H12 Estimation of Living Stature From Selected Anthropometric (Soft Tissue) Measurements: How do These Compare With Osteometric (Skeletal) Measurements?

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The goal of this presentation is to provide research results pertaining to the estimation of living stature from anthropometric measurements. The research compares the accuracy of models using soft tissue measurements to models using skeletal measurements. The use of soft tissue measurements would be of particular utility when working with dismembered bodies, but the results indicate that it is worth the added time and effort to use skeletal measurements when feasible.

This presentation will impact the forensic community and/or humanity by assisting forensic anthropologists working in mass fatality incidents and dismemberment cases.

Forensic anthropologists play an integral part in mass fatality resolution, especially in the triage and analysis of fragmentary human remains. Body dismemberment is a common occurrence in traumatic events such as aircraft crashes. Critical anthropological information will include body part identification (perhaps even determining human vs. non-human), recognition of commingling, documentation of trauma, and assessment of the biological profile (age, race/ancestry, sex, and stature).

Estimation of living stature has obvious utility in the identification process, especially when individuals are observed to be particularly tall or short in comparison to their associated population. Typically, anthropologists estimate stature from the measurement of long bone length. As emergency response to a mass fatality is generally immediate, the presence of soft tissue on the human remains necessitates dissection to expose skeletal landmarks for measurement. As part of this research, a test was performed to observe the accuracy of regression formulae derived from standard anthropometric (i.e., soft tissue) data compared to osteometric (i.e., skeletal) data. The goal was to determine whether anthropometric measurements could be used in place of osteometric measurements, which would remove the added time and effort associated with dissection when working with dismembered remains.

Medical personnel have used anthropometric measurements to estimate stature of the living (particularly the elderly and disabled) who are not able to stand erect. High correlations are cited (e.g., Cheng et al 2001) but most regression equations use age as a variable in the formulae. Since one of the goals of a forensic analysis during a mass fatality is identification, age is unknown and most of the published equations from the health literature are not appropriate.

Using National Health and Nutrition Examination Survey (NHANES) data from 1998-2002 it was possible to construct anthropometric regression equations from a large sample of individuals. Regression formulae were derived from the NHANES data based on age, race/ancestry, and sex. The available anthropometric variables included Standing Height, Upper Arm Length, and Upper Leg Length. Values for the limb portions were recorded to the nearest 0.1 centimeter using a measuring tape. From this data set, a sample of White and Black males between the ages of 18 and 50 were selected (n=3353). The strength of correlation between these variables was compared with those presented by Trotter and Gleser (1958) for skeletal measurements of White and Black males using the Maximum Length of the Humerus and the Maximum Length of the Femur.

It was found that the correlation between stature and the selected skeletal measurements is higher than the correlation seen for the soft tissue measurements (Tables 1-3). It was hypothesized that the lower correlation between the anthropometric data and stature may be related to measurement bias. For example, there is certain to be individual variation of soft tissue thickness (e.g., excessive fat) that would not be related to height and may skew measurement accuracy. In order to test this assumption, Body Mass Index (BMI) was factored into the anthropometric equations. BMI proved to be a significant contributor to the regression equations. Individuals with a BMI value over 25 were removed from the sample and the correlations were re-calculated. The reduced BMI samples show slightly higher correlations as compared to the full samples (Tables 1 and 2). Correlations with standing height improved with the removal of individuals with high BMI scores (>25).

Table 1: Correlation of Upper Arm Length with Standing Height in 18-50 Year Old Males (NHANES data)

White		Black	
All (n=1076) 0.671	BMI<25 (n=425) 0.723	All (n=604) 0.668	BMI<25 (n=297) 0.677

Table 2: Correlation of Upper Leg Length with Standing Height in 18-50 Year Old Males (NHANES data)

White		Black	
All (n=1073) 0.623	BMI<25 (n=425) 0.629	All (n=600) 0.651	BMI<25 (n=297) 0.703

Table 3: Correlation of Humerus and Femur with Standing Height in 18-46 Year Old Males from the Korean War (Trotter and Gleser 1958)

	White	Black
Humerus*	0.733	0.705
Femur*	0.803	0.807

*Values represent the right side only

The regression formulae calculated from the NHANES data for anthropometric measurements are presented in Table 4. Although it was found that a reasonable correlation exists between standard anthropometric measurements and living stature, it is not to the same degree as with skeletal measurements. While an improvement in the anthropometric models was found when BMI was factored into the equation, BMI cannot be determined for isolated body segments and would not be viable in the forensic context.

Table 4. Regression Coefficients for Stature Estimation from Upper Arm and Leg Segment Measurements from the NHANES Data (1998-2002)			
Arm			
	Intercept	Slope	Error
All (n=1680)	96.44	2.08	5.30
White (n=1076)	94.07	2.16	5.27
Black (n=604)	98.33	2.02	5.28
Leg			
	Intercept	Slope	Error
All (n=1673)	113.26	1.47	5.63
White (n=1073)	112.11	1.52	5.54
Black (n=600)	103.52	1.65	5.40

The conclusion drawn from this research is that when estimating living stature from dismembered bodies, limb portions do provide reasonable estimates of living stature and the formulae provided as part of this research may be utilized. However, numerous factors influence these estimates (such as body weight) and it is worth the added effort to take skeletal measurements when feasible and use established regression formulae.

Stature, Mass Fatality, Identification