application or just its presence on the skin.

Continued research should be conducted to determine the mechanism by which the effect of this tape is achieved. Future research may also compare the tape to other current taping options for MTSS. Subjective measures may also be useful in comparing sham or traditional treatments with the use of KT to determine if KT is less bothersome or if symptoms were improved with tape use. Finally, while we speculate the use of this tape as a treatment for MTSS, a future randomized controlled study would provide more valuable evidence to determine if KT should be incorporated in treatment of MTSS.

Conflict of Interest

None declared.

Ethical Approval

All subject recruitment and testing procedures were approved by the University of Delaware Human Subjects Review Board (#247899–2).

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