Lateral Ankle Ligament Strains During Motion Capture of Slow Running Using A Novel Talus Marker

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Summary

The anterior talofibular (ATFL) and the posterior talofibular (PTFL) ligaments are potentially injured during a lateral inversion ankle sprain. Both are inserted on the talus, yet traditional motion capture data of talar motion is limited. A new marker set was proposed and tested during slow running. Strains were estimated with the latest marker set by animating a musculoskeletal model with subject kinematics and compared to those derived from literature-based angular joint ratios from bone pin data [1, 4, and 6]. ATFL strains from the markers were consistently higher than using the bone pin joint ratios, and PTFL strains were similar to strains from using the bone pin angular joint ratios. Although additional testing is necessary to fully validate the new markers, they demonstrate potential for effectively tracking talar motion in relation to estimated ligament strains compared to existing methods and literature values.

Introduction

Ankle sprains constitute over 80% of ankle injuries in sports, and ankle injuries overall account for 10-30% of all sports-related injuries [3]. The anterior talofibular ligament (ATFL) and posterior talofibular ligament (PTFL) are commonly injured during a lateral inversion ankle sprain. However, motion capture technology struggles to accurately track motion at the talus, where both ligaments attach. To address this, a new marker configuration was developed to better capture talar motion during gait. Ligament strains were assessed using this new marker set during barefoot slow-running trials, and the results were compared to strain estimates derived from previously published bone pin angular joint ratios for slow-running.

Methods

Fifty healthy adult subjects (25 males, 25 females; age 25.4 ± 7.9 years; height 172.5 ± 9.4 cm; weight 76.6 ± 18.6 kg) were recruited for this study. Triads were placed just above the lateral and medial malleolus of the right foot and on the calcaneus. A modified triad was placed just inferior to the medial malleolus. Ground reaction forces (AMTI, 1125 Hz) and 3D kinematics (12 camera Qualisys system, 225 Hz) were collected during seven trials of bare-foot slow running at a self-selected pace. Trials were trimmed to 10 frames before the first measurement of a ground reaction force and 10 frames following the last ground reaction force reading and later filtered using a low pass filter with a cutoff frequency of 10 Hz. Subtalar motion was estimated from the angle between the tibia and the calcaneus using proportions of (.43, .48, .25) for the frontal, transverse, and sagittal plans respectively. Proportions were based on data from [1], [4], and [6]. The kinematic data from the current study and from the bone pin ratios were used to animate the talus, leg, and calcaneus of a musculoskeletal model of the foot [5]. Neutral strains were estimated to be 2.7 and 2.3% for the ATFL and PTFL ligaments respectively [7].

Results and Discussion

Measured ATFL strains were consistently higher than those from using the bone pin angular joint ratios with maximum differences occurring at toe-off (Figure 1). Measured PTFL strains were higher than using the bone pin ratios from 0% to 23% of stance and from 71% to 100% of stance. Maximum PTFL strain was 3.8% at 74% of stance. Ligament strains also compared well with other motion capture derived ligament strains [2] as seen in Table 1.

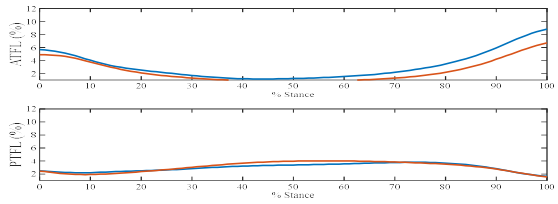

Figure 1: Measured ATFL and PTFL strains (blue) and strains when using compiled bone pin ratios from [1], [4], and [6] (red).

Table 1: Comparison of maximum estimated ligament strains.

	ATFL	PTFL
Measured	8.8% at 100%	3.8% at 74%
Bone Pins	6.7% at 100%	4.0% at 56%
Boey [2]	9.0% ± 8 %	4.0% ± 0.6 %

One size marker set was used for all participants. In addition, the running speed was not dictated by the researchers. Either of these or a different condition may result in more significant variability between the measured ligament strains when using the proposed marker set.

Conclusions

Proposed markers to track talar motion during slow running yielded ATFL and PTFL strains that resemble strains measured when using literature-derived joint angular ratios from bone pin data.

References

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