Should PMHS be Considered as a Surrogate for Normative Populations in Biomechanical Testing of the Ankle-Foot Complex?

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Background

Post-mortem human subjects (PMHS) have been used extensively to observe lower limb responses in many scenarios. For example, PMHS have been used to analyze dorsiflexion loading of the ankle in frontal car crashes[1], tarsometatarsal sprain and axial loading in sports injury[2], and responses to underbody blasts[3]. However, a study has not been done to validate the appropriateness of using a PMHS as a surrogate for living subjects. For example, rigor mortis can cause muscles and tendons to stiffen several days beyond death. While it has been shown rigor may be "broken" with manual exercising of limbs, smaller muscles and tendons that define the arch of the foot may remain altered. Also, activity level of the PMHS prior to death (such as bedridden populations) could influence changes in these same anatomical structures. For these reasons the use of PMHS in predictive studies for living populations should be investigated further.

Objectives

The objectives of this study were as follows: establish a procedure for extensive lower limb anthropometric measurements of PMHS; and validate this procedure through comparison with lower limb measurements of living populations.

Methodology

Lower limb anatomical landmarks were marked on both feet of the subject using previous methods described by researchers for the US Army (ANSUR II[4]), Saltzman et al[5], Williams et al[6], Menz et al[7], and Knapik et al[8]. The PMHS was moved to a seated position where a scale was used to obtain equal weight distribution across feet. Descriptive anthropometric measurements were taken for lengths, breadths, heights, and circumferences on both feet of the seated subject. The PMHS was then moved to standing position, and a pressure mat was used to obtain equal distribution with at least 80% body weight. Standing measurements were taken in comparable fashion to the seated procedure.

Included Data

This study included lower limb anthropometric measurements done on 24 males and 11 females (35 total), paired t-tests comparing left and right feet, paired t-tests comparing seated and standing measurements, and comparisons between PMHS measurements and other studies done on living populations.

Results and Conclusions

In many cases, PMHS measurements agree with values from the studies mentioned earlier such as heel breadth, acropodion foot length, and navicular height (inferior medial border). In other cases, measurements differ such as talar head height and plantar curvature. These differences could result from factors including anthropometric changes in populations over time as well as procedural differences between the current study and past studies. For example, talar head height is a relatively new and seldom performed measurement. Most seated vs standing measurements showed statistical differences especially in height and breadths, which previous work supports. This indicates that weight bearing contributes to foot structure, and seated measurements cannot be substituted for standing measurements. The aforementioned results reveal that for many measurements the ankle-foot complex of PMHS is similar to living populations. That being said it is important to note that differences between weight bearing and

non-weight bearing are significant and thus PMHS biofidelity testing should consider this important boundary condition.

Citations

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