Chapter 6 Case Study (6.2, 6.2.3): Declining Tibial Curvature and Decreasing Mobility

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Biomechanics is a more recent area of research within bioarchaeology, providing information on the mechanical environment in which an individual or a population lives. Cross-sectional geometric properties give information on a variety of morphological features of human long bones that relate to bone's mechanical performance, which in turn is related to patterns of activity, such as mobility. Data from cross-sectional geometric analysis include architecture of trabecular bone, thickness of cortical bone, and longitudinal curvature of bone. This latter data source has not received substantial attention from researchers and, thus, less is understood about the relationship of long bone curvature with behavior. Alison A. Macintosh and collaborators (2015) seek to address this dearth of information, particularly for the tibia, in their study of tibial curvature and its possible relationship to population mobility. The goal of the study by Macintosh and colleagues was to determine whether a correspondence between tibial longitudinal curvature and cross-sectional geometric properties related to mobility exists.

A sample of 216 tibiae were utilized in this study, deriving from four archaeological time periods: Early/Middle Neolithic (5300–4600 BC), Early/Middle Bronze Age (2300–1450 BC), Early–Late Iron Age (850 BC – AD 100), Early Medieval (AD 800–850). All tibiae originated from skeletal remains recovered in Central Europe, including Germany, Austria, Slovakia, Hungary, Czech Republic, and Serbia, and belong to agricultural populations. Sex and age determinations were based on standard osteological protocols (Buikstra and Ubelaker, 1994). Only adults, of both sexes, were included in the study, the majority of which were younger than 40 years of age to reduce the impact of age-related bone changes.

To analyze cross-sectional properties of the tibia, three-dimensional models were produced based on a composition of surface laser scans taken around the circumference of the bone as well as of the joint surfaces. Specialized software enabled the 3D model to be used for all cross-sectional geometric measurements, including the polar second moment of area (J), total subperiosteal area of the section (TA), and bone cross-sectional shape ratios (I_{max}/I_{min}, I_x/I_y). These properties were measured along the tibial length at 5% intervals, with those from 25%, 40%, 50%, and 65% included in statistical analysis. Size standardization for TA and J was utilized to remove effects of body size. To assess tibial curvature, researchers utilized centroid locations from each set of measurements done at 5% intervals. The locations were then used to model tibial curvature, and the anteroposterior displacement of the centroid was measured. Statistical methods employed included one-way analysis of variance (ANOVA), as well as pairwise comparisons between temporal periods. Pearson's correlations were used for centroid displacement and the four cross-sectional geometric properties. A 95% confidence interval was used throughout.

The results indicate that, in both males and females, there are temporal declines in centroid displacement and, therefore, in tibial curvature. The Neolithic and Bronze Age males have greater curvature than Iron Age males, and Neolithic males have more curvature than Medieval males. Neolithic and Bronze Age females have significantly greater curvature than Medieval females. The decline in curvature is also found in conjunction with a decline in the four cross-sectional geometric properties, reflecting a decrease in robusticity. Temporal decreases in J and TA were only statistically significant for males between the Neolithic and Iron Age and between the Neolithic and Medieval periods. Likewise, males from the Neolithic have higher I_{max}/I_{min} values than Iron Age and Medieval males. For females, the only significant decline was in shape ratios. For example, Neolithic females have less circular shape at mid-diaphysis than Medieval females. When pooling all time periods and both sexes, centroid displacement positively correlates with all tibial cross-sectional geometric properties. Centroid displacement does not, however, correlate with variables related to body size.

Collectively, these results support a relationship between tibial curvature and cross-sectional geometric properties for Central European agricultural populations between 5300 BC and AD 850. Moreover, the decline in centroid displacement and, thus, tibial curvature corresponds to a decline in mobility as reflected in declining midshaft tibial cross-sectional geometric properties. This correlation and shift is found in both males and females, although greater temporal change was found for males. Additionally, based on these results, body size does not appear to influence tibial curvature. This study highlights how cross-sectional geometry can be used to assess questions related to mobility and other activity patterns. The study by Macintosh and colleagues also demonstrates the ongoing nature of biomechanical studies as newer variables, such as tibial curvature, are assessed for their effectiveness in reflecting population behaviors. Further research will determine the extent to which tibial curvature can be used as an indicator of mobility.

References

Buikstra JE, Ubelaker DH. 1994. *Standards for data collection from human skeletal remains.* Fayetteville 44.

Macintosh AA, Davies TG, Pinhasi R, Stock JT. 2015. Declining tibial curvature parallels ~6150 years of decreasing mobility in Central European agriculturalists. *American Journal of Physical Anthropology* 157:260-275.