Shape differences in the proximal femur of a cadaver sample based on different classifiers of obesity

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**Introduction**
- Increased proximal femur total area (TA) has been associated with obesity, as based on body mass index (BMI) (Moore, 2008).
- There are many critiques of BMI as a tool for identifying obesity, particularly that BMI may mask variation in body composition.
- Several alternate ways of identifying obesity also exist, but are based on soft tissue measurements.
- These measurements have not been investigated to determine how they affect proximal femoral geometry.

**Hypotheses**
- TA differences will exist between individuals of normal BMI (18-24.9) and overweight/obese BMI (25+).
- TA differences will be more pronounced when individuals are classified by body fat percentage (BF %), due to its inverse relationship with lean mass.
- Waist-hip ratio (WHR) will explain the most variation.
- Other cross-sectional properties will follow similar patterns to TA.

**Materials and Methods**
- 25 cadavers (13 male, 12 female) were obtained from the University of Missouri Gift of Body program.
  - Circumference measurements taken before dissection of neck, arm, forearm, thigh, calf, hip, and abdomen.
  - Intrapinnous distance taken during dissection.
  - Femoral measurements (length, head diameter, bicondylar breadth) were taken after dissection.
  - Right femur was preferred, but left femur was taken if required to avoid hip/knee replacements.
  - Femur was then sectioned at 80% and 50% of biomechanical length and photographed.
  - Cross-sectional properties were derived from photographs using Moment Macro (Ruff 2006)
- Total weights for individuals before embalming were not available, so weight was estimated from femoral head following Ruff et al. (1991)
- Cadavers were classified as obese or normal weight using three types of criteria:
  - WHR >0.9 for males and >0.85 for females
  - Body fat percentage >25% for men and >30% older women (Klatch & McArdle 1977)
  - Body Mass Index >30

**Classifications**
- Method of classifying individuals as obese dramatically affected the proportion of obese individuals.
  - 2/25 using BMI
  - 9/25 using WHR
  - 13/25 using BF%

**Total Area**
- The TA was significantly different (p = 0.019) at the proximal femur using BF%
- TA was not significant when classified using WHR (p = 0.346) or BMI (p = 0.431)

**Cortical Area**
- There is no significant difference in cortical area between any of the obesity classifications.

**Shape**
- Shape (I_{max}/I_{min}) was not significantly different between any of the obesity classifiers.

**Torsional Strength**
- Torsional strength (J) was significantly different (p = 0.041) at the proximal femur using BF%,
  - J was not significant with WHR or BMI

**Conclusions**
- Method of classifying individuals as obese dramatically affected the proportion of obese individuals.
  - This supports the assertion that BMI camouflages variation in BF% for normal-weight individuals.
- TA was significantly larger (p=0.019) at the proximal femur using BF%, but not for WHR or BMI.
  - This may be a factor of sample size, particularly for BMI where n=2.
  - This also suggests that soft-tissue waist breadth is not a contributing factor to biomechanical force.
- This project suggests that increased waist breadth is not the cause of increased TA, and that it may instead be related to body composition, specifically the relative amount of muscle mass versus fat.
- There were no differences in shape or cortical area between normal and obese individuals, regardless of classification.
- Torsional strength (J) was significantly increased (p=0.041) at the proximal femur using BF%, but not WHR or BMI.
  - This supports the results suggesting CA is similar, but TA is larger in obese individuals.

**Future Directions**
- Increase cadavers sample to better encompass high and low BMI individuals.
- Obtain sample with pre-embalming body masses.
- Focus sample size on increasing body fat % variation
- Investigate patterns in a non-elderly sample, particularly for females.
- Activity patterns also influence femoral morphology. Future research will examine the interaction of body fat percentage and different activity patterns on the proximal femur.

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**References**
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