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Original Research Article

Climate, Racial Category, and Body Proportions in the U.S.

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ABSTRACT In 1955, Newman and Munro reported correlations between physical characteristics and climate in a white male U.S. Army sample. For example, the body weight-to-mean annual temperature correlation was −0.460. Because the men descended from relatively recent immigrants to North America, physical clines implicitly derived from differential lifetime growth rather than from natural selection. Consequently, both causation and adaptive function of Bergmann's and Allen's biogeographic rules in humans were called into question. Analysis of male and female data from the 1988 U.S. Army anthropometric survey offers new insights to the 1955 study findings. Using state means of the male subsample identifying themselves as white, as did Newman and Munro, no significant correlations were found between climatic variables and height, weight, BMI, or other body proportions. With individual data rather than state mean values, neither white male nor white female samples showed morphology to climate correlations. Relationships seen in the earlier white sample have disappeared, possibly due to a more uniform growth environment and mobility in the U.S. Black males and females showed some body trait to climate correlations but only at r values of around 0.10. Using state means from the combined sample (racial identification ignored), strong correlations are seen. As examples, mean annual temperature correlates to male relative sitting height at $r = -0.634$ and to female relative forearm length at $r = 0.645$. However, these values are evidently spurious, being products of the higher percentages of whites enlisting from colder areas of the U.S. Am. J. Hum. Biol. 17:393–402, 2005. © 2005 Wiley-Liss, Inc.

The purpose of this paper is to investigate relationships between human body size, body proportions, and climate in a recent U.S. population. We have assumed that geographic differences in body proportions within our species are products of natural selection. Because the lineal body build and relatively long extremities of tropical peoples are ancient traits in our lineage (Ruff, 1994; Walker and Leakey, 1993), and because these features may form a more efficient platform for heat loss, environmental temperature is assumed to have been the selective force responsible for climatic contrasts in body build. Physiological correlates of body build variations have not been fully investigated experimentally, however. In the absence of clear advantages of phenotypes at one end of the distribution, selective advantages are assumed to have been small and slow to produce change.

Americans of African and European ancestry have been in the New World a relatively short time period from an evolutionary perspective. Consequently, if they conform to biogeographic rules here, we must assume that differential growth is responsible rather than natural selection. That is, cold climate would produce heavier bodies (Bergmann's Rule) and foreshortened extremities (Allen's Rule) through nutrition or by direct thermal action on growing tissues. See Mayr (1963) for discussion of climatic rule expression in vertebrates. The 1988 U.S. Army database used for this project offers an opportunity to examine patterns in individual data as well as data aggregated by state of birth. The analysis also includes effects of "race" on geographic distributions of morphology.

In 1955, Newman and Munro raised a question as to developmental versus evolutionary causes of biogeographic rules. Their large male U.S. Army sample had entered the service between 1946 and 1953 and consisted entirely of those of European (white) ancestry. Correlations between mean January temperature from birth state, weight, surface area,

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and weight/surface area ratio showed that as ambient temperatures rose, weight per unit of surface area fell. Their correlation coefficients were nearly as high as those found by Roberts (1953), who used a worldwide sample of population means and climatic data from areas in which the groups lived. Roberts' results, confirming that Bergmann's weight rule applied to humans, were generally interpreted to be a thermally adaptive product of natural selection. Newman and Munro's results suggested an alternative explanation.

That ambiguity was underlined by Katzmarzyk and Leonard's 1998 analysis of a world sample more recent than that used by Roberts in 1953, but with similar methodology. As an example, the more recent data showed mean annual temperature to surface area/mass correlations of about half the strength of those found by Roberts. Katzmarzyk and Leonard interpreted the change to be secular—mostly produced by larger tropical body size due to improved health and nutrition. Interestingly, in the 1998 study, size and relative surface area are more changed than are body proportions. Put another way, Bergmann's size rule may be more sensitive to plasticity responses than is Allen's proportions rule.

If Katzmarzyk and Leonard's 1998 results reflect general secular change, then Newman and Munro's 1955 correlations should undergo reduction in a more recent U.S. Army sample. People from the American South may have increased more in size than have their northern counterparts. Testing that concept is one goal of the current study. Further, the analysis presented here considers both male and female samples as well as information on relative forearm and lower-leg proportions. Body breadth differences are considered as a special problem.

Late 20th-century literature in physical anthropology has shown a strong push to expunge use of 19th-century typological concepts of race (Marks, 1995). Seeing "races" as ancient, homogeneous genetic packages, modified only by admixture, simply runs contrary to what we have learned since the advent of evolutionary genetics. To my knowledge, the effort to overcome that ancient stereotype has been successful within our profession, and no credible physical anthropologist uses these outdated tools.

However, Americans of European ancestry, heterogeneous as they are, had a long evolutionary history in the high latitudes of Europe and might be expected to show genetic adaptations to cold and low winter solar radiation. Among those traits are reduced skin melanin, heat conservation morphology, and circulatory protection from frostbite. Likewise, African Americans should retain markers of their long tropical evolution, such as lineal body proportions and ultraviolet-resistant skin (reviews in Beall and Steegmann, 2000; Steegmann, 2002). Researching and discovering environmental adaptations in our far-flung species does not somehow support traditional racial typologies (Shipman, 2002:13). It is an error to assume that research on biogeographic variation is implicitly or explicitly racist, contrary to views expressed by Armelagos and Goodman (1988). If we are indeed mammals, then the environmental factors should play no less a role in the evolution of hominids than in carnivores or bovids (Mayr, 1963; Peters, 1983; Ruff, 1994; Vrba et al., 1995). As an exercise in how environmental origins influence morphology, and may confuse biogeographic interpretation, a final section of this paper considers patterns of variation in Americans of African and European ancestry.

METHODS AND MATERIALS

Sample

The study sample consists of data from the 1988 U.S. Army Anthropometric Survey. They were made available on disk, with documentation, by Dr. Claire Gordon, Senior Research Scientist in Biological Anthropology at the U.S. Army Research and Development Center (Natick, MA). Unlike Newman and Munro's 1955 database of 15,216 white males, the data used in this study represent a probability sample drawn from the larger 1988 survey. The sample was designed to maximize application to the current army population, spanning both sexes and a range of ethnicities (Gordon et al., 1989). Information on 1,744 men and 2,208 women included military biography, self-assigned racial category, birthplace, and anthropometrics. Unfortunately, data were not collected on whether state of birth was the same as state of residence during childhood, nor information on location of birthplace within states. The survey followed U.S. Federal Government categories of race, such as Hispanic, Pacific Islander, or American Indian. African American is identified as black and European American as white, self-assigned during interviews.

Anthropometrics

The U.S. Army Anthropology Group has developed detailed anthropometric protocols, including clear written descriptions, photographs and drawings, marked landmarks, standardized postures and measurement conditions, and guidance on difficult techniques (Clauser et al., 1988). While some error due to multiple anthropometrists is inevitable, we assume it is random, and errors should be low percentages of the large dimensions used in this study (Gordon and Bradtmiller, 1992). The data set is designed for practical application in military ergonomics so that not all variables match those commonly used in human biology. However, they were easily employed to answer the current research questions.

Table 1 lists biographic and anthropometric variables used in this study, as well as combined measures and indices. Variables such as body mass index (weight kg/stature m^2) and relative sitting height (sitting height/stature × 100) are widely used, while others were constructed from available dimensions in the absence of more familiar measurements. For instance, the relative lower-leg length is mid-patella height/stature × 100, since there was no direct leg length measure. In contrast, relative lower-arm (forearm) length was calculated directly as radius length/(radius + humerus length) × 100. Consequently, the arm proportion index is probably the more exact of the two extremity proportion estimates. See Lohman et al. (1988) for a discussion of methodological issues and Clauser et al. (1988) for specific anthropometric techniques.

TABLE 1. Listing of anthropometric dimensions; numbers in parentheses correspond to the full description in Clauser et al. (1988)

Anthropometrics
Acromion to radiale [upper arm length] (73)
Chest breadth (101)
Chest circumference (102)
Hip breadth [bitrochanteric breadth] (134)
Knee height, mid-patella (141)
Radiale to stylon [lower arm length] (156)
Sitting height (162)
Stature (168)
Weight (193)
Combined Anthropometrics
Arm length [acromion to radiale + radiale to stylon]
Leg length [stature − sitting height]
Indices
Body mass index [weight, kg/stature, m^2]
Chest shape index [chest breadth/chest circumference × 100]
Relative lower arm length [radion to stylon/arm length × 100]
Relative lower leg length [knee height/stature × 100]
Relative sitting height [sitting height/stature × 100]
Biographic
Age; birthplace; self-identified race; sex

Climatic data

All climatic values, summing a 25-year period from 1970 to 1995, were taken from Garoogian (2000). Using a population density map, weather station sites for each state were selected using areas of high population density as rough estimates of where soldiers most likely originated. The army database gives only birthplace by state. Error would increase if population-dense areas had not provided the most soldiers or if soldiers had not grown up in their state of birth—information that is unavailable. Choice of weather station was not always straightforward. For example, climatic values for Kansas used an average of values from Wichita (a mid-sized city in southeastern Kansas), and Kansas City, Missouri (to reflect the large urban population in northeastern Kansas that is part of the greater Kansas City area). Full weather data were not available for Kansas City, Kansas, or adjacent Johnson County, but the nearby Missouri data accurately reflect local conditions. Western Kansas weather values were not used due to low population density there.

Climatic variables employed include temperatures (mean annual; mean coldest month; mean hottest month), relative humidity (mean of morning and afternoon), dewpoint in degrees as a measure of absolute humidity, and latitude. Each individual soldier was assigned climatic values from the state in which he or she was born.

RESULTS

Analysis by state means (white males only)

Although Newman and Munro (1955) used a sample of 15,216 native-born white males, they employed only birth state means of climatic and anthropometric values, giving them an analytical sample of 48. Using 20 white men as the minimum, the 1988 sample had only 24 states usable for analysis. When mean annual, hottest and coldest month temperatures were tested for correlation to anthropometric variables, *no significant correlations appeared between thermal values and height, weight, BMI, relative sitting height, or relative forearm or lower-leg lengths.* While this might be attributable to the smaller 1988 sample size of 24, the states used in this analysis showed a normal thermal distribution with about twice the number of moderate thermal values, as compared to states with hotter or colder climates. It is more parsimonious to conclude that Newman and Munro's correlations are no longer seen.

Full sample, stratified by sex and race

Due to small state subsamples, part of the sample is lost using state means. This analysis consequently employs a large sample by use of individual values. Each soldier was assigned climatic values based on state of birth. Only those identified as black or white are included, as other groups did not show sufficient subsample numbers across the full climatic range. Neither the white male subsample ($N = 1{,}168$) nor the white female subsample ($N = 1{,}131$) showed significant or even near-significant correlations between key climatic and anthropometric variables. Correlations are only marginally stronger in black males and females (Table 2). The strongest of these values explain only about 1% of the variance (r^2) in anthropometric dimensions or indices.

Bergmann's rule, as expressed in human biogeography, states that body weight is greater in colder areas. Because statures are not greater in cold areas, weight for height should increase in higher latitudes. The opposite is true for black males in this sample. However, the correlation coefficients (Table 2) are so low as to render this a trivial finding.

While some significant correlations appear using individual values from the 1988 sample stratified by race, they do not support the recent expression of Bergmann's and Allen's rules. Table 3 compares results from other studies to these findings, using body mass and mean annual temperature as an example.

Full sample stratified by sex, with race ignored

Recall that the assignment of each soldier's race was by means of self-identification during an interview. Those who entered no racial category or entered more than one were excluded from analysis. "Race" then does reflect ancestral geographic origins and whatever biological differences that implies. Admixture between American subpopulations is still far from producing genetic equilibrium. There may be up to 30% European genes in African American populations and lower values of African genes in European American groups (Parra et al., 1998). Among traits for which the two groups should contrast are those predicted by Bergmann's and Allen's rules. Table 4 indicates that, while black and white American soldiers are now of equivalent heights and weights, ancestral temperate/tropic body proportions persist. As predicted by Allen's rule, Americans of European ancestry retain relatively longer trunks and relatively shorter distal arm and leg segments. Height and weights may be influenced by recruiting standards imposed

TABLE 2. Correlation coefficients between climatic and anthropometric variables in the 1988 U.S. Army sample

	Weight	BMI	RelStHt	RelLoLeg	RelForarm
Black females ($N = 921$)					
X annual temperature	−0.018	−0.018	0.019	0.105**	−0.033
X coldest month temp.	−0.022	−0.024	0.021	−0.101**	−0.027
X hottest month temp.	−0.025	−0.011	0.019	0.089**	−0.048
Latitude	0.026	0.028	−0.013	−0.017	0.032
Black males ($N = 457$)					
X Annual temperature	0.050	0.094*	0.066	0.046	0.067
X coldest month temp.	0.053	0.089	0.061	0.044	0.042
X hottest month temp.	−0.052	−0.096*	−0.030	−0.061	0.084
Latitude	−0.065	−0.109*	−0.061	−0.045	−0.066

Abbreviations: RelStHt, relative sitting height; RelLLoLeg, relative lower-leg length; RelForarm, relative lower arm length.
*Significance $P < 0.05$.
**Significance $P < 0.01$.

TABLE 3. Comparative correlations of body mass (weight) to mean annual temperature

Study (date)	Sample	Correlation coefficient
Roberts (1953)	Male, world sample, population means	−0.589**
Newman and Munro (1955)	White male, U.S., state means	−0.460**
Katzmarzyk and Leonard (1998)	Male, world sample, population means	−0.267**
	Female, world sample, population means	−0.279**
Current study (1988 U.S. Army data)	White male, U.S., individual values	0.012 (ns)
	White female, U.S., individual values	−0.015 (ns)

*TABLE 4. Comparison of black and white anthropometric values by t-test**

Variable	Black male (*N* = 457)	White male (*N*) = 1,168	Sig.	Black Female (*N* = 921)	white female *N* = 1137	Sig.
Stature, cm	175.6	176.1	0.163	163.0	163.4	0.157
Weight, kg	79.5	78.6	0.130	62.5	61.8	0.049
BMI	25.73	25.32	0.006	23.51	23.14	0.001
RelSitHt	50.76	52.50	0.000	51.27	53.05	0.000
RelForarmLt	44.88	43.93	0.000	44.39	43.38	0.000
RelLoLegLt	29.40	28.52	0.000	28.69	27.75	0.000

*1988 U.S. Army sample was used. Values are means. "Sig." indicates exact probability of error if difference is accepted, with "0.000" meaning an unspecified level beyond three places.

by the Army (AR-40-501, 2004:11), but selective practices should have no influence on body proportions.

It is clear in Table 5 that correlations are higher within the full sample than within subsamples stratified by race (Table 2). However, coefficients are still low, absolutely, the strongest being only 0.227. Newman and Munro (1955) found mean January temperatures to be the strongest anthropometric predictor. In the present sample, the hottest month predicts best for men and the dewpoint (a measure of water vapor volume) is better for predicting women's physical patterns. None offers a strong methodological advantage. These low correlations might at

TABLE 5. Females and males in the 1988 U.S. Army sample, all racial categories combined

	Mean temperatures				
	Annual	Cold month	Hot month	Dewpoint	Latitude
Males (*N* = 1,774)					
BMI	0.051*	0.053*	—	0.054*	−0.049*
RelSitHt	−0.101**	−0.075**	−0.143**	−0.115**	0.111**
Chest Breadth	−0.047*	—	−0.048*	−0.050*	0.053*
Chest Shape	−0.069**	−0.065**	−0.066**	−0.065**	0.064**
RelForarmLt	0.134**	0.103**	0.167**	0.140**	−0.148**
RelLoLegLt	0.117**	0.095**	0.141**	0.124**	−0.120**
Hip breadth	—	—	—	—	—
Females (*N* = 2,208)					
BMI	—	—	—	—	—
RelSitHt	−0.165**	−0.140**	−0.182**	−0.201**	0.187**
Chest Breadth	−0.073**	−0.064**	−0.082**	−0.092**	0.079**
Chest Shape	—	—	—	—	—
RelForarmLt	0.199**	0.177**	0.197**	0.227**	−0.221**
RelLoLegLt	0.114**	0.091**	0.132**	0.152**	−0.139**
Hip breadth	−0.075**	−0.071**	−0.074**	−0.093**	0.078**

Correlations are between climatic and anthropometric variables.
*Significance probabilities <0.05 to <0.01.
**Probabilities <0.009.

first appear to support Allen's body proportion rule, while Bergmann's weight rule is not supported. Relative sitting height seems to decrease and distal arm and leg segments increase in warmer areas.

This exercise is presented to illustrate the danger of ignoring geographic origins of subpopulations. Because those of African and European origins retain temperate and tropical body proportions (Table 4), part of the variance in these samples is assumed to be explained by ancestral climatic associations rather than by differential growth across the U.S. That issue is clarified by reverting to analysis of data by state rather than by individual.

State mean sample stratified by sex: spurious values if race is ignored

The first four columns in Table 6 show strong correlations between climatic and body proportion variables (relative sitting height, relative forearm length, relative lower-leg length). Body mass index and weight show only one significant value out of the 16 tests, although female hip breadth does show some midlevel coefficients. While the results "support" the expression of Allen's rule in these samples, this appears to be a spurious finding produced by ignoring racial category.

To clarify these results, percentages of white males and white females were calculated for each state sample. Given the differences in black and white body proportions (Table 4), colder climate state samples could show relatively longer trunks and shorter distal arm and leg segments simply because there were higher percentages of whites in those state samples. Percent white was used in these calculations because the distribution was normal, whereas several colder climate states showed no blacks in their samples.

The final column in Table 6 indicates that body proportions correlate more strongly with percentage white than with climate. As a visual example, Figure 1 illustrates correlations between women's relative sitting height, mean annual temperature (Fig. 1A) and percent white (Fig. 1B). If we accept the logic that higher correlation suggests more likely causation, then higher correlation with racial percentage explains the spurious "support" for short term induction of Allen's rule morphology.

Alternative analysis, using t-tests of differences between climatic values for black and white subsamples, showed that blacks occupy warmer, lower-latitude areas. For example, the average mean annual temperature (calculated from birth state data) was 59.9°F for blacks and 54.8°F for whites ($P < 0.0009$). Partial correlations (anthropometrics to climate, % white constant; anthropometrics to % white, climate constant) verified that racial percentages showed stronger relationships to anthropometric indices than did climatic variables. As examples, male relative sitting height correlated to hottest month temperature at $r = -0.731$ ($P < 0.0009$), but only at $r = -0.150$

TABLE 6. Females and males in the 1988 U.S. Army sample, all racial categories combined, by state mean

	Mean temperature				
	Annual	Cold month	Hot month	Latitude	%White
Males (n = 30)					
Weight	0.224 (ns)	0.249 (ns)	0.128 (ns)	−0.095 (ns)	−0.168 (ns)
BMI	0.365 (ns)	0.390 (ns)	0.185 (ns)	−0.282 (ns)	−0.349 (ns)
RelSitHt	−0.630 (0.000)	−0.520 (0.003)	−0.731 (0.000)	0.690 (0.000)	0.861 (0.000)
RelForarmLt	0.610 (0.001)	0.445 (0.014)	0.758 (0.000)	−0.695 (0.000)	−0.732 (0.000)
RelLoLegLt	0.647 (0.000)	0.549 (0.002)	0.703 (0.000)	0.686 (0.000)	−0.883 (0.000)
Hip breadth	−0.246 (ns)	−0.237 (ns)	−0.231 (ns)	0.338 (ns)	0.371 (0.004)
Females (N = 36)					
Weight	−0.202 (ns)	−0.249 (ns)	−0.152 (ns)	0.156 (ns)	0.161 (ns)
BMI	−0.031 (ns)	−0.077 (ns)	−0.014 (ns)	0.028 (ns)	0.037 (ns)
RelSitHt	−0.556 (0.000)	−0.520 (0.001)	−0.480 (0.003)	0.608 (0.000)	0.894 (0.000)
RelForarmLt	0.645 (0.000)	0.614 (0.000)	0.553 (0.000)	−0.693 (0.000)	−0.886 (0.000)
RelLoLegLt	0.382 (0.021)	0.331 (0.048)	0.332 (0.050)	−0.464 (0.004)	−0.645 (0.000)
Hip breadth	−0.490 (0.002)	−0.531 (0.001)	−0.383 (0.021)	0.471 (0.004)	0.619 (0.000)

Correlations are between climatic and anthropometic variables. Exact probabilities of error in acceptance of significance are in parentheses.

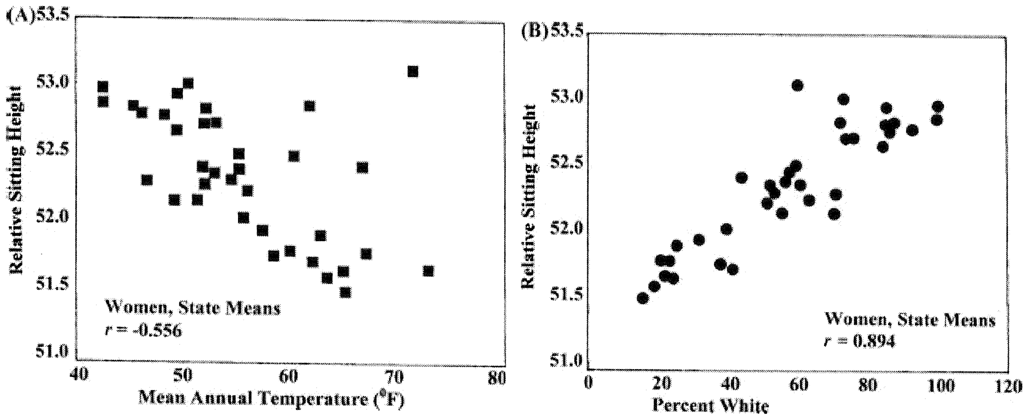

Fig. 1. (**A**) State mean values from the entire women's sample, all racial categories combined, suggesting that relative sitting height (sitting height as % of stature) increases as state mean temperature values decrease ($N = 36$). Also using state means of the combined sample, the scattergram in (**B**) suggests that conclusions from (**A**) are spurious. A more parsimonious explanation is that relative sitting height increases as does percentage of whites in the sample, because whites have higher relative sitting height ($N = 36$).

(ns) with % whites in the samples controlled. Male relative lower-leg length showed an $r = 0.703$ ($P < 0.0009$) to hottest month temperature, but $r = 0.121$ (ns) controlling for % whites.

Body breadth and "Ruff's rule"

Though not the primary aim of this study, body breadth holds a key position in understanding thermal adaptive functions of morphology, and it is considered here as a special case. Of all human post-cranial dimensions and proportions, hip breadth shows the strongest worldwide correlation with climatic variables. In 1994, Ruff reported a correlation of 0.866 between bi-iliac diameter (the maximum lateral distance across the iliac blades) and latitude. Subsamples by sex were consistent, with $r = 0.884$ for 31 male population means and $r = 0.919$ for 25 female groups. This discovery should be known as Ruff's rule. It employs a simpler and more efficient measure than the body mass of Bergmann's rule and is confounded neither by greater relative sitting height in cold areas nor by weight, which is seasonally and nutritionally labile. Ruff also demonstrated that increased body breadth lowers relative surface area, regardless of stature.

Three measures from the 1988 Army sample were used to examine body breadth and climate. Hip breadth is estimated by bitrochanteric diameter, since bi-iliac was not available, and upper body breadth measures are one index and one diameter. The chest-shape index decreases as the chest gets narrower relative to circumference (or, as the chest becomes more "cylindrical"), and the transverse chest breadth is comparable to hip breadth. In the full sample that combines all racial categories, males show no significant climate-to-hip breadth correlations, although chest breadth is marginally greater in colder settings. Females exhibit increased hip and chest breadth as temperatures decrease. Slightly less cylindrical chests are also found in colder area males. However, as suggested in the preceding section, these values are artifacts of change in racial category percentages with climate and are too low to have biological significance in any case.

When tests were run within racial category subsamples, almost no correlations appear between climate and hip breadth or chest index. Only black females show low correlations between chest index and climate. For example, mean annual temperature correlates to chest index at $r = 0.068$, indicating relatively narrower chests in colder areas. These coefficients, while significant at $P < 0.01$, explain at best 0.5% of morphological variance and probably have little relevance to function or differential growth.

DISCUSSION

Newman and Munro revisited

The primary purpose of this investigation was to determine whether climate–morphology correlations, found by Newman and Munro (1955), persist in the 1988 sample. To match the earlier approach, I employed state mean values for the white male army sample. It was unexpected to find no statistically significant correlations between climatic variables and stature, weight, or body proportions in the 1988 sample. It is not clear why there should be such a dramatic change. For instance, body weight correlation to mean annual temperature changed from −0.460 ($P < 0.01$) in 1955 to a nonsignificant 0.049 in 1988.

The 1988 sample was smaller so that only 24 states had subsamples large enough to enter. However, the states were normally distributed climatically. While sampling error cannot be ruled out, that seems to be an unlikely explanation for complete loss of significant correlation.

A better possibility is secular change. Health and nutrition conditions may well have improved sufficiently between growth periods of about 1925–1953 and 1968–1986. The further implication is that conditions in the U.S. may be sufficiently uniform that differential regional growth has disappeared. That explanation was used by Katzmarzyk and Leonard (1998) for changes in the worldwide sample over approximately that same period. As a further issue, Claire Gordon (personal communication) suggests that with the higher recent mobility of American families, birth place may no longer be a useful indicator of climatic conditions that could affect growth.

An additional reason for lack of correlation in this case may be an artifact of changed military recruiting practices. Unlike the 1955 sample, the 1988 soldiers were an "all-volunteer" force with no draftees or conscripts. There was and is an emphasis on recruiting capable, well-educated, highly motivated soldiers. By implication, these men and women may show less regional differentiation than would a group of draftees. Put another way, today's soldiers may not reflect the regions from which they come, as they once did.

Climatic correlations within racial samples (individual data)

Because of differences in body proportions in Americans of African and European descent, individual data should be analyzed by racial category as a most stringent test for climatic effects. In the subsamples of white males and females, there were no morphology–climate correlations. This agrees with the analysis using white male state means but is a much larger sample and strengthens the conclusion about noncorrelation. The preceding paragraphs consider why that may be so. However, Table 2 demonstrates some low correlations in the black subsample. Black women showed relatively longer forearms in warmer states. This conforms to Allen's rule. Contrary to expectation, black male body mass index increased in warmer areas indicating more weight per unit of height there.

While these correlation coefficients within black subsamples are absolutely low and explain little variance, their expression at any level is unexpected, given the results from the white subsamples. It is possible that differences in economic resources and work opportunities expose blacks to more climatic stress, and there may have been some culturally based dietary differences. For example, the traditional southern African American diet includes relatively high levels of animal fats and carbohydrates and would act to increase body mass index. Were undernutrition the issue, blacks would be expected to show lower stature and lower weight for height, and yet the values in Table 4 demonstrate racial category subsamples were of equivalent weight and height. If these correlation values are more than chance associations, then individual economic and dietary data would be needed to resolve the issue, and those data were not collected in the 1988 survey.

An alternative if more ambiguous explanation of correlations for blacks only involves admixture. Generally, northern African American populations show higher white admixture than do those from the South. Higher percentages of European genes could lead to relatively shorter legs and extremity segments, although this has not been empirically demonstrated. Admixture rates in the north range from approximately 13–26% white genes, but there is variation within areas and some southern cities such as New Orleans show elevated rates (Parra et al., 1998). Characteristics of groups with "mixed racial ancestry" are now beginning to be evaluated by military anthropometrists (Yokota and Gordon, 2000).

The costs of ignoring ancestry

In this paper, it has been demonstrated that doing biogeographic analysis without consideration of racial category produces misleading results. While that may seem self-evident, there is pressure within anthropology to avoid research having to do with "race" (Armelagos and Goodman, 1998). Without question, attribution of innate behaviors to typological races has done enormous damage and should be rejected. Unfortunately, environmental histories and the search for environmental adaptations has become "the baby that gets thrown out with the bath water."

To make the point, part of this analysis employed subsamples in which self-identified racial category is ignored. The strongest and most spurious results are shown in Table 6 and Figure 1a. Indices such as relative sitting height or relative forearm length show climate–morphology correlation coefficients in the 0.5–0.7 range, and that would support a developmental cause for Allen's rule body proportions. Ignoring racial category, Americans from hotter areas would be shown to have relatively shorter trunks, longer legs, and elongated forearms and lower legs. On closer examination, Allen's rule in the U.S. military sample is produced by higher percentages of black enlistees from warmer states and more whites from colder areas. Body shape measures correlate more strongly with percentages of whites in each state sample than with climatic variables. In this case, well-intentioned rejection of racial categories would lead to a false interpretation of biological data.

One provocative body proportion issue appeared in this analysis. American men and women of the 1988 U.S. Army sample have body sizes and proportions that are apparently unaffected by birthplace. Comparison of black and white subsamples (Table 4) demonstrates nearly identical heights and weights of blacks and whites. This implies that the two groups have approximately equivalent nutrition and health during growth. However, blacks have relatively shorter trunks and longer legs as well as longer lower-arm and lower-leg segments. Clearly, some of this must result from ancestral genes, but the biology is still puzzling.

Barry Bogin and colleagues (2002, 2003) reported stunning physical change in children of Mayan immigrants. Compared to Guatemalan Mayans—who are very short in stature and short legged—American-born 6- to 12-year-old Mayan children are a mean of 10.24 cm taller and 7.02 cm greater in leg length than their Guatemalan counterparts. Consequently, body proportions, as well as size, are plastic during development, and Bogin et al. offer extensive reviews of the leg proportion issue in both papers. However, they show that American-born Mayans still have relatively shorter legs than American blacks and whites, and that "...this may reflect a genetic predisposition..." (Bogin et al., 2003:759). As blacks and whites in the 1988 U.S. Army sample contrast in body proportions, at least part of the variance in relative sitting height is genetic.

CONCLUSIONS

That differences in body morphology can be produced by differences in growth environment has been recognized since the 18th century and is not a surprise. However, Newman and Munro's 1955 climate–morphology correlations in white males had disappeared in the 1988 army sample, and the rapidity of change is unexpected. The most parsimonious explanation is a smoothing over of regional differences by secular improvement of growth conditions and by population mobility. Further, although height and weight for subsamples of African and European origin are equivalent, those groups retain ancestral body proportions. People of African ancestry retain longer legs and longer distal arm and leg segments as a group, although there is little variation of these traits within either group across the climatic ranges of the U.S. The finding suggests that these aspects of body morphology are expressed, even in optimum growth conditions, and may also be ancient genetic adaptations to thermal selective pressures (the usual interpretation of Allen's rule). If so, physiological advantages of body proportion differentials should be demonstrable experimentally. They have not been systematically investigated.

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