Stature Estimation

1.0 Principle, Spirit and Intent

Stature estimation is one of several biological parameters that may be usefully compared with antemortem records to include or exclude possible identifications of missing persons. Stature estimation is made possible by the relationship of skeletal dimensions with living height. Skeletal remains will be analyzed in a reliable and systematic manner for the purpose of estimating stature using appropriate techniques and the stature estimation process documented.

2.0 Purpose and Scope

These guidelines outline recommended approaches for estimating adult stature from skeletal elements or mostly skeletonized remains. Practitioners of forensic anthropology should implement these guidelines to the extent applicable, practical and appropriate. In the absence of specific guidelines or procedures, the principle, spirit and intent should be met.

3 .0 Approaches

Stature is usually estimated from the skeleton in one of two ways: 1) measuring all bones constituting the components of stature, summing those measurements and correcting for the missing soft tissue, or 2) employing a regression formula with the measurement of a complete bone. Other methods include employing incomplete limb bones, non-limb bones and alternative statistical methods. In selecting the method to be used, consideration of the individual's population, sex and temporal cohort is warranted. Additionally the method chosen is dependent on the presence and condition of the skeletal remains. Alternate statistical approaches (e.g., maximum likelihood estimation) exist to estimate stature. Appreciation of the statistical foundations of these approaches provides an understanding of the advantages and limitations to the various methods.

4.0 Best Practices

If complete remains are present, either the anatomical or regression methods should be used.

4.1 Anatomical Method (Also known as Complete Skeleton Method)

When using the entire skeleton, all of the skeletal elements constituting stature are measured, those measurements are summed, and a soft tissue "correction" is added to that sum. Alternatively, the sum of skeletal elements is employed in a regression formula. Instruments appropriate to the method should be employed.

Measurements consist of cranial height, heights of vertebrae bodies and sacral segment, femoral and tibia lengths, and height of the tarsals. Measurement definitions differ depending on the standard being used. All of these measurements are summed, and then one of two approaches employed. In the first approach, a soft-tissue figure is added based on the sum. This additional soft-tissue figure is claimed to be the same, regardless of sex or ancestry, but differs depending on the sum of skeletal element height measurements. In the second approach, a regression formula is applied employing the skeletal element sum.

Advantages of this method are that it can be employed regardless of the ancestry or sex of the individual. In addition, whole skeleton stature estimation should be more accurate than other techniques, especially when there are anomalous numbers of vertebrae. Moreover if the individual has unusual proportions (e.g., long trunk and short limbs), the anatomical method should provide a more accurate estimation of stature than alternate approaches.

Disadvantages of the technique are that it requires complete elements and a relatively complete skeleton. In addition, the numerous measurements required to estimate stature of a complete skeleton should require more time to collect.

4.2 Complete Limb Bones (Also known as the Mathematical Method or Regression Approach)
This approach requires measuring a limb bone length or bone lengths, selecting the most appropriate regression formula by sex and ancestry, inserting the measurement into the formula, and calculating the estimated stature.

Instruments and measurements appropriate for the method are employed. For most standards, the limb bone measurements are usually maximum lengths. In addition to formulae for individual limb bones, there are also regression formulae for multiple bones. In stature estimation using multiple bones, lengths of two or more bones are added and that sum employed in the formula.

A variety of formulae are available by sex for a number of populations. For accurate stature estimation, formulae from the most similar population, the same sex and temporal cohort should be selected.

After controlling for sex, ancestry and temporal cohort, the best formula is the one with the smallest prediction interval. The formula with the smallest standard error usually employs an element of the lower limb or combined elements including the lower limb bones. Whatever the element or elements—lower limb bones or not—the formula with the smallest prediction interval should be the most accurate and precise, and should be employed in the stature estimation.

A prediction interval should be reported with the estimated stature. To accommodate the range of variation, the 90 percent or 95 percent prediction intervals are generally employed.

5.0 Next-Best Approaches
When complete skeletons or whole limb bones are not available or external factors require altering best practices, other means of estimating stature may be employed. Keep in mind, however, that the precision and accuracy of these alternative methods may be less than those approaches presented in the previous section.

5.1 Fragmentary Limb Bones
Fragmentary limb bones may be used in regression formulae to estimate stature. Some of these methods require estimating bone length and then estimating stature based on the estimated bone length, thus compounding the error present in the estimation. Other techniques employing

fragmentary remains estimate stature directly from the fragment, without requiring the second step of the previous method.

5.2 Non-Limb Bones
Non-limb bones (e.g., skulls, innominates, and bones of the hands or feet) may also be used to estimate stature, and in combinations with limb bones may be as accurate as other approaches.

6.0 Unacceptable Practices
6.1 Trotter's tibia measurement apparently excluded the medial malleolus (Trotter and Gleser 1952, Trotter 1970), although she reported her measurement included the medial malleolus. If Trotter's formulae using these tibia measurements are employed, adjustments should be made.

6.2 For the regression approach, it is inappropriate to report a point estimation alone. Include the associated prediction interval.

6.3 It is inappropriate to report a "range" for a stature estimation based on a regression formula. Statistically speaking, range is the difference between a variable's minimum and maximum observed values. "Interval" is a more appropriate term.

6.4 It is inappropriate to utilize several stature estimation formulae and then average those estimations to produce a single estimation. This approach reduces the accuracy of the estimation and is unacceptable. The single formula with the smallest standard error should be used and its results presented, not an average of estimations.

6.5 When estimating stature from a fragmentary bone length, it is inappropriate to employ the estimated mean bone length in a whole bone stature regression formula without including the additional error such an approach requires. Omitting either error factor produces an unrealistically small estimation of error in living stature.

7.0 Additional Considerations
In addition to the variation inherent in these estimations, the following issues should be considered when estimating stature.

7.1 Age may affect the person's living stature. Stature decreases among middle-aged and older adults. If an accurate and recent antemortem stature measurement is available for a missing middle-aged or older adult, then subtractions from maximal estimate stature may be warranted.

7.2 Reliability of antemortem stature records is often suspect, especially when those records are self-reported. If self-reported antemortem stature records are the only ones available for comparison, then maximal height (i.e., without age-related reductions) estimations or formulae based on self-reported antemortem stature should be considered.

7.3 Some stature estimation techniques are based on samples using cadaver length, not living stature. Depending on the manner the cadaver was measured and adjustments in the techniques to approximate living stature, the stature estimation may be inaccurate.

7.4 A small portion of individuals fall outside the typical stature interval for the population (e.g., particularly short and tall persons), and the estimation of their statures may be less accurate than those with more typical statures. In addition, pathological conditions may adversely affect stature estimation.

7.5 When standards are not available for a target population, special caution should be used when estimating stature.

7.6 The paucity of research related to estimating statures of subadults makes these estimations suspect.

8.0 References Cited

Trotter, Mildred, and Goldine C. Gleser
1952 Estimation of Stature from Long Bones of American Whites and Negroes. American Journal of Physical Anthropology 10:463-514.

Trotter, Mildred
1970 Estimation of Stature from Intact Long Limb Bones. IN T.D. Stewart (ed.) Personal Identification in Mass Disasters, pp. 71-84. Smithsonian Institution, National Museum of Natural History, Washington, DC.