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| **Activity 1.2.4: Height Estimation from Bone** |

Introduction

In Project 1.2.3, you used the length of long bones, particularly the femur and the humerus, to predict height of an individual. You used these formulas on the skeletal remains of our missing person. Now you are going to try them on your own bones.

In the 1950’s, anthropologist Mildred Trotter measured the maximum length of the leg and arm bones of the skeletons of over 5,000 individuals of whom some were soldiers during World War II and the Korean War. Dr. Trotter developed mathematical formulas that correlated their body height in life with the length of their arm and leg bones. Since she looked at such a large sample of bones, she was able to come up with equations for each bone, broken down by gender and ethnicity. Forensic anthropologists have worked to advance the research of Dr. Trotter and have created new methods for estimating stature from bones; however, her work is still highly respected and widely used by professionals.

In this activity, you will test Dr. Trotter’s formulas and use the length of your long bones to estimate your own height. As a class, you will determine which bone measurement seems to best approximate height. You will then explore how scientists can come up with the equations you have been working with in the last two projects by using class data to generate and test your *own* equation to predict height.

Equipment

* Tape measure or string
* Ruler or meter stick
* Anatomy in Clay® Maniken®
* Laboratory journal
* Graph paper (optional)
* Calculator
* Computer with graphing software (optional)

Procedure

Part I: PREDICTING HEIGHT FROM BONE USING FORMULAS SPECIFIC TO GENDER

1. Using a tape measure or a piece of string, measure your height in centimeters. If you are using a piece of string, tie a knot about one to two inches from the end of the strand. Throughout the activity, this knot will establish a starting point for each measurement taken with this string. Repeat this measurement for your partner. **Record all of your measurements and your calculations (including formulas) for the entire activity in your laboratory journal.**

* Actual height = **177.8cm**

1. Find the femur on your Maniken®. Note where the bone begins and ends.
2. Measure the length of your femur in centimeters using a tape measure or a piece of string. Measure from the top of your leg when the bone goes into your pelvis to your knee. Hold the string up to a meter stick or ruler to obtain your measurement in centimeters.

* Maximum Length of the Femur (MLF) = **44.45 cm**

1. To predict your height, use the formula found below. This formula is a generic formula based on only gender.

* Male: (2.32 x MLF) + 65.53 cm ± 3.94 cm
* Female: (2.47 x MLF) + 54.10 cm ± 3.72 cm

1. Compare your predicted value to your actual height. How close were you to the actual value? Be sure to add or subtract the error value before calculating a difference.

* Height Difference (using Femur) = **164.714-172.594cm**

1. Locate the humerus on your Maniken®. Note where the bone begins and ends.
2. Measure the length of your humerus by using the length of your arm from the shoulder joint to the medial epicondyle (bump) of your elbow.

* Maximum Length of the Humerus (MLH) = **35.56 cm**

1. To predict your height, use the formula found below.

* Male: (2.97 x MLH) + 73.5 cm ± 3.94 cm
* Female: (3.14 x MLH) + 65 cm ± 3.72 cm

1. Compare your predicted value to your actual height. How close were you to the actual value? Be sure to add or subtract the error value before calculating a difference.

* Height Difference (using Humerus) = 175.173 -183.05 cm

1. Locate the radius on your Maniken®. The radius is the bone on the thumb side of your forearm.
2. Measure the length of the radius by using the length of your arm from the wrist bone on the thumb side of the forearm to the elbow.

* Maximum Length of the Radius (MLR) = **27.21cm**

1. To predict your height, use the formula found below.

* Male: (3.7 x MLR) + 80.5 cm ± 3.94 cm
* Female: (3.9 x MLR) + 73.41 cm ± 3.72 cm

1. Compare your predicted value to your actual height. How close were you to the actual value? Be sure to add or subtract the error value before calculating a difference.

* Height Difference (using Radius) =**177.237 – 185.117 cm**

1. Compare your data with at least three other groups. Complete Conclusion Questions #1.

Part II: PREDICTING HEIGHT FROM BONE USING FORMULAS SPECIFIC TO GENDER AND ETHNIC ORIGIN.

You will now compare your results in Part I to predictions of height using equations specific to both gender and ancestry. Choose the ethnic group to which you identify and use the specific equation. If you identify with more than one group, compute your height using each formula and compare the results. If you do not identify with any of the groups listed below, simply choose any of the equations. Experiment with the different equations and explore their predictive power.

1. Use the value you measured for MLF in Part I and the formulas found below to predict height. The formulas are broken down by both gender and ethnic origin. **NOTE**: *There are no separate formulae for Asian or Hispanic females. If you are a woman of Asian or Hispanic origins, use the male equation for your racial group and multiply the final result by 0.92 (the proportion that females are of male size) to approximate height.*

* Black Male: (2.11 x MLF) + 70.35 cm ± 3.94 cm
* Black Female: (2.28 x MLF) + 59.76 cm ± 3.41 cm
* White Male: (2.38 x MLF) + 61.41 cm ± 3.27 cm
* White Female: (2.47 x MLF) + 54.74 cm ± 3.72 cm
* Asian Male : (2.15 x MLF) + 72.57 cm ± 3.80 cm
* Hispanic Male: (2.44 x MLF) + 58.67 cm ± 2.99 cm

1. Compare your predicted value to your actual height. How close were you to the actual value? Be sure to add or subtract the error value before calculating a difference.

* Height Difference (using Femur) = **164.34 -171.94 cm**

1. Use the value you measured for MLH in Part I and the formulas found below to predict height. The formulas are broken down by both gender and race. **NOTE**: *There are no separate formulae for Asian or Hispanic females. If you a woman of Asian or Hispanic origins, use the male equation for your racial group and multiply the final result by 0.92 (the proportion that females are of male size) to approximate height.*

* Black Male: (3.26 x MLH) + 62.10 cm ± 4.43 cm
* Black Female: (3.08 x MLH) + 64.67 cm ± 4.25 cm
* White Male: (3.08 x MLH) + 70.45 cm ± 4.05 cm
* White Female: (3.36 x MLH) + 57.97 cm ± 4.45 cm
* Asian Male: (2.68 x MLH) + 83.19 cm ± 4.25 cm
* Hispanic Male: (2.92 x MLH) + 73.94 cm ± 4.24 cm

1. Compare your predicted value to your actual height. How close were you to the actual value? Be sure to add or subtract the error value before calculating a difference.

* Height Difference (using humerus) = **174.24 - 182.74 cm**

1. Compare your predicted values for height from Part I and Part II. Answer Conclusion questions #2 and #3.

Part III: DERIVING YOUR OWN FORMULA

The length of the long bones and associated height are described by a linear equation, meaning that if you were to graph, for a group of individuals, the length of a particular long bone on the x-axis and their heights on the y-axis, the points on the graph should generally fall on a straight line. The equation of the line that is created can then be used to predict height from bone. You will now work with your partner to derive an equation for predicting height using the tibia, your shinbone.

1. Locate the tibia on your Maniken®. Note where the bone begins and ends. You will use measurements of the tibia to determine a formula for estimating height.
2. Measure the length of your tibia by using the length of your leg from the knee to the ankle.
3. Write your height in cm and your Maximum Length of the Tibia (MLT) on the class data table on the board.
4. Create an equation that is specific to gender. With your partner, decide if you are deriving an equation for males or females and then choose at least seven appropriate data points from the class data table.
5. Graph your data set using Microsoft Excel or by hand. Your teacher will provide you with specific directions on coming up with the equation of your line.

* Line Equation: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Once you have generated an equation of your line, try out your equation on at least two classmates not included in your data set. Input their MLT into your equation and compute height.
2. Compare your predicted value to the actual height of your classmates. How close were you to the actual value?

* Height Difference (using Tibia)- Student #1 = \_\_\_\_\_\_\_\_\_\_ cm
* Height Difference (using Tibia)- Student #2 = \_\_\_\_\_\_\_\_\_\_ cm

1. Compare equations with the rest of the class and discuss which equation seemed to do the best job estimating height.
2. Answer the remaining conclusion questions.

Conclusion

1. Measurements from which bone -- the femur, the radius or the humerus -- seemed to best approximate height? Why do you think this is?
2. Which approach seemed to give values closer to your actual height? The formula using only gender or the formula using both ethnicity and gender? Why do you think this is the case?
3. What are the benefits and limitations of using ethnic origins as a factor in the analysis of bones?
4. Why do you think some equations did a better job predicting height than others? What are some of the sources of error in your analysis?
5. How will the age of the sample population affect your results? Suggest a reason why the equations generated for males in the classroom may not be as accurate as they would be if we took these measurements ten years from now.
6. Forensic anthropologists take into account a person’s age when calculating stature. Why do you think most forensic anthropology textbooks also describe adjustments to height calculations for persons over 45?
7. An anthropologist finds a 29-cm humerus in a remote site at a mountain resort. There was a missing person’s report for a woman (approx. 5’5’’ tall) placed just about a week ago. Could this bone possibly belong to her? Why or why not?