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# Stature- and Age-Related Bias in Self-Reported Stature

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**ABSTRACT:** The use of reported stature, especially self-reported stature such as on a driver's license, as a proxy for measured stature is necessary when measured stature is unavailable, for example, in matching data calculated from skeletal remains with data for missing persons. The accuracy of self-reported stature for older persons and especially for tall and short people is not well ascertained. Examination of published reports provides evidence that beginning at age 45, people compound their stature overestimation by an additional amount related to age (women by twice the amount of men). Analysis of anthropometric data from 8000 U.S. Army personnel indicates that the amount of general overestimation of stature by men is 2½ times greater than that by women. Neither tall men nor tall women underestimate their stature, but men in the upper third of the stature range, and women in the upper 10%, self-report their stature with greater accuracy. No trends in accuracy are apparent in the remainder of the stature spectrum for men or women.

**KEYWORDS:** physical anthropology, stature, human identification, height estimation, aging, reported stature

For reasons of economy, convenience, or necessity in forensic science, actuarial, and growth studies, reported—and particularly the subject of this paper, self-reported—stature may replace stature actually measured for the purpose at hand. Examples include large-scale height and weight surveys for life insurers and the determination of whether the stature calculated from skeletal remains matches that of a missing person. In the latter case, for example, driver's licenses or hospital admissions records are common sources of self-reported stature information.

As might be expected, the accuracy of reported stature has been examined to see if its use is valid. Willey and Falsetti [*1,2*] have discussed the accuracy of stature recorded on driver's licenses in a student population; Himes and Roche [*3*] addressed the question from the viewpoint of growth studies; and Rowland [*4*] summarized the results of the Second National Health and Nutrition Examination Survey of 11 284 people in 1976 through 1980 (NHANES II). Although many studies indicate that there is a high coefficient of correlation between measured and reported stature (with $r$ ranging from 0.84 to 0.97 in Himes and Roche's [*3*] review), there is disagreement about the overall accuracy of self-reported stature and the systematic biases, if any, that may affect self-reported

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stature as a "useful proxy," as Himes and Roche call it, for measured stature. Since in situations involving missing persons the available stature is often only a reported one, forensic anthropologists need to know just how accurate such estimates are likely to be in assessing the probable correctness of matchups determined from examination of skeletal remains. In this paper, the authors review validity studies of self-reported stature and present new data relating reported stature to variation in actual stature to provide forensic anthropologists with a basis for such determinations.

## Inaccuracy of Measured Stature

In assessing the accuracy of reported stature, it is important to remember that measured stature is not necessarily a fixed datum invariably determined. Thus, the magnitude of the difference between reported and measured stature may well include a significant error component on the measured side. It is probably impossible to so standardize measured stature that all potential sources of extraneous variation are eliminated, but nevertheless a brief mention of major ones may show the caution with which declarative statements of an individual's *measured* stature should be viewed.

### *Time of Day*

Although Backman's [5] study involved only institutionalized males, it was well designed and utilized a large ($n$ = 200) sample size in concluding that, on the average, stature fluctuates by 2.436 cm (0.95 in.) over a 24-h period. The magnitude of fluctuation was little affected by stature, body weight, or age.

### *Mensurational Technique*

Except in children, stature is usually measured in one of two ways: with the subject standing against a wall or with an anthropometer while the subject is standing free. In an examination of the differences between the two techniques, Damon [*6*] found that stature measured freestanding with an anthropometer was 0.5 to 2.0 cm (0.2 to 0.8 in.) less than stature measured against a wall with a right-angled device, with the greater difference probably characteristic of large-scale freestanding stature surveys. A further complication arises if the instructions for measuring a subject require "grasp[ing] the examinee under the mastoid processes and lift[ing] him gently upward" [*7*]. This procedure, used mainly with children, supposedly minimizes the time-of-day factor mentioned above [*6*]. It was applied, however, in the U.S. Public Health Service's second National Health and Nutrition Examination Survey 1976–80 (NHANES II) [*7*], but not in its first Health and Nutrition Examination Survey 1971–74 (HANES) [*8*], rendering comparison between the stature results somewhat suspect.

### *Variation among Measurers*

Anthropometric survey planners for the U.S. military go to considerable lengths to standardize the measurement techniques used by the persons who do the actual measuring. Stature is one of the easiest anthropometric measurements to standardize among measurers [*9*]. Nevertheless, uniformity even among the experts is difficult to attain, as Steggerda [*10*] demonstrated nearly 50 years ago when he persuaded 21 distinguished physical anthropologists, including Coon, Hooton, Hrdlička, Krogman, Shapiro, Stewart, and Washburn, to measure Mrs. Steggerda's stature. The maximum difference among the 21 was 1.8 cm (0.71 in.).

Perhaps the most revealing inquiry into the accuracy of measured stature was reported by Clyde Snow and Joan Williams [*11*]. They turned up 19 police and medical records of one man's stature taken between the ages of 24 and 44. Only 2 of the 19 measurements were taken by the same person, and those were 1 year apart. Medical personnel (physicians and nurses) took 7 of the measurements, police personnel the other 12. The maximum difference among the measurements taken by medical personnel was 5.1 cm (2 in.), among the police 12.7 cm (5 in.). Differences of that magnitude help explain conflicting "official" records, such as information given to the public after the escape of a convicted armed robber being treated at the Massachusetts General Hospital in Boston that he was 5 ft, 8 in. tall (prison records) or 6 ft tall (district attorney's office) [*12*]. Snow and Williams believe military anthropometric surveys provide the most accurate data, followed by those of medical personnel and then police records.

**Systematic Biases: Age**

That human stature declines with age is widely accepted. Those few studies showing no stature reduction with age, such as that of the Chelsea pensioners [*13*], with no change through age 73, or that of the Columbia University students [*14*], with no change through age 56, may have data irregularities (for example, full stature might not have been attained at initial measurement). A large-scale (1813 men) longitudinal study by Friedlaender and his colleagues [*15*] using 5-year cohorts demonstrated convincingly both a secular trend (an average population change over time) in and the effect of age on stature. They showed significant decreases in the stature of healthy white males in the Boston area, beginning with their 40 to 44-year-old age cohort and continuing through the +70-year-old cohort. These data suggest an *average* stature decrease of approximately 1 mm per year,[2] or 1 cm (0.4 in.) per decade, beginning in the fifth decade of life. A subsequent examination [*17*] of the same database after a 10-year interval affirmed the average decrease found by Friedlaender et al. [*15*]. While a study by Cline et al. [*18*] on white males in Tucson, Arizona, produced results similar to those of the Boston Normative Aging Study [*15,17*], other studies in Baltimore [*19*], Wales [*20*], and Norway [*21*] have shown slightly larger decreases in equivalent male age cohorts.

Cline et al. [*18*] examined over 1000 women and found somewhat larger decreases in their stature than in men in the same age cohorts, as did Miall et al. [*20*] to a greater degree in Wales. Forsdahl and Waaler [*21*], in their gargantuan (over 10 200 individuals) study of women from the northernmost province of Norway whose stature was measured twice with a 5-year interval as part of an X-ray tuberculosis survey, reported a slightly smaller longitudinal decrease than that found by Cline et al. [*18*] for women but substantially larger than that in their own companion study of 9800 Norwegian men. However, the examination by Noppa et al. [*22*] of 1300 Swedish women found their stature decrease to be even less than that in men in the United States (but the oldest women at the end of the 6-year study interval were only 66), while Chumlea et al. [*23*] found much larger decreases, by several orders of magnitude, in a relatively small sample of New Mexico white males and females.

A characteristic of the studies mentioned above, except those of Noppa et al. [*22*] and Chumlea et al. [*23*], is an acceleration of the rate of decrease with age. For example, in the Boston Normative Aging Study of males [*17*] the average decrease in stature in the age cohort 55 to 64 is 0.8 mm/year, but that decrease grows to 1.4 mm/year in the 75 to 84 age cohort. In Arizona females [*18*], the equivalent decreases are 0.9 and 2.0 mm/year.[3] In general, particularly in populations in the United States, it seems reasonable

[2]The 1-mm-per-year figure, corroborated by J. S. Friedlaender, Temple University, Philadelphia, PA (personal communication, 7 May 1990), differs considerably from the 1.56-mm-per-year value calculated by Galloway [*16*] from the same published data.

[3]These figures were determined from a quadratic regression equation calculated with the aid of additional information provided by M. G. Cline, University of Arizona, Tucson, AZ (personal communication, 20 June 1990), rather than being taken directly from Table 3 of Cline et al. [*18*].

to assume a minimum *average* stature decrease, beginning in the mid-forties, of at least 1 mm/year in males and 1.25 mm/year in females, with the annual decrease being larger as people age.

If reported stature in older people demonstrates an increasing overestimation of measured stature, the most probable, though not the only, explanation is a failure of perception on the part of persons over 45 that their stature is decreasing. Supporting this explanation is Galloway's [*16*] finding that, in a sample of 141 males over the age of 50, there was no difference between the average of reported present stature and reported maximum stature. Her companion sample of 409 females over age 50 shows a 1-cm difference between the two.

Studies by Rowland [*4*] and by Stewart et al. [*24*] provide data comparing reported and measured stature subdivided by age and sex (Table 1). These data allow a determination to be made of the amount of the difference that may be attributable to a failure to recognize actual stature reduction after age 45. (Two other studies [*25,26*] indicate an increasing differential with age but do not provide gender-specific summaries of absolute differences.) In Table 1 the difference between reported and measured stature for the 35 to 44 age group has been subtracted from data for the older age groups listed in the table to provide an estimate of the portion of the total difference attributable to aging. In research by Stewart et al. [*24*], the 35 to 44 age group was the youngest examined; in the NHANES II survey reported by Rowland [*4*], there were three young age groups (20 to 24, 25 to 34, and 35 to 44), but within each sex, the differences among these age cohorts between reported and measured stature were nominal.

Where the two studies principally diverge is in the *absolute* amount of the difference between reported and measured stature in each of the older age cohorts in Table 1, with the New Zealand sample of Stewart et al. [*24*] exhibiting mean differences up to twice those recorded in the American NHANES II survey [*4*]. Some similarities between the two studies are apparent in Table 1: the magnitude of the aging differential increases with age and is significantly greater in females. And although the *specific increase* in the aging differential going from age cohort 45 to 54 to age cohort 55 to 64 in both studies is similar, approximately 0.25 cm (0.1 in.) in males and 0.75 cm (0.3 in.) in females, it is not similar in going from age cohort 35 to 44 to age cohort 45 to 54, but rather considerably larger in the New Zealand study, that is, 0.28 cm (0.11 in.) as opposed to 0.69 cm (0.27 in.) in males and 0.48 (0.19 in.) as opposed to 1.04 cm (0.41 in.) in females. These gender and population contrasts are graphed in Fig. 1 to indicate the net effect of aging on the difference between self-reported and measured stature.

The NHANES II stature measuring technique, with upward traction under the mastoid

TABLE 1—*Mean difference (Diff) between reported and measured stature in older male and female age cohorts when the mean difference between reported and measured stature in the 35 to 44 age cohort is subtracted from the total mean difference.*

| | 45–54 Age Cohort | | 55–64 Age Cohort | | 65–74 Age Cohort | |
|---|---|---|---|---|---|---|
| | Diff, cm | *N*[a] | Diff, cm | *N*[a] | Diff, cm | *N* |
| Males | | | | | | |
| Rowland [*4*] | 0.28 | 665 | 0.58 | 1166 | 1.24 | 1148 |
| Stewart et al. [*24*] | 0.69 | 399 | 0.94 | 334 | ... | ... |
| Females | | | | | | |
| Roland [*4*] | 0.48 | 724 | 1.30 | 1261 | 2.44 | 1334 |
| Stewart et al. [*24*] | 1.04 | 181 | 1.76 | 149 | ... | ... |

[a]Sample size data for Stewart et al. [*24*] from A. W. Stewart, University of Auckland, Auckland, New Zealand, personal communication, 27 June 1989.

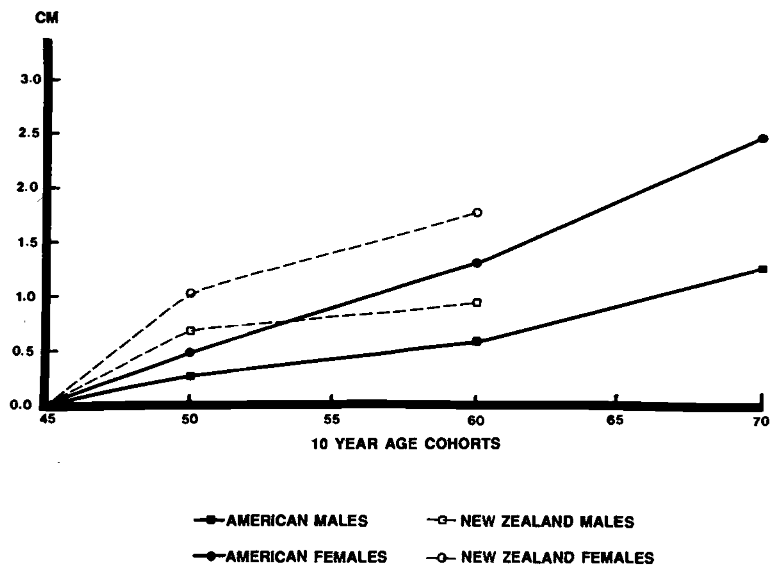


FIG. 1—*Portion of the difference between self-reported and measured stature attributable to aging in three older age cohorts. The values were determined by subtracting the mean difference for the age cohort 35 to 44 from each older cohort. American data from Rowland* [4], *New Zealand data from Stewart et al.* [24].

processes, should maximize measured stature and, as a result, minimize the mean difference between measured and reported stature. Consequently, the results of the NHANES II study should be conservative in this regard relative to the New Zealand outcome, where stature was measured against a wall with a right-angle square, but without upward pressure on the mastoid processes [*27*].

The bias attributable to aging in reported as opposed to measured stature is real and should be compensated for when reported stature substitutes for measured stature. The available survey data, particularly for the population in the United States, suggest that in reported stature there is an overestimation of measured stature *attributable solely to aging* (that is, in addition to other amounts of overestimation) of approximately 0.25 cm (0.1 in.) for males 45 to 54 years old, 0.6 cm (0.25 in.) for males 55 to 64, and 1.25 cm (0.5 in.) for males 65 to 74. In females, in each age cohort, the amounts are double. This latter result, on one hand, seems curious, since later sections in this paper demonstrate that women in general report their stature more accurately than men and since Galloway [*16*] found older women reported their present stature as 1 cm less than their maximum stature while older men reported no differences. On the other hand, actual stature decrease as women age appears definitely greater than that in aging men.

**Systematic Biases: Stature**

The proposition reflecting the possible systematic bias of actual stature is simple; tall people think they are shorter than they are, while short people think they are taller. A modification of this proposition would maintain that tall people report their stature with less of an overestimation than short people. A denial of the proposition would claim that actual stature has nothing to do with the magnitude of overestimation (or underestimation) of one's stature. Actually, *all* of these outcomes, sometimes further subdivided by sex, appear in the literature.

The variety of these results issuing from studies of the relationship of self-reported stature to the range of human height is a part of the question of why the magnitude of the difference between self-reported stature and measured stature varies among studies generally. While this question is not often addressed in the reports themselves, one possibility could involve the incertitude of measured stature mentioned earlier. The presence or absence of significant numbers of persons over age 45 may affect the mean difference between reported and measured stature. Still another possibility sometimes alluded to has been national contrasts [*28*].

Subjects may become sensitized to their "true" stature by their commitment to a medical or growth-oriented study which makes their responses unusually considered and informed. Jalkanen and her colleagues [*29*] demonstrated a negative association in a Finnish study between the error in reported weight and the recency of a medical consultation. The differences between reported and measured stature found by Pirie and her colleagues [*30*] are small compared with those of most other studies, but the sample used was derived from a plasma lipid research program in which the anthropometric measurements were taken on the second of two medical screening examinations [*31*]. In another case, Himes and Roche [*3*] believed that the relatively small mean value (0.3 cm [0.12 in.][4]) they found between measured and reported stature for their 99 Fels mothers may have resulted "from an increased awareness of their own growth and size resulting from having been associated with a longitudinal study of physical growth" (p. 336).

Finally, the sample may have its own perspective that places a special value on tallness. As Himes and Roche [*3*] point out, that is one of the few explanations that comes to mind to account for the exceptional difference of 2.5 cm (1 in.) between self-reported and measured stature for 1905 young (mean reported age of 22.9 years) U.S. Air Force women investigated in 1968 [*32*].

A review of the literature uncovered six studies directly addressing the question of the relationship between the magnitude of measured stature and self-reported stature. (The study by Clauser and his colleagues [*32*], in which the sample of U.S. Air Force women was divided only into tall and short, with no difference being discerned between the two groupings, will not be further considered here, nor will a study of repeated reported stature [*33*] which, although suggesting a relationship to variation in stature, did not examine actual measurements.) The diversity of these six studies' results are easily seen by the response they provide to the following four questions: (1) what population was studied, (2) how big was the sample, (3) do tall people underreport their stature and short people overreport, and (4) what is the mean difference between reported and measured stature (that is, reported minus measured)? In order of sample size, the answers are as follows:

Pirie et al. [*30*]—Minnesotan whites; 1799 women, 1610 men; yes for men, women underestimate their stature; −0.71 cm (−0.28 in.) for women, 0.56 cm (0.22 in.) for men.

Stewart [*26*]—Americans; 1730 women, 1474 men; no, but short women overestimate their stature to a greater degree than tall women, men's overestimation is unrelated to measured stature; 1.07 cm (0.42 in.) for women, 2.09 cm (0.82 in.) for men.

Stewart et al. [*24*]—New Zealand whites; 536 women, 987 men; no, women's and men's overestimation is unrelated to measured stature[5]; 1.60 cm (0.63 in.) for women, 2.14 cm (0.84 in.) for men.

Palta et al. [*25*]—Minnesotans; 499 women, 845 men; no, but short women and men

[4]Galloway [*16*] cites the 1-cm figure given in the abstract of the paper by Himes and Roche [*3*] as one "found" by them, but 1 cm is a figure they "recommend" (p. 338 in Ref *3*) based on an effort to summarize their study's result of 0.3 cm and three other studies' results of 0.8, 0.8, and 2.5 cm (J. H. Himes, University of Minnesota, Minneapolis, MN, personal communication, 7 May 1990).

[5]A. W. Stewart, University of Auckland, Auckland, New Zealand, personal communication, 27 June 1989.

overestimate their stature to a greater degree than tall women and men; 0.9 cm (0.35 in.) for women, 2.3 cm (0.91 in.) for men.

Schlichting et al. [*34*]—Danes; 158 women, 594 men; yes; actual data not provided.

Bouchalová et al. [*35*]—Czechs; 267 women; no, but short women overestimate their stature to a greater degree than tall women; 0.75 cm (0.3 in.).

The variety of results reported in these six studies suggests that the issue of whether being short or tall affects reported stature, and if so by how much, is far from resolved.

## Materials

Data generated from anthropometric surveys of U.S. Army personnel can be used to investigate the difference between self-reported and measured stature, since some surveys collected both [*36,37*]. These military surveys provide several advantages in evaluating the effect of stature variation on reported stature. Among these advantages are the following:

1. Very large overall sample sizes, permitting adequate sample sizes at the tall and short ends of the stature spectrum.
2. Measured stature data uniformly obtained by specially trained personnel.
3. Reported stature data elicited in a nonmedical, nonresearch environment.
4. A representative, healthy, young U.S. population sample.

Possible difficulties with stature data derived from a survey of military personnel include truncation of the very short and the very tall and nonrepresentativeness vis-à-vis the general U.S. population. The HANES [*8*] and NHANES II [*7*] surveys provide comparative bases for addressing these questions, at least in regard to stature, because, as the latter report states, their design "is a complex multistage probability sample" with national estimates "derived through a multistage estimation procedure" with "three basic components: (*a*) inflation by the reciprocal of the probability of selection, (*b*) adjustment for nonresponse, and (*c*) poststratification by age, sex, and race" (in Ref *7*, p. 59).

At the time of the survey, the stature of U.S. Army men was supposed to lie between 152.40 cm (60 in.) and 198.12 cm (78 in.) [*36*]. In the sample the male range was 151.9 to 199.1 cm (4 ft, 11.75 in. to 6 ft, 6.39 in.) [*36*]. Published stature limitations for female U.S. Army personnel in 1977 were not available; the actual female range was 142.6 to 183.8 cm (4 ft, 8.25 in. to 6 ft, 0.36 in.) [*38*]. Like the men, the women measured probably subsumed the full range of permissible stature.

The U.S. Army ranges exceed the ranges utilized in Rowland's [*4*] analysis of the NHANES II data of 1976–1980, in which the range for the sample of 5396 males was limited to 154.94 to 190.50 cm (5 ft, 1 in. to 6 ft, 3 in.) and for 5888 females to 144.78 to 177.80 cm (4 ft, 9 in. to 5 ft, 10 in.). Only approximately 1.8% of those measured and interviewed for NHANES II fell outside the male and female ranges used by Rowland [*4*], and these outliers, when included in a reanalysis by him, did not change the conclusions of his study. These results suggest that the U.S. Army samples, which provide greater stature ranges than Rowland's, are a reasonable representation of the range of stature in the U.S.

In Table 2 the stature means, standard deviations, and sample sizes of the 18 to 24-year-old cohort of males and females utilized in the HANES [*8*] and NHANES II [*7*] projects are presented with similar data for the U.S. Army samples used in this paper. The 18 to 24-year-old cohort was chosen as most comparable with the U.S. Army sample, which has a mean age of 22.2 ± 4.6 years for the males [*36*], and 23.1 ± 5.4 years for the females [*38*]. The stature data for HANES and NHANES II are remarkably similar; the U.S. Army female mean differs little, while the male mean for the Army is about 2.5 cm (1 in.) less than the HANES and NHANES II figures. Figures for stature from

TABLE 2—*Stature means, standard deviations (SD), and sample sizes (*N*) from the Health and Nutrition Examination Survey 1971–74 (HANES)* [8], *the Second National Health and Nutrition Examination Survey 1976–80 (NHANES II)* [7], *the 1966 male and 1977 female U.S. Army anthropometric surveys used in this paper* [36,38], *and the 1988 U.S. Army anthropometric survey* [39].

| | Males | | | Females | | |
|---|---|---|---|---|---|---|
| Study | Mean Stature, cm (in.) | SD, cm (in.) | *N* | Mean Stature, cm (in.) | SD, cm (in.) | *N* |
| HANES 18–24 age cohort | 177.0 (69.7) | 7.1 (2.8) | 772 | 163.3 (64.3) | 6.4 (2.5) | 1524 |
| NHANES II 18–24 age cohort | 177.0 (69.7) | 7.1 (2.8) | 988 | 163.4 (64.3) | 6.6 (2.6) | 1066 |
| U.S. Army, 1966 and 1977 | 174.5 (68.7) | 6.6 (2.6) | 6669 | 163.0 (64.2) | 6.5 (2.6) | 1330 |
| U.S. Army, 1988 | 175.6 (69.1) | 6.7 (2.6) | 1774 | 162.9 (64.2) | 6.4 (2.5) | 2208 |

the interim report on the U.S. Army's 1988 anthropometric survey [*39*] are also included in Table 2. The stature of the average Army man has increased by about 1 cm in the intervening 22 years, with only a 1 mm change in the stature of the average Army woman in the 13 years between the two surveys.

The racial distribution of the U.S. Army samples is reported in a manner which makes detailed comparisons pointless. The male sample, obtained in 1966, is reported as 29.4% white, 14.6% black, and 56.0% from some 38 other explicitly listed "ethnic backgrounds or national extractions " [*36*]. For the U.S. Army female sample, obtained in 1977, the racial distribution is reported as "whites" (74.3%), "blacks" (22.7%), "Orientals" (1.9%), and "not identified" (1.1%) [*38*].

For general perspective, the ratios of white to black soldiers in these two samples can be estimated by reassigning in a plausible way the 38 "ethnic backgrounds or national extractions" for the males. To determine the white-to-black ratio, members of all other categories are set aside, leaving the residual population of males 84.9% white and 15.1% black and of females 76.9% white and 23.4% black.

The HANES survey [*8*] provides U.S. census data suggesting that in 1972 the white-to-black ratio as percentages in the male age cohort 18 to 24 in the general U.S. population was 89.0 to 11.0%. The NHANES II survey [*7*] provides U.S. Census data that suggest that, in 1978, the white-to-black ratio as percentages in the female age cohort 18 to 24 in the general U.S. population was 86.4 to 13.6%. Although for both sexes the figures and the comparisons are imprecise, it is not unreasonable to conclude that, if anything, blacks are overrepresented, but not excessively, in the U.S. Army male and female samples used in this paper.

Stature in the U.S. Army surveys [*36,37*] was obtained in millimetres using an anthropometer with a freestanding subject erect, without shoes and with heels together and head level. Self-reported stature was elicited in inches. No analysis appears to have been made using the self-reported stature of the female personnel. Summary statistics of the male data have been published, along with the suggestion that "perhaps small men may tend to overestimate or exaggerate their size, while large men may tend to underestimate or minimize their body size" [*36*]. However, it was concluded that the data "in their present form do not warrant firm conclusions" and should be analyzed "in the form of individually paired comparisons," as is done in this paper.

## Methods

The large sample sizes afforded by the U.S. Army data permit the measured stature range to be arbitrarily divided into 10 approximately equal subranges with reasonably sized subsamples in almost all. Since stature is measured to the nearest millimetre, the subranges must be defined in whole millimetres. For the 6669 males, the absolute stature range of 1519 to 1991 mm gave a spread of 473 mm. This was divided into 6 subranges of 46 mm, 3 of 49 mm, and 1 of 50 mm, with 2 of the larger subranges at the upper and lower ends of the range. For the 1330 females, the absolute stature range of 1426 to 1838 mm gave a spread of 413 mm. This was divided into 8 subranges of 41 mm and 1 each of 42 mm and 43 mm placed at the range extremities. Table 3 provides, for both sexes, the dimensions of each of the 10 subranges, the mean stature of the subsample in it, and the subsample size.

For each individual in each subrange, his or her measured stature was subtracted from the stature he or she reported. The mean value of these differences was calculated for each of the subranges. These data are also included in Table 3. For both sexes, all but one of these means were positive, meaning that, except for the tallest female subrange, reported stature exceeded measured stature. A close examination of the subrange for the tallest women shows that, in this small subsample of 8, 7 women in fact estimated their stature to the closest inch, and the eighth *over*estimated her stature by ¾ in. (19 mm). Conversion of the estimated stature data from inches to millimetres and the fact that the closest inch was in some cases less than the measured stature in millimetres led to the mean underreporting of 1 mm. Despite this minute technical underreporting, it is clear that in this sample the tallest women accurately report their stature rather than systematically underreport it.

In Figs. 2 and 3, additional analytical results are graphically portrayed. Because the ten subranges for measured stature were close to being of equal size, their limits form a diagonal band with subparallel borders whose lower left limit represents the shortest person and whose upper right limit represents the tallest. Within the band, the line representing the mean value of measured stature varies its relative position somewhat, since particularly at the ends of the range the subrange mean is significantly different from the subrange midpoint. The line representing the subrange mean values of reported stature lies entirely above the line representing measured mean value. The two lines would cross at some point if it were true that tall people believed they are shorter than they are. Finally, the widely separated irregular lines representing the range of *reported* stature within each subrange of measured stature indicate that some people's perceptions of their own stature are grossly defective.

## Correlation Analysis

Himes and Roche [*3*] noted that the somewhat unfamiliar intraclass coefficient of correlation ($r_i$) is a better statistic with which to assess the similarity between reported and measured stature than the standard or product-moment coefficient of correlation ($r$). Haggard [*40*] points out that the development of the intraclass coefficient of correlation can be traced back to the examination of fraternal resemblance around the turn of the century. (Of interest to physical anthropologists is Franz Boas's [*41*] similar but independent idea back in 1916.) Investigators of samples made up of pairs of brothers were not concerned with the correlation between the taller and shorter brothers, but between stature of brothers in general. If each pair of brothers is thought of as a class, then, as Haggard puts it, "the coefficient of intraclass correlation is the measure of the relative homogeneity of the scores within the classes in relation to the total variation among all the scores" (Ref *40*, p. 6). In this paper looking at reported and measured stature, each person, with his or her two scores, becomes a class.

TABLE 3—*Analysis of male and female stature data from U.S. Army surveys divided into 10 subranges: subrange size for measured stature, sample size (N), subrange mean for measured stature, subrange mean for reported stature minus measured stature (Diff), and subrange intraclass correlation coefficients* ($r_i$).

| | Males | | | | | Females | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Subrange | Subrange Size, mm | *N* | Subrange Measured Stature Mean, mm | Diff | $r_i$ | Subrange Size, mm | *N* | Subrange Measured Stature Mean, mm | Diff | $r_i$ |
| 1 | 1519–1568 | 31 | 1551.8 | 29.6 | 0.710 | 1426–1468 | 7 | 1453.7 | 8.6 | 0.463 |
| 2 | 1569–1617 | 152 | 1599.5 | 26.3 | 0.960 | 1469–1509 | 30 | 1492.9 | 10.8 | 0.820 |
| 3 | 1618–1663 | 473 | 1645.0 | 29.5 | 0.983 | 1510–1550 | 106 | 1532.9 | 7.3 | 0.962 |
| 4 | 1664–1709 | 1343 | 1689.0 | 27.8 | 0.995 | 1551–1591 | 247 | 1573.6 | 8.8 | 0.988 |
| 5 | 1710–1755 | 1834 | 1733.3 | 29.4 | 0.996 | 1592–1632 | 308 | 1612.3 | 10.5 | 0.983 |
| 6 | 1756–1801 | 1528 | 1777.1 | 28.6 | 0.996 | 1633–1673 | 308 | 1652.0 | 10.9 | 0.977 |
| 7 | 1802–1847 | 888 | 1821.9 | 26.8 | 0.993 | 1674–1714 | 187 | 1692.1 | 10.5 | 0.982 |
| 8 | 1848–1893 | 328 | 1865.5 | 22.4 | 0.966 | 1715–1755 | 96 | 1732.8 | 12.8 | 0.951 |
| 9 | 1894–1942 | 78 | 1911.9 | 15.7 | 0.924 | 1756–1796 | 33 | 1771.0 | 13.9 | 0.574 |
| 10 | 1943–1991 | 14 | 1964.7 | 9.1 | 0.435 | 1797–1838 | 8 | 1813.8 | −1.0 | 0.740 |
| Total | 1519–1991 | 6669 | 1745.1 | 28.0 | 0.999+ | 1426–1838 | 1330 | 1629.5 | 10.2 | 0.999+ |

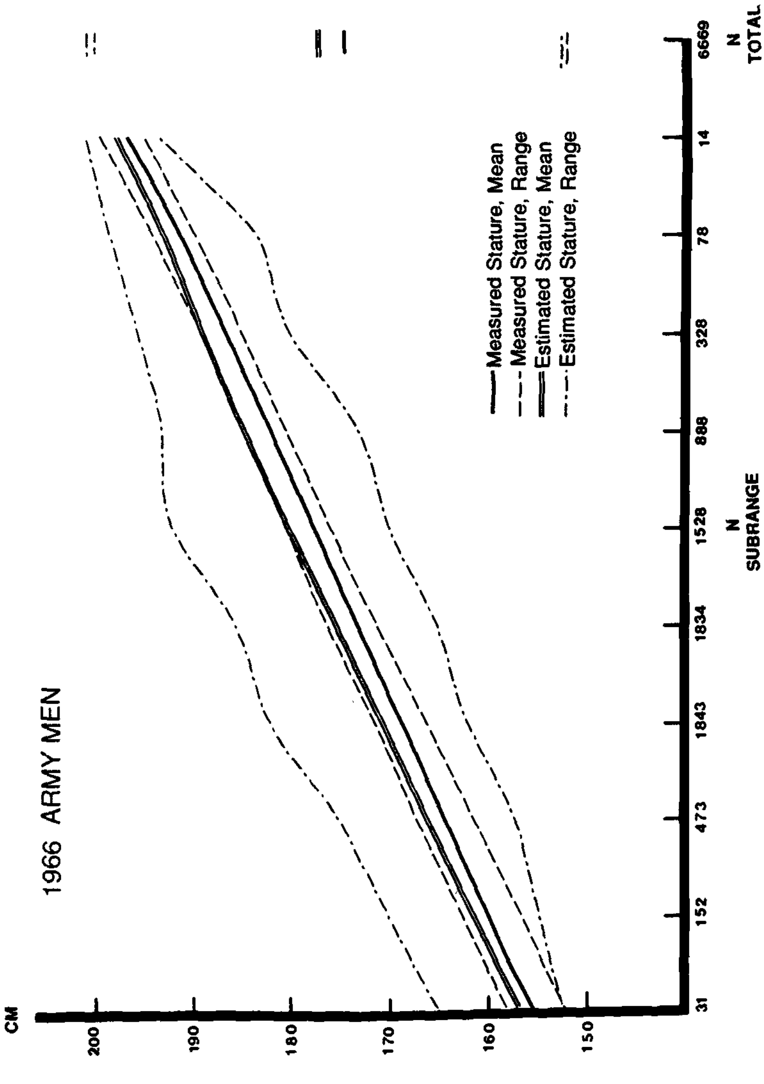


FIG. 2—*Diagrammatic representation of the relationships between the mean and range values for measured stature and self-reported stature for 10 subequal divisions of the total measured stature range for 6669 U.S. Army male personnel.*

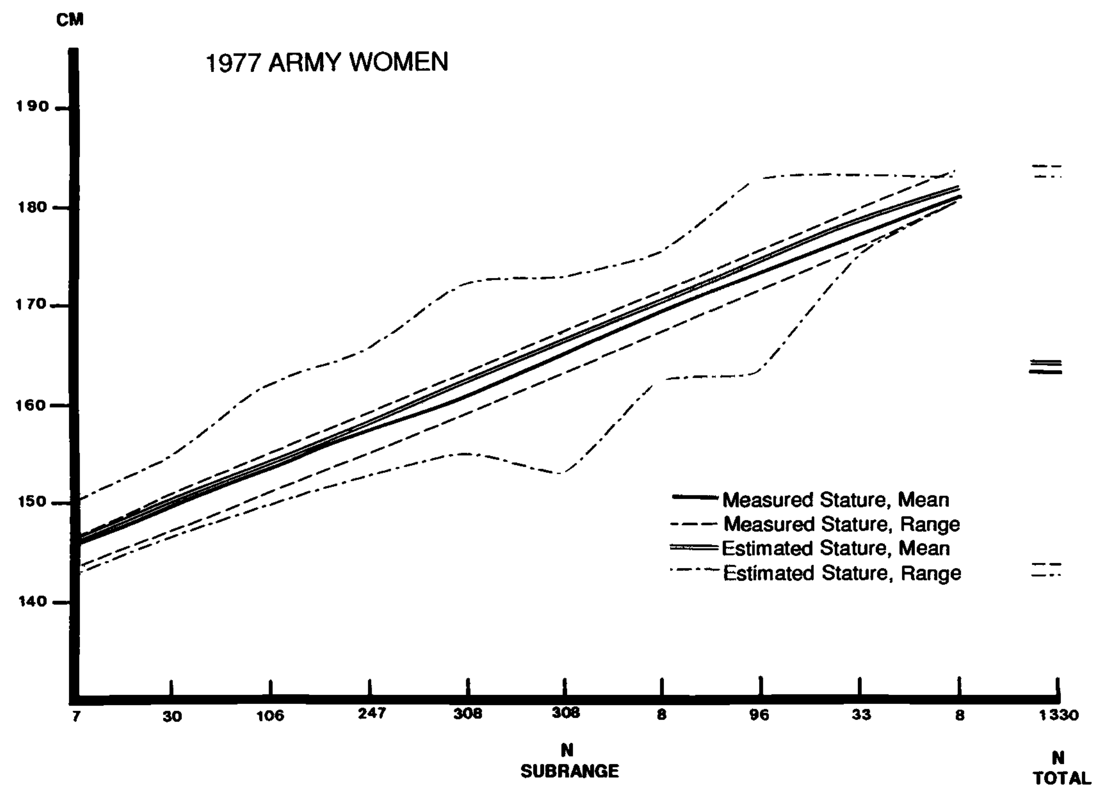


FIG. 3—*Diagrammatic representation of the relationships between the mean and range values for measured stature and self-reported stature for 10 subequal divisions of the total measured stature range for 1330 U.S. Army female personnel.*

A hypothetical example provided by Haggard [40] may make the difference between $r$ and $r_i$ clear:

| Classes (for example, persons) | A | | B | |
|---|---|---|---|---|
| | $x,y$ | Sum | $x,y$ | Sum |
| a | 1,1 | 2 | 1,5 | 6 |
| b | 2,2 | 4 | 2,4 | 6 |
| c | 3,3 | 6 | 3,3 | 6 |
| d | 4,4 | 8 | 4,2 | 6 |
| e | 5,5 | 10 | 5,1 | 6 |
| Total | 15,15 | 30 | 15,15 | 30 |

In both A and B the values for $r$ and $r_i$ are the same, +1.00 in A and −1.00 in B. Computing $r$ involves looking at the columns, where the identity of the pairs of scores going from 1,1 to 5,5 is apparent in A, while in B the pairs of scores are completely reversed.

In the computation of $r_i$, however, the data are viewed in terms of the scores along the rows, that is, classes. In A there is no variation between the pairs of scores in any row; all the variation is *between* the rows. Thus $r_i = 1.00$. In B the situation is just the opposite; all the variation is *within* the rows; there is none between rows and consequently $r_i = -1.00$. Blalock [42] discusses the relationship of intraclass correlation to other measures of association such as analysis of variance and provides the computational details used in this analysis.

The intraclass coefficients of correlation calculated for the self-reported and measured U.S. Army data have very high positive values, indicating that almost all variability lies in differences between persons, very little lies in variability within individuals, a finding similar to that of Himes and Roche [3]. The values of the product-moment coefficient of correlation ($r$) were high for the total samples of both sexes—0.941 for males and 0.964 for females—but the $r_i$ values for the total male sample, as well as the total female sample, exceeded 0.999. Subrange $r_i$ values given in Table 3 are rounded to 3 decimal places.

## Discussion and Conclusions

The analysis of the 8000 U.S. Army personnel and the review of previous studies of reported and measured stature can be used as a framework for the use of reported stature in forensic science applications. It must be understood that the following conclusions represent mean, or expected, outcomes: an individual may well report his or her stature quite at variance with population averages. Nevertheless, as in many other arenas, in the absence of explicit individualized knowledge of a particular case, the expectations for a hypothetical average man or woman can be useful.

*Accuracy of Measured Stature*—A number of factors, including time of day, measurement technique, and variation among individual measurers, combine to make measured stature in adults something less than invariant and a probable contributor to differences between measured and self-reported stature.

*Interrelationship of Reported and Measured Stature*—The intraclass coefficients of correlation calculated for the U.S. Army data demonstrate a very high level of correlation between a person's stature and what he or she reports it to be.

*Magnitude of Overreporting*—On the average, over the entire stature range, men overreport their stature by approximately 2.5 cm (1 in.); women overreport by approximately 1 cm (⅜ in.).

These results, based on a U.S. Army sample larger than those used in the six studies mentioned earlier combined, are not *substantially* out of line with the results of four of those studies; the exceptions are those of Schlichting et al. [*34*], where the data as presented do not allow such an assessment, and those of Pirie et al. [*30*]. The latter study reports only slight overreporting by men [0.56 cm (0.2 in.)] and, surprisingly, found underreporting by women [−0.71 cm (−0.28 in.)]. Possibly the fact that stature was obtained on the second of two medical screening visits [*31*] heightened self-awareness in the study participants, but, at best, that seems only a partial explanation for results that clearly depart from those of most other studies, including this one. As far off in the other direction for women is the study by Clauser et al. [*32*] of U.S. Air Force personnel, where overreporting averaged 2.5 cm (1 in.).

That females, on the average and to a significant degree, more accurately report their stature than males is substantiated by four studies reporting male and female data separately [*2,24–26*]. The data of Schlichting et al. [*34*] do not permit a straightforward determination, and, in effect, Pirie et al. [*30*] and Wing et al. [*43*] (in a quite small sample) did not find a gender difference in stature reporting accuracy.

*Effect of Age*—Men age 45 to 54 may be expected to overreport their stature by approximately 0.25 cm (⅛ in.), men 55 to 64 by 0.6 cm (¼ in.), and men 65 to 74 by 1.25 cm (½ in.) *in addition to* the overreporting otherwise expected. Women age 45 to 54 may be expected to overreport their stature by approximately 0.5 cm (¼ in.), women 55 to 64 by 1.2 cm (½ in.), and women 65 to 74 by 2.5 cm (1 in.) *in addition to* the overreporting otherwise expected.

*Effect of Differences in Stature*—Men up to about 185 cm (73 in.) overreport their stature by about 2.8 cm (1⅛ in.), between about 185 and 190 cm (73 to 75 in.) by about 2.25 cm (⅞ in.), between about 190 and 195 cm (75 to 76¾ in.) by about 1.6 cm (⅝ in.), and those taller than about 195 cm (76¾ in.) by about 0.9 cm (⅜ in.). Overreporting by women is much less, averaging about 1 cm (⅜ in.) up to a stature of about 180 cm (70⅞ in.). Even taller women are likely to report their stature quite accurately.

These estimates, based upon a sample of 8000 U.S. Army personnel, do not bring into question the accuracy of studies of other samples previously published and discussed above. Nevertheless, because of the impressive disagreement among these studies, and because of several possible advantages of the U.S. Army sample data, the latter deserve to be taken seriously when the issue of the effect of stature variation on the accuracy of self-reported stature is a question in an American, or perhaps other, context.

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