AMERICAN JOURNAL OF HUMAN BIOLOGY 4:717–728 (1992)

Growth and Motor Performance of Healthy Senegalese Preschool Children

ERIC BÉNÉFICE
Unité de Recherche, "Maladies de Dénutrition," ORSTOM, Institut Français de Recherche Scientifique pour le Développement en Cooperation, Dakar, BP 1386, Sénégal, West-Africa

ABSTRACT Body dimensions, motor performance tests, and an aerobic stress test were measured on three different occasions on a group of 88 healthy Senegalese children, 3–6 years of age. The children were divided into 3 cohorts according to year of birth: 1985, 1984, and 1983. The children displayed linear growth approaching North American reference data but had significant weight deficits. Their growth, however, proceeded favorably compared to Senegalese children of the previous generation. In the group of children born in 1983, boys were more muscular and had less arm fat than girls. Motor performances of Senegalese children were inferior to those of European children, but after normalization by body mass, differences in jumping and throwing tasks tended to diminish. Stepwise regression showed that variations in motor performances were particularly due to age, body weight, and stature. The importance of nutritional factors is stressed to explain the development of performance and cardiorespiratory fitness of these children. © 1992 Wiley-Liss, Inc.

In West Africa, particularly in the Sahel climatic zone, it is well known that subsistence conditions of the inhabitants are difficult and the prevalence of malnutrition is high (Dillon and Lajoie, 1981; Keller and Fillmore, 1983). Since malnutrition results in stunting and/or wasting, children's growth is a good indicator of nutritional status (OMS, 1983), and, more generally, of the state of health in the community (Lotfi, 1988). Stunting and emaciation denote, in absolute terms, a deficit in muscle mass available for physical activity. One can thus expect suboptimal quantitative performances in activities requiring muscular force in undernourished subjects. Nevertheless, a reasonably high degree of fitness would be required for people living in nonmechanized, agriculture-based areas, where physical strength is a consequent necessity for survival (Spurr, 1988; Ferro-Luzzi, 1985). Furthermore, young children in rural Africa often undertake domestic and subsistence chores; their nutritional status may, therefore, interfere with the way these tasks are carried out. These children also represent the future labor force. An inquiry on their health and fitness status may thus have practical implications.

Relatively few data exist which illustrate the preceding concerns in younger children. The majority of studies deal with school aged children (Areskog, 1971; Davies, 1973; Desai et al., 1981; Malina and Bushang, 1985; Pařizková, 1987). To the author's knowledge, only the study of Ferro-Luzzi et al. (1979) in Italy specifically concerns mildly undernourished preschool children. Children from southern Italy were smaller and lighter than children from central Italy, but had better cardiorespiratory efficiency during exercise. Knowledge of the relationship between physical and functional development in children exposed to undernutrition remains unclear. Such questions are closely connected to the current debate on the long-term consequences of chronic undernutrition (Martorell, 1985; Spurr, 1988).

The aim of the present study is twofold: (1) to describe the physical growth and the development of motor performances and work capacity of healthy, preschool, rural Senegalese children; and (2) to study the rela-

Received December 17, 1991; accepted May 27, 1992.

tionships between growth status and functional and motor performance parameters.

SUBJECTS AND METHODS

Environment

The children were from the villages of Diokhane and Ndondol, which are located in the district of Bambey, in the central part of Senegal known as the "Peanut Basin," and from a residential neighborhood in the nearby coastal town of Mbour. The inhabitants are Muslim Wolof farmers whose principal activity is peanut cultivation. In Mbour, the inhabitants are generally fishermen from the Lebou ethnic group, which is closely related to the Wolofs. The principal diet consists of a bowl of rice with fresh fish at noon and a millet couscous with a peanut sauce, dried fish, or black-eyed peas (*Vigna unguiculata*) in the evening.

Sample

The study took place between September 1988 and November 1989. During this time, the children were examined at three different times at about 6 month intervals. The sample included 88 children (44 boys and 44 girls), divided into 3 cohorts according to year of birth: group A, those born in 1985; group B, those born in 1984; group C, those born in 1983. Thus, at the beginning of the study the youngest were 3 years old and at the conclusion of the study the oldest were 7 years old. There was a delay in recruiting some children because villagers often travel after the peanut harvest; as a result, the average interval between the first and second examinations is slightly shorter than between the second and third examinations. The subjects were chosen following a preliminary household survey in which all children under 5 years of age residing in the villages and in the targeted neighborhood in Mbour were examined. Only children who were in apparent good health were retained as subjects. The exact age of one-half of the subjects was known with certainty. For the remainder, age was determined by referring to a Muslim calendar, showing the principal religious and secular holidays, and by comparison with neighboring children whose exact age was known. Given the young age of the subjects, it is believed that the estimation error is less than 1 month. The initial sample was composed of 107 children, but some were lost due to moving from the area and departure for schooling. Only the results from children participating in all parts of the three visits are considered.

METHODS

The children had four types of examinations: a clinical examination in order to detect recent illness which would impair the tests, an anthropometric examination, a step test, and motor performance tests. A pretest was conducted on 20 children from the Dakar suburbs and appropriate adjustments were made. All measurements and observations were made by the author.

The anthropometric examination consisted of the following dimensions: body weight (kg) measured with an electronic medical scale exact to within 100 g, the children being weighed in underpants; standing height (cm) measured with a portable anthropometer accurate to 1 mm; sitting height (cm), measured with the same anthropometer (the children sat on a table with the back stretched up straight); height of the anterior superior iliac spine (HASIS, cm) (measured standing with the anthropometer); upper arm circumference (cm), measured on the left side with an unstretchable, glass-fibre tape. And four skinfold thicknesses, triceps, biceps, subcapular, and suprailiac skinfolds measured on the left side with a Holtain caliper. The measurements were taken following the techniques of the International Biological Program (Weiner and Lourie, 1981). The measurements of triceps skinfold (*TSF*) and arm circumference (*AC*) permitted an estimation of arm muscle area (*AMA*) according to the formula of Gurney and Jelliffe (1973):

$$AMA\ (\text{cm}^2) = (AC - \pi \times TSF)^2/4\pi.$$

The measurement of cardiorespiratory stress consisted of a step test as described by Cermák et al. (1969) and adapted by Pařízková for preschool aged children. After a sitting rest period of 3 min, the child climbed up and down a two step ladder whose rungs were 23 cm in height for 5 min at a rhythm of 30 steps per minute. During the test, the child was encouraged by an assistant who steadied him slightly by holding but not pulling his hand, in order to convey the rhythm of the metronome which beat on the second. At the end of the test, the child sat and rested for 5 min. During the entire duration of the 13 min test, the heart rate (HR) was recorded every 15 sec with a portable

TABLE 1. Anthropometric characteristics of Senegalese children born in 1985 (n = 18, mean ± SD)

Age (month)	Height (cm)	SH (cm)	AC (cm)	Weight (kg)	TSF (mm)	SSF (mm)	HASIS (cm)	AMA (cm^2)
43.6	98.7	54.2	14.8	14.2	7.2	23.9	56.7	12.6
(3.3)	(4.1)	(2.0)	(1.0)	(1.7)	(2.5)	(3.0)	(3.0)	(2.5)
48.1	101.0	54.9	14.7	15.1	7.1	24.0	58.6	12.6
(3.2)	(4.4)	(2.0)	(1.0)	(2.1)	(1.8)	(3.0)	(3.2)	(2.0)
54.1	104.6	56.3	14.7	15.8	7.0	23.5	60.8	12.6
(3.3)	(4.5)	(2.3)	(0.9)	(1.9)	(1.1)	(3.0)	(3.4)	(2.3)
Difference between examinations:								
$F_{(2,51)}$	8.2***	4.1*	0.0	2.9	0.0	0.1	6.9***	0.0

*$P < 0.05$; ***$P < 0.001$.

recorder, "Sport Tester" (Polar Electro Ky, Kempele, Finland). The weight of the child, the height of the step, and the number of ascents permitted a simple calculation of mechanical work furnished (*W*): *W* = body weight × height of the step × number of steps climbed. Two indices were calculated: (1) an index of cardiac efficiency (*CEI*), which expresses the accomplished effort per heart beat: *CEI* = *W*/sum of HR during work and recovery; and (2) Brouha's Index, which reflects the recuperative capacity of the child: Index = number of seconds of the step test/sum of HR during minute 2, 3, 5 of recovery.

Finally, four motor performance tests were administered: a 20 m dash in which children ran in pairs to stimulate reciprocal motivation; a standing long jump with feet together; a gripping strength test consisting of squeezing a rubber bulb connected to a manometer (Martin, Tuttlingen, RFA); and a distance throw using a 184 g softball (results are presented only for children born in 1984 and 1985). For the last three tests, the best of three consecutive trials was retained for analysis.

The examinations were always conducted in the same order: clinical and anthropometric exams, test of effort, and motor tests. The tests were conducted outdoors in a shaded area during the morning and evening, thus avoiding the hottest period of the day. Only 4 or 5 children could be examined at each session. Since realization of the step test and transfer of heart beat records to a microcomputer took about 35 min per child, there was a delay of at least 1 hr between the effort and the motor tests. The objective of the study was explained to parents and village and religious authorities and their oral consent was obtained. During the testing, which was conducted publicly, the children were accompanied by a family member.

Data analysis was performed using the BMDP program (Dixon et al., 1985). One-way and two-way analyses of variance, covariance analysis, and stepwise regression tests were carried out.

RESULTS

Nutritional status

The children were in good health at the time of the examinations; no subject showed any clinical signs of malnutrition (wasting of muscle and subcutaneous fat) or anemia (pale conjunctiva and tachycardia). According to anthropometric criteria, no subject showed a height deficit for age (*H*/age) or a weight deficit for height (*W/H*) greater than or equal to −2 standard deviations (SD) from the reference median of the National Center for Health Statistics (NCHS), which represents the statistical threshold for malnutrition (OMS, 1983). However, during subject selection, 17 of 88 children (18%) had an *H*/age deficit between −1 and −2 SD from the NCHS distribution and 32 (36%) had a *W/H* deficit of the same order. Only 19 children attained the median for height with respect to age and sex, and the median for weight with respect to height. These proportions did not change during the course of the study.

Growth and motor development and work capacity

Tables 1 and 2 represent the changes in the children's measurements during the study year. There were no differences by sex in the younger children; hence, the values were combined. In all cases there is a regular increase in stature, sitting height, and HASIS from one visit to the next. In con-

Table 2. Anthropometric characteristics of Senegalese children (mean ± SD)

Age (month)	Height (cm)	SH (cm)	AC (cm)	Weight (kg)	TSF (mm)	SSF (mm)	HASIS (cm)	AMA (cm^2)
				Children Born in 1984				
Boys (n = 17)								
52.6	102.5	56.0	14.9	15.6	5.8	21.7	58.6	13.8
(4.2)	(5.7)	(2.5)	(1.1)	(2.1)	(2.9)	(2.9)	(4.2)	(3.6)
58.2	105.5	57.1	14.8	16.5	6.8	21.7	60.3	12.9
(4.0)	(5.9)	(2.7)	(0.9)	(2.1)	(1.2)	(2.9)	(4.4)	(1.8)
65.5	109.7	58.9	14.9	17.9	6.6	21.3	63.7	13.3
(3.9)	(5.8)	(2.6)	(1.0)	(2.3)	(1.3)	(4.0)	(4.7)	(1.9)
Girls (n = 17)								
53.8	104.7	55.9	15.3	16.1	7.1	24.5	61.3	13.8
(3.5)	(4.8)	(2.4)	(1.1)	(2.0)	(2.9)	(2.6)	(3.4)	(3.9)
58.6	107.6	57.1	15.2	16.8	6.3	22.6	63.4	14.1
(3.6)	(5.1)	(2.9)	(1.0)	(2.0)	(2.7)	(3.9)	(3.3)	(2.9)
64.5	110.3	58.6	15.1	17.6	6.6	22.7	65.4	13.6
(3.6)	(5.4)	(2.7)	(1.0)	(2.2)	(1.7)	(3.6)	(3.9)	(2.2)
Two-way analysis of variance								
Difference between examinations:								
$F_{(2,96)}$	11.4***	9.2***	0.03	6.6***	0.03	1.0	11.8***	0.1
Difference between sex:								
$F_{(1,96)}$	2.3	0.0	2.1	0.2	0.3	6.9**	8.8**	0.8
				Children Born in 1983				
Boys (n = 21)								
67.2	111.9	60.0	15.2	18.4	6.2	20.3	65.2	14.0
(4.2)	(3.9)	(2.0)	(0.9)	(1.5)	(1.3)	(3.8)	(3.3)	(1.9)
72.3	114.9	61.3	15.4	19.2	5.9	19.7	67.4	14.6
(3.3)	(3.6)	(2.0)	(0.8)	(1.5)	(1.1)	(3.5)	(3.0)	(1.9)
79.3	118.1	62.5	15.6	20.4	5.1	18.9	69.9	15.5
(2.9)	(3.1)	(1.6)	(0.9)	(1.4)	(0.9)	(3.2)	(2.6)	(1.7)
Girls (n = 15)								
66.7	109.8	58.5	15.1	17.4	6.4	20.9	65.2	13.8
(3.0)	(3.5)	(1.7)	(0.8)	(1.6)	(2.0)	(3.9)	(4.2)	(2.0)
71.1	112.3	59.8	15.4	18.1	6.5	20.8	67.0	14.4
(3.3)	(3.7)	(1.9)	(0.8)	(1.5)	(1.1)	(3.5)	(2.3)	(1.7)
77.3	115.3	60.7	15.0	18.6	5.9	20.7	68.5	13.9
(3.3)	(2.9)	(1.9)	(0.9)	(1.5)	(1.0)	(3.7)	(2.8)	(1.7)
Two-way analysis of variance								
Difference between examinations:								
$F_{(2,102)}$	24.8***	13.4***	0.8	10.2***	3.7*	0.4	13.2***	1.8
Difference between sex:								
$F_{(1,102)}$	13.4***	18.3***	1.0	19.0***	4.6*	2.8	0.9	4.0*

*$P < 0.05$; **$P < 0.01$; ***$P < 0.05$.

trast, body mass and indices of body composition do not change in group A; body weight increases in groups B and C, and *TSF* decreases in group C. Differences by sex are more pronounced in group C than in group B. Boys born in 1983 are taller and have a greater arm muscle area but less subcutaneous arm fat than girls.

The weight and height curves of the children were compared with NCHS medians for age and sex and with observed values of children from the same Wolof ethnic group, recorded in the capital city of Dakar 30 years earlier (Massé et al., 1961; Massé, 1969). The latter represent the only complete set of data which have been published for Senegal. Figures 1 and 2 show that the children in this study display growth in height very close to the NCHS median and clearly greater than that of the 1961 study; in contrast, weight curves show a delay of about 1 year compared to NCHS data and are similar to the 1961 values.

Means and standard deviations for the motor tasks and the aerobic step test are shown in Tables 3 and 4. As for anthropometric data, sexes are combined in group A. There is a significant improvement in performances from one visit to the next for the jumping and running tasks in the 3 groups and in the throwing task for groups B and C. Aerobic indices do not change in younger

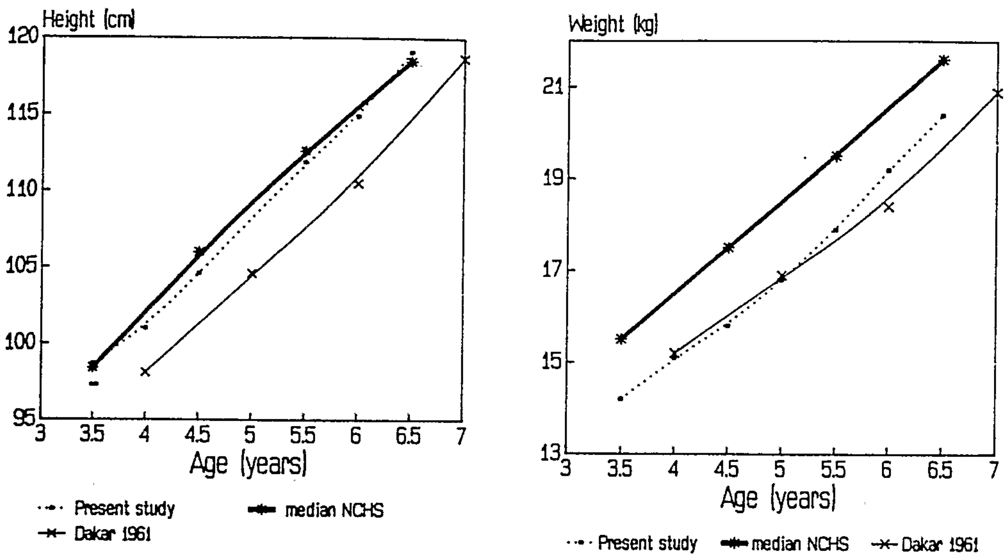

Fig. 1. Height and weight by age: Senegalese boys.

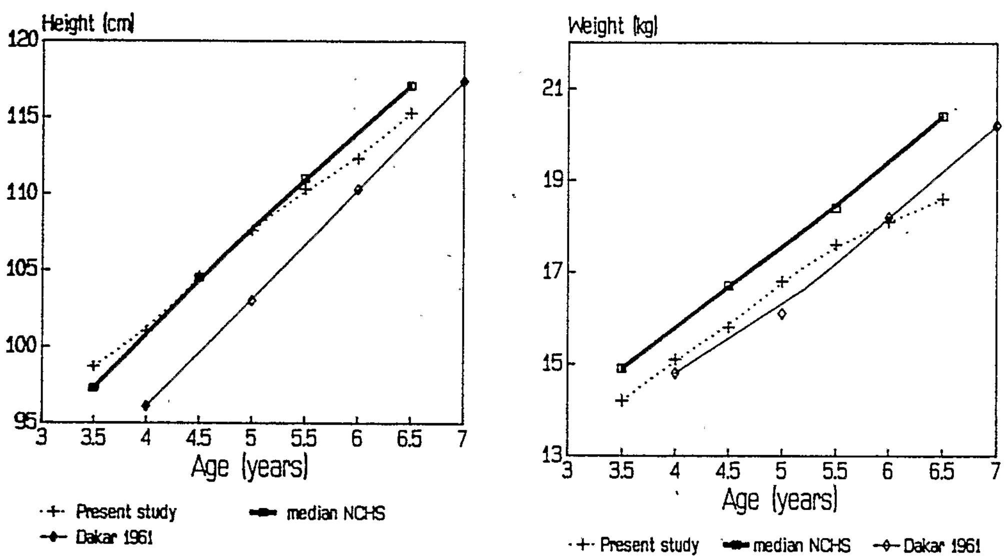

Fig. 2. Height and weight by age: Senegalese girls.

children. Differences exist as a function of sex. Results for boys are better for the softball throw and the aerobic step-test in groups B and C, and for the dash in group C. However, after adjustment for body weight and age by covariance analysis, the sex difference in the 20 m dash disappears. Sex differences remain in the throwing task (group B: $F = 14.4$, $P < 0.00$; group C: $F = 13.4$, $P < 0.00$) and in aerobic indices for group B, but not for group C (*CEI*: $F = 11.6$, $P < 0.00$; Brouha's index: $F = 8.0, P < 0.00$).

The changes in parameters are shown in Figures 3 to 6 and are compared to data

TABLE 3. Motor performance and cardiorepiratory fitness indices of Senegalese children born in 1985, sex combined (n = 18; mean ± SD)

Age (month)	20 m dash (sec)	Standing long jump (cm)	Hand grip strength (kPa)	CEI	Brouha's index
43.6	8.0	42.5	0.21	0.38	0.87
(3.3)	(1.3)	(24.2)	(0.07)	(0.09)	(0.14)
48.1	7.1	59.9	0.23	0.42	0.90
(3.2)	(0.7)	(19.0)	(0.07)	(0.08)	(0.11)
54.1	6.5	66.4	0.23	0.44	0.90
(3.3)	(0.9)	(21.6)	(0.05)	(0.08)	(0.08)
Difference between examinations:					
$F_{(2,51)}$	9.2***	5.8***	0.2	1.3	0.4

***$P < 0.001$.

recorded for Czech children (Pařízková, 1984). The Czech children obtain better scores than the Senegalese children (Figs. 3 to 5, left side). They have a more efficient *CEI*, but boys are not very different in Brouha's index. Czech children weighed 2 to 3 kg more than Senegalese children. Figures 3 to 5 (right side) represent the performances in motor tasks expressed per unit body weight. Czech children still run faster than Senegalese children but the differences in jumping and throwing for distance tend to diminish. Senegalese children over 4.5 years of age even jump farther than the Czech children.

Relationships between anthropometric and motor performance variables

Relationships were studied through stepwise regression separately in the 3 cohorts. The variables describing motor performances and working capacity were the dependent variables. The predictive variables were the following: age at the time of visit, height, HASIS, weight, arm muscle area, and the sum of the four skinfold measurements, plus sex in group B and C. Table 5 indicates the change in R^2 due to each variable entering in the equation ($F > 4$). Age at visit has an independent effect on the dash (all 3 groups), and throwing and jumping performances (groups B and C). Sex has a significant effect only on the throwing task. Body weight and stature play a role in explaining variance of motor tests, while body weight is the strongest predictor of CEI.

DISCUSSION

This study describes the growth, motor performance, and cardiorespiratory adaptation to physical effort of healthy, rural Senegalese children. Their growth in height is near the reference median of the NCHS; however, they generally show a *W*/age deficit, suggesting inadequate coverage of current nutritional requirements. This insufficiency does not produce a lag in height (stunting). A nutritional consumption study, conducted a few years previously, in effect, showed that the region was among the most precarious, being subject to acute demographic pressures and soil degradation. The daily per capita intake was less than 2200 cal and two-thirds of the households did not meet their daily energy requirements (Chevassus and Ndiaye, 1981). A risk of food shortages exists during the period prior to harvest time (September–October). During the study, agricultural conditions were relatively favorable and no increase in the incidence of wasting was observed at the end of the rainy season.

Compared to the group tested 30 years previously (Massé et al., 1961), the present Wolof children are taller, suggesting a positive secular trend over time, but the sample is too small to affirm this with certainty. The trend toward an increase in height without an increase in weight has been observed in other Soudanian populations and appears to have occurred lately (Eveleth and Tanner, 1990). In a study of Nilotic Turkana herders, Little and colleagues (1983) showed that the children had height and weight deficits relative to their age, as defined by the NCHS reference, but that the average adult height approached American norms, although they remained thin. In the Gambia, Billewicz and McGregor (1982) observed that puberty is delayed in comparison to British data. Chronic protein–energy malnutrition may delay puberty and the growth

TABLE 4. Motor performances and cCardiorespiratory fitness indices of Senegalese children (mean ± SD)

Age (year)	20 m dash (sec)	Jumping (cm)	Throwing (m)	Gripping (kPa)	CEI	Brouha's index
			Children Born in 1984			
Boys (n = 17)						
52.6	7.1	58.1	4.4	0.25	0.44	0.90
(4.2)	(0.7)	(19.0)	(1.2)	(0.07)	(0.09)	(0.10)
58.2	6.5	62.5	4.7	0.30	0.46	0.92
(4.0)	(0.7)	(27.7)	(1.7)	(0.07)	(0.08)	(0.11)
65.5	5.8	84.8	6.5	0.26	0.45	0.95
(3.5)	(0.4)	(19.4)	(2.1)	(0.07)	(0.07)	(0.11)
Girls (n = 17)						
53.8	7.0	54.8	3.4	0.28	0.44	0.86
(3.5)	(0.8)	(21.8)	(1.0)	(0.07)	(0.06)	(0.09)
58.6	6.3	62.2	4.3	0.30	0.44	0.85
(3.6)	(0.6)	(21.3)	(1.5)	(0.06)	(0.07)	(0.09)
64.5	5.7	86.5	4.9	0.29	0.48	0.89
(3.6)	(0.6)	(19.4)	(1.7)	(0.07)	(0.05)	(0.10)
Two-way analysis of variance						
Difference between examinations:						
F(2,96)	28.8***	17.6***	11.1***	2.9	4.6**	1.7
Difference between sex:						
F(1,96)	1.2	0.0	9.6***	2.2	3.6	8.2***
			Children Born in 1983			
Boys (n = 21)						
67.2	6.1	81.7	6.3	0.32	0.53	0.91
(4.2)	(0.6)	(16.3)	(1.2)	(0.07)	(0.07)	(0.12)
72.3	5.8	90.5	7.7	0.40	0.54	0.90
(3.3)	(0.5)	(22.5)	(1.6)	(0.07)	(0.07)	(0.10)
79.3	4.9	107.6	8.6	0.40	0.60	0.96
(2.9)	(0.4)	(17.5)	(1.7)	(0.11)	(0.06)	(0.10)
Girls (n = 15)						
66.7	6.4	74.0	5.4	0.33	0.47	0.86
(3.0)	(1.3)	(17.7)	(1.4)	(0.10)	(0.07)	(0.08)
71.1	5.9	87.8	5.8	0.38	0.51	0.90
(3.3)	(0.6)	(16.1)	(1.3)	(0.09)	(0.05)	(0.10)
77.3	5.5	98.4	6.8	0.36	0.52	0.90
(3.3)	(0.7)	(18.1)	(2.4)	(0.07)	(0.06)	(0.10)
Two-way analysis of variance						
Difference between examinations:						
F(2,102)	17.5***	16.6***	12.9***	5.2*	6.7***	1.8
Difference between sex:						
F(1,102)	5.7*	3.4	28.4***	0.7	17.1***	3.4

*$P < 0.05$; **$P < 0.01$; ***$P < 0.01$.

spurt by 1 to 2 years (Lewinter-Suskind, et al., 1989) and subsequent catch-up growth until 25 years of age may occur. In their Turkana herders study, Little and Johnson (1987) believe that the preservation of a sustained growth in height could be due to high animal protein intake, thus compensating for a caloric deficit. In the part of the Soudanian climatic belt where the present study was carried out, cereal-based consumption predominates and despite the small amount of animal protein consumed (only 15% of the total protein intake), the total protein intake was high and its quality, according to amino acid chemical scores, appeared to be satisfactory (Chevassus-Agnès and Ndiaye, 1981). This is in contrast to the Guinean area where food patterns are based on root consumptions (cassava and yams) which led to a poor protein intake. The situation observed in Sahelian Africa contrasts with results of studies conducted in Latin America where height deficits exist but where the preservation of a good height/weight ratio predominates. The existence of a high *W/H* index in Peruvian children could be due to a greater hydration of the non-fat mass (Boutton et al., 1987). After studying the development of gripping strength among Zapotec children, also small in stature, Malina et al. (1991) demonstrated reduced fat free mass per unit of stature and suggested

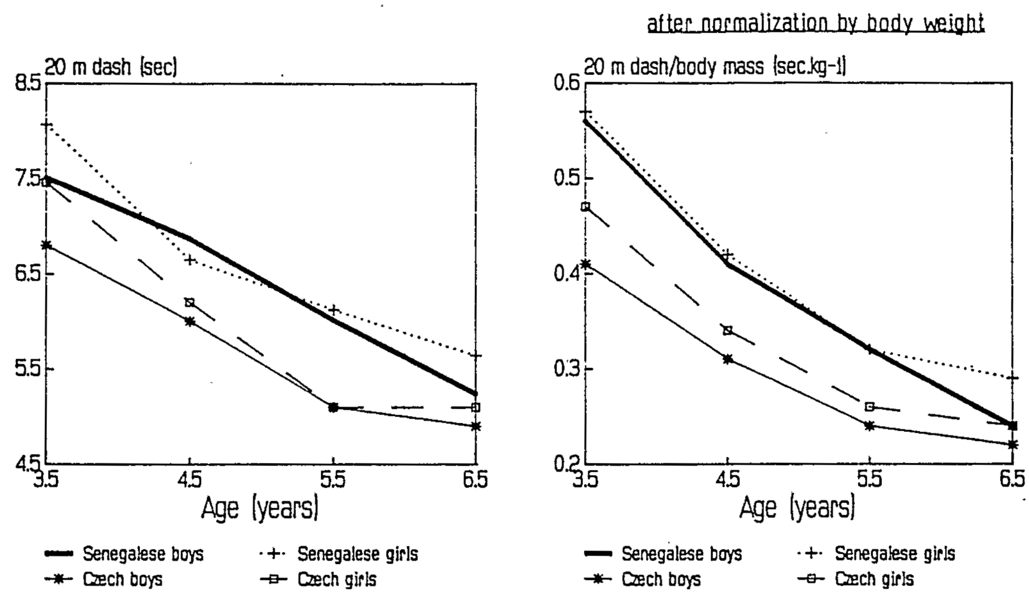

Fig. 3. 20 m dash performance of Senegalese children compared with Czech children.

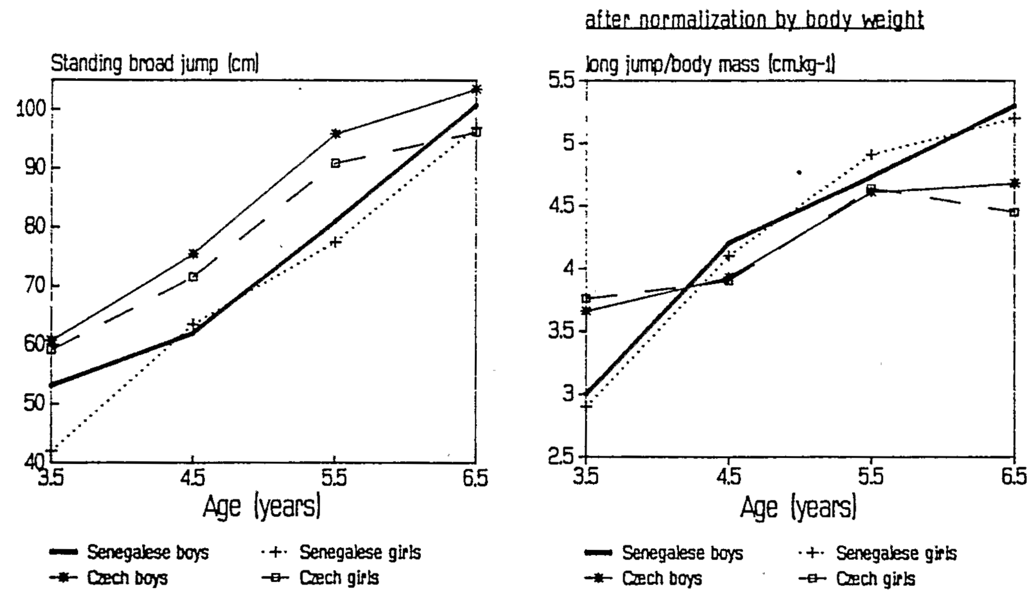

Fig. 4. Standing-broad jump performance of Senegalese children compared with Czech children.

that this may be due to a depletion of the organism's protein reserves. One could, therefore, postulate that for the populations from arid and Soudano-Sahelian Africa, a diet deficient in caloric intake but satisfactory in terms of protein, promotes normal growth in stature.

The growth pattern of girls differs slightly from that of the boys. Sexual dimorphism is more pronounced in the older children,

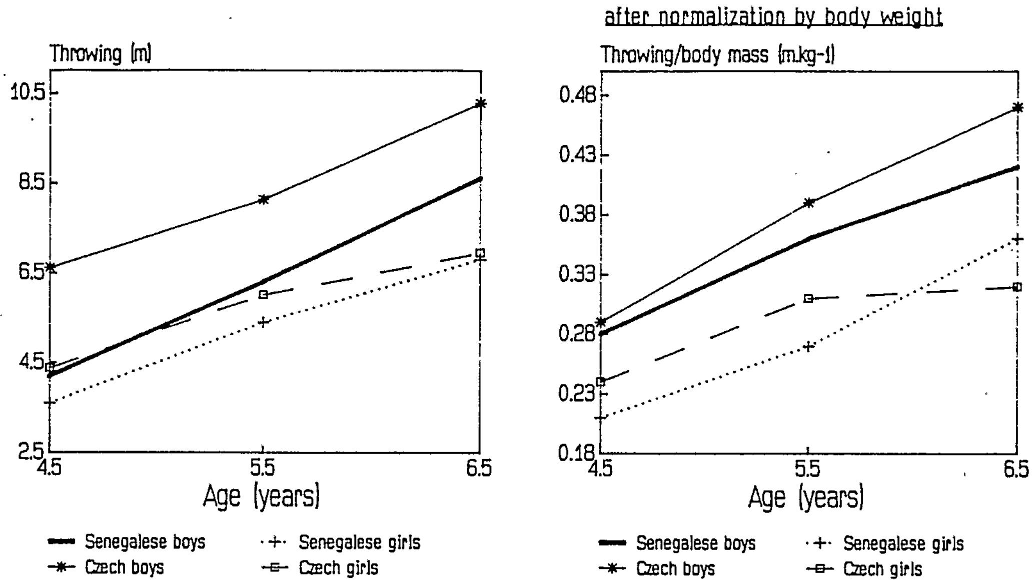

Fig. 5. Throwing performance of Senegalese children compared with Czech children.

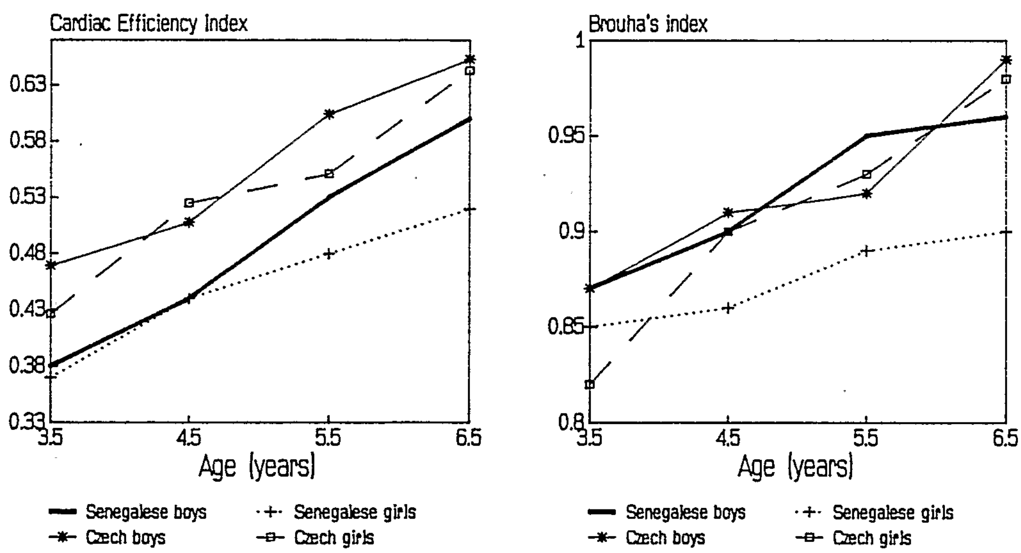

Fig. 6. Aerobic indices of Senegalese children compared with Czech children.

those born in 1983. Boys were taller and had greater arm muscle area and less arm fat than girls. It does not appear that this is due to different diets. Differences in the length of time the children were nursed would cause variations in the body mass (Baranowski et al., 1990), but all the children in this study were breast-fed until approximately 20 months and subsequently ate from a "common bowl" with the adults. It should, however, be noted that the young girls help the women to prepare the meals and thus have the chance to glean a little extra food outside of mealtimes.

TABLE 5. Relationships between age, sex, and selected anthropometric variables and motor and aerobic performances

Variables	20 m dash (sec)	Jumping (cm)	Throwing (m)	Hand grip strength (kPa)	CEI	Brouha's index
			Children born in 1985 (not performed)			
Age at visit	0.05[1]	—[2]		—	—	—
Body mass	—	—		—	0.70	0.16
Height	—	—		0.17		
HASIS	0.42	0.28		—	—	—
AMA	—	—		—	—	—
SSF	—	0.06		—	—	—
Multiple R^2	0.47	0.34		0.17	0.70	0.16
			Children born in 1984			
Age at visit	0.38	0.23	0.06	—	—	
Sex	—	—	0.08	—	0.04	0.07
Body mass	0.04	0.04	0.28	—	0.56	
Height	—	—	—	0.16		
HASIS	—	—	—	—	—	
AMA	—	—	—	—	—	
SSF	0.03	—	—	—	—	
Multiple R^2	0.45	0.27	0.42	0.16	0.60	0.07
			Children born in 1983			
Age at visit	0.04	0.24	0.03	—	—	—
Sex	—	—	0.07	—	—	—
Body mass	—	0.07	0.02	0.23	0.59	—
Height	0.37	—	0.33	—		
HASIS	—	—	—	0.03	—	—
AMA	0.02	—	—	—	—	—
SSF	—	—	0.02 (height removed)	—	—	—
Multiple R^2	0.43	0.31	0.47	0.26	0.59	No step

[1]Change in R^2 due to the variable.
[2]Variable not in equation.

Age at the time of visit had a significant effect on the jumping, running, and throwing tasks. This variable represents, on the one hand, the normal maturation of the child and, on the other hand, the improvement due to familiarization as the study progressed. This training effect also could be reinforced by a high level of habitual physical activity. The young boys, who are often at play, are better prepared than the girls who are occupied with domestic tasks. Recently, in a study dealing with older children using a continuous heart rate minute by minute recording device, the younger the boys, the greater the quantity of activity exhibited, and boys were more active than girls (Bénéfice, 1992). This may explain the better throwing performance of boys.

It was demonstrated that the performances of Senegalese youngsters were inferior to those of well nourished Czech children. A quantitative motor test reflects not only skill, but other factors like body weight and strength. After taking weight into account, differences are less pronounced between the two groups, except for the running test. Besides the reduction in body mass, other factors may be put forward to explain the lower performances of the Senegalese children. The environmental conditions were very different and cultural and psychological factors must also be considered. Motor performance tests call for strong motivation, a sense of competition, and a measure of aggressiveness which are less encouraged in communal Senegalese society than in Europe.

However, the smaller active muscle mass may be considered as responsible for the low physical fitness of the Senegalese children. Available muscle mass quantitatively limits physical performances; this is particularly apparent for working capacity (Spurr et al., 1984). After studying school aged children from different ethnic groups and different social strata in Zaire, researchers showed that differences in levels of performance disappeared when one took into account the children's morphology; moreover, the children who were considered a priori as being disadvantaged, turned in the best performance in certain tests (Ghesquière and d'Hulst, 1988). This, however, will not indicate a similar or superior functional efficiency in these children, but it will highlight the importance of physical growth in the development of motor capacities. Even slight malnutrition diminishes, in absolute terms, the performance level of children. When they are separated into two groups, normal and malnourished according to height/age and weight/height indices, the normal children always have better scores than the malnourished and approach the performance level of their European peers (Bénéfice, 1991).

The children in this study appear to show a positive evolution in terms of growth, compared to those of the previous generation. Environmental factors, in particular those of a nutritional nature, are likely to be responsible for weak performances and low cardiorespiratory fitness compared to European children. The role of cultural practices which encourage game playing among young boys and domestic chores among young girls as they relate to differences observed between the sexes must also be considered.

ACKNOWLEDGMENTS

I thank the children of Lambaye and Mbour and their families for their participation in the study. The assistance of Modou Mbow and Daouda Ndiaye is acknowledged and appreciated. Special thanks are due to the anonymous referees for their useful remarks and editorial assistance.

LITERATURE CITED

Areskog NH (1971) Short-time exercise and nutritional status in Ethiopian boys and young males. Acta Paediatr. Scand.. Suppl. *217:*138–141.

Baranowski T, Bryan GT, Rassin DK, Harrison JA, Henske JC (1990) Ethnicity, infant-feeding practices, and childhood adiposity. Dev. Behav. Pediatr. *11:*234–239.

Benefice E (1991) Nutritional status and development of working capacity of preschool Senegalese children. Early Child Dev. Care *72:*47–59.

Benefice E (1992) Physical activity and anthropometric and functional characteristics of mild malnourished Senegalese children. Ann. Trop. Paediatr. *12* Ann. Trop. Paediatr. *12:*55–66.

Billewicz WZ, McGregor IA (1982) A birth-to-maturity longitudinal study of heights and weights in two West African (Gambian) villages, 1951–1975. Ann. Hum. Biol. *9:*309–320.

Boutton TW, Trowbridge FL, Nelson MM, Wills CA, O'Brian Smith E, Lopez de Romana G, Madrid S, Marks JS, Klein PD (1987) Body composition of Peruvian children with short stature and high weight-for-height. I Total body-water measurements and their prediction from anthropometric values. Am. J. Clin. Nutr. *45:*513–525.

Chevassus-Agnes S, Ndiaye AM (1981) Enquêtes de consommation alimentaire de l'ORANA. In Rapport d'un Groupe de Travail: Etat Nutritionnel de la Population Rurale du Sahel. Ottawa: International Development Research Centre, pp. 57–66.

Čermák J, Čermaková J, Zucova Z, Cermá M, Tuma ST (1969) Die unterschiede in der funktionstüchtigkeit des kreislaufsystems von schürlern der experimentalscwimmklassen im vergleich mit gleichalten, keinen sport treibenden schülern. Schweitzerrische Z. Sportmed. *1:*9–19.

Davies CTM (1973) Physiological responses to exercise in East African children. II The effects of shistosomiasis, anaemia and malnutrition. Environ. Child Health *19:*115–119.

Desai ID, Garcia Tavarès ML, Dutra de Oliveira BS, Desai MI, Cevallos Romero LS, Vichi FL, Duarte FA, Dutra de Oliveira JE (1981) Anthropometric and cycloergometric assessment of the nutritional status of the children of agricultural migrant workers in Southern Brazil. Am. J. Clin. Nutr. *40:*681–689.

Dillon JC, Lajoie N (1981) Rapport sur l'évaluation de la situation nutritionnelle des populations rurales du Sahel. In Rapport d'un Groupe de Travail: Etat Nutritionnel de la Population Rurale du Sahel. Ottawa: International Development Research Centre, pp 67–88.

Dixon WJ (1985) BMDP Statistical Software. Berkeley: University of California Press.

Eveleth PB, Tanner JM (1990) Worldwide Variation in Human Growth (2nd ed.). Cambridge: Cambridge University Press.

Ferro-Luzzi A (1985) Work capacity and productivity in long-term adaptation to low energy intakes. In Blaxter K, Waterlow JC (eds.): Nutritional Adaptation in Man. London: John Libbey, pp. 61–68.

Ferro-Luzzi A, D'Amicis A, Ferrini AM, Maiale G. Nutrition, environment and physical performance of preschool children in Italy. In Somogyi JC, De Wijn JF (eds.): Nutritional Aspects of Physical Performance. Basel: Karger, Biblth. Nutr Diet. Vol. 27, pp. 85–106.

Ghesquière J, D'Hulst C (1988) Growth, stature and fitness of children in tropical areas. In Collins K, Roberts D (eds.): Capacity for Work in the Tropics. Cambridge: Cambridge University Press, pp. 165–179.

Gurney J, Jelliffe DB (1973) Arm anthropometry in nutritional assessment: nomogram for rapid calculation of muscle circumference and cross-sectional muscle and fat areas. Am. J. Clin. Nutr. *26:*912–915.

Keller W, Fillmore CM (1983) Prevalence of protein-energy malnutrition. World Health Stat. Quart. *36:*129–167.

Lewinter-Suskind L, Fuchs GJ, Kaewkantha' S, Suskind RM (1990) Long-term growth potential of previously malnourished children. In Suskind RM, Lewinter-Suskind L (eds): The Malnourished Child. New York: Raven Press, pp. 383–393.

Little MA, Galvin K, Mugambi M (1983) Cross-sectional growth of nomadic Turkana pastoralists. Hum. Biol. *55:*811–830.

Little MA, Johnson BR (1987) Mixed-longitudinal growth of nomadic Turkana pastoralists. Hum. Biol. *59:*695–707.

Lotfi M (1988) Growth monitoring: a brief literature review of current knowledge. Food Nutr. Bull. *10:*3–10.

Malina RM, Buschang PH (1985) Growth, strength and motor performance of Zapotec children, Oaxaca, Mexico. Hum. Biol. *57:*163–181.

Malina RM, Little BB, Buschang PH (1991) Estimated body composition and strength of chronically mild-to-moderately undernourished rural boys in Southern Mexico. In Shephard RJ, Pařiková J (Eds.): Human Growth, Physical Fitness and Nutrition. Basel: Karger, pp. 119–132.

Martorell R (1985) Child growth retardation: a discussion of its causes and its relationship to health. In Blaxter K, Waterlow JC (Eds.). Nutritional adaptation in man. London: John Libbey, pp. 13–29.

Massé G (1969) Croissance et développement de l'enfant à Dakar. Biométr. Hum. *4:*13–23.

Massé G, Moreigne F, Sénécal J (1961) Poids et tailles d'enfants dakarois pendant les 4 premières années de la vie. Bull. Soc. Méd. d'Afrique Noire Lang. Fr. *6:*661–672.

OMS (1983) Mesure des Modifications de l'Etat Nutritionnel. Genève: Organisation Mondiale de la santé.

Pařizková J (1987) Growth, functional capacity and physical fitness in normal and malnourished children. World Rev. Nutr. Diet *51:*1–44.

Pařizková J (1984) Growth, Fitness and Nutrition in Preschool Children. Prague: Charles University.

Spurr GB (1988) Body size, physical work capacity, and productivity in hard work: Is bigger better? In Waterlow JC (ed.): Linear Growth Retardation in Less Developed Countries. New York: Raven Press, pp. 215–243.

Spurr GB, Barac-Nieto M, Reina J, Ramirez R (1984) Marginal malnutrition in school-aged Colombian boys: Efficiency of treadmill walking in submaximal exercise. Am. J. Clin. Nutr. *39:*452–459.

Weiner JS, Lourie JA (1981) Practical Human Biology. London: Academic Press.