

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 in the case of conflicting procedures, the principle, spirit and intent should be met.

3.0 General Principles

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. Forensic anthropologists should be cognizant that living stature (*i.e.*, missing person's recorded height) may be derived from various sources including self-reported stature, family remembrance, or direct measurement.

4.0 Best Practices

If complete remains are present, either the anatomical or regression methods should be used. The measurement guidelines for the chosen technique should be followed. 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 including the use of fragmentary limb bones and non-limb bones. The precision and accuracy of these alternative methods may be less than those approaches presented in the previous section. Additional adjustments to all methods should also be considered where appropriate.

4.1 Anatomical Method (Also known as Complete Skeleton Method)

The anatomical method should provide the most accurate estimate of an individual's living height. Use of the anatomical method is acceptable when skeletal elements constituting stature are available and minimally damaged. Its use is recommended when the ancestry and sex of the individual cannot be estimated, there are an anomalous number of vertebrae or the individual's limb bones appear to be atypical in length.

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. In addition, the type of stature (e.g., self-reported vs. direct measurement) to be estimated should be considered for identification comparisons.

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.

4.3 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.

4.4 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.

4.5 Considerations and Adjustments

In addition to the variation inherent in the above methods, various other factors and adjustments should be considered when estimating stature, including:

Stature decreases with advancing adult age. The anatomical method will provide the most accurate estimate of true height at the time of death. Regression methods estimate a maximum living height and may not include stature reduction associated with advancing adult age. If regression methods are reported then it should be with the understanding that they may provide an overestimation of the actual height at death. While age correction methods exist to account for stature loss with age, their application is problematic.

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.

When using regression methods, some individuals may 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.

Pathological conditions may adversely affect stature estimation.

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

Estimating stature of subadults should be done with caution. The paucity of research related to estimating statures of subadults makes these estimations suspect.

5.0 Unacceptable Practices

The following practices are considered unacceptable and should be avoided when estimating stature:

- The use of Trotter's formulae using tibia measurements without making proper adjustments. Trotter's tibia measurement apparently excluded the medial malleolus

(Trotter and Gleser 1952, Trotter 1970), although she reported her measurement included the medial malleolus.

- Reporting a point estimation alone when the regression approach is used. Include an explicit prediction interval.
- Reporting 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.
- Using multiple stature estimation formulae and then averaging 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.
- Using the estimated mean bone length in a whole bone stature regression formula when estimating stature from a fragmentary bone length, without including the additional error such an approach requires. Omitting either error factor produces an unrealistically small estimation of error in living stature.

6.0 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.