Introduction

In the past two centuries, Americans have significantly increased in size and body weight with corresponding changes in skeletal size and shape (1-7). These observed changes have primarily been linked to changes in nutrition and over-nutrition, healthcare, and socioeconomic status, reduced physical activity, and reduced incidence of infectious diseases during early growth (2,8-10). Of interest to anthropologists is documenting these secular trends and understanding the effects of changes in stature and body weight on the human skeleton.

Aim: Examining the effect of obesity on secular trends in size and shape of the distal femur and proximal tibia.

Purpose:
1) Determined if there is secular change in the size and shape of the distal femur and proximal tibia.
2) To determine if there are significant differences in knee joint size and shape between individuals of normal body weight and obese individuals.
3) To determine if obesity is a possible cause for the secular change.

Materials

The sample consists of American White adult males and females (20-60 years of age) born in the 19th and 20th centuries from three skeletal collections:

- Robert J. Terry Collection, Smithsonian Institution, NMNH, Washington, DC (11)
- Texas State University Donated Skeletal Collection (TX State Collection), San Marcos, TX
- William M. Bass Donated Skeletal Collection (Bass Collection), University of Tennessee, Knoxville, TN (12)

The sample consists of 162 individuals and represents 83 normal weight, 60 obese individuals, and roughly equal numbers of males and females (Table 1). Body Mass Index was calculated for each individual.

Methods

Twenty-one measurements (ten from the femur and eleven from the tibia) representing the size and shape of the shaft and knee joint (13-15) were recorded. Three measurements were created for this study (16):

- Femur intercondylar tubercle distance
- Tibia intercondylar tubercle distance
- Tibia posterial epiphyseal thickness

Three measurements were created for this study (16):

- Femur epicondylar breadth
- Tibia epicondylar breadth
- Tibia posterior lateral epiphyseal thickness

Body Mass Index was calculated for each individual.

BMI = \frac{\text{mass (kg)}}{\text{height (m)}^2}

Normal Weight – BMI 18.5 to 24.9; Obese – BMI ≥ 30

Table 1: Sample Composition

<table>
<thead>
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<th>Sex</th>
<th>19th Century</th>
<th>20th Century</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>18</td>
<td>57</td>
<td>75</td>
</tr>
<tr>
<td>Female</td>
<td>46</td>
<td>82</td>
<td>128</td>
</tr>
<tr>
<td>Total</td>
<td>64</td>
<td>139</td>
<td>203</td>
</tr>
</tbody>
</table>

Comparison of Normal Weight and Obese Individuals: Significant differences were observed in the femoral and tibial midshaft diameters and a few measurements at the knee, primarily at the femoral mediodiandal condyle. The measurements that are significant are different between females (Figure 2) and males (Figure 3).

Results

Sexual Dimorphism: Significant results were seen in all measurements and shape ratios with the exception of body mass index, femoral midshaft shape, and tibial shaft shape at the nutrient foramen. Due to this, all subsequent analysis was performed on the sexes separately.

Secular Trend: Secular trends are observed for many of the measurements and shape ratios, including BMI, shaft dimensions, and knee dimensions, in females, males, and the pooled sexes (Table 2, Figure 1).

Table 2: Secular Trend Results

Discussion

Secular Trends:

Secular trends in femur and tibia length were expected since these trends have been documented in the American population previously (3,4,7). The femur and tibia shaft dimensions and shape were also expected to have significant results since the anteroposterior dimension is correlated with increased limb length (17,18). It is currently unknown what the causal factors are for the mediolateral change in the femoral shaft in females, but one possible factor is obesity.

At the knee joint, males are changing more, in both size and shape, than females, who are changing primarily in shape. An explanation for the difference between the sexes is that women exhibit a greater increase in BMI for this sample than males.

Comparison of Normal Weight and Obese Individuals: The significant results found for the femur and tibia midshafts support previous research that showed that the midshafts and dimensions in the mediolateral direction is increased with increased BMI (1,5,19). It is also possible that the anteroposterior dimension of the midshaft is affected by increased BMI, not just increased limb length as others have indicated (17,18).

The significant difference at the knee lies in the femoral mediodiandal condyle shape for females and the mediolateral breadth of the femoral condyle for males. There is no corresponding difference between normal weight and obese individuals on the tibial mediodiandal condyle for either sex. The reason for this lack of mirrored difference is unknown.

Previous researchers have demonstrated that obese individuals adopt their walking gait to redirect the torque placed on the knee to the ankle when compared with normal weight individuals. This may in part explain why there is a lack of significance results in the knee joint.

Correlation of Obesity with Secular Trend:

Based on the results, it is unclear whether or not obesity has a role to play in the secular trends observed at the knee. However, the results for the femoral and tibial midshafts do indicate that obesity is a causal factor in the trends observed at the midshafts.

Conclusion

This study aimed to determine whether or not secular trends are present in the articular surfaces of the knee joint, whether or not differences exist between normal weight and obese individuals at the knee joint, and whether or not the rise in obesity is a causal factor in the secular trends observed.

The results of this study certainly shows multiple secular trends occurring in the lower limb and that there are differences between normal weight and obese individuals. However, since there were few significant differences between normal weight and obese individuals, a correlation between the rise in obesity and the secular trends could not be confidently established for all results. More research needs to be conducted in order to determine the relationship between the relatively recent rise of obesity and secular changes in the skeleton.

References