An Analysis of Femoral Head Diameters as related to Coxa Magna and Symmetry in a Normal Population of 160 Cadaver Specimens

INTRODUCTION:

Coxa magna is a known sequelae of Perthes disease which has been defined in the literature as an asymmetric increase in femoral head diameter. It carries with it the prognosis of poor hip joint functionality and possible early osteoarthritis of the joint. The amount of asymmetry used to define the condition varies between papers with most in the range of 10-15%. This study hypothesized that the amount of symmetry between nonpathological femoral heads is very high and that the amount of difference between femoral heads of the degree of difference did not rely on the age, gender, height or weight of the specimen in question. Additionally if one were to extrapolate out the norm distribution of the differences between femoral heads, then the current guidelines for Coxa Magna would vastly exceed the possible extremes of the normal population. To date there is no large scale cadaver population studies that examine the difference between femoral heads with respect to population characteristics or pathology such as Coxa Magna.

METHODS:

The sample cadaver population was taken from the Hamann-Todd collection, a osteologic collection at the Cleveland Museum of Natural History of nearly 3000 disarticulated human skeletons gathered from the Cleveland in the early 20th century. To establish a representative sample population; the specimens were divided equally according to ethnicity, gender, and two specific age groups of 20-30 and 30-40 years old. Femurs that were deformed or abnormal due to trauma or osteoarthritic disease were excluded from the study. A total of 160 specimens were analyzed with four groups of 40 representing the combinations of gender and ethnicity: Caucasian males, Caucasian females, African American males, African American females. Each group of 40 was divided into two age subgroups, 20-30 years of age at death, 30-40 years of age.

The samples were digitally photographed in the anterior-posterior (AP) standardized position with a known length reference in order to mimic the AP radiographs that many of the literature studies on Coxa Magna base their measurements on. The images were analyzed using the ImageJ software (nih.gov) measurements were obtained from the photographs. The methodology has been described in previous papers. The best fit femoral diameter was measured with a tolerance within 1mm.

To determine the normal distribution of differences between femoral heads, the absolute difference and percent difference between left and right sides were calculated. Additionally the amount of difference between femur diameters was categorized into varying degrees: (Category 1: < 0.5mm difference, category 2: 0.5-1.0mm, category 3: 1.0-1.5mm, category 4: 1.5-2.0mm., category 5: >2.5mm difference).

Analysis of the femoral head diameters and percent differences were performed using linear regression to determine any association with age, ethnicity, height and weight of the cadaver. When applicable the mean femoral head diameter per individual cadaver was used for comparison. Univariate analysis was performed using ANOVA to determine differences across population characteristics. Chi-square analysis was used for comparing the categories of differences and population characteristics. Statistics were performed using Minitab 16.1 (Minitab Inc., State College, PA, USA). The study was powered to identify a statistically significant difference of 15% between groups.

RESULTS SECTION:

On comparison of the mean femoral head diameters, linear regression resulted in a association of mean diameter and gender (p = 0.01) with univariate analysis demonstrating that the mean femoral head diameters for men compared to women was larger overall (55.73 ± 4.28mm vs. 48.31 ± 3.14mm, p < 0.01). However, the percent difference in the left and right femoral head diameters did not show any correlation (p > 0.05) on linear regression nor on univariate analysis per gender (1.46 ± 1.32%, 1.74 ± 1.35%, p = 0.70). The normal distribution of the differences between left and right femoral diameters is demonstrated by the 95% confidence intervals of the percent difference in femoral heads which was [1.17, 1.76] for men and [1.44, 2.04] for women.

The analysis of the categories of femoral head diameter difference did not show correlation with any continuous variables such as age, weight, height or with the actual mean femoral head diameters (p > 0.05). Chi-square analysis showed that the categories were not correlated to gender, ethnicity or general height(p > 0.05). However, out of the entire sample group of 160 skeletons, roughly 68% of the femur samples fell within 1.0mm of symmetry, whereas only 7% had exceeded 2.5mm.

Figure 1: Frequency of samples in each category of femoral head difference.

DISCUSSION:

This results of this study demonstrated that regardless of the age, height, weight, gender or ethnicity of the specimen the percent difference between left and right diameters stayed consistent. This speaks to the great amount of natural symmetry between left and right femurs in the normal population. In addition the confidence interval of the percent differences between femoral heads were very tight, with even the 99.5% limit of either gender cohort reaching 5% difference between left and right. This either indicates that the current guidelines of Coxa Magna at 10-15% greatly reduce the chance of false positives and thus are sufficiently high to exclude normal variation or that conversely that the criteria for Coxa Magna may need to be lowered to prevent false negatives as the current guideline is well above two standard deviations of the mean.

The limitations of this study include the use of only one view of the femoral head diameter (anterior-posterior) and thus it assumes a corresponding natural sphericity to the femoral head in the population. Additionally the study made measurements on photographs of the samples which may introduce an amount of operator and measurement error into the equation.

SIGNIFICANCE:

This cadaver study critically analyses the dimension definition of Coxa Magna as well as confirms the natural symmetry between left and right femur that many clinical and scientific decisions are based upon.

REFERENCES: