# Seasonal variation and trends in weight and arm circumference of non-pregnant rural Senegalese women, 1990-97

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***Contributors***: FS initiated the collection of maternal anthropometric data. KBS realized continuous data quality control, designed and conducted the statistical analysis and drafted the first version of the manuscript. All authors contributed to the interpretation of the results and to the manuscript.

**Objective**: To describe levels, monthly variations and trends in weight and arm circumference of non-pregnant lactating women living in the Sahel, characterised by one short yearly rainy season (July-October).

**Design:** Mixed unbalanced cross-sectional longitudinal observational study at 3, 5, 7 and 10 months postpartum.

**Setting:** 30 villages in the Sine area of Senegal.

**Subjects**: 3 869 women who had brought their infants into dispensaries for immunisation from January 1990 to February 1997, and 1-5 consecutive children per woman (26 106 visits).

**Results**: Mean weight was 55.7 kg (SD: 7.1), but it varied by 2.5-3.9 kg each year, from high means during the dry season (March-May) to low means at the end of the rainy season (September-November). The prevalence of underweight, overweight and obesity (BMI<18.5, 25-29.9 and >30 kg/m$^2$, respectively) was 7.6% (95% CI: 7.3, 7.9), 6.4% (6.1, 6.7) and 0.4% (0.3, 0.4), but varied strongly by season (P<0.0001 for both). Unlike weight, mean arm increased during the early rains, a peak season of agricultural work (+0.10 cm/mo (SD: 0.6) from June to August vs. -0.35 kg/mo (SD: 1.1) for weight). BMI and arm circumference were positively associated with age (means: 20.8 vs. 22.2 kg/m$^2$ and 25.3 vs. 27.4 cm, at 20-24 and 40-49 y, respectively, P<0.0001 for both).

**Conclusions**: Season was a major determinant of the anthropometric status of rural African women. Negative energy balance reduced body weight from the onset of agricultural labour, while arm circumference increased during early rains, probably due to high physical activity.

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Descriptors: Season, weight change, underweight, Africa, population

## Introduction

The severe droughts which affected the Sahel in the early 1970s prompted studies on the nutritional status of adults which provided evidence for precarious mean values and strong seasonal variations in rural populations (Bénéfice *et al.*, 1984; Loutan & Lamotte, 1984).

Since then, the nutritional status of women of reproductive age living in low-income countries has been extensively described, mainly by Demographic and Health Surveys (DHS, www.dhs.com). Over the last decade, it has become evident that the nutrition transition has reached Africa. In some parts of the continent, many women are now overweight or obese even in rural areas of North Africa (Mokhtar *et al.*, 2001; Benjelloun, 2002; Belahsen *et al.*, 2003) and southern Africa (Walker *et al.*, 2001; Puoane *et al.*, 2002; Vorster *et al.*, 2005), while those living in rural areas of Sahelian West Africa (Senegal, Mali, Burkina Faso, Niger, Mauritania) and in parts of East Africa (Ethiopia, Somali) have lower average values (Martorell *et al.*, 2000).

Seasonal weight loss may be one of the reasons for these differences, as the latter countries have agricultural systems which depend on highly seasonal rainfalls. Their capital cities, on the other hand, face a sharply increasing prevalence of overweight and obesity among women, and prevention is hindered by women's view of overweight as a healthy and desirable condition (Holdsworth *et al.*, 2004; Siervo *et al.*, 2006). This perception probably has roots in the traditional rural lifestyle characterised by poverty, associated with strong physical activity and food shortage during the rainy season.

The present study describes seasonal variations and trends in body weight, body mass index and arm circumference over 7 consecutive years among lactating non-pregnant women living in an agricultural community in rural Senegal.

## Subjects and methods

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*Study population*

This population of >30,000, belonging essentially to the Sereer ethnic group and living in the Sine area of central Senegal, has been subject to demographic surveillance by the IRD since 1962 (8 villages) and 1983 (the remaining 22 villages) (Simondon *et al.*, 2004). The main activity is agriculture (millet and groundnut cultivation), associated with small-scale livestock breeding. During the period under study, more than 90% of adults had participated in field work. Rainfalls occurred from late June or July till October with an average of 501 mm/year from 1990 to 1996 (from 311 mm in 1990 to 778 mm in 1992, Fig. 1).

There existed no access to electricity and no indoor piped water nor refrigerators or stoves; wood or cow dung was used for cooking. Mechanisation of activities is progressing slowly. For agricultural tasks, horses, donkeys and manpower are used rather than engines. Monetary income is very low, and although seasonal migration to the city for labour is common among adolescents and young adults of both sexes, salaries are low (Garnier *et al.*, 2003), and only a small fraction of the income is sent back to families in the villages. Food consumption consists of millet, rice and groundnuts, with small amounts of vegetables and fish.

*Data collection*

This study was nested into a vaccine trial comparing two different pertussis vaccines (Simondon *et al.*, 1997). Vaccination sessions were conducted during the first week of each month in two public and one private (Catholic) dispensary, with one day at each dispensary. For optimal coverage, parents of all eligible infants were invited to attend when their infants were aged 2, 4, 6 and 9 months. Transportation by car was available, and non-attenders were invited once again the following month (i.e. at 3, 5, 7 or 10 months postpartum). Infants were brought to the dispensary by their mothers, and weight and height measurements were recorded for all women who agreed to this, from January 1990 until immunisation was taken over by local nurses in March 1997. Weight was obtained to the nearest 10 g using a Seca electronic scale (770, Hamburg), while standing height was measured to the nearest mm using a stadiometer. Left mid-upper arm circumference (MUAC) was measured (from 1990 to April 1994 only) to the nearest mm using a non-extensible tap.

Maternal birth date, place of residency and parity (defined as the number of live-born children) were extracted from the IRD demographic database.

The pertussis vaccine trial was approved by the Senegalese Ministry of Health. If the parents were not in agreement, their infant was offered a standard EPI (expanded programme of immunization). Women were requested to give oral consent prior to anthropometric measurements.

*Subjects*

Women attending vaccination sessions between January 1, 1990 and February 28, 1997 during a planned visit (at 2-3, 4-5, 6-7 or 9-10 months postpartum) were included in the analysis, provided that they were the mother of the vaccinated infant (more than 99% of children were brought by their mother).

A total of 26,106 weight measurements were taken for 3,869 different women. For a given child, each woman was included with a maximum of 4 visits. Because of the long duration of the vaccine study, women were often included along with 2, 3, 4 or even 5 different children (1361, 722, 41 and 2 women, respectively). Coverage of the vaccination program was high, ~90% at 2-3, 4-5, and 6-7 months postpartum, and ~80% at 9-10 months postpartum.

However, since infant mortality is high in this area and mothers did no longer attend the programme if the child died, loss to follow-up was significant especially at the last visit at 9-

10 months postpartum. Among the 6805 different postpartum periods for which a woman was included at 2-3 months, the proportions seen at subsequent visits were 86.9, 79.5 and 66.3% at 4-5, 6-7 and 9-10 months, respectively.

*Statistical analysis*

Body mass index (BMI) was computed as weight divided by squared height (kg/m$^2$). Underweight, overweight-obesity and obesity were defined as a BMI <18.5, >25 and >30 kg/m$^2$, respectively.

Place of residency was defined as either a large village (>1000 inhabitants) or a hamlet, while age was divided into 6 categories (16-19, 20-24, 25-29, 30-34, 35-39, and 40-50 years).

For analyses of the association of subject characteristics (age, place of residency) with nutritional status (height, weight, BMI, MUAC), only the first visit (at 2-3 months postpartum) with the first child was included for each woman (N=3869). Ten women had missing data for parity.

Analyses of the relationship between nutritional status and age were conducted both with and without 16-19-year-old mothers because they were likely to be still growing.

Seasonal variations in nutritional status (weight, BMI and MUAC) were described month by month (January-December), first by pooling all 7 years together (and omitting data from January-February 1997) and thereafter separately for each year. For these analyses, each woman was included as many times as she had attended the program (from 1-18, n=25,215). However, they were also conducted with each woman included only once, and the biological and statistical significance of results was unchanged (results not shown).

Changes in weight and MUAC were computed for intervals from 3 to 5 months, and their variations with season were tested by comparing means across calendar months of onset of the interval (January-December), including each woman as many times as possible (from 0-

10, n=5883 and n=3476 for change in weight and MUAC, respectively). Additional analyses were conducted on a subgroup of 723 women whose weight changes from 5 to 10 months postpartum had been measured for intervals starting in May-June and ending in October-November (i.e. the period of high weight losses). Regression models included weight change as the dependent variable and maternal age, BMI at 3 months postpartum, child's sex, and year and month of measurement as categorical independent variables. Parity was not included because of its close correlation with age ($r=0.863$, $n=3859$, $P<0.001$).

Analyses were conducted using chi-square tests, chi-square tests for trend, paired t-tests and general linear regression analysis within SAS software, version 8.1. Differences were considered significant for $P<0.05$.

## Results

About 300 women (mean: 300.2) attended each monthly vaccination session, for a total of 3,869 different women. Upon the first visit to the dispensary, mean age was 28.3 ± 7.6 years (range: 16-50) and mean parity (number of live-born children) 4.3 ± 3.0 (range: 1-17).

Mean weight, BMI and arm circumference were strongly and positively associated with age of the women (P<0.001, Table 1). Those aged >40 years had mean weights 3.5 kg higher than those aged 20-24 years. The prevalence of malnutrition was 7.6% (95% confidence interval (CI): 7.3, 7.9) and 6.8% (CI: 6.5, 7.1), for underweight and overweight-obesity, respectively. Both prevalences were associated with maternal age: that of underweight decreased from 8.1% to 2.0 % (P<0.001), while that of overweight-obesity increased from 3.6% to 12.7% between 20-24 and 40-50 years (P<0.001). Even among the latter, the prevalence of obesity was <1% (0.8%, CI: 0, 2.7).

Women living in large villages were 1 cm taller than those living in hamlets (161.8 ± 5.6 vs. 160.8 ± 5.6 cm, P<0.001), while weight, BMI and arm circumference did not vary significantly by place of residency.

*Seasonality in weight*

Mean weight varied strongly by season, with the greatest averages in March-May and the lowest in September-October (Fig. 2). The differences between maxima and minima was 3.7, 3.0, 3.1, 3.3, 2.5, 3.2 and 3.9 kg, respectively, from 1990 to 1996. Since months of minima and maxima varied slightly from one year to the next, the difference in mean weight across seasons was smaller when all 7 years were pooled (Table 2).

Mean change in weight from 3 to 5 months postpartum also varied significantly by calendar month: the change was positive for intervals starting in January-February, close to zero for intervals which began in March-April, and negative from May-August, particularly for those covering July-August and August-September (Fig. 3). From October to December, weight changes were well above zero.

The prevalence of underweight increased each year, from 2-5% in March-March to values between 9.1 and 20.3% during the harvest season (Fig. 4), while that of overweight varied inversely (data not shown).

*Seasonality in arm circumference*

The pattern of change in mean arm circumference by season was similar in several aspects to that of the pattern of mean weight change: high levels in March-April were followed by very low levels at the end of each year. The yearly differences between maximum and minimum values were 1.7 cm, 2.1 cm, 1.6 cm and 1.5 cm, respectively, from 1990-1993. However, there was an important difference when compared with weight change. Indeed, following a decrease in arm circumference between March-April and May, a second increase was observed between May and August, at a time when weight and body mass index were either constant or decreasing (Table 2).

Mean change in arm circumference over a two-month period of time also varied significantly according to season (Table 2). However, the variations were not completely synchronized with those of body weight, particularly for 2-month intervals starting in May and June (body weight decreased, while arm circumference increased) and October (body weight began to significantly increase at that time, while arm circumference was almost constant, Table 2).

*Weight loss during the rainy season*

In the subsample of women with weight data available in both May-June and October-November of the same year, the average change in weight was -0.53 kg/month (SD: 0.52, 95% CI: 0.49, 0.57). Fifteen percent experienced a loss of more than 1 kg/month, while 12.3% gained weight. Weight loss was positively associated with age and dry season BMI; the proportion of women who lost more that 1 kg/month increased from 8.6% to 27.8% between 20-24-year-old and 40-50-year-old women, and from 6.9% to 24.1% for BMI of <18.5 and ≥25 kg/m$^2$ during the months of March-April, respectively (P for trend <0.0001 for both).

In multivariate analyses, higher maternal age and BMI during the dry season (March-April) were independently associated with increased weight losses (P<0.01 for both), while child sex and maternal height and place of residency were not (data not shown).

*Trend in nutritional status from 1990 to 1996*

Mean weight and BMI varied significantly over the 7 years of follow-up (P<0.0001). There was no significant positive trend for weight, but the BMI increased significantly over time (Table 3). The prevalence of overweight-obesity also increased significantly (P for trend <0.001), while the negative trend of underweight was less clear-cut (P for trend < 0.05).

## Discussion

The present study indicates that wide seasonal variations in body weight (3-4 kg) and arm circumference continued to affect women in their reproductive years in rural West Africa at the end of the 20$^{th}$ century. Slight but highly significant positive trends with increasing maternal age were observed for weight, BMI and arm circumference, and longitudinal data confirmed that women gained weight from one postpartum period to the next.

Virtually all women were lactating. Mean duration of breastfeeding is close to 24 months in this population (Simondon & Simondon, 1998), and the prevalence of arrest of lactation prior to 15 months postpartum is below 1%, except if the child had died (Mané *et al.*, 2006). Very few of these women were likely to be pregnant, since the rate of resumption of amenorrhea is only 6.5% at 9-10 months postpartum (Simondon *et al.*, 2003).

Compared to previous studies on this topic, the strength of the present study lies in the fact that it included a large sample of women measured at precise postpartum durations and over monthly intervals for a long period of time, i.e. 7 consecutive years.

There were some limitations. First, 10-20% of women did not attend vaccination sessions with their children, either because they refused vaccination or because they were travelling. These women differed from those who attended in that they had lower parities and higher levels of school education and occupation (Simondon *et al.*, 2003). They may also have been less likely to have participated in field work, and thus it is possible that their body weight varied less across seasons than that of women included in the study. Also, women whose last-born child died stopped attending.

Second, inclusion of adolescent mothers in the analysis is subject to debate, since their growth is not completed. Indeed, due to delayed and prolonged puberty in this population (mean age at menarche: 16.1 years (Simondon *et al.*, 1998; Bénéfice *et al.*, 1999)) and to a strong association between pubertal maturation and corpulence (Simondon *et al.*, 1998; Bénéfice *et al.*, 1999), the use of cut-off points recommended for adults in the definition of underweight and overweight-obesity (<18.5 and >25 $kg/m^2$, respectively) is probably not advisable prior to the age of 20 years (WHO, 1995).

Third, fasting during the Moslem month of Ramadan might theoretically be responsible for seasonal variations in anthropometric status of these women. However, although the majority of this population declares themselves as Moslems, very few women actually fast (K Simondon, unpublished observations). Furthermore, during the period of this study, the Ramadan took place early in the year, prior to the onset of seasonal weight loss (in April 1990, March 1993 and February 1996).

Data on seasonal weight variations were also available from a prospective cohort study of women who had given birth in this setting in 1995 (i.e. a subsample of the women studied here) (Simondon *et al.*, 2003). From March to November 1996, non-pregnant women lost a mean of 4.2 kg (CI: 3.8, 4.6), while from November 1996 to May 1997 they gained 3.7 kg (CI: 3.3, 4.1). These data confirm that seasonal weight loss was close to 4 kg in this female population, even beyond the first year postpartum.

Few previous studies have provided evidence for such wide seasonal variations in body weight. In a large collaborative research programme which focused on this topic (Ferro-Luzzi, 1990), the average annual weight loss of non-pregnant women living in agricultural societies was 1.15 kg in Benin (Schultink *et al.*, 1990; Schultink *et al.*, 1992), 1.6 kg in Ethiopia (Ferro-Luzzi *et al.*, 1990) and 0.5 kg in southern India (Durnin *et al.*, 1990). The seasonal weight difference was 2.7 kg among nomadic women in Niger (Loutan & Lamotte, 1984), below 1.5 kg in rural Bangladesh (Huffman *et al.*, 1985), and 2.5 and 0.1 kg, respectively, in 1981 and 1982 in lactating Sereer women in Senegal (Rosetta, 1986). Possible explanations for the mild weight changes observed in the collaborative research programme, despite frequent monitoring, include the following: 1) BMI during the 'best' season was considerably lower than in Senegal, e.g. 18.1 and 19.0 kg/m$^2$ in India and Ethiopia, respectively (Ferro-Luzzi, 1990), and lower BMI is associated with lower seasonal weight losses (Ferro-Luzzi *et al.*, 1990; Schultink *et al.*, 1990); 2) women participated only marginally in field work (e.g. 3-4% and 7% of the day, respectively, in Ethiopia and Benin (Ferro-Luzzi *et al.*, 1990; Schultink *et al.*, 1990).

Conversely, in a study conducted in eastern Senegal in 1973, the average decrease in weight for males was 3.7 kg from June to August; it appeared to be even stronger among women (Gessain, 1978). Equally strong variations in body weight of women (~4 kg) were reported in a rural area of the Gambia, located ~150 km south of the Senegalese setting (Prentice *et al.*, 1981; Cole, 1993). However, such variations became weaker during follow-up: from 1978-80 to 1988, the seasonal variation decreased to only ~2 kg, whereas mean weight during the 'best' season increased from 54 to 57 kg (Cole, 1993). These changes may have been due to the food supplementation programme for women and children initiated in 1979-80 (Cole, 1993).

For this population, evidence on dietary intake is scarce. A dietary survey conducted in Sereer villages located close to those included in the present study found limited, non significant, seasonal variations in food intake (2182 vs. 2101 kcal/d per capita during the dry and rainy season, respectively (Rosetta, 1988)). In a small-scale study in Mali the average daily energy intake per capita was constant over the year, and seasonal weight loss was explained by increased physical activity only (Adams, 1995)

There was no evidence in favour of maternal nutritional depletion (Winkvist *et al.*, 1992) being associated with high average parities in these Senegalese women, despite a mean fertility index of 7.1 (Delaunay, 2000). On the contrary, mean weight increased by 3.5 kg between 20-25 and 40-50 years of age, that is, for average parities of 1.8 and 9.1, respectively.

Results from previous studies in less developed countries are conflicting: some report a negative association between maternal age or parity and body weight (Huffman *et al.*, 1985; Garner *et al.*, 1994; Miller *et al.*, 1994), while others report a positive association (Miller & Huss-Ashmore, 1989; Adair, 1992). A recent analysis of DHS data found a positive association between overweight and parity in 38 out of 50 countries, with a closer relationship in more wealthy regions (Kim *et al.*, 2006).

In terms of public health it is important to assess whether there exists negative consequences of strong seasonal weight loss. There is no evidence that such loss reduces work capacity; indeed, it is partly due to intensive field work (Bleiberg *et al.*, 1980; Roberts *et al.*, 1982; Lawrence & Whitehead, 1988). Interestingly, during the early months of rain (June-July), the arm circumference of women increased significantly despite their negative energy balance. The most likely explanation is an increase in arm muscle mass. If this hypothesis is correct, then it is remarkable, since these women carry out strong physical activity throughout the year, including tasks involving the arms, such as millet pounding (Bleiberg *et al.*, 1980). Unfortunately, no measurement of fat mass indicators, such as skinfolds, was available for enabling assessment of the relative importance of seasonal variation in muscle vs. fat mass.

In terms of morbidity, the incidence of malaria is clearly much higher in September-November when the prevalence of underweight is at a maximum (Robert *et al.*, 1998). However, malaria attacks are likely to be an additional cause of weight loss rather than a consequence.

Conversely, female reproductive function is affected by seasonality. Birth rates vary significantly over the year in Senegal (Simondon *et al.*, 2004), with the lowest levels in December and the highest in September, suggesting variations in conception rates with minima in September and maxima in December. Women's negative or positive energy balance may therefore affect their fecundity, by regulating the duration of postpartum lactational amenorrhoea (Lunn *et al.*, 1980; Lunn *et al.*, 1984).

Milk production does not seem to be affected to any great extent (Prentice *et al.*, 1983a), but birth weight is significantly lower during the rainy season in rural areas of the Gambia (Prentice *et al.*, 1983b), a decrease which is partially reversible by providing food supplementation to pregnant women (Prentice *et al.*, 1983b; Ceesay *et al.*, 1997). Also, the duration of gestation is reduced during the rainy season (Rayco-Solon *et al.*, 2005). Data from the Gambia suggest that gestation during the rainy season may have delayed, long-term deleterious effects upon adult mortality following infectious disease in the offspring, and the authors hypothesized that maternal nutritional stress was the aetiological factor (Moore *et al.*, 1997; Moore *et al.*, 1999). However, a similar analysis of Senegalese data failed to confirm this finding (Simondon *et al.*, 2004).

Considering long-term health outcome for the mother herself, there is no evidence or theoretical basis for a negative impact of seasonal weight change. Seasonality might even be associated with better long-term outcome, especially since weight loss is partly caused by strong physical activity during field work (Bleiberg *et al.*, 1980; Singh *et al.*, 1989).

Although seasonality in nutritional status did not prevent a moderate increase in weight by age in these women, their mean BMI after the age of 40 was still within the normal range (22.2 kg/m$^2$), and only 12% of persons in this age group were overweight (0.8% were obese). Thus, this rural population combines strong seasonality in body weight with an absence of obesity among women, and there is no evidence of nutrition transition.

Conversely, in Dakar, the capital city of Senegal which is located some 115 km from the Sine, the prevalences of overweight and obesity among women aged 20-50 years were 26.6 and 18.6%, respectively, in 2003, compared with 22.4 and 8.0%, respectively, in 1996 (Holdsworth *et al.*, 2004). In 2004 in Banjul, the capital city of the Gambia, 34% of women aged 35-50 years were overweight, while 50% were obese, leaving only 16% who had normal weight (Siervo *et al.*, 2006). In comparison, young women (14-25 years) were seldom overweight or obese (10 and 4%, respectively (Siervo *et al.*, 2006)).

According to the 'early origin of chronic diseases' hypothesis, maternal undernutrition during gestation carries a strong risk of eventual heart disease and type 2 diabetes in offspring if they are later exposed to a 'modern' lifestyle with high energy intake and limited physical activity (Barker, 1998). Due to high fertility rates and limited available land for agriculture in African populations, rural-to-urban migration is widespread; this means that migrants, especially those who were *in utero* during the rainy season, may be at very high risk of obesity and associated diseases.

In conclusion, strong seasonal variations in body weight and arm circumference were observed in rural Senegal in the 1990s among women in their child-bearing years. In contrast to weight, muscle mass may increase during the first part of the 'hungry season' due to heavy physical activity during field work. Although nutritional intervention in pregnant women is warranted so as to reduce the prevalence of low birth weight, the authors hypothesize that seasonal variations in the nutritional status of non-pregnant women carry long-term health benefits by reducing the accretion of fat mass over time, a characteristic of adults living in Western countries – but now, also, of those living in African cities.

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**Table 1** Mean anthropometric measurements of rural Senegalese women at 2-3 months postpartum, by age

| Age (years) | n [a] | Parity [b] | Height (cm) | Weight (kg) | BMI ($kg/m^2$) | MUAC [c] (cm) |
|---|---|---|---|---|---|---|
| 16-19 | 455 | 1.1 ± 0.6 [d] | 160.9 ± 5.5 | 53.2 ± 6.1 | 20.5 ± 1.9 | 24.7 ± 1.9 |
| 20-24 | 1020 | 1.8 ± 1.0 | 161.4 ± 5.6 | 54.3 ± 6.4 | 20.8 ± 2.0 | 25.3 ± 2.1 |
| 25-29 | 770 | 3.6 ± 1.5 | 161.1 ± 5.8 | 54.9 ± 6.6 | 21.1 ± 2.1 | 25.9 ± 2.2 |
| 30-34 | 752 | 5.7 ± 1.7 | 161.1 ± 5.6 | 56.5 ± 7.1 | 21.8 ± 2.4 | 26.6 ± 2.4 |
| 35-39 | 530 | 7.4 ± 1.9 | 161.0 ± 5.8 | 57.1 ± 7.5 | 22.0 ± 2.4 | 27.1 ± 2.6 |
| ≥ 40 | 342 | 9.1 ± 2.4 | 161.1 ± 5.7 | 57.8 ± 7.4 | 22.2 ± 2.3 | 27.4 ± 2.6 |
| All | 3869 | 4.3 ± 3.0 | 161.1 ± 5.7 | 55.4 ± 6.9 | 21.3 ± 2.3 | 26.2 ± 2.5 |
| | | * | | * | * | * |

* Differences across age groups using ANOVA: P<0.0001

[a] Each woman was included only once

[b] Based on live-born children only (data missing for ten women)

[c] N=3022 (MUAC measurements were no longer taken after 1993)

[d] Values are means ± SD

**Table 2** Weight and arm circumference at 3 months postpartum, and changes in weight and arm circumference from 3 to 5 months postpartum, in rural Senegalese women from January 1990 to December 1996, by calendar month

| **Calendar month at 3 months post-partum [a]** | **Weight at 3 months postpartum (kg) (N=6591)** | **Weight change from 3-5 months (kg/mo) (N=5883)** | **MUAC at 3 months postpartum (cm) (N=3828)** | **MUAC change from 3-5 months (cm/mo) (N=3476)** |
|---|---|---|---|---|
| January [b] | 55.6 ± 7.0 (670) [c] | 0.26 ± 1.1 (594) | 25.9± 2.3 (376) | 0.24 ± 0.6 (334) |
| February [b] | 56.7 ± 6.9 (504) | 0.15 ± 1.0 (449) | 26.5 ± 2.4 (320) | 0.27 ± 0.6 (286) |
| March | 57.1 ± 7.1 (494) | 0.09 ± 1.1 (426) | 26.6 ± 2.4 (298) | 0.06 ± 0.6 (252) |
| April | 56.5 ± 6.6 (631) | -0.04 ± 1.1 (566) | 26.9 ± 2.3 (321) | -0.17 ± 0.6 (289) |
| May | 56.8 ± 7.0 (499) | -0.14 ± 1.0 (452) | 26.3 ± 2.5 (279) | 0.16 ± 0.5 (257) |
| June | 56.3 ± 6.8 (658) | -0.35 ± 1.1 (610) | 26.3 ± 2.3 (387) | 0.10 ± 0.6 (363) |
| July | 56.5 ± 6.5 (573) | -0.95 ± 1.1 (528) | 26.5 ± 2.4 (327) | -0.07 ± 0.7 (297) |
| August | 55.8 ± 7.0 (459) | -0.95 ± 1.0 (409) | 26.7 ± 2.5 (283) | -0.26 ± 0.6 (253) |
| September | 54.7 ± 7.2 (407) | -0.12 ± 1.1 (367) | 26.3 ± 2.8 (233) | -0.18 ± 0.7 (218) |
| October | 53.8 ± 6.7 (421) | 0.61 ± 1.3 (393) | 25.9 ± 2.7 (257) | 0.09 ± 0.6 (239) |
| November | 54.5 ± 6.9 (595) | 0.67 ± 1.0 (543) | 25.6 ± 2.2 (348) | 0.25 ± 0.5 (316) |
| December | 54.7 ± 6.6 (670) | 0.71 ± 1.1 (546) | 25.8 ± 2.4 (399) | 0.37 ± 0.6 (372) |
| | * | * | * | * |

*Comparison of increments across the 12 months of the year using GLM: P<0.0001

[a] Measurements were taken during the first week of each month

[b] Data from January-February 1997 were excluded

[c] Values are means ± SD (n)

**Table 3** Change in anthropometric status of rural Senegalese women from 1990 to 1996

| Year [a] | Sample size | Weight (kg) | BMI (kg/m$^2$) | MUAC [b] (cm) | Underweight (BMI<18.5) (%) | Overweight-obesity (BMI>25) (%) |
|---|---|---|---|---|---|---|
| 1990 | 2491 | 55.5 ± 6.7 [c] | 21.3 ± 2.2 | 26.4 ± 2.5 | 6.0 | 4.9 |
| 1991 | 3455 | 55.6 ± 6.9 | 21.4 ± 2.3 | 26.4 ± 2.5 | 6.3 | 6.8 |
| 1992 | 3926 | 56.0 ± 7.1 | 21.5 ± 2.3 | 26.4 ± 2.5 | 5.4 | 6.1 |
| 1993 | 3977 | 55.7 ± 7.1 | 21.5 ± 2.4 | 26.5 ± 2.5 | 5.2 | 6.4 |
| 1994 | 3840 | 56.3 ± 7.2 | 21.7 ± 2.4 | --- | 3.5 | 8.5 |
| 1995 | 3843 | 55.7 ± 7.2 | 21.5 ± 2.4 | --- | 2.1 | 6.3 |
| 1996 | 3912 | 55.7 ± 7.0 | 21.5 ± 2.4 | --- | 7.7 | 7.7 |
| Difference across years | | P<0.001 | P<0.001 | P<0.001 | P<0.001 | P<0.001 |
| Trend over time | | NS | P<0.01 | NS | P=0.034 | P<0.001 |

[a] Measurements taken from January to December

**Legends for figures**

**Fig. 1.** Monthly rainfalls from January 1990 to December 1996 in a rural area in the Sine, Central Senegal.

**Fig. 2.** Seasonal variation in mean weight of rural Senegalese women from 1990 to 1996, for measurements taken during the first week of each month, using the average (55.8 kg) as the baseline (SD ~ 6.2-7.2 kg; n ~300 women per month)

**Fig. 3**. Seasonal variation in mean weight change from 3 to 5 months postpartum in rural Senegalese women, by calendar month at 3 months postpartum from 1990 to 1996

**Fig. 4**. Seasonal variations in the prevalence of underweight (BMI<18.5) and overweight-obesity (BMI>25) of rural Senegalese women from 1990 to 1996 (P<0.001 for both)

Figure 1

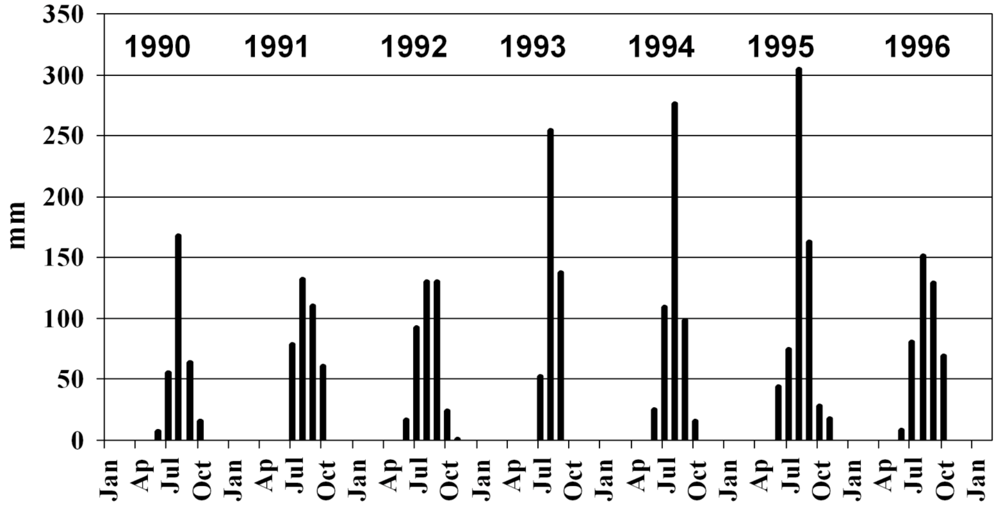


Figure 2

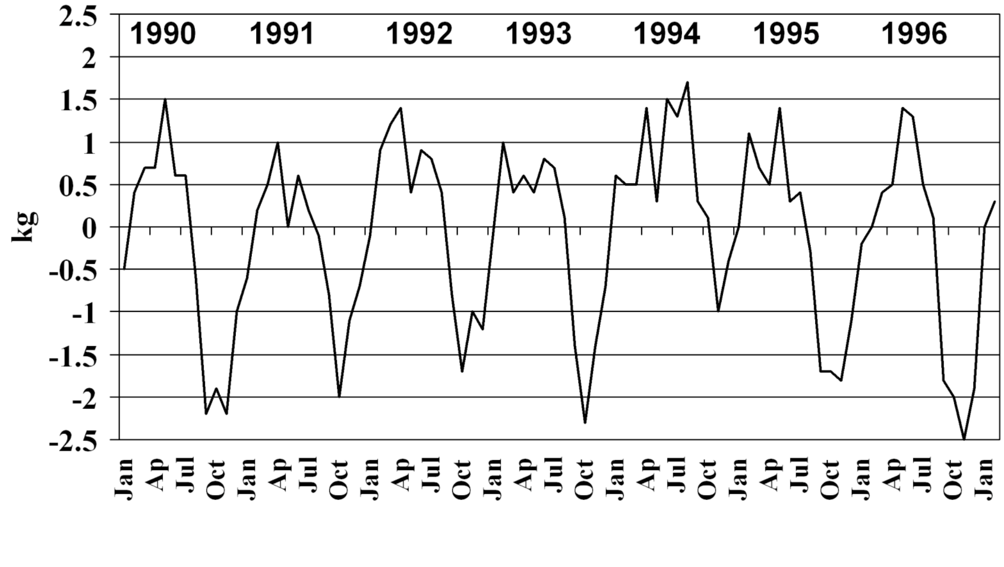

Figure 3

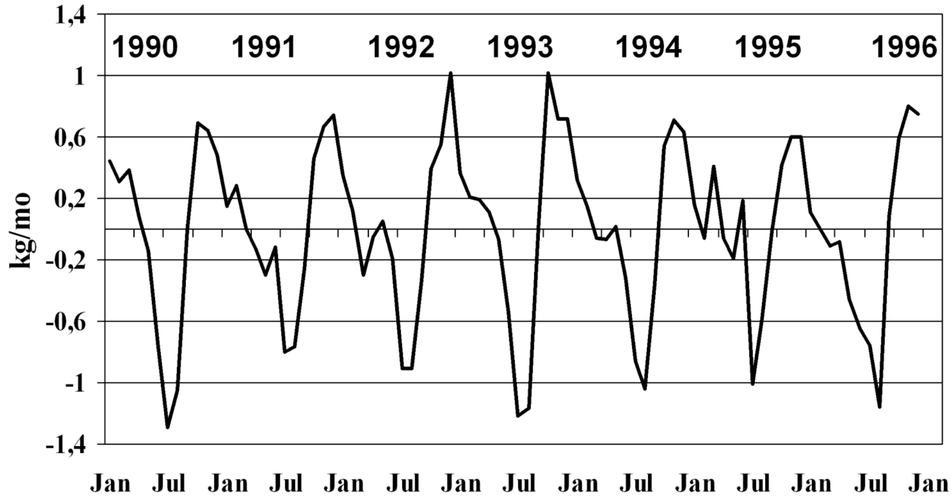


Figure 4