Growth and Malnutrition of Rural Zimbabwean Children (6–17 Years of Age)

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ABSTRACT The rural environment is an important factor in delayed growth in developing countries. The aim of this study was to investigate the effects of poor rural living conditions on the growth of a Shona sample in Zimbabwe. In total, 982 subjects aged 6–17 years were analyzed. Mean values of height, weight, skinfolds (triceps, subscapular, suprailiac, biceps, medial calf), cormic index, body mass index (BMI), arm composition (total upper arm area, upper arm muscle area, arm fat area, and arm fat index), fat percentage (%F), centripetal fat ratio (CFR), and the contribution of each skinfold to the adiposity of the trunk and upper limbs are presented. Weight, height, BMI, cormic index, SSCP, TRCP, arm circumference, and arm composition are compared with NHANES percentiles. Boys and girls showed stunting and underweight at ages 11–15 and 8–15, respectively; boys presented particularly severe malnutrition and their means of height and weight were below the 10th percentile. The means of arm circumference, UMA, UFA, and TRCP were below the 15th percentile in both sexes. The contribution of the skinfolds generally showed an overall prevalence of TRCP in both sexes; the contribution of SSCP was prevalent only for the 16- to 17-year-old boys. Males presented a higher CFR than girls after 14 years while females showed an irregular pattern. There was a high incidence of brachycormia and mesocormia in females and males, respectively. Height, weight, and BMI were similar to the values observed in other sub-Saharan countries, although body size was slightly larger than in South Africa and smaller than in Tanzania. The results provide a useful database for future comparisons. Am J Phys Anthropol 136:214–222, 2008.

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Many studies on growth have been carried out in Africa because of the widespread malnutrition and delayed growth. In particular, rural environments of sub-Saharan Africa have an influence on growth and development, especially in preschool children who are particularly exposed to malnutrition (Spurr, 1998). Height retardation, regarded as an index of chronic malnutrition (Waterlow, 1972), leads to decreased final stature or stunting. Most studies on chronically malnourished populations have dealt with height and length retardation (Waterlow, 1988, 1994), whereas other anthropometric traits have been considered less frequently (Billewicz and McGregor, 1982; Cameron et al., 1994; Benefice et al., 2001). However the issue of long-term malnutrition, resulting in stunted growth, remains a matter of concern. A growing number of studies in poor third-world populations indicate the emergence of obesity and/or degenerative diseases (Popkin, 1994; Monteiro et al., 1995; Sawaya et al., 1995; Martorell et al., 1998; Walker et al., 2001; Semproli and Gualdi-Russo, 2007). Moreover a link between mild stunting and obesity has been postulated in a society undergoing nutritional transition (Sawaya et al., 1998). Studies of relative fat distribution in developing countries, especially Africa, are rare (Cameron, 1992).

The aim of this study was to describe growth and nutritional status in a Shona population of eastern Zimbabwe using an extensive set of anthropometric measurements.

MATERIALS AND METHODS

Study area

The study area (Fig. 1), now a zone for communal land development, was a territory reserved for the Shona population during the period of racial segregation in the late 1970s. Following independence, the new state of Zimbabwe designated the territory for agricultural development despite the low fertility of the area.

The local people belong to the Budya ethnic group. The Budya (a subgroup of the Shona population) is the main ethnic group in the Mutoko district. The main town of the district is one of the largest in Mashonaland East. The region is characterized by veld, i.e. typical highland fields. Its dry climate and sandy soil, making it difficult to grow any kind of crops, differentiate the Mutoko region from others in Zimbabwe characterized by high rainfall and abundant harvests. The highland of the study area is 900 m a.s.l., although the altitude is not sufficient to prevent malaria outbreaks.

Sample

The sample included 982 subjects (484 males and 498 females) aged 6–17 years (Table 1). All subjects were healthy and not inbred. All the children were Bantu-speaking and belonged to the Shona population, the

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largest Zimbabwean ethnic group (71% of the total population). They came from rural areas surrounding the Catholic mission near Mutoko in the Mashonaland East province of Zimbabwe. The All Souls Mission area includes the public Luisa Guidotti Hospital, cofinanced by Italian and Zimbabwean sources; both the mission and the hospital are socioeconomic centers for the local population. The families of the area are involved in subsistence farming and cattle rearing. As there are no factories or farms near the mission, only a few families rely on regular salaries (teachers, hospital attendants, and nurses). Therefore, the men often migrate to the main Zimbabwean towns (Chitungwiza, Mutoko, Marondera) along the roads leading to the capital, Harare, to find jobs as bricklayers or blue-collar workers.

The data in this study were drawn from two rural public schools near the mission: Rukau primary school (RPS) and Rukau secondary school (RSS). Almost all the children enrolled in the study came from low-income families. These two schools served a large area of the district, forcing many students to walk long distances to reach the school. There were seven classes in the RPS and four classes (forms) in the RSS. At the end of 4 years of secondary school, the students take exams for the secondary school certificate which provides the opportunity to get a job as a laborer or salaried employee. In a few cases, they continue their studies at the university level. Subjects’ dates of birth were taken from school records. Some dates of birth were missing or probably incorrect; however doubtful cases (∼7% of the original sample of 1,056 children) were excluded from our database.

In total, 31 anthropometric measurements were taken on all the children in the selected age group. The variables considered in this study were: height, sitting height, weight, upper arm circumference, skinfolds (triceps [TRCP], biceps [BCP], subscapular [SSCP], suprailiac [SPIL]), sitting height, arm circumference, and their related parameters could not be measured in the 14–17 year age class, because of these children’s heavier academic schedules which limited measurement opportunities. The survey was carried out from September to December 1999. Afterward because of the dangerous political situation in the country, it was no more possible to collect new data. The measurements were taken by the same anthropometrist according to Lohman et al. (1988). A Martin anthropometer was used to measure height to the nearest 0.1 cm, a Schoenele electronic scale to measure weight to the nearest 0.1 kg, a nonstretchable plastic-coated measuring tape to measure circumferences to the nearest 0.1 cm, a spreading calliper to measure breadths to the nearest 0.1 cm, and a Holtain skinfold calliper to measure skinfolds to the nearest 0.2 mm.

**Data analysis**

Mean values and standard deviations for all parameters were calculated for each age class. The body mass index (BMI: weight/height$^2$) and the cormic index (sitting height/height ratio) were calculated and %F was computed according to Slaughter et al. (1988).

Two approaches were used to determine the fat pattern in the trunk and upper limbs. The first is based on the ratios of the natural log values of individual skinfolds to the natural log of the sum of individual skinfolds, e.g. ln (TRCP)/ln (TRCP + BCP + SSCP + SPIL). This demonstrates the contribution of each skinfold to the sum of the skinfolds (Cameron et al., 1992). The second method is computation of the centripetal fat ratio: CFR = SSCP/SSCP + TRCP (Cameron et al., 1994). Total upper arm area (TUA = C$^2$/4π; where C = arm circumference), upper arm muscle area (UMA = (C – πTRCP$^2$/4π), upper arm fat area (UFA = TUA – UMA), and arm fat index (AFI = (UFA/TUA) × 100) were calculated using the equations of Frisancho (1990).

Percentiles of NHANES III for height, weight, and BMI and percentiles of NHANES II for sitting height, cormic index, TRCP, SSCP, arm circumference, and arm composition were used to evaluate the state of growth. The use of reference data from industrialized western countries (NHANES III) is necessitated by the absence of growth standards for children from developing countries. However the NHANES III and II reference data will be discussed as yardsticks rather than as standards, according to the suggestions of Waterlow et al. (1977) and the findings of Nyrongo et al. (1999). Finally the values of the main parameters were compared with the results of studies conducted in other African countries.

Statistical analyses were carried out with STATISTICA 5.0. Since the parameters were not normally distributed, the nonparametric Kolmogorov-Smirnov test
was used to test the significance of differences between the sexes (*P*-values).

**RESULTS**

Tables 2 and 3 report the mean and standard deviation of the parameters recorded in the rural boys and girls aged 6–17 years. Both sexes showed a regular increase in height and weight with advancing age. Males generally had higher height values than females and the differences were significant in the age classes of 11 to 14 and 17 years (*P* < 0.01). Weight was generally higher in females than males after 7 years, with significant differences at 13 and 15 years (*P* < 0.01). BMI was also generally higher in girls after 12 years; in fact, the values increased in females from 12 to 17 years. In contrast, there was no evident increase in boys. Both sexes had comparable sitting height values; the values were significantly higher in females only at 11 and 13 years. At these ages, significant differences were also found in the cormic index.

The skinfold thicknesses, fat percentage, and UFA generally did not increase with age in the boys; there was only a slight increase of SSCP between 15 and 17 years and of UFA from 11 to 13 years. However, the skinfolds, fat percentage, and UFA increased with age in the girls. Moreover the mean values of the same parameters were higher in females at all ages. Sex differences in SSCP, TRCP, BCP, SPIL, UFA, and %F were significant in most age classes, with higher values in females (Tables 2, 3). TUA and UMA increased with age but the mean values were similar in males and females (except TUA at 13 years). The ratios of the log of each skinfold to that of the sum of the four skinfolds demonstrated that TRCP contributed to the sum more than the other three skinfolds at all ages in both sexes. The only exception was in males at 16 and 17 years of age, when the contribution of SSCP exceeded that of TRCP. After TRCP, the order of importance in both sexes was SSCP, SPIL (although SPIL > SSCP in 7-year-old girls), and BCP; the last skinfold had a limited contribution to adiposity. These results are consistent with the normal pattern of growth in children. Sex differences in the four skinfold ratios were significant at almost all ages. The CFR pattern for the Rukau boys and girls is shown in Tables 2 and 3. Boys had higher CFR values than girls.

### Table 2. Descriptive statistics for males with significant differences between boys and girls

<table>
<thead>
<tr>
<th>Parameter</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
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<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
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<tr>
<td><strong>Males</strong></td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
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<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
<td>M/SD</td>
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<tr>
<td>Height</td>
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<td>122.2</td>
<td>127.2</td>
<td>130.3</td>
<td>136.5</td>
<td>141.7*</td>
<td>146.1**</td>
<td>151.9*</td>
<td>158.3*</td>
<td>165.5</td>
<td>165.5</td>
<td>166.7**</td>
</tr>
<tr>
<td>Sit. height</td>
<td>6.8</td>
<td>6.1</td>
<td>6.1</td>
<td>5.2</td>
<td>6.1</td>
<td>7.1</td>
<td>7.0</td>
<td>7.4</td>
<td>7.7</td>
<td>6.7</td>
<td>6.7</td>
<td>5.5</td>
</tr>
<tr>
<td>BMI</td>
<td>14.7</td>
<td>14.6</td>
<td>15.0</td>
<td>14.9</td>
<td>15.1</td>
<td>15.8</td>
<td>15.9</td>
<td>16.1*</td>
<td>16.8*</td>
<td>17.3*</td>
<td>18.5</td>
<td>18.8</td>
</tr>
<tr>
<td>TRCP</td>
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<td>0.9</td>
<td>1.1</td>
<td>1.0</td>
<td>1.1</td>
<td>1.7</td>
<td>1.3</td>
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<td>1.3</td>
<td>1.7</td>
<td>1.5</td>
<td>1.1</td>
</tr>
<tr>
<td>SSCP</td>
<td>3.0</td>
<td>3.4</td>
<td>2.8</td>
<td>3.1</td>
<td>4.2</td>
<td>4.3</td>
<td>5.0</td>
<td>5.4</td>
<td>7.5</td>
<td>6.7</td>
<td>4.8</td>
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<tr>
<td>BCP</td>
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<td>15.0</td>
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<td>15.1</td>
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<td>15.9</td>
<td>16.1*</td>
<td>16.8*</td>
<td>17.3*</td>
<td>18.5</td>
<td>18.8</td>
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<tr>
<td>SPIL</td>
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<td>2.0</td>
<td>1.5</td>
<td>1.5</td>
<td>2.2</td>
<td>1.3</td>
<td>1.9</td>
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<td>1.3</td>
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<td>%F</td>
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<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45**</td>
<td>0.46</td>
<td>0.45</td>
<td>0.46</td>
<td>0.47**</td>
<td>0.48</td>
<td>0.51**</td>
<td>0.54**</td>
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<td>0.8</td>
<td>0.8</td>
<td>0.6</td>
<td>0.7</td>
<td>1.2</td>
<td>1.2</td>
<td>0.7</td>
<td>1.3</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>ln SSCP</td>
<td>3.4</td>
<td>3.2</td>
<td>3.2</td>
<td>3.1</td>
<td>3.0*</td>
<td>3.3*</td>
<td>3.1*</td>
<td>3.2*</td>
<td>3.1*</td>
<td>3.4*</td>
<td>3.4*</td>
<td>3.4*</td>
</tr>
<tr>
<td>ln BCP</td>
<td>15.4</td>
<td>22.0</td>
<td>24.4</td>
<td>25.3</td>
<td>28.3</td>
<td>29.4</td>
<td>32.0</td>
<td>34.5*</td>
<td>38.9*</td>
<td>43.6*</td>
<td>50.9</td>
<td>52.2</td>
</tr>
<tr>
<td>ln SPIL</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
<td>0.7</td>
<td>0.5</td>
<td>1.1</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* *P* < 0.01; **P* < 0.5.
females starting from 14 years. Girls showed an irregular pattern with mean values that tended to increase slowly.

**Comparison with reference data**

The mean values of height, weight, and BMI in both boys and girls were generally below the 50th percentile of NHANES III (Figs. 2A–4B). The boys’ height (Fig. 2A) approached the 50th percentile at 6, 7, and 8 years and shifted below it thereafter. The lowest values were reached between 12 and 15 years (10th–5th percentile). There were no signs of catch-up to normal values in the oldest school children. The girls’ height pattern (Fig. 2B) showed some differences from that of the boys: the mean values were generally between the 50th and 25th percentiles, except between 11 and 13 years when they shifted slightly under the 25th percentile. Mean weights followed a unique pattern in boys (Fig. 3A). From slightly lower than the 50th percentile of NHANES III from 6 to 8 years, the values decreased and approached the 10th percentile between 12 and 15 years and dropped below the 10th percentile at 17 years. There was no evidence of any catch-up of growth. The female weight trend was different. The mean values (Fig. 3B) approached the 25th percentile at 6 and 7 years and reached the 50th percentile at 8 years, after which the values decreased toward the 10th percentile at 12 years. A substantial catch-up occurred after that age, leading the girls back to values near and at the 50th percentile at 16 and 17 years, respectively. Therefore, according to the NHANES III charts for height and weight, the boys showed more severe malnutrition than their female counterparts in the study area. In both sexes the BMI values (Fig. 4A,B) were above the 10th percentile of NHANES III, although the trend was different in boys and girls. A marked catch-up of BMI took place in girls after 12 years of age, bringing the mean value near the 50th percentile after 13 years, even though the values had previously fluctuated between the 10th and 25th percentiles. In contrast, there were no signs of catch-up in the boys; their mean BMI values approached the 25th percentile until 12 years of age, after which they fell to slightly above the 10th percentile (except at 16 years).

In boys, the mean values of sitting height were generally below the 25th centile and reached the lowest values...
at 6, 9, and 13 years of age. However, the mean values did not follow a well-defined pattern, exhibiting unstable fluctuations. A similar trend was observed for the females. The values of sitting height observed in the present article were low when compared with the American reference (NHANES II). However, they were in accordance with those reported in other studies on African populations (Biasutti, 1967; Semproli and Gualdi-Russo, 2007).

In males the cormic index values were below the 5th percentile at 6 years and then increased to reach the 75th percentile at 12 years of age, after which they decreased to near the 15th percentile at 13 years. In females the cormic index values started at below the 5th percentile at 6 years and then increased to the 50th percentile at 9 years, after which they oscillated between the 15th and 25th percentiles. However, the girls generally had a slightly shorter trunk than the boys.

The analysis of arm circumference and arm composition (TUA, UMA, and UFA) revealed a similar trend in boys and girls, with mean values below or near the 15th percentile. Males had slightly lower values for arm circumference, TUA and UMA, with means below the 5th percentile. UFA was also lower in males, oscillating between the 5th and the 15th percentiles. The arm fat index (AFI) varied between the 25th and the 50th percentiles, in males (Fig. 5A), and between the 15th and 25th percentiles in females (Fig. 5B). The mean values of TRCP (Fig. 6A,B) and SSCP skinfolds were mainly below the 50th percentile in both sexes. The skinfold thickness values did not fall below the 10th percentile, with the only exception of the 15- to 16-year-old males for the subscapular.
Comparison with different African populations

Figures 7 and 8 show the charts for stature, weight, and BMI in our sample and in seven African subequatorial populations from South Africa (Monyeki et al., 2000), Namibia (Singer and Kimura, 1981), Botswana urban (Corlett, 1986), Botswana rural (Corlett and Woollard, 1988), Tanzania sedentary (Facchini and Toselli, 1994), Tanzania seminomadic (Sellen, 1999), and Kenya (Semproli and Gualdi-Russo, 2007). As shown in Figure 7, the means of the Zimbabwean children were quite close to those of all the other populations in the various age ranges. The mean heights of the Zimbabwean boys were slightly higher than their counterparts except for Tanzanian sedentary at 7 and 8 years and Namibian at 17. As shown in Figure 8, the Zimbabwean boys were generally slightly heavier than their counterparts from Namibia, Botswana urban, Botswana rural, South Africa, and Tanzania seminomadic, although the Tanzanian sedentary and Kenyan boys had higher mean weights than the Zimbabwean boys.

The mean heights of the Zimbabwean girls (Fig. 7) were higher than those of their counterparts from Namibia, Botswana (urban and rural), South Africa, Tanzania (sedentary and seminomadic), and Kenya. The Zimbabwean girls were also generally heavier than their counterparts in neighboring countries except Kenya. The mean values of the Namibian girls (Fig. 8) were very close to those of the Zimbabweans, just slightly below 7 to 13 years of age and slightly above thereafter. However, the Botswana urban, Botswana rural, South African, and Tanzania seminomadic girls had lower values than their Zimbabwean counterparts. The Tanzania sed-
Growth patterns were investigated in boys and girls from the rural area surrounding the All Souls Mission in the province of Mashonaland East, Zimbabwe. This study is one of the first to provide growth charts for Zimbabwean children which can be used for further comparisons of growth trends in sub-Saharan Africa.

In light of our effort to examine numerous anthropometric characters in a large sample of children, this study has several limitations that should be considered when interpreting the results. The risk of confusing the effects of environmental changes with the effects of age (inherent in the cross-sectional design) is increased by the precarious living conditions of these children. Moreover, as the large majority of working places were located outside the area considered, our study was also restricted by difficulties in finding subjects which fell within the 17–20 years old age group. These limits, the cross sectional design and the age range, lead us to pay particular attention when observing eventual catch up with growth.

The results were compared to the data of the NHANES III project. The patterns of growth variables observed in all studies of African children indicate that the effects of poor living conditions gradually affect the growth process, causing an increasing shift away from the 50th percentile of NHANES III. The adverse socio-economic environment and the low levels of food availability compromise and probably delay the physical development of African children in all phases of growth (Cameron, 1991).

Our study also revealed a shift from the NHANES III yardsticks for height and weight in both boys and girls. The delay was particularly evident in boys: it was statistically significant and increased with age. However, the girls showed a subsequent catch-up of growth which returned them near the median values of the reference data. No catch-up was detected in boys for either height or weight.

BMI values showed a similar pattern in both sexes. Low weight for height was found to characterize children from South Africa (Cameron, 1992; Monyeki et al., 2000). Monyeki et al. (2000) observed that mean heights, weights, and BMI of South African children from 3 to 10 years were mostly below the 5th percentile in both sexes. This supports the suggestion by Eveleth and Tanner (1991) that low percentiles for height, weight, and BMI at early ages reflect an adaptive mechanism to low food intake, and the subjects usually show compensatory growth during puberty. Nevertheless males do not catch up completely with weight and low BMI values are typical of adult males in South Africa.

Similar characteristics may be present in the population of our study area in Zimbabwe. The observed sex differences are comparable to those recorded in all previous studies in sub-Saharan countries. Girls always show better growth than boys, probably due to their lower eco-sensitivity to environmental challenges (Hiernaux and Hartono, 1980; Corlett, 1986; Benefice and Malina, 1996; Monyeki et al., 2002). As stressed by Monyeki et al. (2000), the causes of the growth trend may include some characteristics of the social behavior of rural societies. The ability of boys to become independent cattle herders during the school-going years places them at higher risk of malnutrition than girls, who are generally involved in domestic work and food preparation during the same period. This may have long-term effects during adolescence. For example, the girls showed a trend to increasing values of all the skinfolds beginning from age 13. A similar pattern was absent in the boys who maintained low values in all the age classes. Analysis of the ratios of the log of each skinfold to that of the sum of the four skinfolds demonstrated the prevalent contribution of the upper limbs to total body fat in both sexes; the contribution of the biceps and suprailiac skinfolds was low. While the triceps pattern decreased with age in boys, the girls showed a slow but constant increase. These results are in accordance with those of Cameron et al. (1992).

Analysis of the CFR showed a trend of increasing fat centralization with age, especially in boys. Sexual dimorphism in fatness and fat patterning was particularly evident at ages 16 and 17: unlike the boys, the girls showed fat deposition mainly in the extremities. Comparable results were found by Cameron et al. in their longitudinal study (1994); females consistently had a greater amount of total fat which became significantly greater than that of males after the peak of height velocity. Cameron et al. suggested that a rapid gain in fat at the beginning of the female reproductive life may have adaptive significance in an energetically suboptimal
environment, i.e. the fat stores may maintain a positive energy balance during pregnancy, protecting against maternal depletion.

CONCLUSIONS

This article reports descriptive anthropometric data and examine age and sex differences in anthropometric outcomes of Zimbabwean rural students (6–17 years of age). The data show that the growth status of Zimbabwean children is very poor relatively to Western reference data; on the other hand, they may be typical for a sub-Saharan population. While females showed tendency toward a catch-up growth with age, the delay of growth increase with age in boys. This is observed in height, weight, and BMI. In females also a tendency toward an increment of skinfold thicknesses with age is observed, but not in males. Suprailiac and triceps skinfolds, TRCP and SPIL skinfolds contribution to the sum of the all considered skinfolds and CFR suggested a sexual dimorphism in fatness and fat patterning in the oldest age that may be related with the beginning of female reproductive function.

The characteristics of the children of the present sample are in accordance with other studies on sub-Saharan children. In fact, all the countries considered in the comparison showed a high incidence of under-nutrition. The most malnourished children were in the South African sample (with mean BMI values generally below the 5th percentile) while the least undernourished were in Tanzania (with BMI values generally between the 25th and 50th percentiles). As stated earlier, the social roles of boys and girls differ in Africa and this may be reflected in their different growth patterns. As reported in other studies on African samples (Sellen, 1999, 2000), boys become increasingly involved in herding activities that involve both high level of physical activity and allocation of time to work rather than to food consumption. Despite of inference limits by the cross-sectional nature of the data, our findings are consistent with this hypothesis. It has been suggested that malnourished subjects show a minimal catch-up of growth if they continue to reside in the same environment that gave rise to stunting in early childhood, although stunting can be reduced if the environment improves (Martorell et al., 1994).

The results presented here provide a clearer picture of anthropometric indicators in school-age children of a specific rural Zimbabwean population, where the condition of under nutrition persists. These findings can help identify the most urgent needs of intervention programs, focusing on the most sensitive age/sex groups: (girls from 9 to 13 years of age and boys 13–17 years old) to help all subjects increase their growth potential and work capacity and reduce their susceptibility to disease.

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LITERATURE CITED


