

Differential Sexual Dimorphism in Bone Diameters of Subjects of European and African Ancestry

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KEY WORDS Bone · Bone-areas · Sexual dimorphism · Negro · Black · Percent sex difference.

ABSTRACT The 1,589 low-income adult subjects of primarily African ancestry (American Negroes or "Blacks") showed systematically less sexual dimorphism in total subperiosteal area (TA), medullary area (MA) and cortical area (CA) than did 4,379 low-income adult subjects of European derivation ("Whites"). These systematic findings have implications both to the sexing of skeletal remains from diverse populations and to an understanding of population divergences in bone remodeling.

While sexual dimorphism in many body lengths is comparatively small, averaging 6–7% for adult stature, percent sexual dimorphism is much greater for some bony dimensions, for many tissue masses (including the skeletal mass) and for bone volumes as variously measured. By way of example, sexual dimorphism in skeletal weight is of the order of 33%, and percent sexual dimorphism in the total subperiosteal area or "bone envelope size" of the second metacarpal comes close to 40% (cf. Garn, '70). The question is whether this degree of sexual dimorphism, as ascertained for living, well-nourished contemporary American-born adults of European ancestry applies to other populations or when the conditions of life are somewhat different.

To answer this question, we have extended our previous radiogrammetric studies of the hand skeleton to an additional 5,968 adult subjects between the ages of 20 and 55, from nine states (California, Kentucky, Massachusetts, Michigan, New York, South Carolina, Washington, West Virginia and Texas). Of the total number, 4,379 were of European derivation (designated as "Whites" in the Multi-State Survey of 1968–70) and 1,589 were of largely-African ancestry, designated as "Blacks," and confirmed by the high frequency of triquetral-lunate fusion (Garn et al., '71). Both groups were generally of low income and with individual income-

needs ratios largely below 2.0, using the Orshansky index (Orshansky, '65).

Measurements on the postero-anterior hand radiographs included the total subperiosteal diameter (T) and the medullary cavity width (M), as described in Garn ('70). The bone areas were computer-calculated to provide the total subperiosteal area (TA), the medullary cavity area (MA) and the cortical area (CA) as described in Garn ('70) and Garn, Poznanski and Nagy ('71) and our earlier publications. Percent sexual dimorphism was calculated, for each decade grouping as:

$$100 \left(\frac{M}{F} - 1.0 \right)$$

In the initial steps of the data comparison, percent sexual dimorphism was separately expressed for both American White and American Negro participants, for each of four decade groupings, and for each of the three metacarpal areas described above. However, the differences were sufficiently systematic, in all 12 age-race comparisons to justify pooling of the data as in table 1.

Simply to summarize the table, per cent sexual dimorphism in metacarpal areas was greater in the subjects of European ancestry. It was 37% for total subperiosteal area (TA) in the 4,379 subjects of European derivation and 30% in those of largely-African ancestry. The area of the medullary cavity (MA) was even more di-

TABLE 1

*Adult sexual dimorphism in metacarpal areas*¹

Measurement	Metacarpal areas				Per cent sexual dimorphism	
	Whites		Blacks		4379 Whites	1589 Blacks
	1654 Men	2725 Women	401 Men	1188 Women		
Total subperiosteal area (TA)	69.56	50.69	74.44	57.05	37.1	29.8
Medullary area (MA)	10.50	6.32	13.29	9.43	65.3	39.3
Cortical area (CA)	59.06	44.36	61.15	47.63	33.1	27.9

¹ Age range 20–55, all areas expressed as mm², per cent sexual dimorphism $100 \left(\frac{M}{F} - 1.0 \right)$. See also Garn ('70) and Garn, Sandusky and McCann ('72). Per cent sexual dimorphism calculated from decade means.

vergent in respect to sexual dimorphism — 65% in “Whites” and 39% in “Blacks.” Male-female differences in cortical area (CA) were again larger in those of European derivation (33%) and systematically smaller in those of largely-African descent (28%).

Now the subject samplings were controlled as to age, to eliminate those still adding bone at the most rapid pace, and those older individuals in the most-active bone-losing phase (cf. Garn, '70). The sample size was large, very nearly 6,000 in all, so that the differences could not be attributed to chance. Per-capita incomes were reasonably comparable in that the majority of subjects fell below an income-needs ratio of 1.5, roughly equivalent to \$1260 per capita, in the present sample.

We further considered the possibility that the very large population differences in sexual dimorphism in medullary cavity areas might be due to hemoglobinopathies and consequent medullary enlargement in a proportion of American Negro or Black women. However, the proportion of female homozygotes for G6PD (glucose-6-phosphate deficiency) could not be more than 1%, assuming a heterozygote frequency of 11 per cent, and neither thalassemia major nor the sickle-cell disease are known to affect one sex disproportionately. The evidence, therefore, was for rather large population differences in the degree of sexual dimorphism in bone areas unrelated to abnormal hemoglobins or red-cell enzyme defects.

For those interested in the sexing of prehistoric or archeological populations, such differences in per cent sexual di-

morphism of bone areas constitute an obvious note of caution. As is so often the case, criteria appropriate for one population do not exactly serve to discriminate between the sexes in another population. Dimensionally, the participants of largely, African origin are systematically larger in bone diameters than those of European derivation, from early childhood through old age, as shown throughout the present survey. At the same time, the relative difference between the sexes (per cent sexual dimorphism) is systematically greater in those of European ancestry than in those of largely-African origin. Using the metric criteria for one group, one would surely err in sexing individuals of the other group.

The present radiogrammetric data raise still other problems. If the Black or American Negro group represents only 75–80% of African genes, as Reed's summary data suggest (Reed, '69, and references in Reed, '69), then per cent sexual dimorphism in the West African groups that contributed most to the American Negro population should be even less than in our data. If we assume that activity levels in part determine the level of sexual dimorphism in skeletal areas and volumes, then populations and cultures that allow greater physical labor for the female might show lesser sexual dimorphism in both bone diameters and bone masses. Or, it may be that the relative remodeling rates at both bone surfaces, though influenced by nutritional level during growth as we have elsewhere shown, are also genetically determined, and the present data may be taken as a case in point.

As it stands, from comparisons of nearly 6,000 low-income adults, excluding those in the more active bone-gaining and bone-losing phases, adults of largely-African ancestry exhibit consistently less sexual dimorphism in all three metacarpal areas than those of European derivation.

ACKNOWLEDGMENTS

Radiogrammetric data analyses were completed under Contract HSM 110-69-22 and its successor HSM 21-72-522 (P) with the Center for Disease Control, Atlanta, Georgia, using radiographs taken during the course of the Ten-State Nutrition Survey of 1968-1970. The manuscript was completed by Shirley M. Garrett.

LITERATURE CITED

- Garn, S. M. 1970 The earlier gain and the later loss of cortical bone. Charles C Thomas, Springfield, Ill.
- Garn, S. M., A. R. Frisancho, A. K. Poznanski, J. Schweitzer and M. B. McCann 1971 Analysis of triquetral-lunate fusion. *Am. J. Phys. Anthropol.*, 34: 431-434.
- Garn, S. M., A. K. Poznanski and J. M. Nagy 1971 Bone measurement in the differential diagnosis of osteopenia and osteoporosis. *Radiol.*, 100: 509-518.
- Garn, S. M., S. T. Sandusky and M. B. McCann 1972 Differential bone loss in women of African ancestry. *Invest. Radiol.*, 7: in press.
- Orshansky, M. 1965 Counting the poor: Another look at the poverty profile. *Soc. Sec. Bull.*, 28: 3-29.
- Reed, T. E. 1969 Caucasian genes in American Negroes. *Science*, 165: 762-768.