THE EFFECTS OF KNEE TAPING TECHNIQUES ON LOWER EXTREMITY KINEMATICS DURING RUNNING

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The purpose of this pilot study was to investigate the effects of gender, speed, and tape on 2D lower extremity kinematics and stride characteristics during running. Eight healthy runners participated. Taping interventions (Leukotape, Kinesio Tape, no tape) and speeds (2.35 m/s, 3.35 m/s) were randomized and lower extremity stride kinematics were obtained using the Peak Motus System. Comparisons were made using descriptive statistics. Females exhibited greater hip and knee flexion, while males had greater ankle dorsiflexion and plantarflexion. Females spent more time in support while males spent more time in the air. Faster speed was associated with greater hip flexion and extension, peak knee flexion, and less time during contact. As a result, gender and speed seem to have effects on lower extremity stride kinematics, whereas type of tape does not.

KEYWORDS: leukotape, kinesio tape, biomechanics, gender, speed.

INTRODUCTION: Running is a popular form of physical activity; however, it is also linked to various lower extremity injuries (Ferber & Macdonald, 2014). A commonly used technique for injury prevention and rehabilitation of athletic injuries is taping (Aytar et al., 2011). The clinical reasoning behind taping is to minimize pain, improve proprioception, increase muscle strength, improve gait, as well as enhance functional outcomes by providing support during movement (Aytar et al., 2011). Two popular types of tape that have emerged in recent years include Leukotape, a highly adhesive rigid tape (Campolo, Babu, Dmochowska, Scariah, & Varughese, 2013), and Kinesio tape, an elastic tape that can be stretched up to 120-140% of its length (Campolo et al., 2013; Fu et al., 2008; Lee, Lee, Jeong, & Lee, 2012).

While there is considerable research investigating running biomechanics, there has been limited to no research examining the effects of gender (Chumanov, Wall-scheffler, & Heiderscheit, 2008; Ferber, Davis, & Williams, 2003), speed (Nicola & Jewison, 2012; Novacheck, 1998), and the type of tape used on two-dimensional lower extremity kinematics during running. Therefore, the purpose of this pilot study was to investigate the effects of gender, speed, and tape on two-dimensional lower extremity kinematics and stride characteristics during running.

METHODS: Eight healthy runners were recruited for this study, 4 males (mean age: 23 ± 2.45 years; height: 174.63 ± 5.24 cm; weight: 77.25 ± 8.14 kg) and 4 females (mean age: 23.25 ± 1.71 years; height: 170.82 ± 8.64 cm; weight: 58.50 ± 4.51 kg). Ethical approval was received from the Lakehead University Research Ethics Board prior to data collection.

Kinematic data was collected using a JVC Mini DV camera positioned to the right of the treadmill (Woodway ELG), perpendicular to the plane of movement. The camera was then manually focused and the shutter speed was set to 1/750 of a second. Additionally, a floodlight was positioned next to the camera in order to ensure appropriate lighting.

Upon arrival, participants determined the order of the three taping interventions (Leukotape, Kinesio Tape, no tape) and two running speeds (2.35 m/s, 3.35 m/s) via a randomization process. Based on the initial intervention chosen, the appropriate taping technique was then applied to the participants' right knee. For the Leukotape intervention, McConnell's Medial Glide technique was used. This involved first applying a thin layer of Hypafix over the anterior aspect of the patella, followed by the application of Leukotape from the lateral border to the medial border of the patella, while simultaneously gliding the patella medially (McConnell, 1986). For the Kinesio Tape intervention, the Quadriceps Facilitation technique was used. This involved anchoring a Y-strip with a long base mid thigh (at the muscle belly), then applying 15% stretch until the musculotendinous junction was reached, in which case the tails were applied with paper off tension around either side of the patella (Kinesio Taping

Association International, 2013). All taping interventions were applied to the participant's right knee and were performed by the same taping practitioner.

Bony landmarks on the hip, knee, and ankle, were then identified using retroreflective markers and tape, which were placed at the average center of rotation of each joint (Kivi, Maraj, & Gervais, 2002). The first and second markers were placed on the greater trochanter and lateral epicondyle of the femur, respectively. The third marker was positioned on the lateral malleolus of the fibula. The fourth and fifth markers were placed on the outside of the running shoe on the middle of the calcaneus and base of the fifth metatarsal, respectively.

Following the placement of the retroreflective markers, participants were asked to run on the treadmill. Participants first engaged in a 2 minute warm-up, at a self-selected pace below 2.35 m/s. The running speed was then increased to the participant's initial chosen speed, where they ran for 2 minutes and 20 seconds. The same procedure was then followed for the second running speed. Participants then engaged in a 2 minute cool down run at a self-selected pace. Following this, a 5 minute recovery period was given before the application of the next taping intervention. The same procedure was followed for the remaining taping interventions.

The kinematic variables included hip, knee, and ankle flexion and extension at initial contact (IC) and toe off (TO), as well as peak knee flexion during midstance (PK). The hip and knee angles were defined as the joint angles between the knee, hip, and y-axis, and the hip, knee, and ankle respectively. Conversely, the ankle angle was defined as the segment angle between the long axis of the shank segment (as defined by the knee and ankle joint markers) and the long axis of the foot segment (as defined by the ankle and toe joint markers). Stride characteristics included contact time (the amount of time spent in contact with the ground from the moment of IC until TO) and flight time (the amount of time spent in the air from the moment of TO until IC). Using the Peak Motus System (9), the segmental endpoints (hip, knee, ankle, heel, and toe) were manually digitized for three consecutive strides and the events (IC and TO) were selected. The data was then processed at 60 Hz and filtered using a quintic spline. Using Microsoft Excel, angular displacements during IC, TO, and PK were highlighted, and stride characteristics were calculated. Angular displacements and contact times were then averaged over the three strides (with the exception of flight time being averaged over only two strides due to data availability). A separate excel file was then used to calculate the descriptive statistics.

RESULTS/DISCUSSION: Gender and speed differences were found in both lower extremity kinematics and stride characteristics (Table 1-4). Females exhibited greater hip (F_{IC}= 164.04$\pm$1.99°; M_{IC}= 167.54$\pm$2.12°) and knee flexion (F_{IC}= 167.73$\pm$0.93°; M_{IC}= 170.42$\pm$1.65°; F_{PK}= 142.83$\pm$1.28°; M_{PK}= 146.35$\pm$1.21°) than their male counterparts. While this finding conflicts with the previous research, it may be attributed to females being more susceptible to knee injuries. Perhaps greater flexion is used to further absorb the impact of the landing, allowing the force to be dissipated throughout the body, resulting in a decreased impact on the joints. Furthermore, males showed greater degrees of ankle dorsiflexion (F_{IC}= 88.60$\pm$1.00°; M_{IC}= 84.14$\pm$1.08°) and plantarflexion (F_{TO}= 51.90$\pm$1.01°; M_{TO}= 55.99$\pm$0.825°). A possible reason for this difference may be attributed to overall muscular strength. Perhaps males had a larger propulsion force that required more plantarflexion at TO. Furthermore, in order for them to maintain the same speed, they may have also exerted a larger braking force at IC, requiring more ankle dorsiflexion.

Females were also found to spend more time in contact with the ground than their male counterparts (F_{CT}= 0.28$\pm$0.03s; M_{CT}= 0.26$\pm$0.02s). Conversely, males were found to spend more time in the air (F_{FT}= 0.45$\pm$0.02s; M_{FT}= 0.48$\pm$0.01s). Furthermore, the faster speed was associated with greater hip flexion and extension (S_{IC}= 167.57$\pm$1.95°; F_{IC}= 164.01$\pm$2.11°; S_{TO}= 197.14$\pm$1.23°; F_{TO}= 201.28$\pm$0.74°), peak knee flexion (S_{PK}= 145.39$\pm$1.82°; F_{PK}= 143.79$\pm$2.39°), and less time in contact with the ground (S_{IC} = 0.30$\pm$0.01s; F_{IC}= 0.25$\pm$0.00s). While there is limited to no literature supporting these findings, it is unknown why these differences exist. While it may be attributed to the small sample size, future research is needed to confirm or refute these findings.

While gender and speed appeared to have an effect on lower extremity kinematics, the type of tape did not (Table 1-4). This finding was not anticipated, however, it may be explained by issues that arose during data collection and the method of tape application. Although Leukotape is said to be a highly adhesive rigid tape, it had trouble remaining adhered to the skin throughout the protocol. This is likely the result of some participants having large amounts of hair on their legs as well as excessive sweating. As a result, the taping intervention may not have worked in the way in which it was designed, ultimately imitating the no tape condition. Furthermore, the amount of stretch applied to the Kinesio Tape during the application process may not have been large enough to elicit a change in the lower extremity.

Table 1
Hip Kinematics

	Initial Contact (deg)	Toe Off (deg)
Gender		
Females	164.04±1.99	199.71±1.96
Males	167.54±2.12	198.70±2.81
Speed		
Slow	167.57±1.95	197.14±1.23
Fast	164.01+2.11	201.28±0.74
Tape		
Kinesio Tape	165.87±2.86	199.10±2.79
Leukotape	165.41±2.95	198.93±2.26
No Tape	166.09±3.04	199.60±2.71

Table 2
Knee Kinematics

	Initial Contact (deg)	Toe Off (deg)	Midstance (deg)
Gender			
Females	167.73±0.93	163.34±2.63	142.83±1.28
Males	170.42±1.65	164.84±1.82	146.35±1.21
Speed			
Slow	169.38±1.26	163.19±2.56	145.39±1.82
Fast	168.78±2.48	164.99±1.75	143.79±2.39
Tape			
Kinesio Tape	169.33±2.18	164.17±1.98	144.99±2.67
Leukotape	168.34±1.91	163.43±2.59	144.50±1.76
No Tape	169.51±1.97	164.66±2.76	144.29±2.63

Table 3
Ankle Kinematics

	Initial Contact (deg)	Toe Off (deg)
Gender		
Females	88.60±1.00	51.90±1.01
Males	84.14±1.08	55.99±0.825
Speed		
Slow	86.75±3.00	53.81±2.25
Fast	86.00±2.20	54.01±2.57
Tape		
Kinesio Tape	86.32±2.87	53.68±2.78
Leukotape	86.37±2.94	54.02±3.15
No Tape	86.43±3.11	54.13±1.32

Table 4
Stride Characteristics

	Contact Time (seconds)	Flight Time (seconds)
Gender		
Females	0.28±0.03	0.45±0.02
Males	0.26±0.02	0.48±0.01
Speed		
Slow	0.30±0.01	0.46±0.03
Fast	0.25±0.00	0.47±0.01
Tape		
Kinesio Tape	0.27±0.03	0.46±0.02
Leukotape	0.27±0.03	0.46±0.02
No Tape	0.27±0.03	0.47±0.04

CONCLUSION: Since running is an extremely popular form of physical activity linked to numerous lower extremity injuries that require the use of tape, the findings of this study are applicable to the area of sport and exercise. By providing preliminary evidence on taping and 2D lower extremity kinematics and stride characteristics during running, this study begins to bridge the gap between sports and biomechanics, while also contributing to the advancement of rehabilitation and biomechanics in sport. Furthermore, the findings of this study directly benefit the health care professionals and runners alike currently using tape, or debating its use. While this study reveals that different taping techniques do not seem to alter 2D lower extremity kinematics or stride characteristics in healthy runners, future research with a larger sample size, pathological population, and 3D analysis is warranted.

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