TECHNICAL NOTE

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Corrections for Age in Estimating Older Adults' Stature from Long Bones

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ABSTRACT: Stature estimates based on long bone measurements require a correction factor to compensate for stature decrease in older people. Such a correction should exclude the effect of any secular trend in stature and reflect the age at which stature begins to decrease, sex differences, and the increasing rate of change with age. Stature corrections which meet these requirements for ages 46 through 85, based upon two recent large-scale longitudinal anthropometric studies, are provided in tabular form.

KEYWORDS: physical anthropology, human identification, musculoskeletal system, stature, height estimation, aging, long bones

Because in the 20th century stature has gradually increased in virtually all populations, the apparent *decrease* in stature in older people is a composite: an actual stature decrease incident to aging (longitudinal trend) and a decrease attributable to the fact that the maximum stature attained by older people is less than that attained by adults born later in the century (secular trend). The use of cross-sectional data confounds these two components: the decrease in an average person's stature, say between age 50 and age 80, cannot be determined by simply subtracting the average stature of a sample of 80-year-old people from that of one, however similar, composed of 50-year-old people, since the younger sample will have the secular stature advantage of having been born 30 years later.

Materials and Methods

To devise a correction factor for age to apply when calculating stature from long bones, physical anthropologists have determined the longitudinal element by another partitioning of stature, one presuming that long bone lengths reflect only secular change while changes in other parts of the skeleton and connective tissue produce the longitudinal decrease [*1*,*2*]. Therefore, the argument goes, if a stature decrease correlated with age appears in a sample population after the difference due to variation in the length of the long bones

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has been statistically manipulated to hold it constant, that trend will reflect longitudinal change only. That stature trends exclusive of long bone lengths reflect only longitudinal change, however, can be questioned [3].

Deriving estimates of the effect of age on stature from long bone measurements has definite drawbacks. When stature measurements of the living are available, long bone lengths are measured from X-rays [2], and when direct long bone length measurements are possible, living stature is estimated from cadaveral length [1]. When both living stature and long bone measurements come to hand, such as in the examination of Korean war dead, the sample is too young to provide direct evidence for aging. Age records for cadavers are often estimates or even ranges, as in the Terry collection utilized by Trotter and Gleser [1].

Why not use data provided by longitudinal studies of the living to correct stature calculated from long bones for age? One reason may be that data from large-scale American surveys are only recently being published. Galloway [4] and Galloway and Cox [5] have provided a formula to replace the one proposed by Trotter and Gleser [1] 40 years ago. Rather than using actual longitudinal aging data, however, Galloway [4] determined longitudinal change by combining measured and recollected data, and produced a result at variance with the actual longitudinal study cited.[2]

At the present time there are at least two American studies that document stature change with age based upon direct longitudinal examination of over 1000 individuals of each sex. The results of both are in general, although not perfect, accord with other similar studies worldwide [7]. One of these has examined 1212 male veterans in Boston, Massachusetts, who are essentially white, healthy, and middle-income, over a 10-year interval [3,8]. The other has analyzed a community sample of 1009 Anglo-white women in Tucson, Arizona, from varied social-environmental statuses over a minimum 5-year interval [9,10].

In both of these studies the decrease in stature with age has been partitioned into its secular and longitudinal components. Three characteristics of longitudinal stature decrease emerge: the decrease begins around age 45, is somewhat greater in females, and in both sexes accelerates with age. The correction for age provided by Trotter and Gleser [1]

$$\text{loss} = 0.06\,(\text{age} - 30)\text{ cm}$$

reflects none of these: it presumes that the decrease begins at age 30 and that it is linear and the same in both sexes.

Although Hertzog et al. [2] observed a substantial gender difference and accelerating loss with age, their study aimed at validating a method for partitioning stature variation into its aging and secular constituents and did not provide forensic anthropologists a formula with which to calculate stature loss at specific ages. They did estimate cumulative stature loss by decade.

The alternative provided recently by Galloway [4]

$$\text{loss} = 0.16\,(\text{age} - 45)\text{ cm}$$

recognizes 45 as the beginning age for age-related stature decrease, but even if its derivation is accepted as valid, it does not take into account sex differences or the increasing rate of loss with age.

[2]Galloway [4] calculated an annual longitudinal stature decrease of 1.56 mm from data on men published by Friedlaender et al. [6]. J. S. Friedlaender, Temple University, Philadelphia, PA (personal communication, 7 May 1990), concurs that a figure of approximately 1 mm/year better represents the same published data.

Results and Discussion

The data published by Borkan et al. [*3*] for males and by Cline et al. [*10*] for females provide the basis for calculating quadratic regression equations to, in effect, smooth the transition between 10-year cohorts when determining the average decrease in stature for men and women at the ages listed in Table 1. Table 1 provides forensic anthropologists an easy means for applying the results of these current research measures of longitudinal stature decrease in age-adjusting the stature estimates they make from long bones in older individuals. To use the table, it is only necessary to locate the figure in millimetres given for the known or estimated age (or an average of the appropriate figures for an age range) of the subject and subtract it from the maximum stature estimated from long bones or, indeed, known from some other source. The applicability of these results to populations other than white Americans is assumed but remains untested.

For comparative purposes, Table 2 supplies stature loss determinations from Table 1

TABLE 1—*Amounts, in millimetres, that should be subtracted from maximum stature estimates to compensate for the decline in stature due to aging for ages 46 to 85.*[a]

Age	Male	Female	Age	Male	Female
46	2.5	0	66	17.5	14.2
47	2.9	0	67	18.6	15.6
48	3.3	0.1	68	19.8	17.1
49	3.8	0.2	69	21.0	18.6
50	4.3	0.4	70	22.2	20.2
51	4.8	0.7	71	23.4	21.8
52	5.4	1.1	72	24.7	23.5
53	6.1	1.6	73	25.9	25.2
54	6.7	2.1	74	27.2	27.0
55	7.4	2.8	75	28.6	28.8
56	8.2	3.5	76	29.9	30.7
57	8.9	4.2	77	31.3	32.6
58	9.8	5.1	78	32.7	34.5
59	10.6	6.0	79	34.2	36.5
60	11.5	7.0	80	35.6	38.5
61	12.4	8.0	81	37.1	40.5
62	13.4	9.2	82	38.6	42.6
63	14.4	10.3	83	40.1	44.7
64	15.4	11.6	84	41.7	46.8
65	16.4	12.9	85	43.2	49.0

[a]Male data from Borkan et al. [*3*]; female data from Cline et al. [*10*]. Additional mean age value information was provided by M. G. Cline, University of Arizona, Tucson, AZ (personal communication, 20 June 1990).

TABLE 2—*Comparison of the amount of decline, in millimetres, from the maximum stature provided by five studies at five representative ages (separately for males and females if so determined).*

Age	Trotter and Gleser [*1*]	Hertzog et al. [*2*] Male	Hertzog et al. [*2*] Female	Galloway [*4*]	Cline et al. [*10*], Male[a]	This Study [*3,10*][a] Male	This Study [*3,10*][a] Female
40	−6	−10	0	0	0	0	0
50	−12	−10	0	−8	0	−4	0
60	−18	−19	−29	−24	−7	−12	−7
70	−24	−22	−62	−40	−20	−22	−20
80	−30	−31	−65	−56	−34	−36	−38

[a]Additional mean age value information was provided by M. G. Cline, University of Arizona, Tucson, AZ (personal communication, 20 June 1990).

for five representative ages and those for the same ages calculated from the formulas given by Trotter and Gleser [*1*], by Galloway [*4*], and from the data provided by Hertzog et al. [2]. Results for these five ages, based upon the companion 5-year interval examination of 751 males by Cline and her colleagues [*10*], are also included merely to indicate that the size of decrease and the modest gender difference seen in Table 1 are in the main confirmed by another longitudinal study.

In summary, the results of two recent large studies of measured stature decrease with age in the living, put in a format useful for forensic anthropology in Table 1, suggest that Galloway's [*4*] conclusions overstate stature loss, those by Hertzog et al. [2] overstate female stature loss and sex differences, and the original formula of Trotter and Gleser [*1*], while more consonant with observed longitudinal change in the living, posits a too-early start for stature decline and a too-modest finale.

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