Nutritional status and age at menarche of Senegalese adolescents

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Summary. Growth and maturation during adolescence has not been well described in rural African populations, although it may represent the missing link between high levels of preschool stunting and nearly 'normal' adult heights. In 1995 the homes of subjects aged 10.3-17.5 years, living in a rural area of Senegal, were visited, and all adolescents present, 1527 boys and 1126 girls, were included in the analysis. A number of girls were absent because they worked in the capital city Dakar. Resident girls (n = 705) had significantly higher means than boys for all anthropometric variables (weight, body mass index, arm circumference and muscle arm circumference, triceps and subscapular skinfolds), except for height and head circumference. Girls who had just returned from seasonal migration to Dakar (n = 415) were, on average, 2 kg heavier, but not taller, than resident girls (p < 0.0001). The girls fell off in height from 11 to 13 years compared to the NCHS reference and then 'caught up' until the age of 17, while boys fell off during the entire age span. Mean age at menarche was estimated at 16.1 years (95% fiducial CI: 15.8-16.4) from status quo data by probit analysis. No significant difference was found between residents and migrants. Postmenarcheal girls had better nutritional status than premenarcheal girls in terms of height, weight, body mass index, percentage body fat and arm muscle circumference (p < 0.0001). In conclusion, puberty, as assessed by age at menarche, is delayed by about 3 years in this population, probably due to malnutrition.

1. Introduction
While the nutritional status of preschool children has been extensively described for African populations, either through national surveys or reviews (Eveleth and Tanner 1990, Cameron 1991), less attention has been paid to older children (Cameron 1991). One reason might be the difficulties in interpreting nutritional status in this age group (WHO Working Group 1995). During adolescence, growth and nutritional status are heavily influenced by the sexual maturation process, and thus cannot be accurately assessed without a knowledge of the degree of sexual maturation (Sizonenko and Himes 1993). However, evaluation of pubertal stages through cross-sectional studies is difficult, due both to low acceptability by the study subjects and to a high degree of subjectivity. Despite these difficulties, this very important age group should not be neglected (WHO Working Group 1995). Indeed, in developing countries, female adolescents are about to begin their long-lasting reproductive life, and this period might be adequate for interventions aimed at improving maternal health and nutrition. Moreover, adolescence is often considered to be a period in which stunted children can catch up (Kulin, Bwibo, Mutie and Santner 1982, Dreizen, Spirakis and Stone 1967, Cameron, Kgamphe, Leschner and Fantant 1992) and is thus an important age group for the study of long-term consequences of stunting, the most prevalent type of protein-energy malnutrition worldwide (de Onis, Monteiro, Akré and Clugston 1993).

Urban versus rural residence is a major determinant of nutritional status in developing countries, for preschool children as well as for adolescents (Kulin et al. 1982) and adults (Maire, Delpeuch, Cornu, Tchibindat, Simondon, Massamba, Salem and Chevassus-Agnès 1992). In general the nutritional status is lower in rural areas,
although poor urban children sometimes suffer from higher prevalences of malnutrition than rural children (Cameron 1992, Adair, Vanderslice and Zohoori 1993). In the Serere ethnic group from central Senegal, which was studied here, many adolescent girls are sent to the capital city of Dakar to work as maids. These large-scale seasonal migrations give an opportunity to study the impact of a change in the environment on the physical development of adolescents.

The objective of the study presented here was to describe the nutritional status of Serere males and females aged 10–17 years from a rural area of Senegal. Seasonally migrating girls who returned to their homes were measured shortly after arrival, and their nutritional status was compared to the status of permanent resident girls. Mean age at menarche was estimated by probit analysis from status quo data, and sexual maturation was compared between residents and migrants. Nutritional status was also compared between pre- and postmenarcheal girls.

2. Subjects and methods

The Niakhar study area is a rural region located in the ‘peanut basin’ in Central Senegal, about 150 km from the capital city Dakar, and it has been under continuous demographic monitoring since 1983, when a central demographic and epidemiological database was constituted. The population of 26 600 is of the Serere ethnic group, and over 90% are farmers who grow millet and groundnuts during the rainy season, which lasts from July to October. A detailed description of the study area has been published previously (Simondon, Bénéfice, Simondon, Delaunay and Chahnazarian 1993).

For the present study all subjects born in the area between January 1978 and October 1984 (aged 10-3–17-5 years), who were still alive and had not emigrated in February 1995, were identified from the database. Systematic birth date registration started in early 1983, so for the youngest subjects (10–12 years old), ages were known to be accurate. For the older subjects the recall method, including calendars of local events, had been used in 1983 when they were under 5 years of age (Briend, Garenne, Maire, Fontaine and Dieng 1989).

Data collection was done via three surveys, which all involved home visits. The first survey was conducted from March to May—the dry, hot season during which migrants are absent. Migrants who returned to the study area during the 1995 rainy season were measured during one of two later surveys, in June or in August. Prior to the surveys, oral, as well as written, information about the project was communicated to all subjects or to their parents at their homes. Weight was recorded to the nearest 100 g using electronic beams (Tefal) frequently checked against standard weights; left upper arm circumference and head circumference were measured to the nearest 1 mm, triceps and subscapular skinfolds were measured to the nearest millimetre using a pair of Holtain calipers, and height was measured to the nearest millimetre using Harpenden anthropometers. Height and skinfolds were measured twice, and the means computed in order to minimize measurement variability. The two teams of measurers were well trained and measurements were standardized at the beginning of the study.

Girls were asked whether they had experienced menstruation and whether they were pregnant. When a girl was very young or unable to answer the questions, her mother was asked. Birth dates, collected as described above, were obtained from the database. Age groups for tables were from 10-50–11-49 to 16-50–17-49 years, while
Nutrition and menarche in Senegal

those for the figures were defined differently (from 10.0–10.99 to 17.0–17.99), in order to allow for comparisons with other growth data.

Statistical analyses used one- and two-factor ANOVA (BMDP statistical software). Arm muscle circumference (AMC) was computed using the mid-upper arm circumference (MUAC) and triceps skinfold thickness (TRI) from $AMC = MUAC - 3.14 \times TRI$ and expressed in centimetres. Percentage body fat (BF) was computed for girls using the triceps and subscapular skinfold thicknesses (TRI and SUB) from $BF = 1.33 \times (SUB + TRI) - 0.013 \times (SUB + TRI)^2 - 2.5$ (Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan and Bemben 1986). Percentage body fat could not be obtained for boys, since the estimations depend on the pubertal stage, which was not known here. Reference data used were the NCHS reference for weight and height (WHO 1983) and triceps skinfold (from Eveleth and Tanner 1990), and a national survey in the USA by Najjar and Rowland (1987) for upper arm circumference (from Eveleth and Tanner 1990).

Mean age at menarche and the standard deviation were estimated using probit analysis (Statistical Analysis Package), together with fiducial confidence intervals. Mean ages at menarche of resident and migrant girls were compared using logistic regression. Pregnant girls and subjects with missing height or weight measurements (mainly due to physical handicaps such as poliomyelitis sequelae) were excluded from the analysis of nutritional status, while pregnant girls were kept in the analysis of age at menarche.

3. Results

Among a total of 1927 eligible girls, 1131 (59%) were present during at least one survey and were thus included in the study. The majority of girls who were not included (>90%) were migrants who did not return to the study area during the rainy season in 1995. Five girls were excluded because of missing weight or height measurements. Six girls who declared they were pregnant were excluded from the analyses of nutritional status. Among the remaining 1120, 705 were classified as residents and 415 as migrants. As expected, the migrants were older than the residents on average (14.2 vs. 12.8 years, $p < 0.0001$). The inclusion rate was greater for boys than for girls (1536 out of 1976; 77.7%). Nine boys were excluded because of missing measurements, leaving 1527 boys, all residents, for the analysis.

Boys tended to be smaller than girls from 11 to 16 years, but taller at 17 years (tables 1 and 2). Mean weight, body mass index, arm circumference, arm muscle circumference and triceps and subscapular skinfolds were all greater for girls than for boys ($p < 0.001$) in all age groups considered. Older children had higher mean body mass index than younger children, while skinfolds remained constant over age in males and increased with age in females.

The mean weight of girls was significantly greater for migrants than for residents, by approximately 2 kg ($p < 0.0001$; tables 2 and 3). Mean body mass index, left upper arm circumference, arm muscle circumference, skinfolds and percentage body fat were also significantly greater ($p < 0.0001$). Overall, mean height did not differ significantly between groups. Only the youngest migrants (11–13 years old) tended to be taller than the residents of the same age, but the differences were not significant.

The difference between the mean height of the Senegalese boys and the NCHS reference increased during the entire age span considered, and their mean height ended below $-2$ z-scores at age 16–17 years, while their mean weight remained...
Table 1. Nutritional status of resident boys (means and SD).

<table>
<thead>
<tr>
<th>Age</th>
<th>n</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>MUAC (cm)</th>
<th>MC (cm)</th>
<th>HC (cm)</th>
<th>Skinfolds (mm)</th>
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</table>

BMI: body mass index; MUAC: mid upper arm circumference; MC: muscle circumference; HC: head circumference.

Table 2. Nutritional status of resident girls (means and SD).

<table>
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<tr>
<th>Age</th>
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<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
<th>MUAC (cm)</th>
<th>MC (cm)</th>
<th>HC (cm)</th>
<th>BF (%)</th>
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BMI: body mass index; MUAC: mid upper arm circumference; MC: muscle circumference; HC: head circumference.

p: Difference from resident boys; ***: < 0.001, n.s.: not significant.

roughly parallel to the reference and well above −2 z-scores (figure 1). They tended to be taller than the Turkana boys (Little, Galvin and Mugambi 1983) at all ages, and taller than the Kamba boys (Kulin et al. 1982) from 10 to 13 years of age. The difference between the mean height and weight of the resident girls and the NCHS reference increased from age 10 to 12 years, and decreased thereafter (figure 2). The resident girls tended to be taller than the Turkana at all ages and taller than the Kamba at most ages. Their arm circumference was also greater (figure 3).

Among the 1126 girls with complete anthropometric measurements, 1028 (91.3%) had provided information on menarche. Ninety-one per cent of the missing informa-
Table 3. Nutritional status of migrant girls (means and SD).

<table>
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<tr>
<th>Age</th>
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<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
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<th>BF (%)</th>
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BMI: body mass index; MUAC: mid upper arm circumference; MC: muscle circumference; HC: head circumference.

p: Difference from resident girls; *** < 0.001, n.s.: not significant.

Figure 1. Mean height and weight of Senegalese boys compared to the NCHS reference (medians and -2 z-scores) and to Turkana and Kamba Kenyan boys.
tion concerned girls under 14.5 years who were unable to answer, and whose mothers were absent from the home at the time of the survey. Mean age at menarche was estimated at 15.8 years (SD 1.9) for residents and 16.3 years (SD 2.0) for migrants. The 95% fiducial confidence intervals were 15.3–16.5 years and 15.9–16.8 years, respectively, and the difference between residents and migrants was not statistically significant. When all girls were pooled together the mean age at menarche was 16.1 years (SD 2.0), with a 95% fiducial confidence interval of 15.8–16.4. However, a bias in these estimations cannot be ruled out, since 59 residents and 39 migrants had no information on menarcheal status. Since almost all these girls were under 14.5 years of age, and did not know themselves whether they had experienced menstruation, it is very likely that they were premenarcheal. Using the ‘maximum bias hypothesis’, i.e. considering that all non-responders were premenarcheal, did not change the estimate (mean 16.1, CI 15.8–16.4).

Nutritional status was more strongly related to menarche than to migration status between the ages of 14 and 17. Mean weight was 8–10 kg greater for girls who had experienced menarche compared to the other girls of the same age (table 4). Mean height was superior by 8 cm at 14 years and by 4 cm at 16–17 years, and mean body mass index and skinfolds were all significantly higher. The mean body mass index
was higher in the older age groups than in the younger age groups among postmenarcheal girls, before and after adjustment for migration status, suggesting that the body mass index continues to increase significantly after menarche. Mean height differed less by age group in postmenarcheal girls than in premenarcheal girls from...
age 14 to 17 (1.8 cm vs 6.1 cm). This reflects the strong deceleration in growth in height after menarche.

4. Discussion

This study was designed to measure the nutritional status of all adolescents living in a rural area in West Africa, and therefore used home visits rather than surveys in schools. However, 41% of the girls were not at home during the survey and most of these had migrated to town. Such high levels of migration are common in the area. In 1992, 37.2% of the girls aged 10–14 years and 42.5% of those aged 15–19 years had migrated during the dry season (Paquet 1992), while 84% of female adolescents aged 15–19 years had migrated to the capital city of Dakar at least once during their lifetime (Delaunay 1994). Boys usually migrate at older ages, as their earning capacities increase.

Migration status was closely related to nutritional status among girls. The mean weight of migrants was approximately 2 kg above the mean weight of the permanent resident girls at all ages, and their body mass index, arm circumference, arm muscle circumference and skinfold thickness were all higher. These differences are noteworthy given the low social status of the migrants in Dakar. They live crowded into small rented rooms, are usually not in charge of cooking during their work (Delaunay 1994) and therefore do not have easy access to food. Their salaries are very low (1500–20000 F CFA, i.e. $US 3–40 per month) and are usually paid directly to a member of their family (Delaunay 1994). Despite these adverse living conditions their nutritional status was significantly better than that of the girls who remain in the villages. However, an important shortcoming of the interpretation of the better nutritional status of migrant girls was the fact that the nutritional status of the migrants prior to migration was not known. Therefore, the relationship between migration and nutritional status might have been due to reverse causality (Kaplowitz, Martorell and Engle 1993), e.g. only the girls with good nutritional status were sent to Dakar, so that the greater body mass index and skinfold thickness were a cause, rather than a consequence, of migration. However, neither height nor maturation, as assessed by mean age at menarche, differed between adolescent migrants and residents, suggesting that the nutritional advantage of migrants was recent. In addition, for a subsample of 650 residents and 397 migrants, preschool nutritional status was known from an earlier study (Briend et al. 1989). Mean height-for-age and mean weight-for-height did not differ significantly between migrants and residents at the age of 0–5 years when adjusted for age. Therefore, the better nutritional status of migrant girls is probably a consequence of migration. This conclusion is also consistent with the experience of adults interviewed in the area, who all considered that girls gain weight during their stay in Dakar.

Another methodological problem is that the resident girls were measured in April, while the migrants were measured either in June or in August. Since seasonal variations in nutritional status are very significant in this area, with weight losses of up to 3.8 kg (7%) among adult women between April and September (Simondon et al. 1993), the status of residents would have been even lower if they had been measured in August, so the impact of migration on nutritional status is probably underestimated.

Puberty, as assessed by age at menarche, is heavily delayed in this rural population. The delay is about 3–3.5 years compared to European girls and 3–6 years compared to a US national sample of girls of African origin (12.5 years,
MacMahon 1973, cited by Eveleth and Tanner 1990). No marker of sexual maturation was available for boys, but their height deficit at 16–17 years (mean height below -2 z-scores of the NCHS reference) suggests a delay at least equal to that found in girls. The late establishment of height superiority of the boys relative to the girls, which has already been described for Kenyan Turkana adolescents (Little et al. 1983), can also be considered an indicator of delayed sexual maturation. In rural Kenyan boys the onset of puberty was delayed by 3 years compared to urban well-nourished boys (Kulin et al. 1982).

A strong secular trend towards lower age at menarche has been observed in all developed countries over the past 150 years, as in Denmark, where the mean age at menarche was 17.0 years in 1840 vs 13.0 years in 1983 (Helm and Helm 1987). Therefore, the age at menarche can be used as a marker of social development, like the infant mortality rate and the height of young children. Mean age at menarche in this rural Senegalese population is higher than in rural South Africa in 1990 (14.0 years; 95% CI 13.7–14.3, Cameron, Kgampphe and Levin 1991) and 50 years ago (15.7 years, Kark 1943, cited in Cameron et al. 1991), and it is also higher than in rural Kenya (15.3 years, Kuh et al. 1982). In a middle-class population from the capital city of Dakar, median age at menarche was estimated to be 14.0 years in 1956 (95% CI 13.0/12, 14.2/12, Massé 1969). According to our knowledge no more recent data are available on well-off Senegalese adolescents. A few examples of even later menarche than described for these Senegalese girls have been reported for other rural African populations (e.g. 16.5 years in Tutsies and 17.0 years in Hutus from Rwanda; Heintz 1963, cited in Eveleth and Tanner 1990).

Most authors consider that chronic malnutrition is the main determinant of delayed puberty (Dreizen et al. 1967, Kulin et al. 1982, Eveleth and Tanner 1990). However, 'chronic malnutrition' should then be defined as a more or less permanent energy deficiency (wasting) rather than as stunting, since stunting per se does not seem to delay puberty very much. In rural Guatemala, for instance, menarche was delayed by only 1 year, according to a recent study (mean age 13.7 years, Khan, Schroeder, Martorell and Rivera 1995), although the mean height of girls was lower than the third percentile of the NCHS reference already at the age of 3 years, and remained below the fifth percentile during adolescence (Martorell, Schroeder, Rivera and Kaplowitz 1995). In addition, nutritional supplementation during preschool life had no impact on age at menarche (Khan et al. 1995) despite a significant positive impact on height and weight which persisted at adolescence (Rivera, Martorell, Ruel, Habicht and Haas 1995). Therefore wasting, which is highly prevalent in Africa (7.2% of preschool children, de Onis et al. 1993) but virtually absent in Latin American (1.4% in Guatemala, de Onis et al. 1993), is probably a much stronger determinant of delayed puberty than stunting.

At what age will malnutrition have an impact on the timing of puberty? Some authors suggest that the infant and preschool nutritional status is more important for sexual maturation than the status just prior to the onset of puberty (Largo 1993). In Norway the correlation between the gross national product (GNP) and age at menarche was higher when the year of birth of the women was considered than when childhood years were chosen for the GNP (Liestøl 1982). However, the importance of early nutritional status for the timing of puberty needs confirmation through longitudinal studies, while the importance of nutritional status immediately prior to menarche already has been established: on average, girls with a higher weight and...
body mass index mature earlier than girls with low body weight within a given population (Liestøl and Rosenberg 1995, Onat and Ertem 1995).

In this cross-sectional study it is not known whether girls with earlier onset of menarche had higher body mass and body fat mass than the other girls prior to menarche, or whether these differences were constituted partially or completely after menarche. Mean body mass indices of premenarcheal girls aged 14–17 years were consistently lower than the means of well-nourished premenarcheal Australian girls aged 11–15 years (17.0–18.7 vs 18.9–19.4 kg/m²; O’Dea and Abraham 1995), while the means of postmenarcheal girls were very similar in the two populations (19.3–21.1 vs 19.9–21.1 kg/m²).

The pubertal growth of these malnourished African populations enables them to reach a final height close to those of well-nourished Western populations. Indeed, mean heights of adult Sereres (161.4 cm for women and 172.5 cm for men, Simondon et al. 1993) are only slightly lower than French means (163.2 cm for women and 174.5 cm for men; Sempé, Pédro and Roy-Pernot 1979). ‘Catch-up’ in height during adolescence has also been described in rural South African black children (Cameron 1992), although the onset of puberty was much less delayed in these populations (mean age at menarche 14.2 and 14.6 years). Longitudinal studies have demonstrated that the catch-up growth in height of rural African adolescents is due to prolonged growth rather than to higher peak height velocities (Cameron, Gordon-Larsen and Wrchota 1994).

Pubertal growth thus permits a kind of catch-up growth at the population level in Africa, but it is not known whether the severely stunted preschool children reach final heights similar to those of the less stunted, or whether the late-maturing adolescents reach final heights similar to those of relatively early matures. Studies from India (Satyanarayana, Radhaiah, Murali Mohan, Thimmayamma, Pralhad Rao, Narasinga Rao and Akella 1989) and Guatemala (Martorell, Rivera, Kaplowitz and Pollitt 1991) suggest that the most stunted children have a later onset of puberty but total adolescent height increments similar to those of the less stunted children, so that catch-up growth does not occur at the individual level.

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References


Nutrition and menarche in Senegal


Résumé. La croissance et la maturation pendant l’adolescence n’ont pas été correctement décrits dans les populations rurales africaines, bien qu’elles puissent représenter le chaînon manquant entre les taux élevés d’arrêt de croissance préscolaires et des tailles adultes ‘presque normales’. En 1995, les foyers de sujets âgés de 10-3 à 17-5 ans vivant dans une zone rurale du Sénégal, ont été visités et tous les adolescents présents: 1527 garçons et 1126 filles, inclus dans l’analyse. Une partie des filles étaient absentes parmi qu’elles travaillaient dans la capitale, Dakar. Les filles résidentes ($n=705$) présentaient des moyennes significativement plus élevées que les garçons pour l’ensemble des variables anthropométriques (poids, indice de masse corporelle, circonférence du bras et circonférence maigre du bras, plis cutanés tricipital et sous-scapulaire), à l’exception de la stature et de la circonférence de la tête. Les filles qui venaient juste de revenir de leur migration saisonnière à Dakar ($n=415$) pesaient en moyenne 2 kg de plus que les résidentes, mais n’étaient pas plus grandes ($p<0.0001$). Les filles présentaient un déficit de croissance de 11 à 13 ans par rapport aux références NCHS, puis rattrapent jusqu’à l’âge de 17 ans, alors que les garçons présentent le déficit pendant l’ensemble de la période de croissance observée. L’âge moyen des premières règles est estimé à 16-1 ans (dégé de confiance 95% et CI: 15.8–16.4) par analyse de probits sur données de status-quo. On n’a pas trouvé de différence significative entre résidents et migrants. Les filles régulées présentent un statut nutritionnel meilleur que les filles non-régulées en termes de stature, poids, indice de masse corporelle, pourcentage de graisse et circonférence maigre du bras ($p<0.0001$). En conclusion, la puberté estimée par l’âge aux premières règles, est retardée de près de trois ans dans cette population, probablement à cause de la malnutrition.