AMERICAN JOURNAL OF PHYSICAL ANTHROPOLOGY 88:309–321 (1992)

Nutritional Status of Adults in Rural Mali

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KEY WORDS Anthropometry, Weight, Height, Africa, Female buffering, Variability

ABSTRACT An anthropometric assessment was conducted of 441 adults from six rural villages in southern Mali. As is typical for human populations, females are shorter and lighter than males. Both females (N = 320) and males (N = 121) are shorter and lighter than their U.S. counterparts. Mean weight in the sample is 53.4 ± 8.5 kilos for females and 58.8 ± 6.5 kilos for males. Mean height is 160.4 ± 5.7 cm for females and 171.3 ± 6.6 cm for males. The data for height in males are very similar to those reported from other surveys in Mali, and show no evidence for a positive secular trend in height. Mean body mass index (BMI) is 20.8 for females and 20.0 for males. These are lower than U.S. averages, but well above suggested cutoff points for malnutrition in adults. Average arm circumference is 26.5 cm for females and 26.4 cm for males. Females have relatively large arm circumferences due, in part, to the heavy manual labor they perform. Average head circumference is 53.0 cm for females and 54.8 cm for males. For both sexes, these values are more than 1 standard deviation (SD) below the U.S. means. Adult values for anthropometric measurements reflect childhood stresses of malnutrition and disease, and a lifetime of accommodation to a high-carbohydrate, low-protein diet, and hard physical labor. Females are significantly closer to the U.S. standards than males for weight, height, BMI, and arm circumference; these findings support the idea that females are buffered from environmental stresses relative to males. In addition, females exhibit significantly more variability than males for weight, arm circumference, and head circumference, but not for height, suggesting that variability in adult height does not reflect the presence or absence of female buffering or the level of environmental adversity. © 1992 Wiley–Liss, Inc.

Children under 5 years of age usually represent the subpopulation most likely to suffer inadequate growth and high levels of mortality due to malnutrition and disease in populations living under conditions of environmental stress. However, birth weight and early childhood growth are also affected by maternal size and nutritional status. Studies of adult nutritional status in such populations can provide information about the long-term effects of early childhood growth deficits, as well as the impact of these deficits on the growth of subsequent generations. In addition, data on adults can be used to examine the issues of whether females are "buffered" from environmental stress relative to males in terms of final adult body size, and the impact of such buffering (the equivalent of living in a better environment) on within-population variability in body size.

Although the mechanisms are not well understood, there is substantial evidence that, given similar treatment in terms of access to dietary resources and health care, females exhibit lower levels of malnutrition (and, consequently, patterns of growth more simi-

Received August 10, 1990; accepted January 22, 1992.

lar to U.S. standards), morbidity, and mortality than males. In cases where males fare better than females for any of these factors, it is usually possible to document cultural preferences for male children. The concept of physiological "buffering" of females has been proposed as a proximate explanation of these findings (Eveleth, 1975; Stini, 1985; Stinson, 1985). According to Eveleth (1975), under adverse environmental circumstances, the phenomenon of female buffering will lead to reduced sexual dimorphism in adults. Stinson (1985) reviews the growth and development literature on this topic, citing evidence both for and against the concept.

The related question of whether adverse environmental conditions would lead to more or less variability has likewise received attention in the recent literature. Stini (1985), building on the concept of female buffering, concludes that the males in any population should be more variable than the females, because they are affected more by environmental stresses. Comparing populations from different environments, Schmitt and Harrison (1988) have proposed what Bogin (1991) calls the "environmental adversity hypothesis," predicting that adverse environments will lead to greater variability for height and weight among adults. Comparing children's growth in affluent and poor societies, this prediction has been confirmed for height and height velocity (Harrison and Schmitt, 1989). However, Bogin (1991:285), using Guatemalan data on growth, found that "degree of environmental adversity does not correlate uniformly with growth variability." Bogin (1991) suggests that the degree of variability reflects environmental heterogeneity, rather than environmental quality.

For adults, however, Schmitt and Harrison's (1988) survey of 62 anthropometric studies found that height variability was not associated with environmental quality, and weight variability was greatest under favorable environmental conditions.

If adverse environmental conditions do lead to greater variability (Stini, 1985; Harrison and Schmitt, 1989), then adults in populations living under such conditions should, in general, be more variable than their U.S. counterparts. Additionally, if evidence for female buffering is present in the population, then males should be more variable than females. Conversely, following Schmitt and Harrison (1988), one would predict that the levels of variability in adult height in populations living under adverse environmental conditions will not differ significantly from levels of variability in U.S. populations; in addition, if evidence for female buffering is present, females should be the more variable sex for weight and other anthropometric measures related to weight, such as body mass index (BMI) and arm circumference, but not for height.

The purpose of this paper is to present data from a cross-sectional anthropometric survey of 6 rural villages in Dogo Arrondissement (district) in southern Mali (West Africa). During the survey, conducted in 1989, a total of 1,132 individuals were measured. In this paper, data on the adults (N = 441) are reported and analyzed, and used to evaluate the 2 sets of predictions outlined above. These data can also serve as a baseline for future evaluations of the Association Malienne pour l'Insertion Professionnelle des Jeunes (AMIPJ) project's impact on the nutritional status of the population, and provide comparative data for assessments of adult nutritional status in other populations in Mali and other regions of Africa.

MATERIALS AND METHODS

In 1987, AMIPJ, a Malian private voluntary organization, began a rural development/credit program in the remote rural villages of Dogo Arrondissement in southern Mali. AMIPJ provides small loans and education in business management to groups of village women for income-generating activities (Freedom From Hunger Foundation, 1989). The project was designed to eventually include a nutrition education component, which is intended to help translate the profits from the entrepreneurial activities of the women into better nutritional status and health for all the villagers.

Dogo Arrondissement is part of the Circle of Bougouni, in the Region of Sikasso, in southern Mali. It is located approximately

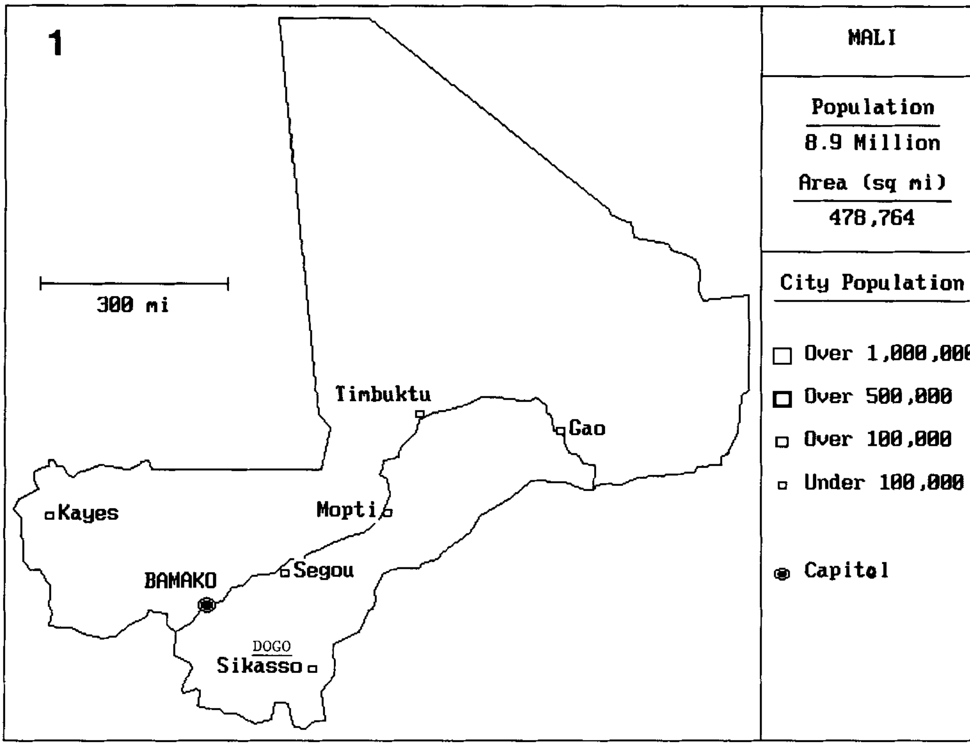

Fig. 1. Map of Mali showing location of Dogo Arrondissement. (Copyright 1990 PC Globe, Inc., Tempe, AZ. All rights reserved worldwide.)

60 miles south and east of the capitol city of Bamako, between the Bani and the Baoule Rivers (Fig. 1). The villages are accessible only by dirt roads, and public transportation (a weekly transport) serves only Dogo itself, the center of the Arrondissement. Table 1 provides demographic information for Dogo Arrondissement (Census, 1987).

According to AMIPJ, there are 85 villages in the Arrondissement, of which 15 are currently participating in the credit program. One of the reasons AMIPJ chose this region of Mali for its project is because this area represents a context where the major causes of malnutrition could be overcome through a credit/education program. AMIPJ is a small, relatively young organization, and they did not want to begin with an area where factors beyond their control—chronic inadequate rainfall, drought, insect devastation, etc.—were major contributors to malnutrition. Dogo Arrondissement is considered to be generally self-sufficient in staple food supplies, with relatively rich soil (for Mali) and adequate rainfall every year to assure plentiful harvests. According to Freedom From Hunger Foundation personnel, this region of Mali was not seriously affected by either of the last 2 major droughts (1974–75 and 1984–85). Despite these impressions by project personnel, analyses of growth data from 575 children under 12 years of age from these villages reveal widespread malnutrition, especially during the first 3 years of life (Dettwyler, 1991).

The anthropometric survey was conducted in September 1989, immediately prior to and during the corn harvest, which came just before the millet and sorghum harvests. Thus, anthropometric measurements were taken during the traditional "hungry season," when adult anthropometric values should be at their lowest for the year. In reality, Dogo Arrondissement does

TABLE 1. Demographic information for Dogo Arrondissement from the 1987 census

Population in 1976	25,786
Population in 1987	27,287
Annual average growth rate	0.55
No. of compounds	1,808
No. of households	4,478
No. of households per compound	2.5
No. of people per compound	15.1
No. of people per household	6.1
No. of men	13,183
No. of women	14,104
Male/female sex ratio	93.47

not really have a hungry season and village granaries still contained grain from the 1988 harvest.

Villages consist of traditional round Bambara houses, made of mud brick with conical thatched roofs, surrounded by the agricultural fields. Each extended household consists of several one-room houses which surround a central compound where most daily activities take place. Water is obtained from traditional wells or wells dug by CARE in the 1970s. Most compounds have an associated pit latrine. Only Dogo itself has electricity, which is used only to light the commandant's compound. One of the smaller villages has a television set, powered by a car battery.

Ethnically, the villagers are overwhelmingly Bambara, with small percentages of Fulani, Dogon, Mandinka, Senoufo, and other ethnic groups present. Patterns of social organization are patrilineal and patrilocal, and from analyses of surnames, marriage patterns seem to be primarily village endogamous but lineage exogamous. In several villages, two surnames accounted for the vast majority of villagers, with people of one surname usually married to people of the other surname. This implies that the populations sampled in this study are relatively homogeneous genetically.

The villages of Dogo Arrondissement are primarily subsistence agricultural villages. The main field crops are millet, sorghum, corn, rice, peanuts, and okra. Cotton is also grown as a cash crop. Agriculture is totally rain-fed, using only human energy resources and the short-handled hoe. *Karite* (shea nut) processing provides the primary source of oil. In family gardens, villagers grow a variety of vegetables, including okra, squash, tomatoes, manioc, beans, onions, hot peppers, and a number of unidentified plants whose leaves are used in sauces. Wild plants, especially baobab leaves, are collected for use in cooking and as herbal medicines. Small herds of cows, goats, and sheep are found in every village. Chickens and guinea fowl provide meat and eggs, although the eggs are often sold for cash or allowed to hatch. The two rivers provide fish, but are too far away for people to go every day. Hunting of wild animals is officially forbidden, but young boys still hunt birds and lizards with slingshots. Some of the villages have a small weekly market, but only the weekly market in Dogo itself attracts outside vendors. Very few processed or imported foods are used in the villages. The staples of the diet are *to* (a thick porridge made from millet, sorghum, or corn) and *kini* (rice), served with a variety of sauces, including tomato/onion, peanut butter, and okra sauce. Meat is rarely eaten, perhaps once a week, when small portions are purchased in the market, usually from someone who has slaughtered an animal and is selling the meat in order to raise cash quickly.

In each of the six participating villages, anthropometric measurements were taken of all villagers who agreed to cooperate. Approximately 60% of the population of each village participated, with proportionately more adult women than adult men. The larger sample size for the adult women reflects several factors. First, women in general expressed a greater willingness to participate, perhaps because they were attending the measuring session anyway to have their children evaluated. Second, many adult men were working in the fields harvesting corn. Third, some men were not present in the village because they had migrated to the regional or national capitols, or to other countries, to work.

Adults were defined as all individuals aged 19 years or older. Birth registration in this area began about 25 years ago, and many older adults have only a very general idea of their ages. Elderly individuals are rare in these populations. Estimates made by the author place most of the adults in the sample between 19 and 50 years of age, but more precise estimates of adult ages were not attempted.

All of the measurements were taken by the author and recorded by one of the field assistants. Height was measured using a portable adult height measuring board manufactured by Perspective Enterprises of Kalamazoo, Michigan. The measuring board is calibrated to the nearest .10 cm, and was checked for accuracy several times daily. Bathroom scales, calibrated to the nearest .10 kg, were used to measure weight. The scales were always placed on a flat, hard surface, and their accuracy was also checked several times daily. All subjects were barefoot and wore similar lightweight clothing; weights have not been adjusted for clothing. Arm and head circumferences were measured with a plastic coated, non-stretchable measuring tape.

In the sample of 320 women, 27 reported that they were pregnant and 293 reported that they were not pregnant. It was not possible to confirm these statements. Running the analyses both with and without the "admittedly pregnant" women did not change the results, so all women have been included in the analyses.

Interpretation of adult anthropometric data is somewhat problematic because of the lack of standards for U.S. adults comparable to the National Center for Health Statistics (NCHS) standards available for U.S. children. Many of the comparative data sets for U.S. adults are broken down by ages in decades and/or by "race" (e.g., Frisancho, 1990). Accurate ages are not available for adults in this study. In addition, the use of "U.S. black" reference standards is not particularly appropriate, since "U.S. black" populations are based, for the most part, on descendants of people from various regions of Africa, with varying and often unknown amounts of admixture from European gene pools.

An alternative, followed in this study, is to use the NCHS reference data on weight and height for 18 year olds for comparison (Hamill et al., 1979). According to Tanner (1990:19):

> "For practical purposes, however, it is useful to have an age at which we may say that growth in stature virtually ceases, i.e., after which only some 2% is added. At present in North America and northwest Europe the average boy stops growing, in this sense, at 17.5 years and the average girl at 15.5 years. There is a normal range of variation amongst individuals, amounting to about 2 years, on either side of these averages."

The adult head circumference data obtained in this study are compared to the Roche et al. (1987) standards for head circumference developed from the Fels Longitudinal Study. In accordance with Tanner's (1990) claim for height, but with reference to head circumference standards, Roche et al. (1987:708) state: "The present data will allow interpretation of head circumference values for parents, using 18-year values as reference data."

The arm circumference reference standards used in this study are those of Roche and Malina (1983:1076), derived from U.S. data from Cycles II and III of the Health Examination Survey conducted by the NCHS in 1963–65 and 1966–70. These standards end at age 17 years for both males and females.

Comparable standards do not exist for BMI. BMI, defined as weight in kilos divided by the square of height in meters, is often used as a measure of obesity in adults. For example, Burton and Foster (1985) define a standard BMI of 22.4 for females and 22.7 for males, which they describe as a "weight goal" for Americans. Values of 26.9 for females and 27.2 for males represent 20% overweight, and values of 31.4 for females and 31.8 for males represent 40% overweight (Burton and Foster, 1985). There is less consensus about which BMI values should be used as cutoff points for malnutrition in adults. Pryer and Crook (1988:12–13) cite studies which report BMI values of around 22 for Britain, Norway, and the United States, and state "those with a BMI below 20 have a greater risk of mortality." They (Pryer and Crook, 1988:13) also cite studies in India and Java which report average BMI values of 19 or 20, and state "for

TABLE 2. Comparison of weight, height, BMI, arm circumference, and head circumference by sex and village

Village (N)	Mean weight (SD)		Mean height (SD)		Mean BMI (SD)		Mean arm circ (SD)[1]		Mean head circ (SD)	
	Females	Males	Females	Males	Females	Males	Females	Males	Females	Males
Torokoro (64F, 23M)	53.2 (7.0)	60.5 (3.8)	159.5 (5.0)	173.3 (5.7)	20.9 (2.3)	20.2 (1.5)	26.4 (2.3)	26.7 (1.2)	52.8 (1.5)	55.4 (1.3)
Merediela (65F, 26M)	52.7 (6.2)	58.9 (5.9)	160.1 (6.2)	170.1 (6.6)	20.6 (1.9)	20.4 (1.5)	26.2 (2.3)	26.4 (1.5)	53.1 (1.3)	54.5 (1.7)
N'tenkoni (35F, 14M)	55.6 (12.7)	58.2 (7.5)	161.1 (5.8)	170.9 (8.3)	21.3 (4.0)	19.9 (2.1)	28.1 (4.2)	26.2 (2.3)	52.6 (1.6)	54.3 (1.8)
Famabougou (34F, 23M)	51.5 (6.9)	57.3 (6.6)	159.3 (5.4)	170.3 (6.9)	20.3 (2.3)	19.7 (1.9)	26.2 (2.3)	26.0 (1.9)	52.9 (1.5)	54.6 (1.4)
Dogo (93F, 16M)	55.2 (9.4)	60.4 (5.8)	161.8 (5.8)	173.2 (5.2)	21.0 (3.2)	20.1 (1.4)	26.5 (2.7)	27.0 (1.5)	53.2 (1.5)	55.4 (1.2)
Siramana (29F, 19M)	51.8 (7.3)	57.8 (9.2)	159.1 (5.4)	170.4 (6.6)	20.4 (2.6)	19.8 (2.2)	25.9 (2.3)	26.3 (3.0)	52.7 (1.6)	54.7 (1.4)
Combined (320F, 121M)	53.6 (8.5)	58.8 (6.5)	160.4 (5.7)	171.3 (6.6)	20.8 (2.8)	20.0 (1.8)	26.5 (2.6)	26.4 (1.8)	53.0 (1.5)	54.8 (1.5)

[1] The only significant differences found between villages were for females for arm circumferences ($P = .014$). The women of N'tenkoni have significantly greater arm circumferences than the women of Torokoro, Merediela, and Siramana.

such populations it has been tentatively suggested that a lower BMI cutoff point of 18 be used as an index of adult malnutrition." Finally, Waterlow (1986) has recommended that a BMI of 15 be the lowest acceptable limit for adequately nourished humans.

RESULTS

Village comparisons

Table 2 presents the mean values for weight, height, BMI, arm circumference, and head circumference broken down by sex and village. Within each sex, analysis of variance was used to determine if there were any significant differences among the anthropometric measurements in the 6 villages.

The men of Dogo and Torokoro were the best nourished, with the greatest average weight and height, as well as the greatest average arm and head circumferences. However, none of the differences between the villages for the males were statistically significant.

The women of Dogo and N'tenkoni were the best nourished, with the greatest average weight and height, as well as the greatest average BMI values and arm circumferences. The women of Dogo and Merediela have the greatest head circumferences. The only significant difference between the villages for the females was for arm circumference. The women of N'tenkoni have significantly greater arm circumferences ($P = .014$) than the women of Torokoro, Merediela, and Siramana.

The data from all 6 villages were combined for all other analyses.

Male/female comparisons

Weight

Figure 2 shows the distribution of weight for males and females in the sample, with all the villages combined. Table 3 compares Malian males and females relative to U.S. standards for mean value, mean z-scores, and mean standard deviations (SD) of the z-scores for the variables of weight, height, arm circumference, and head circumference. The mean weight for females is 53.6 kilos, and the mean z-score for weight compared to the NCHS standards is −0.52. The mean weight for males is 58.8 kilos, and the mean z-score for weight compared to the NCHS standards is −1.12. The difference between males and females for weight z-scores is significant ($P = .0001$). Females show significantly more variability for weight than males as well ($P = .0008$), although both sexes show less variability than the NCHS standards.

Height

Figure 3 shows the distribution of height for males and females in the sample, with all

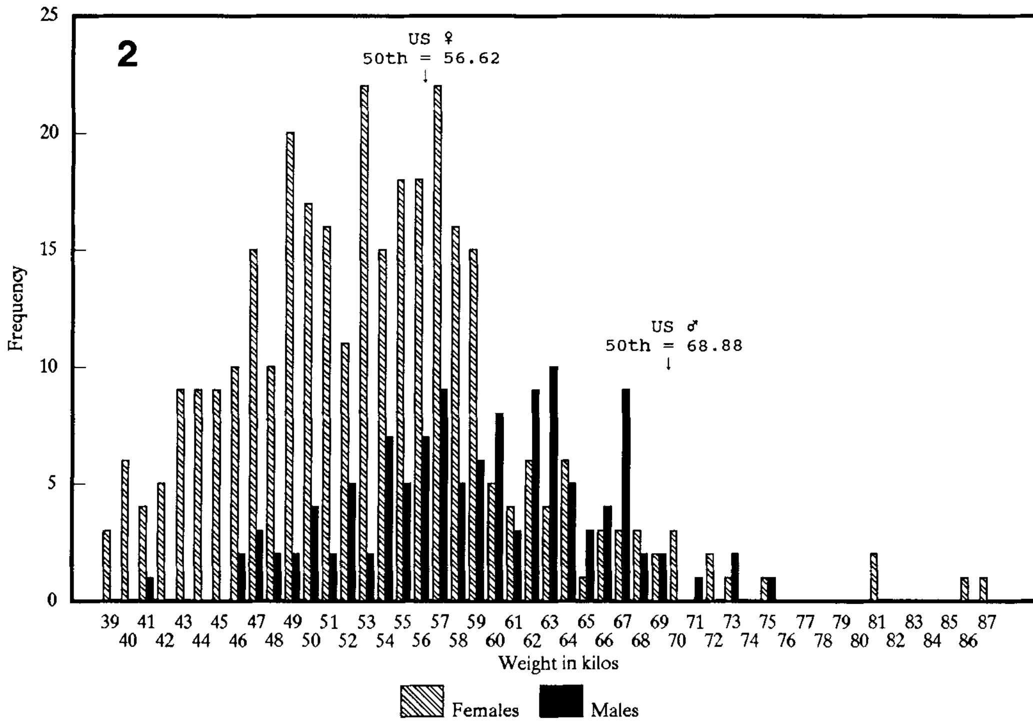

Fig. 2. Frequency distribution of weight, sexes separate.

TABLE 3. Comparison of Malian males and females relative to U.S. standards, villages combined

Variable	Sex	N	Mean value	Sex with larger value (P^1)	Mean of z-scores	Sex showing more buffering (P^2)	SD of z-scores	Sex showing more variability (P^3)
Weight (kilos)	F	320	53.6	Males (.0001)	−0.52	Females (.0001)	0.93	Females (.0008)
	M	121	58.8		−1.12		0.71	
Height (cm)	F	320	160.4	Males (.0001)	−0.55	Females (.0061)	0.96	Males (.5811)
	M	121	171.3		−0.84		0.99	
Arm circumference	F	320	26.5	Females (.6877)	+0.12	Females (.0001)	0.86	Females (.0000)
	M	121	26.4		−0.73		0.62	
Head circumference	F	316	53.0	Males (.0001)	−1.19	Males (.2615)	1.11	Females (.0012)
	M	121	54.8		−1.08		0.86	

[1] Test for significane of male/female difference for mean of variable (t-test on the raw data)
[2] Test for significance of male/female difference for z-score of variable; this tests whether one sex is significantly "buffered" relative to the other, when both are compared to their respective U.S. standards (t-test on the z-scores).
[3] Test for significance of male/female difference for the standard deviation of the z-scores; this tests whether one sex shows significantly more variability than the other (folded f-test on the standard deviations of the z-scores).

the villages combined. Table 3 compares males and females relative to U.S. standards for height. The mean height for females is 160.4 cm, and the mean z-score for height compared to the NCHS standards is −0.55. The mean height for males in the sample is 171.3 cm, and the mean z-score for height compared to the NCHS standards is −0.84. The difference between males and females for height z-scores is significant (P = .0061).

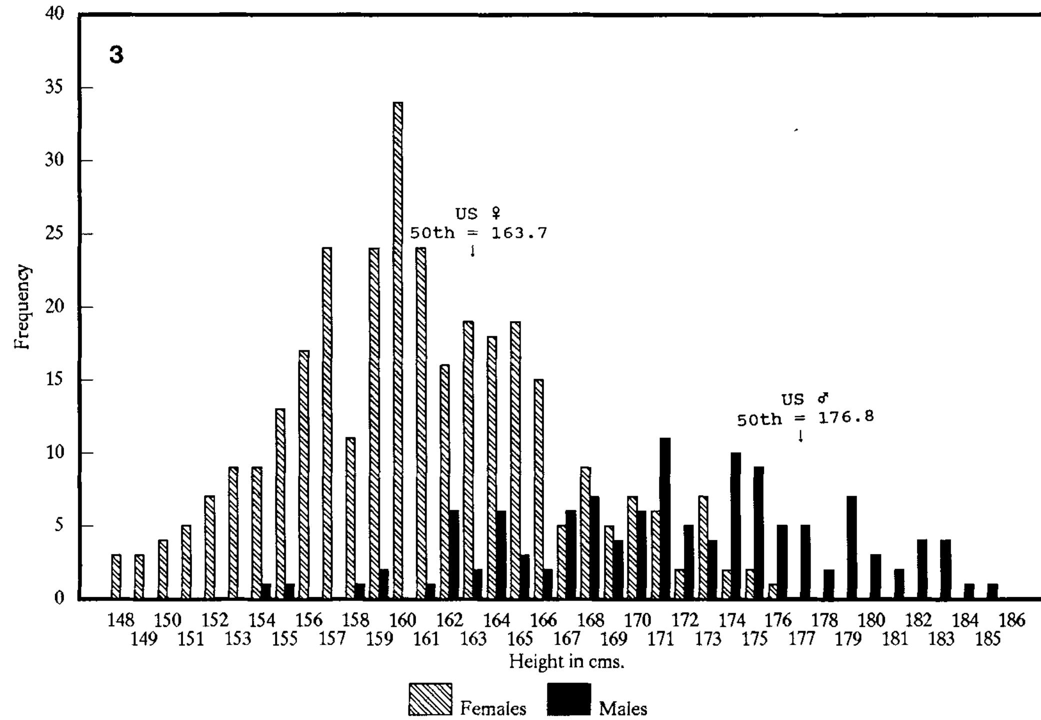

Fig. 3. Frequency distribution of height, sexes separate.

Males show slightly more variability in height than females, but the difference is not significant ($P = .5811$). Variability for both sexes is quite similar to the levels of variability seen in the NCHS standards.

Body mass index

Figure 4 shows the distribution of BMI values for both males and females in the sample, with all the villages combined. The mean BMI for females in the sample is 20.8, with a SD of 2.8. The mean BMI for males is 20.0, with a SD of 1.8. The males have a slightly lower mean BMI than the females, but the difference is not statistically significant. The females exhibit more variability than the males for BMI values, as measured by their larger SD. Compared to other populations, the mean BMI values for both sexes are lower than the U.S. averages but above all of the proposed cutoff points for malnutrition.

The mean value for BMI in males, 20.0, is farther below the U.S. standard of 22.7 (2.7 units) than the mean value for BMI in females, 20.8, is below the U.S. standard of 22.4 (1.6 units). As with weight and height, this pattern is consistent with the concept of female buffering. Because the U.S. standards for BMI do not report SD, z-scores for BMI values cannot be calculated.

Using Pryer and Crook's (1988) suggested cutoff point of 18 as the lower limit of BMI for an adequately nourished adult, 12% of the adult population of Dogo Arrondissement will be classified as malnourished (11.9% of the females and 12.4% of the males). This figure is in general agreement with previous findings that 17% of the children in this population under 12 years of age are classified as malnourished, using a cutoff point of −2 SD for weight-for-height (Dettwyler, 1991).

Arm circumference

Figure 5 shows the distribution of arm circumference for males and females in the

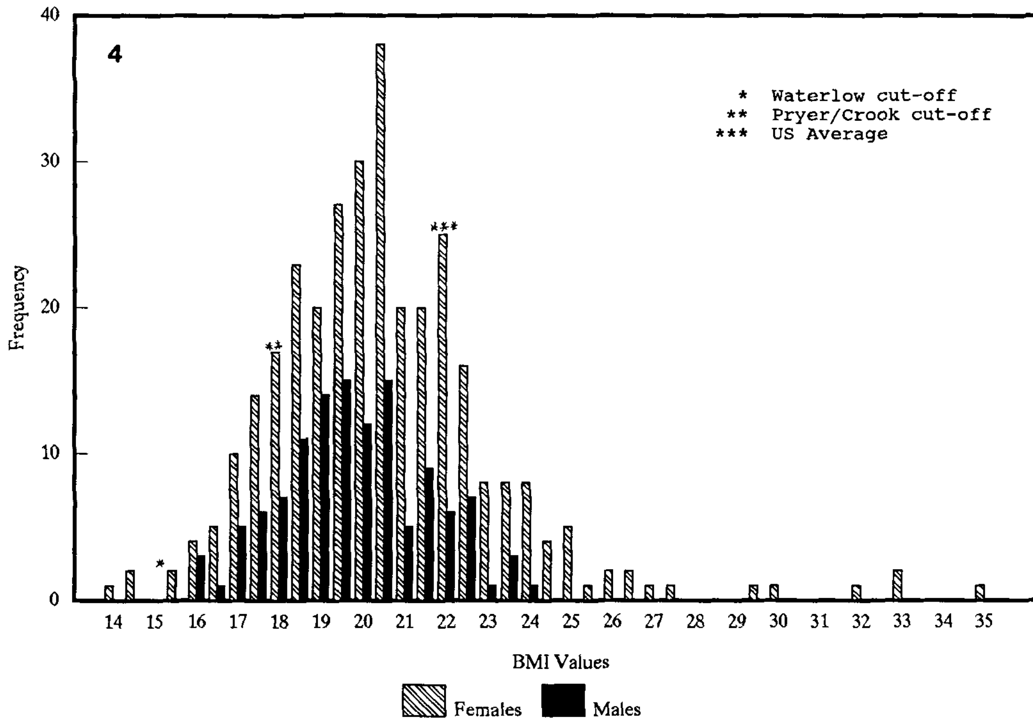

Fig. 4. Frequency distribution of BMI values, sexes separate.

sample, with all the villages combined. Table 3 compares the males and females relative to U.S. data for arm circumference (Roche and Malina, 1983). The mean arm circumference for females is 26.5 cm, and the mean z-score for arm circumference compared to U.S. data is +0.12. The mean arm circumference for males is 26.4 cm, and the mean z-score for arm circumference compared to U.S. data is −0.73. The difference between males and females for arm circumference z-scores is statistically significant (P = .0001). Females also show significantly more variability than males (P = .0000), although both sexes show less variability than the U.S. data (U.S. data from Cycles II and III of the Health Examination Survey by the NCHS, 1963–65 and 1966–70, cited in Roche and Malina, 1983:1076).

Head circumference

Figure 6 shows the distribution of head circumference for males and females in the sample, with all the villages combined. Table 3 compares the males and females relative to U.S. standards for head circumference (Roche et al., 1987). The mean head circumference for females is 53.0 cm, and the mean z-score for head circumference compared to U.S. standards is −1.19. The mean head circumference for males is 54.8 cm, and the mean z-score for head circumference compared to U.S. standards is −1.08. Although males are closer to the U.S. standards for head circumference than females, the difference is not statistically significant (P = .2615), while the females exhibit significantly more variability than males (P = .0012). Females show more variability than the U.S. standards and males show less variability.

For both males and females, the average head circumference is slightly more tha 1 SD below the U.S. standards. Analyses of head circumference data for children in these populations (N = 691) reveal that the

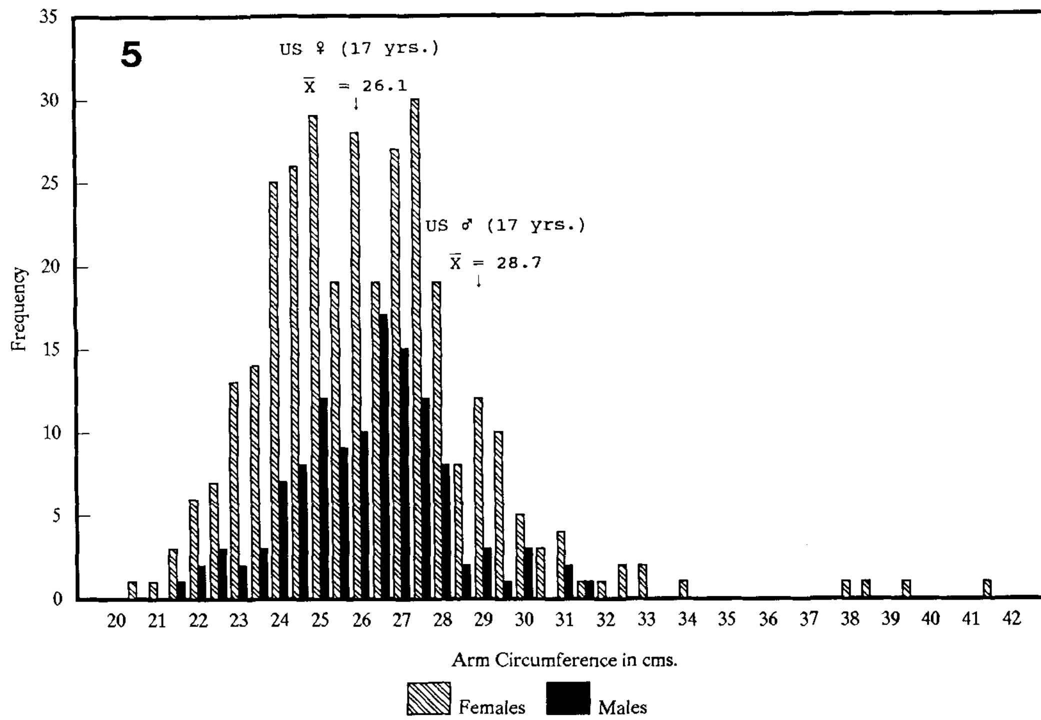

Fig. 5. Frequency distribution of arm circumference, sexes separate.

adult values are the result of deficits in growth in head circumference during the first 3 years of life, which are only partially compensated for by catch-up "spurts" during middle childhood and late adolescence (Dettwyler, unpublished manuscript).

Secular trend

A review of studies of adult height in rural Malian males (Prazuck et al., 1988) found no evidence for a positive secular trend. The height data reported here are very similar to those reported by Prazuck et al. (1988) and confirm their findings (Table 4).

DISCUSSION

An anthropometric assessment was conducted of 441 adults from 6 rural villages in southern Mali. The sample represents a population living under "adverse environmental conditions," suffering from chronic, mild to moderate environmental stress from malnutrition and disease, primarily during the early childhood years (Dettwyler, 1991). As is typical for human populations, females are shorter and lighter than males. Both sexes are shorter and lighter than their U.S. counterparts.

Comparing each sex to standards from developed countries, females are significantly closer to their respective standards than males for weight, height, and arm circumference. Ethnographic research has not revealed any preference in this culture for females in terms of access to dietary resources and health care. Thus, these results support the hypothesis that females are physiologically buffered from environmental stress during growth and that such buffering affects final adult body size. At the same time, the females are also the more variable sex, exhibiting significantly more variation than the males for all measures except height.

The data from this survey confirm the findings of Schmitt and Harrison (1988) that adult weight variability is decreased under adverse environmental conditions. Males in this population, in comparison with

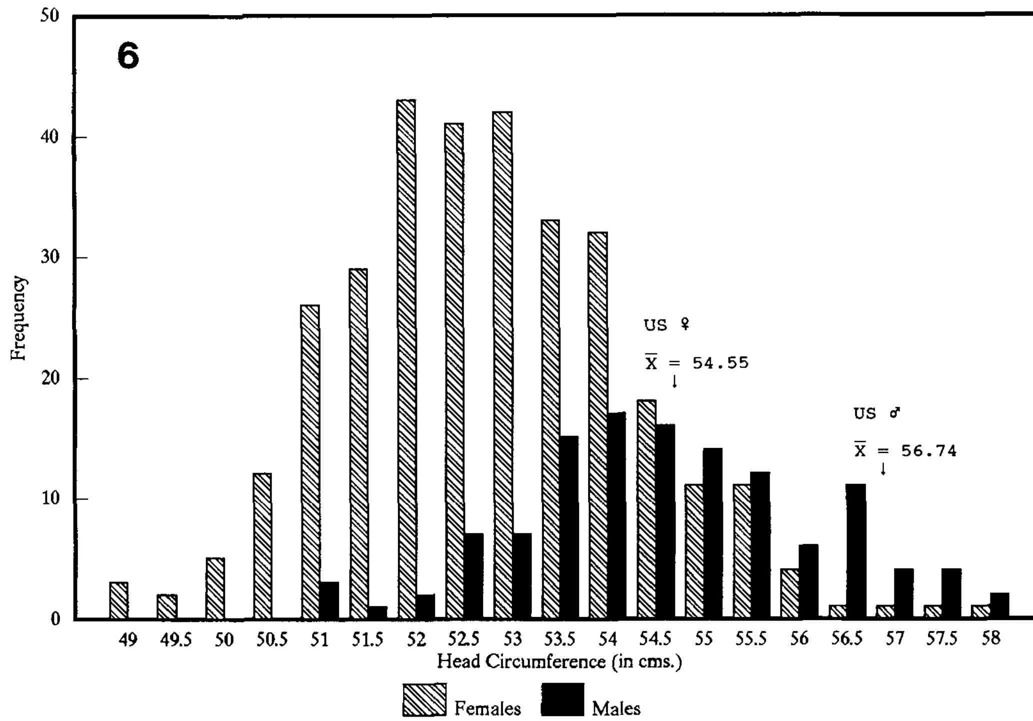

Fig. 6. Frequency distribution of head circumference, sexes separate.

TABLE 4. Comparison of studies of adult male height in Mali[1]

Year of study	N	Mean height (cm)
1885	45	169.4
1902	75	171.7
1917	371	171.1
1948	4,211	171.4
1985	2,158	171.9
1989	121	171.3

[1] Data from 1885–1985 reported in Prazuck et al. (1988).

the "buffered" females, live in the more adverse environment. Within the sample, males exhibit significantly less variation than females for weight, arm circumference, and head circumference, and both sexes show less variability for weight than the NCHS standards. Although females exhibit buffering for height, they are not more variable than the males, and height variability for both sexes is similar to that seen in U.S. populations. These results confirm Schmitt and Harrison's (1988) findings that adult height variability does not reflect levels of environmental adversity.

In their survey of 62 published studies of adult height and weight, Schmitt and Harrison (1988) also found that females were significantly more variable than males for weight, but not for height. They (Schmitt and Harrison, 1988) attribute their findings for weight to differences in amount of body fat, which is known to be highly variable. Female weight variability is also affected by reproductive factors such as pregnancy status and/or progressive maternal depletion due to multiple pregnancies. A careful examination of Figure 2 reveals that although a few women with very high weights contribute to the greater variability of females, most of the increased variability relative to males comes from the significant number of women at the lower end of the weight scale.

These results indicate that buffering per se does not reduce variability, as some authors have suggested (Stini, 1985). The findings from this study also suggest that height variability is not an appropriate measure of female buffering or level of environmental adversity in human populations. This would be particularly true for skeletal samples, where height may be the only anthropometric measure available.

The data for height in males in these rural villages are very similar to those reported from other surveys in Mali, and confirm a lack of evidence for any positive secular trend in height in this country.

The average BMI values in both males and females are lower than U.S. averages, but well above the various suggested cutoff points for malnutrition in adults. The BMI values suggest that the diet is sufficient to maintain adequate body weight relative to height in most adults (88% of the adult population), even under conditions of hard physical labor. The greater variability in BMI scores among the females reflects, for the most part, their greater variability in weight.

The lack of sexual dimorphism in arm circumference in this population may be due, in part, to the heavy physical labor that women perform. Beginning in middle childhood, every female spends several hours a day pounding millet, sorghum, and/or corn into flour. During *karite* processing season, even more time is devoted to pounding, and then grinding, the *karite* nuts. Young girls and women also chop firewood, wash clothes by hand, and haul water to the surface from deep wells. Males generally do not perform arduous physical labor until adulthood. This difference in labor patterns, as well as female buffering, contributes to the relatively large upper arm circumference of the females in this population, compared both to males in the same population, and to U.S. females. A study of the Kayapo Indians in Brazil likewise attributes a lack of sexual dimorphism in arm circumference to the manual labor performed by females (Black et al., 1977, cited in Stinson, 1985).

The functional significance of relatively small head circumferences is not well understood. However, the head circumference data do support the mounting evidence that early childhood malnutrition has lasting consequences for development (Chavez and Martinez, 1981; Pelto and Pelto, 1989).

CONCLUSIONS

The small body size of the adult rural Malians measured in this study is best viewed not as an adaptation to their environment, but as a reflection of the childhood stresses of malnutrition and disease, followed by a lifetime of accommodation to a high-carbohydrate, low-protein diet, and hard physical labor. The data support the concept of significant female buffering under conditions of environmental stress, and greater variability in the more buffered sex for all variables except height. Conditions of environmental adversity seem to decrease variability in adult weight and weight-related variables, but do not affect adult height variability. It is important that future studies addressing the issue of physiological buffering distinguish between the issue of buffering per se, as measured by comparison to U.S. standards, and the issue of the effects of environmental stress on variability. It is also important that future studies distinguish between the effects of environmental adversity on variability in anthropometric measures *during growth*, and the final effects of such adversity on variability in adult body size.

ACKNOWLEDGMENTS

This research was supported by the Fulbright Scholar Program of the United States of America. Kathleen Stack from the Freedom From Hunger Foundation, a major supporter of AMIPJ, originally suggested this project. AMIPJ provided logistical support in the field. I especially thank AMIPJ personnel Bakary Traore, Falaye Doumbia, Tiedo Ba, Saran Sidibe, and Abibatou Niare, and all the villagers of Dogo Arrondissement for their assistance. Grateful acknowledgment is also made to my field assistants, Moussa Diarra and Heather Katz, and to my daughter Miranda.

Dr. David L. Carlson of the Texas A&M Archeological Research Laboratory provided essential technical assistance with the statistical analyses. Discussions with Helen Danzeiser helped clarify the issues of female buffering and variability. Dr. Steven Dettwyler provided assistance with the production of the figures, and offered many helpful suggestions. Dr. Barry Bogin drew my attention to the work of Schmitt and Harrison. Dr. Matt Cartmill, Dr. Barry Bogin, and the anonymous reviewers provided extremely useful comments on earlier drafts.

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