Physical Fitness and Body Composition in Relation to Physical Activity in Prepubescent Senegalese Children

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ABSTRACT

Relationships among estimated body composition, habitual physical activity, and physical fitness were considered in Senegalese children 8.5–13.5 years of age. Anthropometric dimensions (arm and calf circumferences, trunk, and extremity skinfolds, body mass index), four motor performances (dash, standing long jump, throw, grip strength), a step-test (cardiorespiratory fitness), and heart rate (HR) monitoring (physical activity) were collected in 140 children (66 boys and 74 girls). Age and sex had a major effect on indicators of body composition and physical fitness. Height stunting used as an indicator of chronic undernutrition had a remarkable effect on body composition but only a limited influence on physical fitness. Physical activity, represented by percentage of time above the flex-HR (%fHR), did not vary with sex, age, and nutritional status. However, there was a low-to-moderate correlation between %fHR and several body composition indices, grip strength, and cardiorespiratory fitness. Comparisons of children in the upper and lower quartiles of %fHR indicated that better indices of body composition in boys, and better strength and cardiorespiratory fitness in girls were positively associated with a higher level of physical activity. Am. J. Hum. Biol. 10:385–396, 1998.

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Body size and proportions of growing children are factors affecting physical performance (Malina, 1994). In developed countries, there is a special concern about fatness because of its negative influence on fitness (Parizkova, 1996). In the U.S., subcutaneous fat has increased over time (Bar Or and Malina, 1995). Physical inactivity is often considered a significant factor in overweight; however, inactivity is a relative concept and the level of activity needed by children to achieve and maintain fitness is not exactly known (Bar Or and Malina, 1995). Paradoxically, obese children expend more energy in physical activity per task than normal weight children, though not differing in the daily volume of physical activity (Gazzaniga and Burns, 1993). Results of studies on physical activity and adiposity are equivocal. However, it seems that obese adolescents are less active than their peers although their total energy expenditure is equal or even greater (Bar-Or and Baranowski, 1994). Further, the negative effect of adiposity on fitness is more apparent at the extremes of fatness; a moderate increase of subcutaneous fat may have only a marginal effect on physical performance (Beunen et al., 1993; Malina et al., 1995).

The preceding are based on observations of children in developed countries. The majority of the world’s children, however, live under marginal nutritional and economic circumstances. Chronic undernutrition leads to stunted growth and reduced body size. Further, a high level of habitual physical activity may be needed for subsistence in many parts of the world. Competition between the physiological requirements of the
children during growth and maturation, and the social pressures for domestic or economic tasks may be assumed.

Studies of undernutrition and motor performance of children in developed countries have been done in Mexico (Malina and Buschang, 1985; Malina and Little, 1985; Malina et al., 1991), Brazil (Rocha da Ferreira et al., 1991; Matsudo, 1993; Anjos and Boileau, 1992), Zaire (Ghesquière et al., 1984), and Senegal (Benefice, 1993). These studies generally show absolute lower performances compared with well-nourished children, but also stress the role of small body size in the outcomes. The same applies to maximal oxygen consumption, where absolute values are lower in malnourished children, but are quite equal after normalization for body weight or lean body mass (Spurr and Reina, 1989).

Physical activity is also a factor of variation in physical performance, especially for aerobic power. However, the effect of a high level of physical activity, like sport training, is less than in adults (Livingstone, 1994; Morrow and Freedson, 1994). Further, it is difficult to distinguish these effects from those of maturation during puberty (Malina, 1989).

Studies of physical activity of children in developing countries are scarce and the impact of malnutrition is not clear. The difference in physical activity levels between undernourished and normal children, expressed as %VO₂max, in Colombia is not significant (Spurr and Reina, 1990). However, the aim of this study is to describe variation in motor fitness of 8.5–13.5 year old Senegalese children in relation to anthropometric indices of muscle and fat mass, and estimated physical activity.

**SUBJECTS AND METHODS**

**Sampling**

The study was carried out in 3 villages of the district of Lambaye in the center of Senegal known as the “peanut basin” (14°45 north latitude and 17°30 west longitude). This area has a typical dry and hot Sahelian climate. Inhabitants are Muslim farmers cultivating millet and peanuts during an unique and brief rainy season (June to October). The nutritional situation is mediocre with an estimated per capita energy intake less than FAO/WHO/UNU requirements, and chronic undernutrition is widely prevalent (Chevassus and Ndiaye, 1981).

A sample of 140 children (66 boys and 74 girls) with a mean age of 11.3 years (SD = 1.4), ranging from 8.5–13.5 years of age, was drawn from a health and fitness survey in the area. Children were recruited after a preliminary home-to-home census was done in the villages. They were selected on the basis of 1) absence of clinically detectable abnormalities, especially in the orthopedic, neuromotor, or nutritional spheres; 2) known age after birth roles or determined with an accuracy of about 3 months using a local calendar of Muslim ceremonies and events; and 3) consent given by the parents.

As parents were illiterate, after complete information about the aim and methods to be used in the survey, oral consent was given and the presence of a familiar person during the tests was required. The study was authorized by national and regional administrative authorities of Senegal.
suprailiac, Trunk skf) skinfolds were used as proxies for fat mass and distribution. CC and estimated arm muscle circumference (AMC) calculated after Gurney and Jelliffe (1975) as AMC = AC - π x TSF, were used as a proxy for limb muscle mass. The body mass index (BMI, weight/stature²) was also calculated.

Motor fitness

Motor fitness items included 3 trials of the following tests: 1) softball throw for distance (m); 2) standing long jump (m); and 3) hand grip strength measured by squeezing a rubber bulb connected to a manometer (MartinR, Tuttlingen). Values were pressure expressed in kilos Pascal (Watanabe, In addition, children had to run a distance of 33 m with time recorded in seconds (sec). They ran bare feet on a levelled sandy track. The children had no previous training. The day before testing, the tests were demonstrated and the children had an opportunity to practice. To estimate the reliability of the measures, test-retest correlations were calculated by measuring a subsample of 40 children after a one day interval. Coefficients were moderate for the dash (0.67), jump (0.73) and grip strength (0.71), and high for the throw (0.93). There was no significant difference between sexes.

Cardiorespiratory fitness

Cardiorespiratory fitness was estimated with a step-test with 3 two-step benches with different heights: 17, 23, and 30 cm. This allowed a gradual increase of effort. After 3 minutes rest in a sitting position, the children started going up and down the steps at a rhythm of 30 steps per minute, given by a metronome. They stepped for 3 minutes at each bench height; the total exercise time was thus of 9 minutes. They...
ing occurred between 8-10 a.m. to rather, the flex-HR (DIR) method (Spurr et al., 1988) was used. The flex-HR is the critical cut-off value of HR between resting measurements and the lowest HR recorded during exercise. The cut-off being the index not included in this analysis. Forty children attended an elementary school; in these cases, data were collected during holidays. There were no differences in anthropometric indices, performances, or activity patterns between children attending or not attending school, and in consequence this factor was not taken into account in the analysis.

**Statistical analysis**

Data were analysed using the BMDP statistical software (BMDP statistical software Inc., Los Angeles CA). Means, partial correlations, 3-way analysis of variance, and covariance analysis were used. A p value of .05 was accepted as significant.

**RESULTS**

Compared with the World Health Organization reference (WHO, 1986), children were short in stature: median height-for-age (H/age) = -1.05 z-score (range -3.5-1.5) and underweighted: median weight-for-age (W/age) = -1.47 z-score (-2.86-1.29). About a quarter of the sample was below 2 standard deviations and less than 10% were above the median in both nutritional indices. These deficits could be attributed to mild-to-moderate malnutrition. Given the age of the subjects, this must be a chronic form of malnutrition and skin dryness of the skin at certain periods. In practice, only 7-8 hours of recorded time were usable. Children were instructed not to change their habitual activities. Recording occurred between 8-10 a.m. to 4-6 p.m. The data were then down-loaded and interfaced with a PC. The Polar Electro® program was not used to analyze the results. Rather, the flex-HR (fHR) method (Spurr et al., 1988) was used. The flex-HR is the critical cut-off value of HR between resting measurements and the lowest HR recorded during exercise. The cut-off being the index not included in this analysis. Forty children attended an elementary school; in these cases, data were collected during holidays. There were no differences in anthropometric indices, performances, or activity patterns between children attending or not attending school, and in consequence this factor was not taken into account in the analysis.

**TABLE 1. HR values in different levels of activity (mean ± SD [range]) of prepubescent Senegalese children**

<table>
<thead>
<tr>
<th>Activity</th>
<th>HR (bpm)</th>
</tr>
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<tbody>
<tr>
<td>Lying</td>
<td>76.0 ± 9.0</td>
</tr>
<tr>
<td></td>
<td>(56-99)</td>
</tr>
<tr>
<td>Sitting</td>
<td>94.6 ± 13.7</td>
</tr>
<tr>
<td></td>
<td>(66-129)</td>
</tr>
<tr>
<td>Standing</td>
<td>106.1 ± 14.6</td>
</tr>
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<td></td>
<td>(74-147)</td>
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<tr>
<td>Light activity</td>
<td>133.3 ± 13.8</td>
</tr>
<tr>
<td></td>
<td>(99.6-174.6)</td>
</tr>
<tr>
<td>Moderate activity</td>
<td>162.5 ± 14.9</td>
</tr>
<tr>
<td></td>
<td>(107-191)</td>
</tr>
<tr>
<td>Vigorous activity</td>
<td>162.8 ± 15.2</td>
</tr>
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<td></td>
<td>(116.3-194.6)</td>
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Tester for at least 12 hours, but several problems occurred: electrode displacement, discomfort due to the heat, and excessive dryness of the skin at certain periods. In practice, only 7-8 hours of recorded time were usable. Children were instructed not to change their habitual activities. Recording occurred between 8-10 a.m. to 4-6 p.m. The data were then down-loaded and interfaced with a PC. The Polar Electro® program was not used to analyze the results. Rather, the flex-HR (fHR) method (Spurr et al., 1988) was used. The flex-HR is the critical cut-off value of HR between resting measurements and the lowest HR recorded during exercise. The cut-off being the index not included in this analysis. Forty children attended an elementary school; in these cases, data were collected during holidays. There were no differences in anthropometric indices, performances, or activity patterns between children attending or not attending school, and in consequence this factor was not taken into account in the analysis.

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**TABLE 2. Anthropometric characteristics (mean and SE) of Senegalese children**

<table>
<thead>
<tr>
<th>Age</th>
<th>Boys</th>
<th>Normal</th>
<th>Undernourished</th>
<th>p probability</th>
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<tr>
<td></td>
<td>N</td>
<td>N</td>
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**PHYSICAL FITNESS OF SENEGALESE ADOLESCENTS**

*Table continued...*

...gain more trunk than extremity fat, as it is exercise and 1st-min recovery (Figure 1).
### TABLE 3. Motor and physical fitness indicators (mean and SE) of Senegalese children

<table>
<thead>
<tr>
<th>Age</th>
<th>Nutritional Status</th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;11.3</td>
<td>Undernourished</td>
<td>9</td>
<td>7.0 (0.51)</td>
</tr>
<tr>
<td>&gt;11.3</td>
<td>Normal</td>
<td>18</td>
<td>6.6 (0.54)</td>
</tr>
<tr>
<td>&lt;11.3</td>
<td>Undernourished</td>
<td>17</td>
<td>6.6 (0.39)</td>
</tr>
<tr>
<td>&gt;11.3</td>
<td>Normal</td>
<td>23</td>
<td>7.5 (1.00)</td>
</tr>
</tbody>
</table>

**Effects:**
- S = sex;
- A = age;
- N = nutritional group.

**ns** = not significant.

### DISCUSSION

Anthropometric indices of body composition of the Senegalese children varied with age, sex, and nutritional status. Age and sex differences in motor and cardiorespiratory fitness were also observed, but mild-to-moderate undernutrition had only a limited effect in the run and throw.

Girls had higher indices of fat mass than boys. It is known that at the beginning of puberty, maturation is associated with sex differences in muscle, fat mass, and relative fat distribution. Girls gain more subcutaneous fat on the extremities than boys, and the Trunk/Extremity ratio increases more in...
Activity and Body Composition  
n) Boys

Indices of body composition

Activity and Body Composition  
b) Girls

Indices of body composition

Fig. 2. Activity and body composition (mean ± 1 SD): a) Senegalese boys; b) Senegalese girls.
Activity and Physical Performances

a) Boys

![Chart showing physical performances for boys with bars for low and high activity levels.]

b) Girls

![Chart showing physical performances for girls with bars for low and high activity levels.]

Fig. 3. Activity and motor fitness (mean ± 1 SD): a) Senegalese boys; b) Senegalese girls.

boys (Malina, 1996). Hormonal regulation of growth differs between boys and girls and accounts for differences in fat mass. More-sensitive to nutritional influence; higher IGF1 in girls allows them to be better prepared for the metabolic demands of preg-
act but, as a result, there was no signifi-
can boys were better than girls in most
pared with boys during nutritional stress
role.
have a lower stroke volume and that auto-
portional to the cross-sectional area of a
Actually, while having less arm muscle
better cardiorespiratory efficiency.

ture children, who are sometimes termed
factors such as skill, training, physical ac-
tivity, and motivation play an important
relationships may not be observed in imma-
boys.

cary design did not permit the assessment of
were obviously more advanced than other.
America (Simon et al., 1995). While the sur-
metabolic non-specialists (Bar Or, 1983).
"metabolic non-specialists" (Bar Or, 1983).
mean the difference in nutritional sta-
can boys; however this

grip strength in both sexes. Strength is pro-

timated indicators have the advantage of tak-

PHYSICAL FITNESS OF SENEGALESE ADOLESCENTS

The higher values of HRs of girls during
Physical activity is a factor frequently in-
method in evaluating physical activity in
cause there are substantial differences in

Further, in West Africa, it is often difficult

The main limitation of the present
study was the difficulty of monitoring HR

terfering with subject behavior. HR record-

advantages and limitations of the HR method had been

to investigate physical activity without in-

 advantage of taking into account the underlying cardiorespi-

ding appear to be an acceptable alternative

monotonous. In another study of physical

the BMI can thus be misleading.

Interindividual variation in maturation

interrogated with boys during nutritional stress
explain why Senegalese prepubescent girls
such as chronic undernutrition. This could
explain why Senegalese prepubescent girls
have better force than boys; however this

could also mean that these Senegalese girls

because there are substantial differences in

have better aerobic fitness than boys; however this

could also mean that these Senegalese girls

The length of

In the present

the BMI can thus be misleading.

the BMI can thus be misleading.

This could explain why Senegalese prepubescent girls

have better aerobic fitness than boys; however this

could also mean that these Senegalese girls

constitute an acceptable alternative

the BMI can thus be misleading.

__393__
As a rule, the overall level of activity of the Senegalese children was low. While they spent 50% of their time over the fHR, they had less than 10 min per day in moderate to vigorous activity. This is consistent with other observations from Senegal: in a previous study, children spent only 4% of their time above 140 bpm, with differences between sexes (Benefice, 1992); Diakh and colleagues (1992) noticed in a rural district between ages (ORSTOM). I thank my research assistants, Ndiaye, Mow, and Baranowski for their participation in the surveys. I especially indebted to the editor for his assistance and suggestions on the manuscript.

In both sexes grip strength is greater in active children. Cardiorespiratory fitness is influenced by activity in girls, but not in boys. This could mean that boys were fit for undernourished boys to meet their energy requirements. In the case of undernourished girls, it is likely that their important participation in domestic tasks does not permit a reduction in habitual activity to the same extent (Bénéfice, 1993).


