Investigating Appropriateness of Using Cadaver Foot as Surrogate for Living Subjects Using Imaging Modalities

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Introduction

X-ray and ultrasound imaging modalities have been useful tools for measuring the human foot. Often, experimental work has used cadavers to investigate injuries and biomechanics of feet; however, little work has been done to compare various foot measurements from PMHS to living humans. Thus, the goal of this study is to investigate the ability of the PMHS foot to be representative of living humans using x-ray and ultrasound measurements.

Methodology

Fifty male and female PMHS, ranging in age from 47 to 100 years old, were obtained through the Ohio State University Body Donation Program. Bilateral AP and lateral standing x-rays were acquired through the use of a tilt table, where Tek scan was used to ensure 80% or more of their body weight was held up by their own feet. Intermetatarsal angle 1-2, hallux valgus angle, and navicular height measurements were chosen for their clinical significance and analyzed according to clinical standards. Ultrasound was used to characterize calcaneal plantar soft tissue using a custom-built ultrasound fixture with a load cell and a fixed Phillips Lumify L12-4 Hz transducer. Once the foot was positioned, ultrasound images were taken following the application of incremental forces (0N-30N). Each static ultrasound image was used to measure thickness (T) as the distance between the calcaneus and skin in ImageJ software. Compressibility index (CI) was calculated as maximum (30N) T/baseline T (0N). The displacement (D) from the baseline unloaded thickness was calculated at each force and used to create force-displacement curves to quantify stiffness. Both X-ray and ultrasound data were compared using a one sample t-test to living population measurements found in literature searches for combined genders.

Results and Conclusion

PMHS radiographic measurements were not significantly different from reported literature values, thus past research papers using PMHS radiographic measurements are valid for AP and lateral radiographic views (Table 1). For the ultrasound measurements, generally, baseline PMHS calcaneal thickness was significantly smaller ($p<0.001$) than reported values from young healthy controls. Overall, PMHS CI was significantly larger ($p<0.001$) than comparative data indicating larger displacement of calcaneal tissue per baseline value. Stiffness and CI from calcaneal PMHS tissue significantly varied from other studies. Although bony structures of the foot and their relative positions appear similar between PMHS and living populations as seen measured using x-ray, ultrasound comparisons indicate PMHS plantar soft tissue may not be fully representative of living populations.

Table 1: Comparison of PMHS vs. living subject's radiographic measurements

	R/L Intermetarsal angle (IMA 1-2) WB		R. Hallux Valgus Angle WB		R. Navicular Height WB	
	Mean +/- SD	P-value	Mean +/- SD	P-value	Mean +/- SD (cm)	P-value
Theoretical	9.7 +/- 1.7 [3]	0.143	19.7 + 10.4 [1]	0.21	4.02 +/- 0.82 [2]	0.896
Experiemntal	9.187 +/- 2.01		16.9506 +/- 8.94		3.9883 +/- 0.82	