The Impact of Therapeutic Ankle Taping and Foot Posture on the Kinematics of the Knee and Ankle while Running

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Overpronation is a misalignment of the calcaneus, contributing to overuse injuries in runners. Taping may control the position of the calcaneus to correct foot pathologies associated with overpronation. The purpose of this study was to explore the effect of therapeutic ankle taping and foot posture on the kinematics of the knee and ankle during running in participants with neutral and pronated foot types. Forty healthy participants ran on a treadmill with the application of Kinesio Tape®, Leuko Tape®, and no tape. A significant main effect for foot posture indicated that participants with a pronated foot type (p=.03) ran with a decreased amount of plantarflexion at the toe off phase of running when compared to a neutral foot type for all taping conditions. As plantarflexion occurs at toe off to propel the runner to the swing phase, a more rigid taping technique may be beneficial to provide support to the calcaneus.

KEYWORDS: Running injuries, Kinesio Tape®, Leuko Tape®, calcaneal taping, running gait

INTRODUCTION: Foot pronation is a weight bearing, tri-planar movement that is most often associated with overuse running injuries (Hreljac, Marshall, & Hume, 2000). Foot pronation typically involves calcaneal eversion, talar adduction, and ankle plantarflexion that causes lowering of the medial longitudinal arch and abduction of the forefoot (Franettovich, Chapman, Blanch, & Vincenzino, 2008). During the first half of the midstance phase of running, foot pronation is important in absorbing the shock of landing (Cheung & Ng, 2007). Nevertheless, overpronation during the second half of the midstance phase has been found to restrict the necessary movements to propel the individual through the swing phase. Previous research has shown that therapeutic taping may control the position and alignment of the calcaneus placing it in an improved biomechanical position by increasing the medial longitudinal arch height (Agrawal & Deshpande, 2015; Vincenzino, Franettovich, McPoil, Russell, & Skardoon, 2005). Research exploring Kinesio Tape® (KT) when applied to the ankle and foot region has purported that the primary purpose of KT is to inhibit pain, improve circulation and lymphatic drainage, and reduce the delayed onset of muscle soreness (Csapo & Alegre, 2014). Leuko Tape® is a non-elastic sports tape that has also been used widely in injury rehabilitation and prevention settings due to its rigid properties. The concept of applying the tape to the calcaneus is to achieve pain relief and alter range of motion, thereby reducing stress on the plantar fascia (Agrawal & Deshpande, 2015). It is imperative to explore the effect of therapeutic tape while running to determine the most appropriate type of tape to apply during a dynamic activity. Therefore, the purpose of this study was to explore the effect of therapeutic ankle taping and foot posture on the kinematics of the knee and ankle during running in participants with neutral and pronated foot types.

METHODS: After ethical approval was received from the academic institution, 18 healthy males (age=24.3 ± 2.3 years; height=182.7 ± 8.1 cm; mass=85.0 ± 24.6 kg) and 22 females (age=22.3 ± 2.2 years; height=166.8 ± 6.9 cm; mass=65.3 ± 19.4 kg) were recruited to participate in this study. After obtaining consent, participants were asked to complete a demographic questionnaire. The Foot Posture Index© (FPI) was then used by the researcher to quantify and categorize the degree to which a foot was situated in a neutral, pronated, or supinated position (Redmond, 1998). Across all participants, 20 displayed a neutral foot type (3.2 ± 1.1, p=*.0001*) that was indicative of a score ranging from 0 to +5, 20 displayed a pronated foot type (7.4 ± 1.5, p=*.0001*) that was

indicative of a score ranging from +6 to +12, and 0 participants displayed a supinated foot type that was indicative of a score ranging from 0 to +5. Seven reflective markers were then placed on the participant's right lower extremity on the head of the fifth metatarsal, lateral malleolus, calcaneus, femoral epicondyle, and greater trochanter of the right leg (Richards, 2008). The sixth and seventh markers, referred to as wands, were placed in the middle of the lateral aspect of the tibia and femur. The participant was then asked to perform a warm up on the treadmill including a slow run at a self-selected speed at a 0% grade for five minutes. After the warm up was completed, he/she was assigned his/her first of three taping conditions. The three taping conditions included a KT, LT, and no tape (NT) condition. For the foot pronation KT technique, the participant was asked to sit in a chair with his/her right leg elevated and resting on a chair (Figure 1a). Three 20 cm strips of tape were applied to the foot with the ankle held in a relaxed, neutral position. The first piece of KT was anchored on the dorsal surface of the third cuneiform and wrapped laterally under the calcaneus with 50-75% tension around the posterior ankle ending on the apex of the medial malleolus (Kase, Martin, & Yasukawa, 2006). The second piece of KT was applied to the dorsal surface of the second cuneiform and wrapped around the calcaneus medially and around the posterior ankle, ending on the apex of the lateral malleolus with 50-75% tension. The third piece of KT extended from the dorsal surface of the third cuneiform, wrapped laterally around the posterior aspect of the ankle, over the navicular, and extended up to the medial distal third of the lower leg just above the medial malleolus with 50-75% tension. Each strip of tape was then rubbed three times in the direction of the tension to activate the adhesive allowing the tape to firmly adhere to the participant's skin (Kase, Martin, & Yasukawa, 2006).

(a) (b)

Figure 1: Taping Techniques. (a) Kinesio Tape® technique; (b) Leuko Tape® technique.

For the Modified Mulligan calcaneal LT technique, the participant was also asked to sit in a chair with his/her right leg elevated and positioned on a chair (Figure 1b). A 20 cm piece of LT was applied 5 cm above the inferior border of the lateral malleolus and laid diagonally across the lateral surface of the calcaneus. The calcaneus was held in an externally rotated and adducted position while pulling the tape around the posterior aspect of the calcaneus and up and around the ankle medially, anchoring onto the lateral aspect of the tibia (Agrawal & Deshpande, 2015). The order of conditions was randomized. Based on the first condition selected, the tape was applied to the participant's right leg before beginning the first trial. If the NT condition was selected first, the participant was asked to begin his/her first trial without the application of tape. Three Basler acA1300 digital cameras were set up adjacent to the right side of the treadmill. Two cameras were set up diagonally to the right side of the treadmill and one camera was positioned perpendicular to the treadmill, so the field of view encompassed the participant's right lower extremity. Video was recorded using the Contemplas© Templo motion capture system at a sampling rate of 100 Hz and shutter speed of 1/1000. All trials were performed at a speed that was calculated by the researcher to be 10% faster than what was chosen for the warm up (2.86 m/s ± .33). Each trial consisted of five minutes of running with video data collected in the last 30 seconds. For the second and third trials, the same methodology was used, but with a new taping technique.

Data were analyzed using the Vicon Motus© 10.01 motion analysis software program. Three consecutive running strides were digitized for each participant. The data were smoothed with a Butterworth digital filter with the optimal cut off frequency that ranged between 3 to 9 Hz as determined using the Jackson Knee Method (Jackson, 1979). Statistical analysis was completed using IBM SPSS©V25 software. Repeated measures factorial analyses of variance (ANOVAs) were performed to examine interaction effects between the independent variables that included the type of therapeutic tape (KT, LT, or NT) and foot posture (neutral, pronated). Although multiple kinematic measures were recorded during each trial, dependent variables were selected that have been identified by previous literature to occur as a result of overpronation (Dugan & Bhat, 2005). These variables included ankle angle at the initial contact and toe off phases of running, peak (maximum) knee angle and peak knee valgus during the stance phase of running, change in tibial internal rotation during the stance phase of running, and knee angle at the toe off phase of running. The statistical significance was set at $p<.05$. Descriptive statistics were also calculated for the data obtained from the demographic questionnaire, FPI©, and for the independent and dependent variables of interest.

RESULTS/DISCUSSION: There were no significant interaction effects between the application of therapeutic tape and foot type for any of the variables included in Table 1.

Table 1: Participant Results.

Variable (º)	Kinesio Tape® (M ± SD)		Leuko Tape® (M ± SD)		No Tape (M ± SD)	
	Neutral	Pronated	Neutral	Pronated	Neutral	Pronated
Ankle Dorsiflexion at Initial Contact	6.2 ± 1.7	2.3 ± 1.7	3.3 ± 1.7	1.1± 1.7	2.4 ± 1.7	1.8 ± 1.7
Peak Knee Flexion at Midstance	39.9 ± 1.4	37.6 ± 1.4	38.4 ± 1.4	37.7 ± 1.4	38.9 ± 1.4	37.4 ± 1.4
Change in Tibial Internal Rotation at Midstance	9.7 ± 1.8	8.1 ± 1.8	10.8 ± 1.8	10.7 ± 1.8	8.4 ± 1.8	10.1 ± 1.8
Peak Knee Valgus at Midstance	1.7 ± 1.5	3.0 ± 1.5	1.9 ± 1.5	1.9 ± 1.5	1.7 ± 1.5	2.7 ± 1.5
Knee Angle at Toe Off	20.8 ± 1.8	18.2 ± 1.8	20.3 ± 1.8	17.8 ± 1.8	18.2 ± 1.8	17.4 ± 1.8
Ankle Plantarflexion at Toe Off	2.5 ± 2.5*	8.7 ± 2.5	4.1 ± 2.5*	10.3 ± 2.5	9.4 ± 2.5*	10.6 ± 2.5

* Significant main effect ($p<.05$).

There was however, a significant main effect of foot type for ankle angle at toe off ($F=5.0$, $p=.03$, $\eta_p^2=.42$). Bonferroni post hoc analysis revealed that participants with a pronated foot posture had decreased degrees of ankle plantarflexion at toe off (4.56 ± 2.0) when compared to participants with a neutral foot posture across all taping conditions. As overpronation can be identified by dorsiflexion at the ankle, it is suspected that the increased amount of dorsiflexion seen in the participants with a pronated foot posture may have occurred as a result of the overpronation extending through the second half of the midstance phase (Dugan & Bhat, 2005; Franettovich et

al., 2008). Furthermore, decreased plantarflexion at the toe off phase of running may restrict necessary movement to propel the individual through the swing phase (Cheung & Ng, 2007). As the degree of pronation during the midstance phase was not directly measured within this study, future research should include both direct and indirect measures of pronation to explore this effect further. It was also anticipated that the application of therapeutic tape would have an effect on peak knee flexion, change in tibial internal rotation, and peak knee valgus during the midstance phase of running as they have also been found to occur as a result of overpronation (Dugan & Bhat, 2005). Vincenzino et al. (2005) found significant decreases in overpronation when applying a therapeutic taping technique including strips of tape extending more proximally up the tibia. Therefore, future research should explore the effect of therapeutic tape on the lower extremity kinematics with a different taping technique that provides more support to the calcaneus while running.

CONCLUSION: Based on the results of this study, there were no significant interaction effects between the application of therapeutic ankle taping and foot posture in participants with neutral and pronated foot types on the kinematics of the knee and ankle while running. Future research should explore the effect of therapeutic tape by directly measuring pronation throughout the stance phase and using different taping techniques to provide more support to the foot and ankle while running. Examining the effects of therapeutic tape on foot pronation throughout the running gait cycle may allow patients, coaches, and clinicians to gain insight into the most effective type of tape and technique to use to control overpronation.

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