H104 The Impact of Obesity on Morphology of the Femur

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After attending the presentation, attendees will better understand how differences in bone shape between weight classes might be explained by biomechanical adaptations used by overweight individuals to cope with increased adiposity. Additionally, attendees will see key theories behind adaptive cellular bone remodeling, and how direct, noninvasive bone measurements can be used to make inferences into activity and mechanical load.

This presentation will impact the forensic science community by illustrating how weight can indirectly alter bone shape. As obesity clearly affects how an individual appeared to others in life, this has great potential to aid in efficient identification of the deceased using skeletal remains.

The goal of this project was to evaluate whether adult weight (specifically obesity), impacts the human skeleton. The project design operated under the null hypothesis that biomechanical adaptations made by overweight individuals would *not* trigger adaptive cellular bone remodeling and therefore would not result in significant alteration of long bone shape or size. External measurements of diaphyseal cross- section were used as an indication of morphology, as these properties are said to be influenced by load and mechanical action. Using standards largely devised by Ruff (1983), anteroposterior (AP) and mediolateral (ML) dimensions were measured at 20%, 35%, 50%, 65% and 80% of diaphyseal length, measuring superiorly from the distal end.

The left femur was used as it possesses two unique properties: (1) it is a weight bearing bone; and, (2) its unique articulation with the pelvis results in forces that do not travel longitudinally through the diaphysis (as in the tibia). The latter property offers greater potential for morphology to reflect differences in force movement between weight classes due to biomechanical modification of overweight individuals. Three categories were formed based on body mass index (BMI): underweight (BMI < 17.5), normal weight (BMI between 19.5 and 24.5) and overweight (BMI < 26.5). To ensure each category was distinct, individuals with intermediate BMI scores were not included for analysis. To control for morphological differences due to ancestry and sex, only males of European ancestry were evaluated. To control for the effect of age on cross-sectional geometry, individuals in all three groups were age-matched to within one year, and age was included in all statistical analyses. The sample consisted of 184 individuals, 67 of whom were overweight, 59 normal weight, and 58 underweight.

After controlling for age, multivariate statistics show significant (p- *value* < 0.05) elongation of the ML dimension of the proximal and midshaft femur in overweight individuals, with t-tests confirming that ML dimensions are significantly large in this weight class (p-*value* < 0.05). These results suggest that femora of overweight individuals undergo abnormally high rates of sagittal stress. These findings correlate well with biomechanical gait analyses, which show that overweight individuals display significant increases in step width and hip abduction, disproportionately large ML ground reaction forces, and longer periods of stance when compared to normal weight controls. These activities, especially when coupled with movement of excess mass, could explain abnormal sagittal stress of the proximal femur.

In addition, size and shape variables were computed according to Mosimann and colleagues (Mosimann 1979; Darroch and Mosimann 1985); however, they were not log transformed. The ANOVA results show that BMI has a significant effect on overall ML size (p-*value* < 0.05). However, these same tests show no significant effect of BMI on bone shape. This suggests that increases in BMI are associated with increases in ML size, but do not appear to be associated with a change in shape.

As the prevalence of obesity in the American public continues to increase, so too does the need to estimate weight in forensic contexts. The implication that weight can indirectly alter bone shape has great potential to aid in efficient identification of the deceased, as obesity clearly affected how an individual appeared to others in life. Additionally, these findings can contribute to public health and outreach endeavors related to health implications of obesity.

Obesity, Bone Morphology, Biomechanics

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