THE IMPACT OF FRESH AND USED ANKLE TAPING ON LOWER EXTREMITY BIOMECHANICS DURING SPORTS SPECIFIC MOVEMENTS

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This study aimed to investigate the effects of ankle taping on lower extremity joint biomechanics. Kinetic and kinematic data were collected from 25 participants using 3D motion capturing and force platforms without shoes for running (RUN), drop jumping (DJ), and 180° change of direction (COD), in tape applied fresh (TF) and tape after sports-specific use (TU) conditions compared to a barefoot (BF) baseline. Taping conditions decreased peak ankle excursions and moments for the frontal and sagittal planes for some of the sports-specific movements. However, TF did not significantly alter the knee and hip moments in the frontal and sagittal planes. Reducing ankle excursion likely offers some protection to extreme joint ranges. To reduce restrictions imposed by fresh taping on the sagittal plane ankle ROM, applying ankle taping already during the pre-match warm-up might be useful.

KEYWORDS: ankle injury, ankle sprains, athletic tape

INTRODUCTION: Ankle taping is a commonly used method as a preventive measure and to prevent recurrent injuries and reduces the risk of repetitive injuries of the ankle by limiting the range of motion (ROM) of the ankle joint (Dizon & Reyes, 2010). These kinematic changes could alter ground reaction force application (e.g., increasing loading rates), which could increase the risk of lower extremity injuries (Megalaa et al., 2022). Although the effects of taping on joint kinematics are relatively well reported, it is not yet clear how these changes in joint ROM affect lower limb kinetics, in particular for more proximal joints, i.e., knee and hip. It is also known that the ankle ROM-restrictive properties of taping are reduced after sports-specific exercises, already after the first 15 minutes, but how the alteration of restriction affects lower limb kinetics (in particular knee and hip biomechanics) in detail remains unclear (Forbes et al., 2013). When protecting the ankle, tape interventions interact with the stabilizing characteristics of athletic footwear. Furthermore, there is a lack of correlation between changes in joint kinematics and data collected from shoe-mounted markers, particularly for the frontal plane, which can lead to miscalculations of the biomechanical measurements (Reinschmidt et al., 1992). Therefore, when analysed within athletic footwear, a precise understanding of the isolated effects of taping interventions on ankle biomechanics might be hard to reach. Consequently, this study aims to determine (1) whether there are changes in the kinetics and kinematics of lower extremity joints during sports-specific tasks with and without taping during barefoot movements. (2) Whether there will be any change in the taping-induced kinetic and kinematic alterations of the lower extremities obtained after using the tape for a specific time.

METHODS: Twenty-five healthy participants (ten women and fifteen men) participated in the study with no ankle injury in the last 12 months (age: 24.8 ± 2.5 years, mass: 73.0 ± 10.1 kg, height: 1.76 ± 0.99 m). All participants performed warm-up and stretching exercises for approximately 10 minutes. The randomized testing conditions were defined as barefoot (BF), tape applied fresh (TF), and tape after sports-specific use (TU). For the TF condition, a standard method of taping to restrict ankle motion was applied (EuroTape Platinum Grade 3.8 cm * 11.4 m, Mueller®, USA) to the participants by the same sports physician as described in the literature (Abian-Vicen et. al, 2008). Nearly half of one roll of tape (4-5 m) was used per person. For the TU condition, participants performed standardized running, sudden acceleration, changing direction, and jumping movements with their own sports shoes for 15 minutes after the TF data collection phase. Subsequently, we collected the data for the TU condition without athletic footwear. The movements for each condition were performed on a tartan floor (CONICA AG, Zürich, Switzerland) without shoes. Three valid trials of running (RUN; 4.5 ± 0.2 m/sec), drop jumping (DJ; 25 cm height), and 180° change of direction (COD; approach speed 3.0 ± 0.2 m/ sec) were performed as sports-specific movements for every condition. Ground reaction forces were collected through two 0.6 x 0.9 m force platforms embedded in the floor (1000 Hz, BMS60900, AMTI, MA; USA). Spherical retroreflective markers (diameter: 14 mm) were used to track (200 Hz, Miqus, Qualisys AB, Gothenburg, Sweden) the motion of the right lower extremity (Willwacher et al., 2016). The marker and ground reaction force data were filtered using a 4th-order, low-pass Butterworth filter with a cut-off frequency of 20 Hz. For each trial, we extracted peak joint angles and moments with each plane of motion. We averaged these peak values across the three trials obtained for each condition and motion for further statistical analysis. To identify differences between conditions, we used repeated measures ANOVAs. In the presence of a significant main effect, we performed Bonferroni adjusted post-hoc dependent sample t-tests for a more detailed analysis of the differences between conditions. The alpha level was set to 5% for all statistical tests.

RESULTS: Run-up speeds were not different between conditions in RUN and COD ($p > 0.05$). However, in DJ, a higher average resultant ground reaction force (GRF) application was identified for BF compared to TF ($p = 0.001$), but not for TU ($p = 0.116$). The TF condition decreased peak ankle inversion angles for COD, DJ, and RUN. This significant reduction effect persisted for all movements in the TU condition (Table 1, Figure 1). The TF condition also significantly decreased peak ankle dorsiflexion angles for the COD and RUN movement (Table 1). This significant reduction disappeared in the TU condition (Table 1). Peak ankle eversion angles decreased with TF and TU conditions for the RUN movement (Table 1). TF and TU conditions decreased peak ankle inversion moments for the DJ and RUN movement **(**Table 1). In addition, peak ankle plantar flexion moments were significantly lower for the same movements between the same conditions (Table 2). The TU condition decreased peak ankle inversion and peak ankle plantar flexion moments for COD (Table 2). This significant effect did not exist in the TF condition. The TF condition had no effect on knee and hip moments in the frontal and sagittal planes for all movements (Table 2). The TU condition increased the peak knee extension moment compared to the BF and TF conditions for the RUN movement (Table 2). TU condition increased peak hip extension moment for the COD movement compared to the BF and TF conditions (Table 2).

DISCUSSION: This study is one of the most comprehensive studies of ankle taping and its effects on lower extremity biomechanics in the literature. The results show that ankle taping significantly restricted the peak ankle inversion for all dynamic movements and the peak ankle dorsiflexion for COD and RUN movements, which is consistent with the literature ((Megalaa et al., 2022). However, the significant restrictive effect of taping on peak ankle dorsiflexion during COD and RUN disappeared with the use of tape. The results of the study on the ankle joint might be interpreted as follows: once the tape is applied and the layers of the tape are loosened, the restrictive effect of the tape is released primarily in the sagittal plane, which might be the effect of differential stresses experienced by the individual components of the tape (Sato et al., 2023). The stirrups would probably be the last to be affected as many layers of interlocking strips secure their integrity. While the movement intensities (approach speeds) were not different between conditions in RUN and COD, in DJ a lower movement execution intensity (average GRF) was observed in TF. This might have affected the results and should be considered in future studies, e.g., by standardizing jump height through biofeedback.

CONCLUSION: Considering the reduced ankle joint excursions and moments observed, known rehabilitation times, and treatment costs, we suggest that using tapes might be a valuable tool for injury prevention, especially for athletes with chronic ankle instability. Taping the ankle during the warm-up period might be a feasible option to reduce the unwanted restriction effects on ankle dorsiflexion.

Table 1. Mean ± 1 standard deviation of peak angles for the ankle, knee and hip joints in all planes for results with a significant ANOVA main effect. *p < .05, ** p < .01, *** p < .001 revealing significant Bonferroni-corrected post-hoc tests. a indicates that the Mauchly's test of sphericity identified a violation of the assumption of sphericity (p <.05) and that Greenhouse-Geisser correction was applied. P-value adjusted for comparing a family of 3. BF: barefoot, COD: 180° change of direction, DJ: drop jumping, RUN: running movement, TF: tape applied fresh, TU: tape after sports-specific use. [1],[2] indicates that for some participants this angle was still in the knee adduction and knee abduction, for others it was already in the opposite direction.

Movement	Angles in [°]	BF	TF	TU	ANOVA p-value
COD	Peak ankle inversion	15.4 ± 3.9 TF***, TU***	11.3 ± 4.1 BF***	12.6 ± 3.5 BF***	<.001
COD	Peak ankle dorsiflexion	-20.4 ± 6.9 TF*	-16.3 ± 5.5 BF*	-18.4 ± 5.7	0.032_a
DJ	Peak ankle inversion	12.3 ± 3.8 TF***, TU*	9.1 ± 3.1 BF***	10.4 ± 3.5 BF*	<.001
RUN	Peak ankle inversion	10.3 ± 3.3 TF***, TU**	7.5 ± 3.1 BF***	8.5 ± 3.4 BF**	<.001
RUN	Peak ankle dorsiflexion	-17.1 ± 5.1 TF*	-13.4 ± 5.8 BF*, TU*	-16.8 ± 6.6 TF*	0.009

Table 2. Mean ± 1 standard deviation of peak moments for the ankle, knee and hip joints in all planes for results with a significant ANOVA main effect. *p < .05, ** p < .01, *** p < .001 revealing significant Bonferroni-corrected post-hoc tests. a indicates that the Mauchly's test of sphericity identified a violation of the assumption of sphericity (p <.05) and that Greenhouse-Geisser correction was applied. P-value adjusted for comparing a family of 3. BF: barefoot, COD: 180° change of direction, DJ: drop jumping, RUN: running movement, TF: tape applied fresh, TU: tape after sports-specific use.

Movement	Moments in [Nm/kg]	BF	TF	TU	ANOVA p-value
COD	Peak ankle inversion	0.38 ± 0.30 TU*	0.30 ± 0.17	0.27 ± 0.18 BF*	0.042_a
COD	Peak ankle plantar flexion	1.83 ± 0.28 TU*	1.79 ± 0.31	1.70 ± 0.31 BF*	0.003
COD	Peak hip extension	2.18 ± 0.77 TU (0.075)	2.14 ± 0.66 TU*	2.33 ± 0.83 BF*	0.012
DJ	Peak ankle inversion	0.85 ± 0.42 TF*, TU**	0.71 ± 0.34 BF*	0.70 ± 0.31 BF**	0.004
DJ	Peak ankle plantar flexion	2.43 ± 0.70 TF***, TU*	2.21 ± 0.59 BF***	2.30 ± 0.68 BF*	<.001
RUN	Peak ankle inversion	1.03 ± 0.40 TF*, TU***	0.89 ± 0.31 BF*	0.84 ± 0.40 BF***	<.001
RUN	Peak ankle plantar flexion	2.69 ± 0.40 TF (0.055), TU**	2.59 ± 0.44 BF (0.055)	2.56 ± 0.45 BF**	0.017_a
RUN	Peak knee extension	-2.69 ± 0.46 TU**	-2.69 ± 0.56 TU**	-2.84 ± 0.54 TF**, BF**	<.001

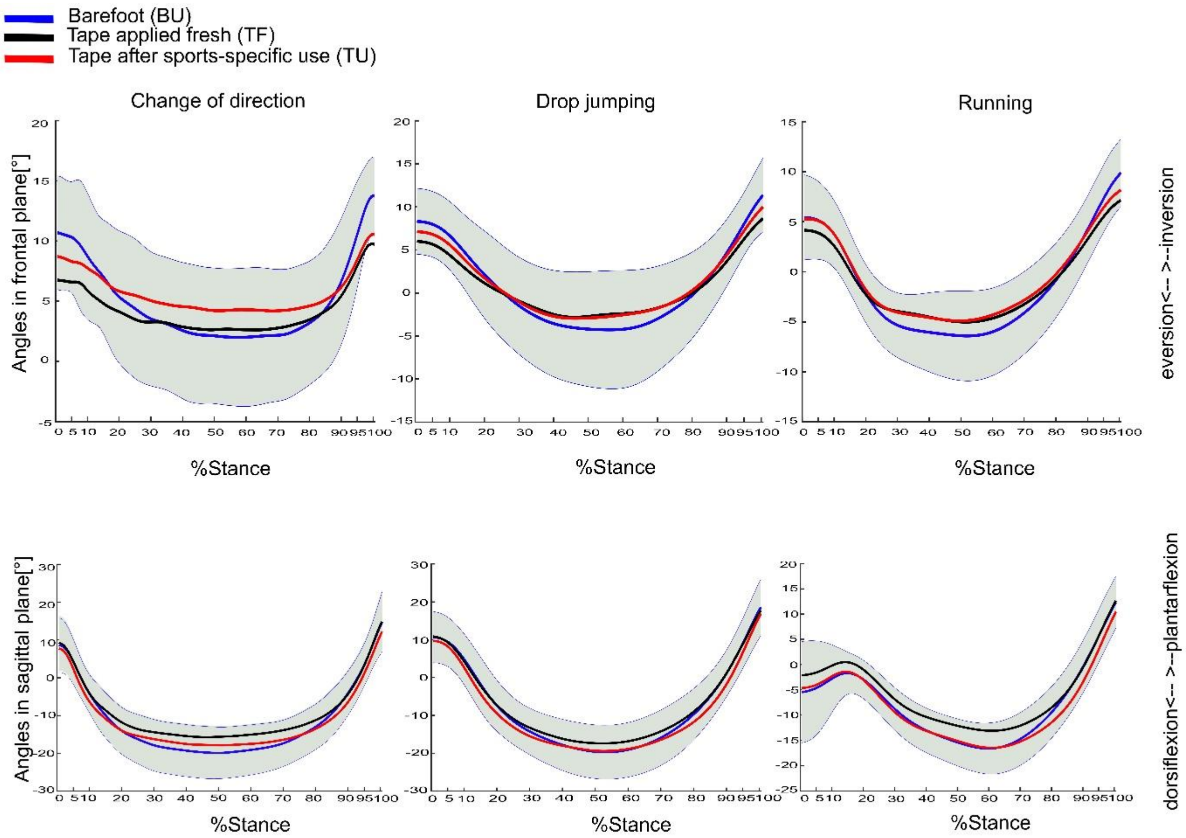

Figure 1. Average, time normalized curves of ankle joint angles in the frontal and sagittal planes for all conditions and movements. The stance phase on the force plate was normalized to 100% percent. The grey shaded areas highlight an area of ±1 standard deviation around the mean of the barefoot condition.

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