Project Overview

Specific Aims

1. Develop a prediction model for *body build weight*
2. Develop a model to predict gender using skeletal body measures

Data Sources

Body girth measurements and skeletal diameter measurements, as well as age, weight, height and gender, are given for 507 physically active adults - 247 men and 260 women - most of whom were within normal weight range. These were primarily individuals in their twenties and early thirties, with a scattering of older men and women, all physically active (several hours of exercise a week). The initial measurements were taken at a university and at a military, postgraduate school. Additional measurements were performed by technicians in dozens of health and fitness clubs. This is a convenience sample. Subjects were not randomly sampled from their respective populations and thus inference, based on statistical design principles, cannot be made to these populations. However, these data may be used to explore predictive models.

Data Description

Nine skeletal measurements (diameter measurements) were included in the study. A broad-blade anthropometer was used to measure the biacromial, biiliac, bitrochanteric, and chest diameters along the trunk and a smaller version of this anthropometer was used for the four skeletal measurements along the limbs - the elbow, wrist, knee, and ankle diameters. For the chest depth measurement, the depth attachment of the anthropometer was activated. Firm pressure was applied at each bodily site to compress the flesh and obtain "bone to bone" measurements. It should be kept in mind that at the time of physical maturation, the nine skeletal sites, like height, have generally attained their maximum size.

Regarding skeletal measurements, Behnke and Wilmore (1974, p. 39), note:

> The diameters of the body can be measured rather accurately and with a high degree of reliability because of the nature of the measurement. In almost all instances, the measurements are made with a bone-to-bone contact, i.e., the soft tissue is compressed... . It is important to use the fingers of both hands to locate the precise bony landmarks, placing the blade of the anthropometer immediately over the identified landmark.

Twelve girth (or circumference) measurements are used in the study. They, in contrast to skeletal (diameter) measurements, are not fixed over time except for the three "bony" girths of the wrist, knee, and ankle, which remain relatively constant over the life span. The other nine girths, the changeable ones, were measured at these sites: shoulder, chest, waist, navel, hip, thigh, bicep, forearm, and calf. A plastic tape was used with uniform compression and horizontally.

Specific Aim 1

Aim 1.a is to determine how well weight can be predicted from body build measures for a dataset of physically active young individuals within the normal weight range.

The best regression equation for weight from these variables becomes the group's equation for body build weight, which is based on measurements that are largely constant over the adult years and will not be affected by changes in body fat or muscle mass. Body build weight could thus serve as a benchmark for maintaining a young adult profile into old age.

Aim 1b is to evaluate body mass index (BMI) for this population and its utility with respect to body build weight.

According to the National Institutes of Health (www.nih.gov)

> In the majority of epidemiologic studies, mortality begins to increase with BMIs above 25 kg/m^2. The increase in mortality generally tends to be modest until a BMI of 30 kg/m^2 is reached. For persons with a BMI of 30 kg/m^2 or above, mortality rates from all causes, and especially from cardiovascular disease, are generally increased by 50 to 100 percent above that of persons with BMIs in the range of 20 to 25 kg/m^2.

The dataset offers some examples of where a BMI below 20 kg/m^2 or above 25 kg/m^2 does not reflect underweight or overweight in terms of body build weight, thus raising questions about the value of this obesity index for individuals whose body build is smaller or larger than is typical for their height.

Specific Aim 2

Aim 2 is to develop, validate, and evaluate a parsimonious model to discriminate gender for skeletal remains of adults.

Forensic scientists can fairly accurately determine the gender of adults given their skeletal remains; apparently an accuracy rate of 90% or more is possible if the skeletal remains are complete (see Joyce and Stover 1991 or Wingate 1992, for instance). Most useful to this determination of gender are the pelvis and the skull (see, for example, Nickell and Fischer 1999; Innes 2000; Owen 2000). As male and female skeletons show very little difference before puberty, gender determination from a child’s skeleton is extremely difficult.

The skeletal measurements discussed above, as well as height - all of which were performed on living individuals - are virtually identical with measurements that would be taken on the skeletons of these individuals (recall, from the discussion above, measurements are made essentially with bone-to-bone contact, the soft tissues being compressed). Consequently, the ten variables in our dataset that can be measured on a skeleton: biacromial diameter, biiliac diameter (or "pelvic breadth"), bitrochanteric diameter, chest depth, chest diameter, elbow diameter, wrist diameter, knee diameter, ankle diameter, and height can contribute to the forensic science classification problem of determining gender. The importance of the pelvis in gender determination suggests that we include biiliac diameter ("pelvic breadth") as a classifier variable, but this particular pelvic measurement proves to be ill-suited for the purpose. In fact, it is the skeletal variable in our dataset with the lowest predictive power for gender.

The Data

The data are found in a fixed-format text file: body.dat.txt. A key to data layout and is given below.

Columns	Variable
	Skeletal Measurements: All are measured in centimeters (cm).
1 – 4	Biacromial diameter
6 – 9	Biiliac diameter, or "pelvic breadth"
11 – 14	Bitrochanteric diameter
16 – 19	Chest depth between spine and sternum at nipple level, mid-expiration
21 – 24	Chest diameter at nipple level, mid-expiration
26 – 29	Elbow diameter, sum of two elbows
31 – 34	Wrist diameter, sum of two wrists
36 – 39	Knee diameter, sum of two knees
41 – 44	Ankle diameter, sum of two ankles
	Girth Measurements: All are measured in centimeters (cm).
46 – 50	Shoulder girth over deltoid muscles
52 – 56	Chest girth, nipple line in males and just above breast tissue in females, mid-expiration
58 – 62	Waist girth, narrowest part of torso below the rib cage, average of contracted and relaxed position
64 – 68	Navel (or "Abdominal") girth at umbilicus and iliac crest, iliac crest as a landmark
70 – 74	Hip girth at level of bitrochanteric diameter
76 – 79	Thigh girth below gluteal fold, average of right and left girths
81 – 84	Bicep girth, flexed, average of right and left girths
86 – 89	Forearm girth, extended, palm up, average of right and left girths
91 – 94	Knee girth over patella, slightly flexed position, average of right and left girths
96 – 99	Calf maximum girth, average of right and left girths
101 – 104	Ankle minimum girth, average of right and left girths
106 – 109	Wrist minimum girth, average of right and left girths
	Other Measurements:
111 – 114	Age (years)
116 – 120	Weight (kg)
122 – 126	Height (cm)
128	Gender (1 - male, 0 - female)

References

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Innes, B. (2000), *Bodies of Evidence: The Fascinating World of Forensic Science and How it Helped Solve More Than 100 True Crimes*, Pleasantville, NY: Reader's Digest Association, pp. 71-72.

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Nickell, J., and Fischer, J. F. (1999), *Crime Scene: Methods of Forensic Detection*, Lexington, KY: The University Press of Kentucky.
Owen, D. (2000), *Hidden Evidence: Forty True Crimes and How Forensic Science Helped Solve Them*, Buffalo, NY: Firefly Books, p. 48.
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