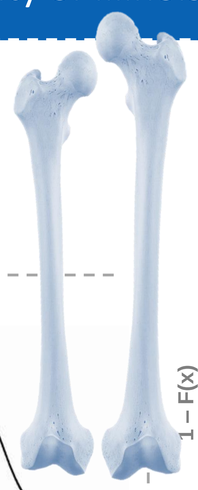
Differences in bilateral asymmetry of the femur between recent and archaeological human populations using multivariate measures

AMANDA B LEE [1] and LYLE W KONIGSBERG[1]
[1] Department of Anthropology, University of Illinois at Urbana-Champaign

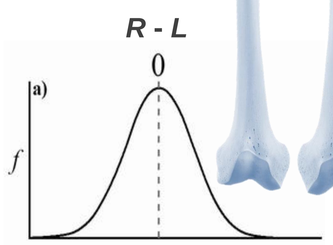
Introduction



This study aims to determine whether there are different levels of asymmetry in the femur between archaeological and recent human samples.

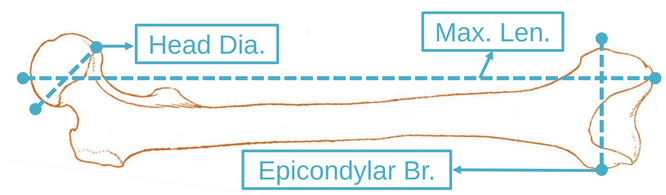
Methods

2 patterns



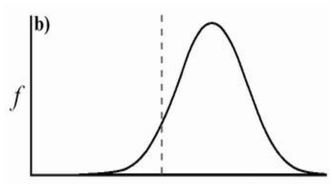
Fluctuating Asymmetry (FA):
Differences between sides have a non-zero variance

- Asymmetry = right minus left to create a vector of three measurements



- Zhivotovsky (1992) generalized index of FA (GFA)
- Generate p-value using **randomization**: The observed F-ratio (GFA1/GFA2) is compared to the distribution of ratios obtained under 10,000 random permutations of the original data matrix
- Generate p-value between GFAs of two samples

Directional Asymmetry (DA):
One side is generally larger than the other



- Asymmetry = right minus left measurements
- Find Mahalanobis distance between two samples' vectors of means
- Generate p-value using randomization (10,000 iterations)

Sample

1. Forensic Data Bank (Recent)
➢ n=679

2. Goldman Osteometric Data Set (Archaeological)
➢ n=1,256

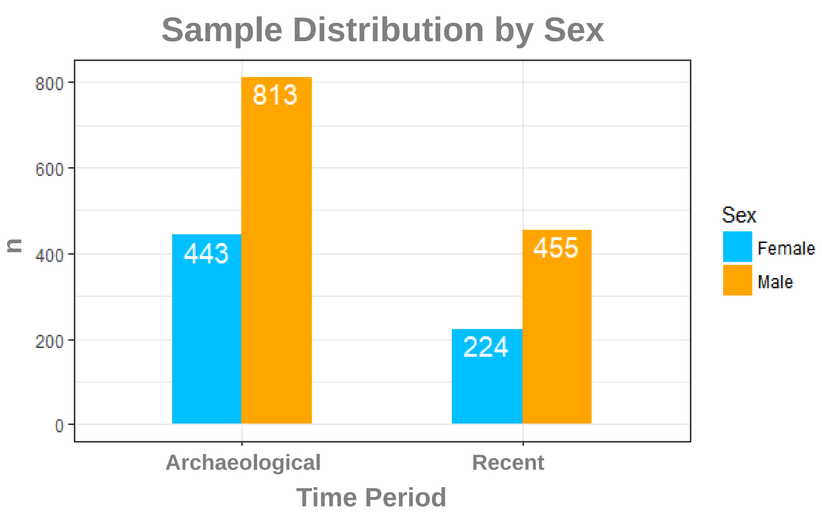


Figure 1. Distribution of the samples by sex

Results

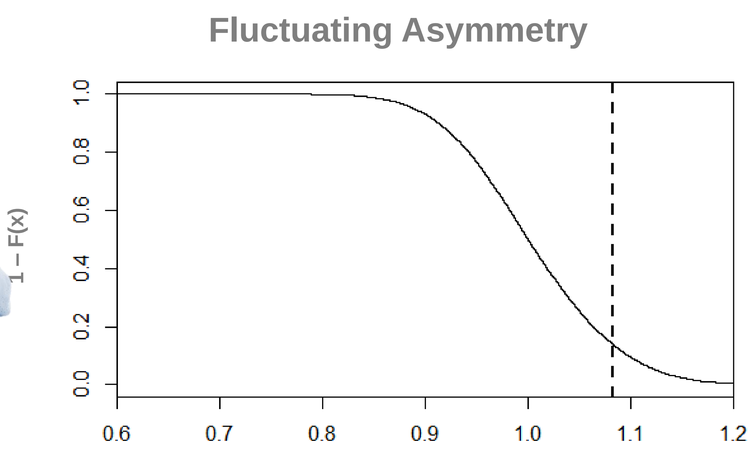


Figure 2. One minus the distribution function plot of ratios of GFAS, with dashed line marking the true ratio between the samples

- One minus the distribution function plot shows that beginning at a ratio of 0.85, the probability of getting a larger ratio of GFAs sharply declines (*Fig. 2*)

p (Zhivotovsky) = **0.022**
p (randomized) = **0.142**

- Zhivotovsky's *p*-value < 0.05: the two samples have significantly different levels of FA
- *However, this p-value should only be used if the data are multivariate normal*

Mardia test *p*-value <<0.0001

- A Mardia test shows the data are not multivariate normal
- Interpret the randomized *p,* which does not require multivariate normality: **the levels of FA between both samples are not significantly different**

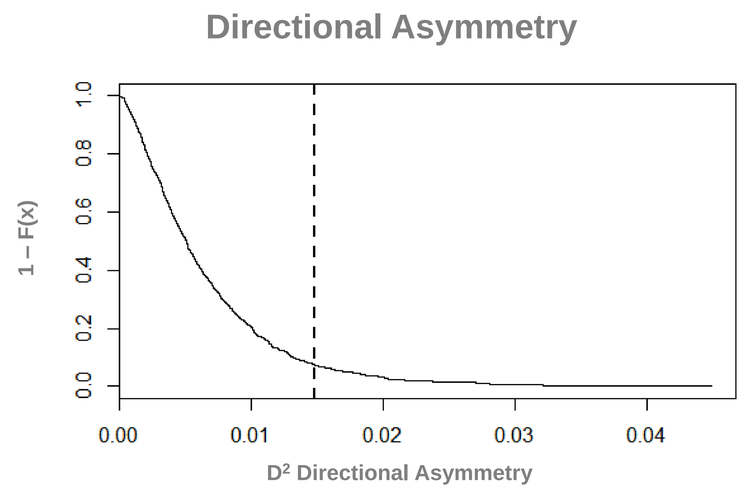


Figure 3. One minus the distribution function plot of D^2, with a dashed line marking the actual D^2 between the two samples

- Survival plot shows a very low probability of getting a D2 higher than 0.019 (*Fig. 3*)

p = **0.075**

- *p* > 0.05: the archaeological and recent samples have **similar levels of directional asymmetry**

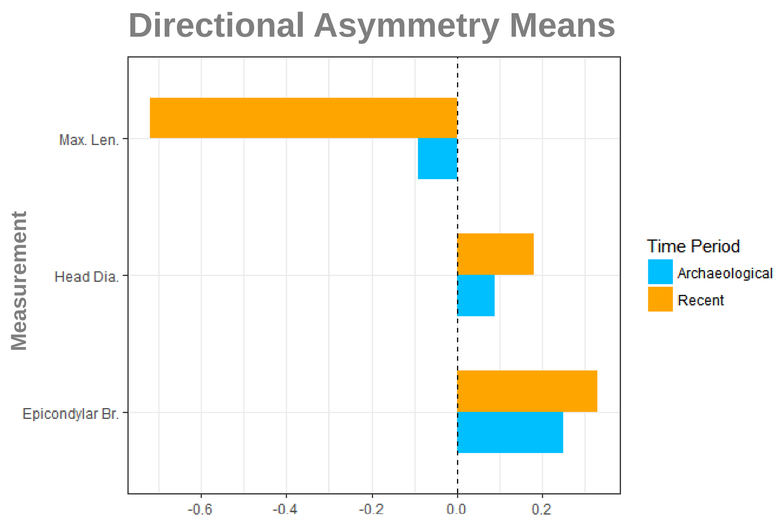


Figure 4. Plot of DA means in each sample for every measurement

	Recent	Archaeological
Max. Len.	-0.72 mm	-0.09 mm
Epicondylar Br.	0.33 mm	0.25 mm
Head Dia.	0.18 mm	0.09 mm

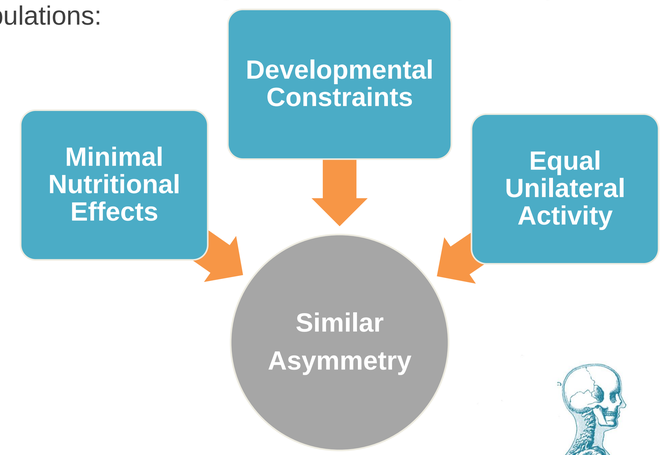
Table 1. DA means in each sample for every measurement

- All measurements are asymmetrical in the same direction
- Note the crossed asymmetry in Max Len. (*Fig. 4*)

Discussion and Conclusion

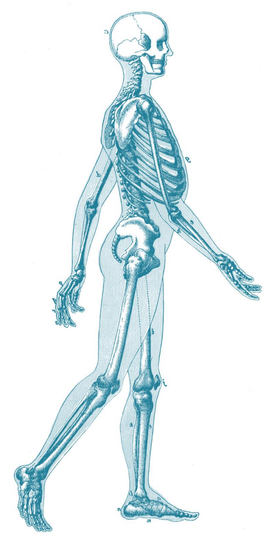
The archaeological and recent samples have similar levels of bilateral, multivariate asymmetry.

Bilateral asymmetry has been used to assess factors such as **nutritional health**, **developmental stability**, and **activity**. Potential factors driving similar levels of asymmetry between populations:



These results have implications for:

- Canalization of different bones
- Target Phenotypes
- Evolutionary Anatomy
- Mechanical Constraints
- Bone Remodeling
- Multivariate Asymmetry Studies



Future Directions

- ➢ Test all limb bones
- ➢ Compare different populations
- ➢ Test different combinations of measurements
- ➢ Analyze different measures of asymmetry

Thank you to Drs. Stephen Ousley and Richard Jantz for granting us access to the Forensic Data Bank data