

Quantifying the Effect of Ankle Posture on the Positions of Bones of the Foot/Ankle Complex for Injury-Prediction Studies

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Abstract

The ankle is the most common site of injury for an occupant during a frontal vehicular collision [1]. This injury is also associated with impacts with the ground after falling from a height, as well as improvised explosive device detonations in combat zones. Damage to this region can result in a high level of impairment, accompanied by long-term monetary healthcare costs and emotional distress. By understanding the factors which cause ankle injury, suitable protective systems can be designed. This would contribute to lowering the risk of these incidents and their associated psychological, physical and financial repercussions.

The risk of injury to the ankle in different loading scenarios has previously been evaluated experimentally and numerically with the ankle in a neutral posture (e.g. [2]). However, the ankle can assume a wide variety of positions during injurious events. Whole limb tests are typically conducted with little attention given to the posture of the ankle. A concern with this type of testing is the variability in joint alignment required to control the load path during impact, with fractures occurring in the tibia, talus and calcaneus. It has been shown, at the wrist, that for falls, the orientation of the scaphoid and lunate affect both the location of fracture and fracture load in the radius [3]. Therefore, the hypothesis of this work is that ankle posture will affect the positions of the bones of the foot/ankle, thus altering the fracture threshold and location.

In order to test this hypothesis, a previously developed, CT-compatible device which can adjust the angles of the ankle independently in three dimensions has been incorporated into a new CT-compatible test frame. This test frame can apply forces via the use of pulleys and hanging weights to a cadaveric lower leg fixed at the proximal tibia. CT scans will be performed to determine the locations of the bones of the foot and ankle during testing. The difference in the position of the bones between the neutral and repositioned ankle will be quantified by the change in location of the center of gravity, as well as the change in absolute distance of any point. Testing will be conducted using a cadaveric lower leg from an individual representative of the 50th percentile male, and the specimen will be dissected to allow for application of strain gage rosettes to the surfaces of the calcaneus and talus bones. This will allow for calculation of the principal surface strains. The locations of these strain gauges will be recorded in the CT scans so that a finite element model can be developed and validated in the future. It is anticipated that the posture of the ankle will greatly affect the positions of the associated bones, and ultimately the load pathway and injury tolerance of the foot/ankle complex. To our knowledge, this effect has not been previously investigated in the literature and the results from this study will be useful

for future research in determining injury limits of the ankle and for developing postural guidelines to minimize injury.

- [1] Morris, et al., STAPP CAR C., 1997.*
- [2] Funk, et al., J. Biomech. Eng., 2002.*
- [3] Troy and Grabiner, J. Biomech., 2007*