Original Research Article

Height and Relative Leg Length as Indicators of the Quality of the Environment Among Mozambican Juveniles and Adolescents

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ABSTRACT The growth status of Mozambique adolescents was assessed to test the hypothesis that relative leg length is a more sensitive indicator of the quality of the environment than the total height. The sample comprised 690 boys and 727 girls, aged between 9 and 17 years, from Maputo. It is divided between those living in the Centre of Maputo and those living in the slums on the periphery of the city. Height, weight, and sitting height were measured and the sitting height ratio was calculated. The hypothesis that relative leg length is more sensitive than total stature as an indicator of environmental quality is not uniformly confirmed. Overall, mean stature is greater for the centre group than the slum group, but relative leg length as measured by the sitting height ratio does not differ. Compared with African-American references (NHANES II), all centre girls, 9- to 14-year-old slum girls, all slum boys, and the oldest centre boys show relatively shorter legs. These findings show that within the Mozambique sample, relative leg length is not sensitive enough to distinguish the quality of the living environment. Mozambique was a colony of Portugal until 1975. Civil unrest and warfare characterized the late Colonial period and the postindependence period until a peace settlement was concluded in 1992. It is possible that all socioeconomic status groups within the country suffered sufficiently to reduce relative leg length compared with the better-off African-American reference sample. Possible genetic influences on relative leg length are also discussed. Am. J. Hum. Biol. 21:200–209, 2009.

Our purpose in this article is twofold. First, we present anthropometric data for a sample of juveniles and adolescents from Mozambique, which is a country underrepresented in the worldwide anthropometric literature. Indeed, good quality, recent anthropometric data from Africa are less well represented in the literature than data from any other continent of the world (Cameron, 1991, 2003; Akachi and Canning, 2007). One of the reasons for this is the warfare and civil unrest that characterized Africa's former European Colonies after their independence in the 1960s and 1970s. This hostility and instability makes anthropometric surveys difficult and dangerous. Another reason for the paucity of growth and development research is the poverty of the vast majority of the post-Colonial African population. Poverty is associated with so many social, economic, and political problems that studies of human growth seem to be relatively unimportant.

The physical growth of children and youth, however, is a sensitive indicator of the quality of the social, economic, and political environment in which they live (Fogel, 1986; Komlos, 1994; Tanner, 1981). Anthropometric measurements, especially height, may be used to characterize the relative biological and socioeconomic status (SES) of different groups of people. Anthropometry is especially useful for economic history research, that is, before the existence of modern socioeconomic indicators, such as wages and gross domestic product (Steckel, 1998). Anthropometry is also useful in more recent times when social unrest destroys traditional economies (Bogin and Varela-Silva, 2003; Victora et al., 2008). In this tradition, we present data on height, weight, and sitting height to characterize the biological and SES of Mozambican juveniles and adolescents who grew up during and following the end of official post-Colonial hostilities in their country.

Mozambique was a Portuguese colony between 1505 and 1975. Five years after reaching independence, a civil war began and lasted until 1992 (Bruck, 2001). During this time, the socioeconomic situation devastated Mozambique, making it one of the poorest countries in the world. After the end of the war, there were some improvements in the living conditions as the economic recovery of the country proceeded. However, these socioeconomic changes were limited. According to the 2007 census, Mozambique has a population of 21,397,000 with a density of 25/km^2 (178th most dense of 240 nations). The per capita gross domestic product (2005 estimate) is US$1,389, ranking 158th of 179 nations surveyed by the International Monetary Fund. The Gini ratio (2007 United Nations estimate), a measure of the inequality of wealth distribution, is 0.45–0.49 (1.0 = perfect inequality, USA = 0.47, EU average = 0.30). The Human Development Index (HDI, a normalized measure based on life expectancy, literacy, education, standard of living, and GDP per capita) for 2007 is 0.384, ranking 172 of 177 nations surveyed by the United Nations. Between 1995 and 2000, Mozambique had a life expectancy at birth of 40.6 years and an infant mortality rate of 127 per thousand (Programa das Nações Unidas para o Desenvolvimento, 2001; UNPD, 2002). These statistics are among the worst of any nation.

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Our second purpose in this article is to test the hypothesis that relative leg length is a more sensitive indicator of the quality of the environment than is total stature. Here, we use the sitting height ratio (SHR) ([sitting height/stature] × 100) as the measure of relative leg length. There is wide support for the use of relative leg length as an indicator of the quality of the environment for growth during infancy, childhood, and the juvenile years of development, the time of life during which the lower limbs grow at a faster rate than the trunk, head, or upper limbs (Ali et al., 2000; Billewicz et al., 1983; Bogin et al., 2001; Bogin et al., 2002; Bogin and Rios, 2003; Boldsen, 1998; Dangour, 2001; Dangour et al., 2002; Frisancho et al., 2001; Frisancho, 2007; Gunnel et al., 1998a; Gunnel et al., 1998b; Han et al., 1997; Jantz and Jantz, 1999; Lawlor et al., 2003; Leitch, 1951; Malina et al., 2004; Martin et al., 2004; Tanner et al., 1982; Udjus, 1964; Velandez-Melandez et al., 2005; Wadsworth et al., 2002).

For groups of children and youth, short stature because of relatively short legs (i.e., a high SHR) is a marker of an adverse environment. An example comes from the comparison of Guatemalan Maya children (5–12 years old) living in rural Guatemala and in the United States. The US living sample is, on average, 11.54 cm taller and 6.83 cm longer-legged than the Guatemala living group (Bogin and Loucky,1997; Bogin et al., 2002). In this case, nearly 60% of the increase in stature is due to greater leg length.

The research also finds that leg length, rather than trunk length, is a better predictor of adult-onset disease, such as coronary heart disease (CHD) and atherosclerosis (Davey Smith et al., 2001; Langenberg et al., 2005; Lawlor et al., 2002; Lawlor et al., 2004; Tilling et al., 2006). The association of these diseases with leg length indicates that environmental adversity during the prepubertal period of growth and development may compromise both current growth and future health.

Even within a population that has a biological propensity for longer legs, such as people from sub-Saharan African origins (Bogin and Varela-Silva, 2008; Eveleth and Tanner, 1990; Norgan, 1988), we hypothesize that those African groups living in a more favorable environment will have relatively longer legs in proportion to total stature than those who live in a less favorable milieu. To test this hypothesis, we analyze a sample of Mozambique juveniles and adolescents living in Maputo, the capital of Mozambique. Part of this sample live in the Centre of Maputo, an area of, generally, higher SES. The other part of the sample lives in the slums of peripheral area of Maputo, a low SES area.

MATERIALS AND METHODS

Sample

During July/August 2000, a cross-sectional anthropometric survey was carried out in six primary and secondary schools of Maputo. These schools were selected randomly among all the schools in Maputo; three of them are located in the urban Centre of Maputo and the other three in the slums. The physical infrastructure of the urban centre is similar to that in an industrialized country, i.e., concrete and steel buildings, served by national electricity, water, and sanitation systems. The slums surrounding the centre are composed primarily of houses made of cane reeds and other impermanent materials, which do not have legal connection to any urban services, such as electricity, water, and sanitation.

The sample comprised 1,417 subjects, 690 boys and 727 girls. From these, 392 boys and 327 girls are from the slums and 298 boys and 400 girls are from the Centre of Maputo. The ages range from 9.0 to 17.99 years. The age groups are formed by whole-year categories, i.e., 9.00–9.99, 10.00–10.99, and so on. Anthropometric variables and family SES characteristics were collected by the first author.

Mozambique became an independent nation in 1975. According to the Mozambique Human Development Report (UNDP, 1998), the postindependence years between 1975 and 1981 showed an increase in socioeconomic instability, which disrupted the agricultural, health, and education systems. With the onset of the civil war in 1981, the situation became even worse, especially between 1983 and 1989, the years of the most intense warfare in the country. All of the participants in this study were born during war time, but the youngest ones, born in 1991, spent only their prenatal period and first postnatal year of life under war conditions. The oldest age group, born in 1983, spent 9 years growing-up under war conditions.

It was not possible to assess skeletal or sexual maturation in the sample. In an attempt to provide some control for maturity status, the sample is divided into three age groups for some analyses. These age groups are as follows: 9–11 years (preadolescence); 12–14 years (early adolescence); and 15–17 years (middle-to-later adolescence). We use these age groups as likely stages of adolescence given reference values for South African juveniles and adolescents (Cameron et al., 1993).

Anthropometric measures

At each school, anthropometric measurements were carried out using standardized procedures (Lohman et al., 1988). Anthropometric measurements were performed with the subjects lightly dressed and without shoes. Height and sitting height were measured using a stadiometer, with the head positioned to the Frankfort plane, weight was measured using an electronic scale with a precision of 100 g. These direct measurements are used to calculate body mass index (BMI = weight in kg/height in meters^2) and the sitting height ratio (SHR = [sitting height/stature] × 100). SHR provides the indirect estimation of leg length, with a lower SHR value indicating relatively longer legs in proportion to total stature.

Sociodemographic data

During the anthropometric examination, adolescents reported family characteristics and place of residence. Parents' educational status is categorized into three levels: (1) Primary; (2) Secondary; and (3) University level. For the size of the family, we used six categories: (i) one; (ii) two; (iii) three; (iv) four; (v) five; and (vi) six or more children. The places of residence are grouped in two categories: (1) slums and (2) centre.

Statistical analysis

Descriptive statistics were calculated for height, weight, BMI, and SHR by place of residence (centre vs. slum), age group, and sex. The anthropometric data for each participant were standardized by age and sex into z-score deviations from the African-American references of the National Health and Nutritional Examination Survey II (NHANES II; Frisancho, 1990). Using these z-score deviations, the participants were classified into six nutritional status groups, following the cutoff points recommended by the World Health Organization (de Onis M and Blössner M, 1997): (1) no stunting or wasting (normal height-for-age or weight-for-height, within 1.99 standard deviation [SD] of the reference), (2) stunting (chronic malnutrition, height-for-age between SD −2.00 and SD −2.99, (3) severe stunting (severe chronic malnutrition, height-for-age equal or below SD −3.00), (4) wasting (acute malnutrition, weight-for-height below SD −2.00), (5) overweight (BMI between SD +2.00 and SD +2.99), and (6) obesity (BMI equal or above 3 SD).

The statistical significance of the z-score deviations from the reference are evaluated with one-sample t-tests. The difference between the z-score deviations of the centre and slum groups is tested by a factorial ANOVA. Each of the anthropometric variables was tested separately (i.e., one analysis for height, weight, BMI, and SHR) using age, sex, and place of residence as the categorical predictors. Age was grouped into three categories: (1) preadolescence, (2) early adolescence, and (3) middle-to-later adolescence, as described earlier.

Finally, stepwise multiple linear regression was used for a series of sociodemographic analyses. In these analyses, one of the anthropometric measures is the dependent variable and “age,” “place of residence,” “parents’ education,” and “size of the family” are the independent predictor variables. No covariate adjustments were made, nor were any adjustments made for unequal sample sizes and variances as the F-test of linear regression is robust to deviations from normality (Lindeman et al., 1980).

RESULTS

Comparisons between slums and centre

Subjects who lived in the Centre of Maputo showed better living conditions expressed by a higher educational level of both parents and smaller size of the families (Table 1). The differences in mother’s education are, perhaps, most striking. In the centre, 68.5% of the mothers have secondary schooling or higher, whereas in the slums 78.2% of the mothers have only primary education, including those with incomplete primary schooling. About 40% of those sampled from the slums and 30% of those sampled from the centre did not know the educational level of their parents. This might bias the exact estimates of educational level, but probably does not bias the general pattern of differences between the two groups. Families who lived in the slums have more children (68.3% have four or more) compared with those from the centre (63.3% have three or less). These differences in parents’ education and family size are statistically significant (Chi-square test, $P < 0.001$).

Descriptive statistics for the anthropometric data of boys and girls by place of residence and age are summarized in Table 2.

Nutritional status classification by place of residence is shown in Table 3. Boys and girls from the slums show a significantly higher percentage of stunting (6.1%, 3.7%) than boys and girls from the centre (0.3%, 1.8%). There are no cases of wasting and the percentages of overweight and obesity are very low and confined to boys and girls from the centre.

TABLE 1. Sociodemographic characteristics of the sample

	Slums	Centre
	n (%)	*n* (%)
Father’s education[a]		
Primary school only	255 (60.3)	87 (18.6)
Secondary school	151 (35.7)	237 (50.6)
University	17 (4.0)	144 (30.8)
Total responses/total sample	423/719 (58.8)	468/698 (67.1)
Mother’s education[a]		
Primary school only	340 (78.2)	165 (31.4)
Secondary school	88 (20.2)	289 (55.0)
University	7 (1.6)	71 (13.5)
Total responses/total sample	435/719 (60.5)	525/698 (75.2)
Size of the family[a] (number of siblings)		
1	40 (5.9)	133 (19.1)
2	74 (10.9)	161 (23.1)
3	102 (15.0)	147 (21.1)
4	105 (15.4)	110 (15.8)
5	119 (17.4)	62 (8.9)
6	242 (35.5)	83 (11.9)
Total responses/total sample	682/719 (94.9)	696/698 (99.7)

[a]$P \leq 0.001$ (Chi square).

Comparisons between the Mozambique sample and the African-American references

We next compare the Mozambique data with the United States African-American reference data (Frisancho, 1990). We choose these references because the data are derived for a large, nationally representative sample of the United States population—the Second National Health and Nutrition Examination Survey, 1971–1974 (NHANES II). Because populations with significant sub-Saharan African ancestry have relatively longer legs than European or Asian origin populations (Bogin et al., 2001; Bogin and Rios, 2003; Eveleth and Tanner, 1990; Norgan, 1988), the choice of the NHANES II African-American references seems best for comparison with the Mozambique sample, as there is no other similarly large and well-sampled African-ancestry data sets. The African-American references are used only as a basis of comparison with the Mozambique data. The African-American data are not used as a standard or growth, that is, as the desired growth status by age and sex.

For this comparison, we group the Mozambique data by age into likely maturational status groups: 9–11 years (preadolescent); 12–14 years (early adolescent), and 15+ years (middle-to-late adolescent). We calculate statistical significance of mean z-score differences at two levels: (1) between the two Mozambique samples (slums vs. centre) and (2) between the African-American references and the two Mozambique samples. The slums versus centre comparison is based on a factorial ANOVA and the Mozambique versus African-American reference comparison is based on one-sample t-tests, as described earlier. The results are shown in Figures 1–4.

The Mozambique samples from the centre are significantly taller than the subjects from the slums, except for girls in the 15+ age group (see Fig. 1). All age groups of boys and girls from the slums are significantly shorter than the African-American references. Boys and girls

TABLE 2. Descriptive statistics (means and standard deviations) for height, weight, BMI, and sitting height ratio (SHR) by age, sex, and place of residence

Age (yr)	Place of residence	Boys, Mean ± SD					Girls, Mean ± SD				
		N	Height (cm)	Weight (kg)	BMI (kg/m^2)	SHR	N	Height (cm)	Weight (kg)	BMI (kg/cm^2)	SHR
9	Slums	34	131.6 ± 6.4	28.9 ± 4.0	16.6 ± 1.3	51.9 ± 1.1	28	135.7 ± 5.4	31.7 ± 3.9	17.1 ± 1.3	51.5 ± 1.5
	Centre	25	140.9 ± 6.6	34.3 ± 5.2	17.5 ± 1.8	50.9 ± 1.5	39	141.4 ± 4.9	34.5 ± 6.0	17.1 ± 2.2	51.2 ± 1.1
	Total	59	135.6 ± 7.9	31.2 ± 5.2	17.0 ± 1.5	51.5 ± 1.3	67	139.0 ± 5.8	33.3 ± 5.3	17.1 ± 1.8	51.4 ± 1.2
10	Slums	33	138.6 ± 6.6	32.2 ± 3.7	16.6 ± 1.6	51.2 ± 1.8	29	141.8 ± 5.8	36.2 ± 5.1	17.9 ± 1.8	51.7 ± 1.2
	Centre	45	143.5 ± 7.6	36.8 ± 7.9	17.7 ± 2.9	50.7 ± 1.4	58	149.3 ± 6.5	41.2 ± 7.4	18.5 ± 2.5	50.9 ± 1.2
	Total	78	141.5 ± 7.5	34.8 ± 6.8	17.2 ± 2.5	50.9 ± 1.5	87	146.8 ± 7.1	39.5 ± 7.	18.2 ± 2.4	51.2 ± 1.2
11	Slums	30	142.2 ± 4.9	34.47 ± 3.3	16.8 ± 1.5	51.3 ± 1.3	28	146.5 ± 6.8	39.4 ± 7.5	18.3 ± 2.8	51.3 ± 1.1
	Centre	47	149.2 ± 8.1	39.1 ± 6.4	17.3 ± 1.7	50.3 ± 1.0	81	152.7 ± 6.1	44.1 ± 7.3	18.9 ± 2.7	51.1 ± 1.5
	Total	77	146.4 ± 7.8	37.3 ± 5.9	17.1 ± 1.6	50.7 ± 1.2	109	151.1 ± 6.8	42.8 ± 7.6	18.7 ± 2.7	51.2 ± 1.4
12	Slums	46	149.7 ± 7.0	39.8 ± 6.1	17.7 ± 1.9	50.1 ± 1.1	35	152.5 ± 6.0	45.4 ± 6.2	19.3 ± 1.9	50.9 ± 1.3
	Centre	49	155.2 ± 8.5	43.3 ± 7.2	18.0 ± 1.8	50.2 ± 1.5	70	156.8 ± 6.7	48.9 ± 8.6	19.8 ± 3.1	50.9 ± 1.7
	Total	95	152.5 ± 8.2	41.6 ± 6.9	17.9 ± 1.9	50.4 ± 1.3	105	155.4 ± 6.8	47.7 ± 8.1	19.6 ± 2.7	50.9 ± 1.5
13	Slums	43	155.5 ± 8.1	44.4 ± 7.1	18.2 ± 1.6	50.4 ± 1.3	44	155.6 ± 5.1	48.5 ± 6.6	20.0 ± 2.2	51.0 ± 1.3
	Centre	44	159.1 ± 8.5	46.5 ± 7.9	18.0 ± 1.9	50.0 ± 1.3	67	156.8 ± 6.3	51.1 ± 8.7	20.8 ± 3.3	51.5 ± 1.5
	Total	87	157.3 ± 8.5	45.5 ± 7.5	18.1 ± 1.6	50.2 ± 1.3	111	156.3 ± 5.9	50.1 ± 8.0	20.5 ± 2.9	51.3 ± 1.4
14	Slums	63	162.4 ± 6.7	50.3 ± 6.4	19.0 ± 1.7	50.1 ± 1.2	48	156.2 ± 6.0	51.6 ± 6.1	21.2 ± 2.1	51.4 ± 1.6
	Centre	15	164.5 ± 5.2	51.5 ± 7.1	19.1 ± 2.1	50.6 ± 1.2	19	158.5 ± 5.3	56.4 ± 9.9	22.5 ± 4.0	52.0 ± 1.3
	Total	78	162.8 ± 6.5	50.5 ± 6.5	19.1 ± 1.7	50.2 ± 1.2	67	156.8 ± 5.9	53.0 ± 7.6	21.5 ± 2.8	51.6 ± 1.5
15	Slums	65	164.7 ± 6.6	53.5 ± 7.3	19.7 ± 1.9	50.3 ± 1.4	38	158.2 ± 5.4	54.2 ± 7.6	21.6 ± 2.6	51.2 ± 1.4
	Centre	20	168.6 ± 6.4	57.4 ± 8.1	20.1 ± 2.3	50.5 ± 1.2	18	162.7 ± 7.1	54.8 ± 4.6	20.8 ± 2.2	51.4 ± 1.3
	Total	85	165.6 ± 6.7	54.4 ± 7.6	19.8 ± 2.0	50.3 ± 1.3	56	159.7 ± 6.3	54.4 ± 6.7	21.4 ± 2.5	51.3 ± 1.3
16	Slums	50	169.6 ± 5.8	58.7 ± 6.9	20.5 ± 2.1	50.7 ± 1.4	44	159.0 ± 4.6	55.1 ± 7.9	21.8 ± 3.0	51.1 ± 1.5
	Centre	36	173.3 ± 6.7	60.7 ± 8.7	20.2 ± 2.6	50.5 ± 1.1	33	160.1 ± 6.7	53.5 ± 8.1	20.8 ± 2.4	52.2 ± 1.7
	Total	86	171.1 ± 6.4	59.6 ± 7.7	20.4 ± 1.7	50.6 ± 1.3	77	159.5 ± 5.6	54.4 ± 8.0	21.4 ± 2.8	51.6 ± 1.6
17	Slums	28	171.7 ± 6.0	60.3 ± 5.6	20.2 ± 1.4	50.9 ± 1.2	33	160.0 ± 5.6	57.8 ± 7.0	22.6 ± 2.5	51.6 ± 1.2
	Centre	17	171.3 ± 3.8	63.1 ± 9.2	21.4 ± 2.7	50.8 ± 1.2	14	161.1 ± 4.8	58.6 ± 6.9	22.6 ± 3.1	51.9 ± 1.0
	Total	45	171.6 ± 5.2	61.4 ± 7.2	20.7 ± 2.1	50.9 ± 1.2	47	160.4 ± 5.4	58.1 ± 6.9	22.6 ± 2.7	51.7 ± 1.1

TABLE 3. Percentage of normal nutritional status, stunting, severe stunting, overweight, and obesity by sex and place of residence (Chi-square test of proportions)

	Normal (%)	Stunting (%)	Severe stunting (%)	Wasting (%)	Overweight (%)	Obesity (%)
Boys[a]						
Slums (n = 392)	93.6	6.1	0.3	0	0	0
Centre (n = 298)	99.7	0.3	0	0	0.7	0
Girls[a]						
Slums (n = 327)	96.3	3.7	0	0	0	0
Centre (n = 400)	98.3	1.8	0	0	1.3	0.3

[a]$P \leq 0.001$.

from the centre, when compared with the reference values, are significantly taller in the 9–11 age group, not different in the 12–14 age group, and significantly shorter in the 15+ age group.

The results shown in Figure 2 indicate that both boys and girls from the slums are significantly lighter than their counterparts from the centre in the age groups of 9–11 and 12–14 years, but not different in the 15+ age group. The boys from the slums are always significantly lighter than the references. The boys from the centre are significantly heavier than the references in the age group of 9–11, but by the ages of 12–14 they do not differ from the reference values, and by the age of 15+ they are significantly lighter. Girls from the slums are always significantly lighter than the reference values. Girls from the centre are heavier than the reference data at ages 9–11, do not differ from the references at ages 12–14, and are significantly lighter than the references in the age group of 15+ years.

Figure 3 data indicate no differences in BMI between the boys and girls from the slums and from the centre for any age group. When compared with the African-American reference values, boys from the slums have, at all ages, significantly lower BMI values than the references. Among the boys from the centre, the 12–14 and the 15+ age groups show significantly lower BMI values than the references. Girls from the slums show lower BMI values than the references at the ages 12–14 and 15+. Girls 15+ from the centre show also significantly lower BMI values.

The analysis for SHR is shown in Figure 4. The 9–11 group of boys from the slums show a significantly higher value of SHR (relatively shorter legs) when compared with their counterparts in the centre. Boys from the slums show, at all age groups, a significantly higher value of SHR than the African-American references. The boys from the centre have significantly lower SHR (relatively longer legs) than the references in the 9–11 age group, no differences are found in the 12–14 age group, and by the age 15+ they show a significantly higher value of SHR. Girls from the slums, in the age groups of 9–11 and 12–14 have significantly higher values of SHR than the African-American references (i.e., shorter legs in relation to total stature), but no difference in the 15+ age group. Girls

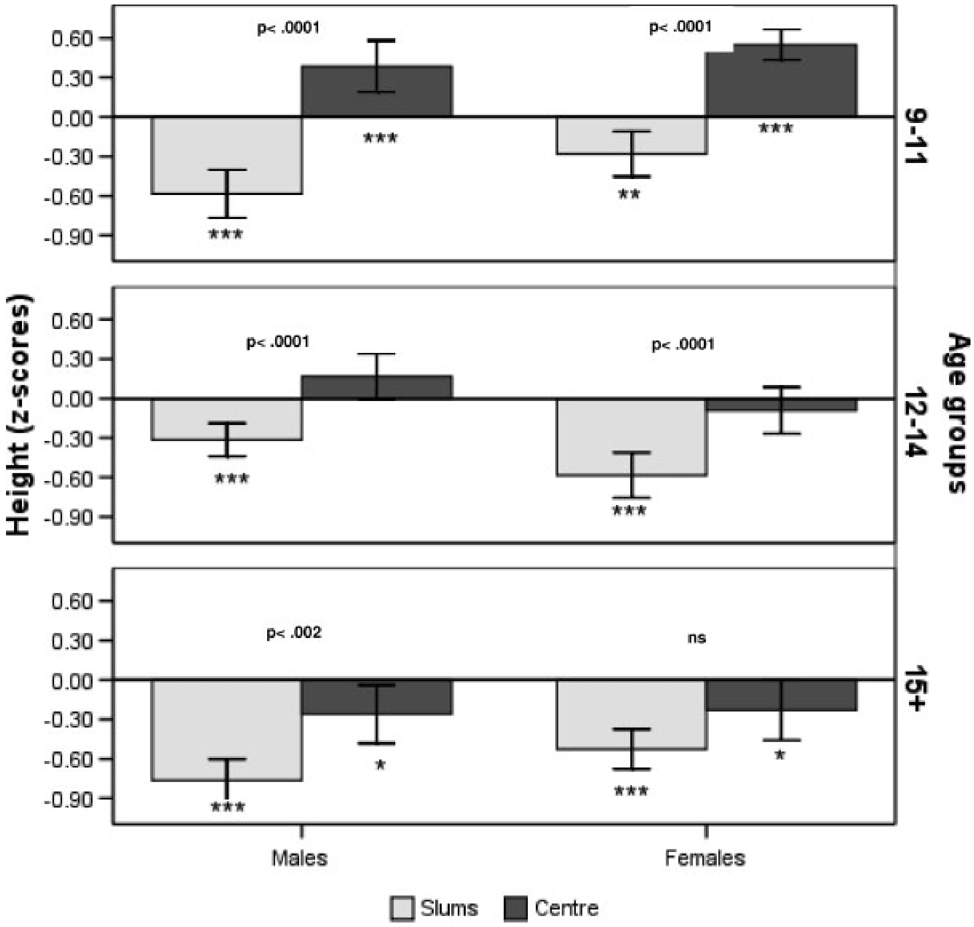

Fig. 1. z-scores for height, by age group, sex, and place of residence. Comparison between adolescents from the slums and from the Centre of Mozambique. The P values refer to the post-hoc comparisons, from the factorial ANOVA, between places of residence. The asterisks denote significant differences between the African-American reference values and the given group (one-sample t-test, $^*P \leq 0.05$; $^{**}P \leq 0.001$; $^{***}P \leq 0.0001$).

from the centre have greater SHR (shorter legs) than the references at all ages (see Fig. 4).

Analysis with sociodemographic variables

Stepwise multiple linear regression analysis is used to determine the association between the sociodemographic and the anthropometric variables. The z-score values of height, weight, BMI, and SHR are used as dependent variables. Place of residence, participant's age and sex, mother's education, and father's education are the independent variables. In the case of height (Table 4), each of the independent variables, other than sex, is a significant predictor, explaining 18.9% of the total variance. Age associated negatively with height, meaning that difference between the Mozambicans and the reference become greater with age. Within the Mozambican sample, place of residence (centre), mother's education, and father's education associate positively with height.

The predictors for weight are participant's age, mother's education, place of residence, and sex, explaining 15.9% of the total variance (Table 5). Age is, again, associated negatively with weight, and mother's education and place of residence (centre) associated positively with weight. Sex was positively associated, indicating that compared with the reference data Mozambican girls tend to be relatively heavier than Mozambican boys.

The significant predictors of BMI are age (negative association) and mother's education (positive association), but these explain only 4.3% of the variance. The statistically significant predictors of SHR are sex (positive) and place of residence (negative), but these two variables explain only 1.1% of the variance. In practical terms, neither BMI nor SHR are associated with the sociodemographic variables.

DISCUSSION

The analysis reported here is one of the few studies of physical growth as an indicator of health in the postwar period of Mozambique. Previous studies are by Padez (2003) and Prista et al. (2003, 2005). It is estimated that 1 million Mozambicans died during the civil war. The war displaced an estimated 4 million people within Mozambique and about 1.7 million sought refuge by migrating to neighboring states of Malawi, Zimbabwe, Swaziland, Zambia, Tanzania, and South Africa. By the mid-1990s most of these internal and external refugees were repatri-

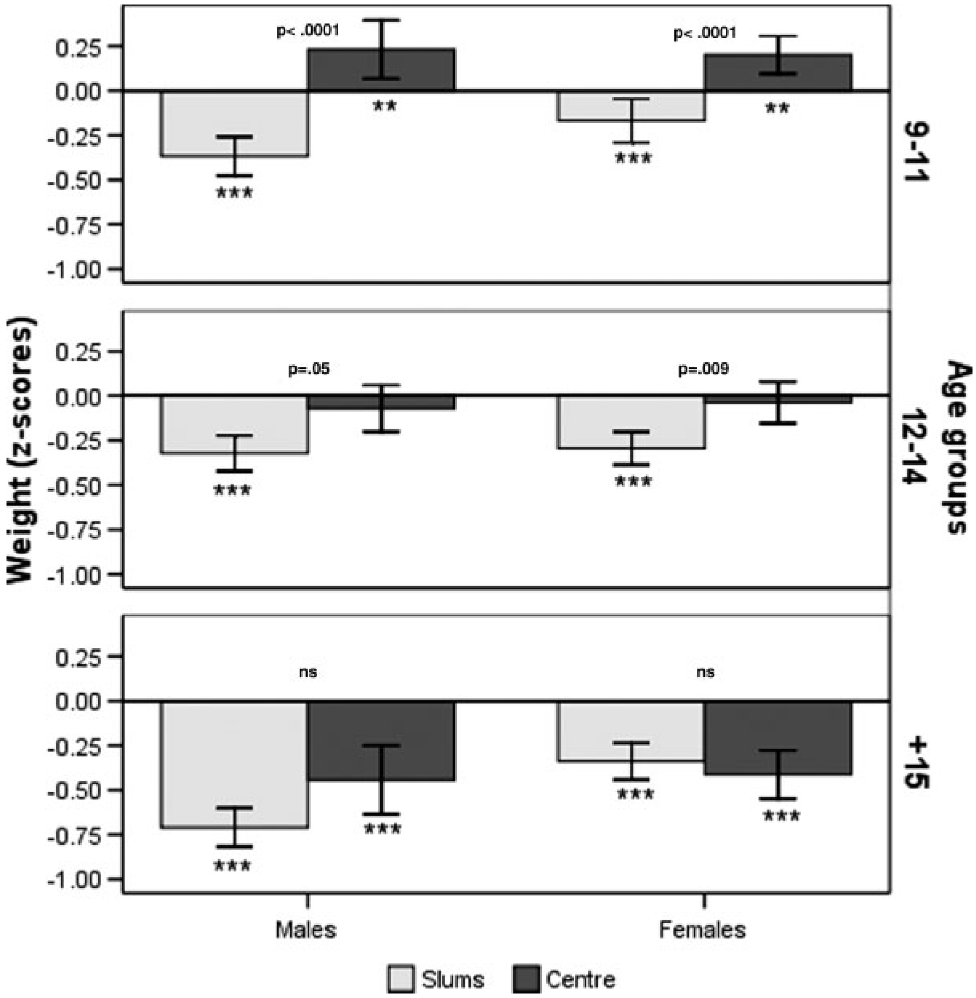

Fig. 2. z-scores for weight, by age group, sex, and place of residence. Comparison between adolescents from the slums and from the Centre of Mozambique. The P values refer to the post-hoc comparisons, from the factorial ANOVA, between places of residence. The asterisks denote significant differences between the African-American reference values and the given group (one-sample t-test, $^{*}P \leq 0.05$; $^{**}P \leq 0.001$; $^{***}P \leq 0.0001$).

ated to their places of origin in Mozambique (CIA Factbook, 2008 and BBC Country Profile http://news.bbc.co.uk/1/hi/world/africa/country_profiles/1063120.stm).

Prista et al. (2005) compared the growth status of a 1992 sample of school children, measured just after the end of civil war, with a 1999 sample (1,098 boys and 1,173 girls, age 6–17 years). Height, weight, BMI, fat mass, and lean body mass are always higher in the 1999 sample than in the 1992 study, showing the recovery of growth status after the war.

All of the boys and girls of our sample were born during war-time, but the younger ones spent less time growing under that war environment. The “time-of-birth” effect related to the civil war can be seen in Figures 1 and 2 in terms of the pattern of height and weight of the centre sample from the youngest to oldest age groups relative to the African-American references. There is no evidence of a “time-of-birth” effect or recovery from war time, for the slum groups. Boys and girls living in the slums of Maputo, of all three age groups, are shorter and lighter relative to the African-American references.

Boys and girls from the centre in the 9–11 and 12–14-year-old age groups are significantly taller and heavier than their age mates from the slums. The centre boys of the 15+ age group are also taller than the slum boys of the same age, but the two groups of girls do not differ significantly in this oldest age group. In weight, neither boys nor girls differ significantly in the 15+ age group. This pattern of age differences in growth may be further evidence of the time of birth effect, that is, due to the war imposing equally poor conditions for growth on the oldest participants from both the centre and the slums. Another possibility is that the younger two age groups show an advancement of maturational status and the tempo of growth for the better-off centre group. By age 15+, however, the slum group has caught-up in maturation with the centre group to the extent that mean weight for both boys and girls and mean height of the girls have equalized. As we do not have any maturational indicators, and these are cross-sectional data, it is not possible to eliminate either likelihood. Future research could be designed to test this “maturational difference” hypothesis.

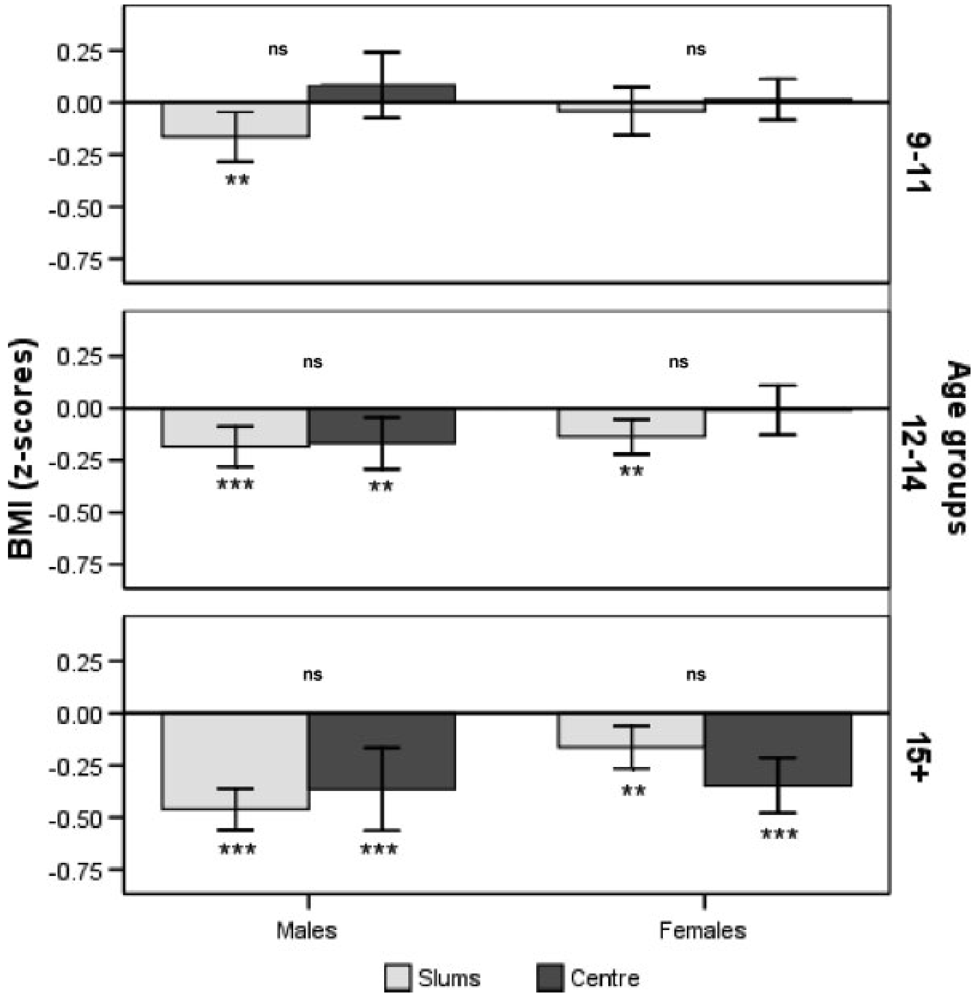

Fig. 3. z-scores for BMI, by age group, sex, and place of residence. Comparison between adolescents from the slums and from the Centre of Mozambique. The P values refer to the post-hoc comparisons, from the factorial ANOVA, between places of residence. The asterisks denote significant differences between the African-American reference values and the given group (one-sample t-test, $^{*}P \leq 0.05$; $^{**}P \leq 0.001$; $^{***}P \leq 0.0001$).

The BMI of the slum and centre samples do not differ at any age (see Fig. 3). Overall, this seems to indicate that the differences in height and weight of the centre and slum samples, when these differences exist, are proportional. There is little evidence of excessive weight. That there is more stunting in the slums is hardly surprising, but the levels of stunting and lack of wasting are lower than might be expected given the recent history of Mozambique.

Our hypothesis that relative leg length is more sensitive than total stature as an indicator of environmental quality is not clearly supported. There is only one statistically significant difference between centre and slum for SHR, for boys of the 9–11 year age group. The sociodemographic stepwise regression analysis for the Mozambique sample finds that only 1.1% of the variance in SHR is explained. It may be that genetic factors regulating body proportions in the Mozambique sample overpower the environmental differences between the centre and slum groups. Another possibility, suggested by a reviewer, is that the overall similarity in the thermoregulatory environment of the centre and the slums may influence body proportions equally (Ruff, 1994). More likely, however, unmeasured environmental variables, associated with the history of the war and its legacy of adverse living conditions for both slum and centre residents are important factors. An example of this comes from the Civil War in Guatemala (1978–1996). During that time, the mean height of children, juveniles, and adolescents of both high and low SES groups declined (Bogin and Keep, 1999). This was due, in part, to disruptions in the food supply, the decline in the quality of the drinking water, episodes of cholera, and a general decline in the economy. Similar problems in Mozambique during and after the war would have impacted growth in height and body proportions of all Mozambique young people. How these problems would differentially affect total stature versus relative leg length is not known.

There is support for our SHR hypothesis when the Mozambique sample is compared with the African-American references. The Mozambique sample shows, in general, relatively shorter legs (greater SHR, Fig. 4). Two

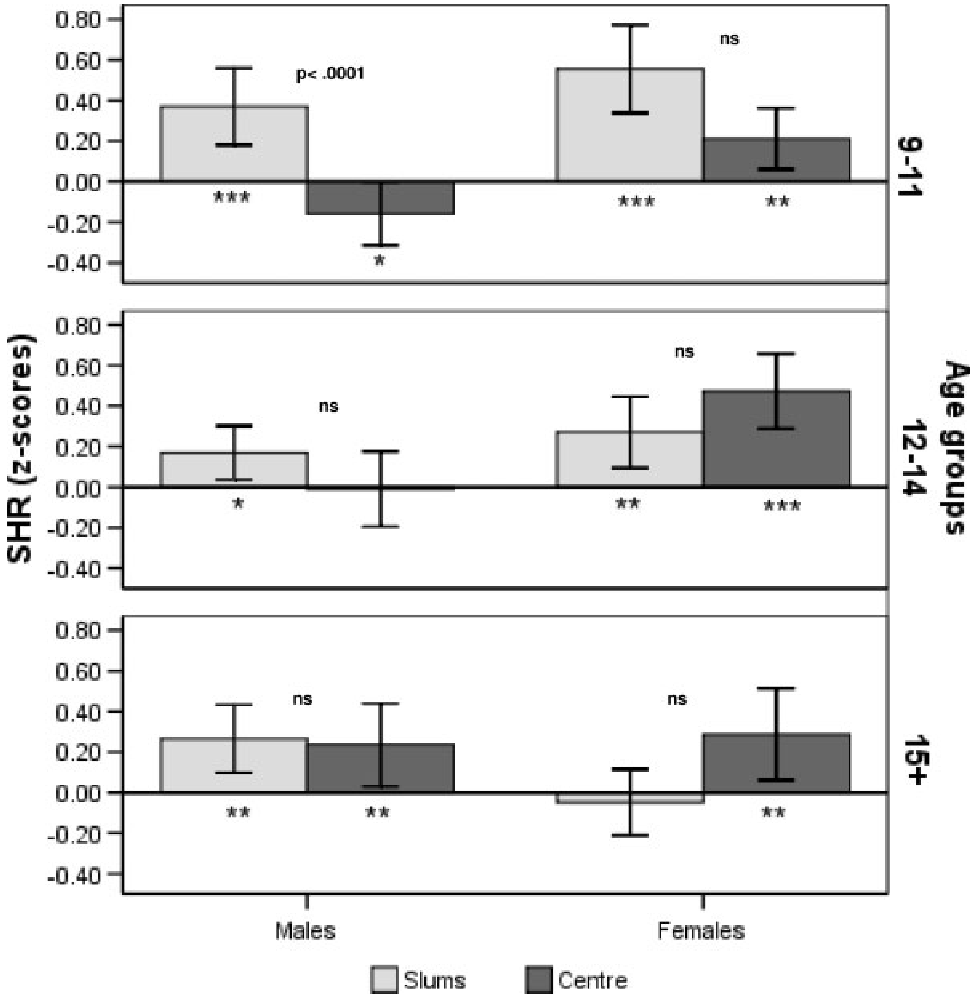

Fig. 4. z-scores for SHR, by age group, sex, and place of residence. Comparison between adolescents from the slums and from the Centre of Mozambique. The P values refer to the post-hoc comparisons, from the factorial ANOVA, between places of residence. The asterisks denote significant differences between the African-American reference values and the given group (one-sample t-test, $^*P \leq 0.05$; $^{**}P \leq 0.001$; $^{***}P \leq 0.0001$).

TABLE 4. Predictors of height (stepwise multiple regression)

Step	Predictor	Adjusted R^2	Standardized B	Significance (P)
1	Place of residence	0.129	0.361	0.001
2	Place of residence	0.170	0.271	0.001
	+ Age		−0.223	0.001
3	Place of residence	0.185	0.205	0.001
	+ Age		−0.217	0.001
	+ Mother's education		0.145	0.001
4	Place of residence	0.189	0.185	0.001
	+ Age		−0.215	0.001
	+ Mother's education		0.097	0.023
	+ Father's education		0.095	0.025

TABLE 5. Predictors of weight (stepwise multiple regression)

Step	Predictor	Adjusted R^2	Standardized B	Significance (P)
1	Age	0.106	−0.328	0.001
2	Age	0.145	−0.281	0.001
	+ Mother's education		0.206	0.001
3	Age	0.153	−0.245	0.001
	+ Mother's education		0.160	0.001
	+ Place of residence		0.115	0.005
4	Age	0.159	−0.240	0.001
	+ Mother's education		0.162	0.001
	+ Place of residence		0.106	0.009
	+ Sex		0.084	0.013

exceptions to this general tendency are the 9–11 years old centre boys, who have relatively longer legs than the reference and 12–14- year-old centre boys who do not differ in SHR from the reference. In these cases, it is possible that the SHR results attest to improved conditions for the wealthier families of Maputo following the end of the war. It should be noted that African-Americans, as a group, are generally of lower SES than other ethnic groups in the United States, but of higher SES than the vast majority of Africans in Africa. Some Africans, of course, have higher SES than African-Americans as a whole. The "time of birth effect" for the SHR of the centre boys may reflect the fact that since the end of the civil war the centre families live under better conditions than African-Americans, and the relatively longer legs of the 9–11 years old boys is a result of this. If so, then our results add some support to the "leg length - quality of life" hypothesis.

The oldest girls from the slums do not differ from the African-American references. Good living conditions are not likely to be the explanation here, and no other cause is known to us.

These findings for SHR are further complicated by the fact that the SHR of the centre girls is significantly greater (relatively shorter legs) than the references at all ages. The differences in the response of the SHR to changing environmental conditions may be explained by the fact that the growth of girls is, generally, less sensitive to environmental factors (Stinson, 1985; Bogin, 1999). A well-documented example is the work of Jantz and Jantz (1999). They examined secular change in the length of long bones of the leg (femur and tibia) of skeletal samples of Americans dating from the mid-19th century to the 1970s. Secular change in bone lengths of the men was stronger than that of the women. In addition to the Mozambique boys being more sensitive to environmental change, it is also possible that the SHR results indicate a bias against the girls and in favor of boys in terms of parental investment (e.g., healthcare, feeding, work demands, and/or emotional stimulation). The centre girls do not show the "time-of-birth" or war-effect, which is perhaps evidence of a consistent gender bias. A gender bias effect could be formulated as testable hypothesis in future research. More detailed observation of within-family allocation of resources and expectations on children for labor are required to evaluate the possibility of gender bias.

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