Mal J Nutr 15(2): 137 - 153, 2009

Biosocial Correlates of Nutrition and Chronic Energy Deficiency among Adult Females of two Ecological Zones in Madhya Pradesh and Uttarakhand, India

Gautam RK & Thakur R

Department of Anthropology, Dr. H.S. Gour University Sagar-470003
Madhya Pradesh, India

ABSTRACT

The paper aims to draw out biosocial correlates of nutrition through body mass index (BMI) and chronic energy deficiency (CED). The findings are based on cross-sectional data of 446 women aged 18-60 years from six different endogamous groups of two ecological zones. The mean age of studied women varied from 31 to 36 years. The mean age at menarche was found to be 14.50±1.32 years. Similarly mean age at menopause was found to be 46.22±4.00 years. The mean of reproductive life span varied from 27 to 35 years. Average number of pregnancies per women was 4.44±2.52, average foetal loss was 0.11, children surviving per women was 3.61, whereas average child loss per women was found to be 0.62 and average family size was 9.51. Variations in mean BMI kg/m^2 between populations ranged between 18.56 and 20.71. Prevalence of CED was highest among the Brahmin women of Uttarakhand (58.3%) followed by Ahirwar of Madhya Pradesh (47.1%). Incidence of CED was found lowest among Brahmin women of Madhya Pradesh (24.0%). Linear regression coefficient (b ± standard error) of BMI on Cormic Index for these women was 33.1 ± 8.1 (t=4.0, p=0.001), and correlation coefficient (R) was 0.189. Out of 6 anthropometric variables considered for regression analysis, 5, namely weight, hip circumference, waist circumference, mid arm circumference and sitting height showed significant correlations with BMI. Significant differences in sitting height and Cormic Index of women from the hills and plains indicate the role of ecology in shaping its habitants. Out of 9 demographic variables, only age of respondent and family size were found to have a significant impact on low BMI status. The present study postulates that the nutritional status of women has improved over the last decades.

Keywords: Adult females, chronic energy deficiency, Madhya Pradesh, nutrition, Uttarakhand

INTRODUCTION

India is passing through a demographic and nutritional transition. In the last few decades, many parts of the world witnessed progress in agriculture consequently India also became self-sufficient in major food grains. Yet under-nutrition continues to be a major problem especially in rural populations (Rao, 2001). Indian society is stratified on the basis of caste and sex. Women, who constitute one of the two halves

Correspondence author: Dr Rajesh K.Gautam; Email: *goutamraj@rediffmail.com*

of society, are at the bottom of stratified society. This stratification is more prominent in rural India. Beyond its inherent societal characteristics, the Indian continent also provides an opportunity to study human beings in different ecological setups. In the present study, an attempt was made to find out biosocial correlates of nutritional status through body mass index among adult females of rural India because the nutritional status of women is least studied in general and particularly among Indian women. As women have a crucial role in reproduction, child bearing, nurturing and lactation, they are susceptible to malnutrition. For the present investigation, samples were drawn from two different ecological setups - hills of Uttarakhand (UK) state and plains of Madhya Pradesh (MP).

Anthropometry is considered to be an important tool for assessing nutritional status of individuals or of the community. Hence, measurements namely stature, sitting height, weight and indices based on these measurements evolved by different scholars have been extensively used to define the extent of malnutrition. Body mass index (BMI) expressed as a ratio of weight to height square can be a good parameter to grade chronic energy deficiency (CED) in adults (Naidu, Neela & Rao, 1991). There are many studies based on this aspect (Ferro-Luzzi *et al.,* 1992; Naidu & Rao, 1994; Khongsdier, 2001). Inadequacies in nutritional intake or under-nutrition can be considered as a major source of many adverse effects on growth and health of individuals (Gordon *et al.,* 1968). Knowledge of nutritional status of a community is necessary to have a comprehensive idea about its development process, as under-nutrition is one of the major health problems in developing countries. It is reported that the basic causes of under-nutrition and infections in developing countries are poverty, poor hygienic conditions and little access to preventive health care (Mitra, 1985; WHO, 1990). Hence, assessment of nutritional status of a population has attracted the attention of not only the nutritionists and other biological scientists, but also the economists and other social scientists with a view to understanding the health and socio-economic status of the population (Osmani, 1992). Literature on BMI of adult Indians is limited to certain geographical areas or populations. Noteworthy among them are the study of BMI among the North-East Indians (Khongsdier, 2001), South Indian populations (Ferro-Luzzi *et al.,* 1992) and Central Indian (Gautam *et al.,* 2006, Adak *et al.,* 2006a;b; Gautam & Adak, 2007, Gautam 2007a ;2007b). However, little is known about the BMI of female populations (Ferro-Luzzi *et al.,* 1992; Rao, 2001). The present study is an attempt to fill this gap.

Early age at menarche, together with other indicators of early biological maturity, have been shown to be associated with increased adult body mass index (Parsons *et al.,* 1999). Between 1972 and 2003, 10 longitudinal studies found a negative relation between age at menarche and adult weight-for-height (Pierce & Leon, 2005), assessed by BMI in all but one study (Miller, Billewicz & Thomson, 1972), but at least one longitudinal study showed no relation between age at menarche and adult BMI (Wellens *et al.,* 1992). If there is a true causal link between age at menarche and adult BMI, it could be argued that this association may play a role in explaining the temporal trends in obesity. Age at menarche has been declining (Pierce & Leon, 2005) at the same time as adult BMI has been increasing, although the rate of decline has slowed or stopped in some countries in recent times (Styne, 2004). Correlation of nutrition and fertility is rarely discussed and contradictory. This study shall also address this gap.

METHODOLOGY

The study sample was drawn from hills and plains. They belong to six endogenous groups; geographically, the two regions are in such a location that there is no chance of

inter-marriage and gene flow among residents of these two locations. A multistage stratified sampling technique was adopted for selection of sample. Firstly, two states were selected. One at central location, that is, Madhya Pradesh which is comparatively plain in topography and another at the border, that is, Uttarakhand on the Himalayas. After selection of states, one district was selected from each of the states keeping in mind the location and altitude of the district. In this way district Sagar was selected from Madhya Pradesh and district Nainital was selected from Uttarakhand; again 5 and 8 villages were selected respectively from both the districts. Six endogamous groups viz. 1.Brahmin, 2.Thakur, 3.Chamar (of Madhya Pradesh); and 4. Brahmin, 5. Rajput and 6. Arya (of Uttarakhand) were selected for the present study. The criteria for inclusion / exclusion of sample were as follows:

1. Women between the ages of 18 to 60 years
2. Not currently pregnant
3. Had not given birth during the last 6 months
4. Had not experienced fetal loss viz. abortion or still birth during the last 3 months
5. Was not severely ill during the last three months
6. Not menstrurating at time of study
7. Not with any congenital malformation of any degree

Finally the women were selected randomly. Age determination was one of the important aspects of the study. Hence proper attention was paid to age determination of the selected women. It should be noted that of the 446 women selected for the study, 77% were literate; so their age was confirmed from school records (mark sheet). For age determination of the 23% illiterate women, the help of their children and husbands was sought.

Anthropometric measurements were taken following standard techniques (Martin & Saller, 1956). All the measurements were taken by adequately trained female investigator. And accuracy of the data was assured. Subjects were not chosen on the basis of body structure and proportion. Efforts were also made to exclude closely related individuals like sisters, mothers and daughters and those with any kind of physical deformities. Therefore, the sample was free of selection bias. For convenience, only adult females who looked apparently active and healthy (not suffering from any apparently visible infection or disorder) were considered for inclusion in the sample.

In this study, body weight (W), height (H) and sitting height (SH) were taken to calculate cormic index (SH / H) and BMI (W / H^2). Both MS-EXCEL and SPSS software were used to analyse the data. Cormic index and body mass index were calculated for each individual followed by calculation of central tendency viz. mean and deviation of each of the measurements among each population. Further ANOVA-Test or one-way analysis of variance was performed. For screening the CED groups, the value 18.5 kg / m^2 was taken as a cut-off point following James, Ferro-Luzzi & Waterlow (1988), Ferro-Luzzi *et al*. (1992), Khongsdier (2001), Gautam *et al*. (2006), Gautam (2007a;b). Regression analysis was performed to find correlates of BMI.

Area and people

Though India is carrying 16.6% of the world's population, the sub-continent is comparatively poor in natural resources as it has only 2% of land, 1% of rainfall and 0.5 % of forests (Gautam & Adak, 2007). The country is unique for its ecological and cultural diversity.

Madhya Pradesh: Sagar

The state of Madhya Pradesh (Figure 1) is characterised by low hills, extensive

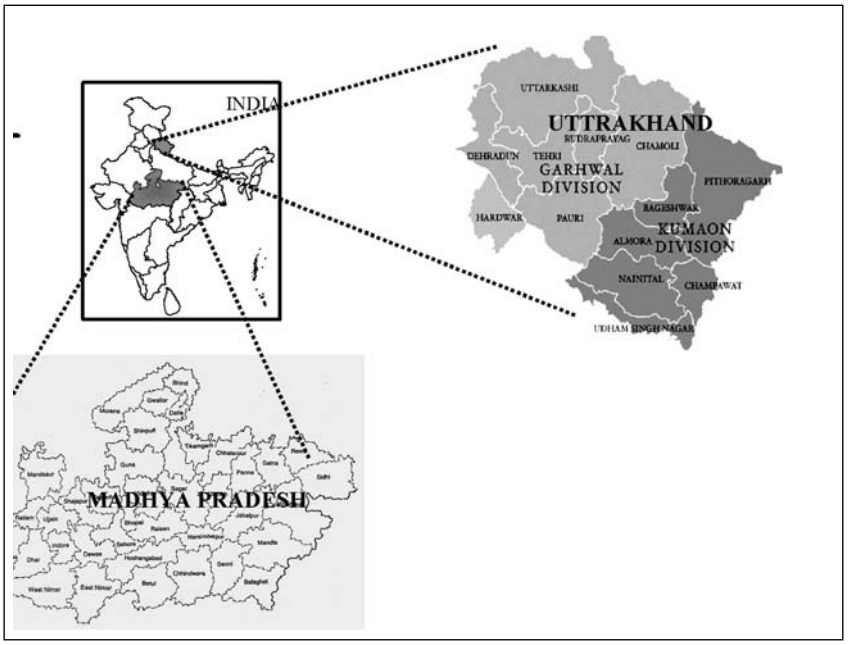

Figure 1: Locational map of Uttarakhand and Madhya Pradesh

plateaus, and river valleys. The district of Sagar lies in the north-central region of Madhya Pradesh. The total area of the district is 10,252 sq. kms. It is the 16th largest district in the state. It is inhabited by people of diverse ethnic, religious and linguistic backgrounds. The diversity in morphological features of the population is well marked in Sagar. Hindi is the main language spoken in the district. The sample for the present study was taken from the following three endogamous caste groups of 5 different villages of the district.

1. *Brahmin:* The Brahmins are priestly caste of India and are at the top of the caste hierarchy of Hinduism. They are also large landholders who do not practice agriculture but instead hire labour for agricultural tasks. A total of 50 women of Brahmin caste were included in the present investigation. The women do not enjoy equal privilege like the males and widespread sex discrimination can be observed. The sample was drawn from rural families who are considered more dogmatic.
2. *Thakur:* They consider themselves as the warrior class. The warriors occupy the second position in the Hindu caste hierarchy and are known as the *Kshatriya.* They subsist on agriculture and animal domestication. Very few of them are in other sectors. For the present investigation, a total of 100 Thakur women were chosen.
3. *Chamar or Ahirwar***:** In the vertical caste hierarchy of Hinduism, the Chamar are at the bottom. They are also known as Ahirwar (in this paper both words are being used). They are considered as 'untouchables' especially in rural India. There is strong prohibition against the Chamar in some jobs. If they are employed, their identity is concealed. In order to provide constitutional protection, Chamar is included in the list of scheduled castes who suffer from similar discrimination. A total of 34 women of this caste were included in the present investigation.

Uttarakhand: Nainital

Uttarakhand is a hilly state; spread on the Siwalik range of the Himalayan foothills. Geographically Nainital district is divided into two zones viz. Hilly and Bhabar. The samples for present study were drawn from 8 different villages located in the Hilly region of the district which is above 1500 metres mean sea level (Bhatt, 1997). The Brahmin, Rajput and Arya were the three endogamous caste groups selected for inclusion in the present study. Brief details of each these castes are given below:

1. *Brahmin:* The Brahmin of Uttarakhnad are slightly different from the Brahmin of Madhya Pradesh. They do not practise priesthood. Most of them are non-vegetarians. They practice agriculture and animal domestication. In social ranking they are at the top, like other Brahmins in India. Although they enjoy higher social status, they have to work in tough ecological conditions where their terrace-like agricultural fields are located. A total of 60 Brahmin women were selected for the study.
2. *Rajput:* Uttarakhand is dominated by the Rajputs. They practice agriculture and horticulture; simultaneously they domesticate the cow and buffalo. Beside traditional occupations, they are also employed in the Indian army in large numbers and hold most of the government jobs and political positions. A total of 150 Rajput women of Uttarakhand living in 5 villages were included in the present investigation.
3. *Arya:* Arya is a group of artisans that includes blacksmiths, coppersmiths, carpenters and weavers. These artisans are considered as 'untouchables' and fall into the scheduled castes; they are provided constitutional safeguards. Still, they are treated as 'unclean' and are prohibited in many day-to-day activities. A total of 52 Arya women were included in the present study.

RESULTS

Mean and SD values for biological characteristics viz. current age, age at menarche, age at menopause, reproductive life span, number of pregnancies, foetal loss, children surviving, child loss and family size for studied women is shown in Table 1a. The average age of the study subjects varied from 31.2 to 37.1 years among Thakur and Ahirwar respectively, while it was 33.6 years for the total population. Similarly, mean age at menarche ranged from 13.7 years among the Brahmins of Madhya Pradesh to 16.1 years among the Rajput of Uttarakhand. Age at menopause ranged from 43.3 years among Thakur to 48.5 years among the Brahmin of Madhya Pradesh, although mean age at menopause is approximately two years lower among the women of hills compared to those of the plains. Delayed menarche and early menopause resulted in a shorter reproductive life span among women of the hills. The mean reproductive life span for women of Uttarakhand was 28.34 years compared to 31.91 years for women of the plains. The reproductive history of studied women was recorded in terms of enumeration of pregnancy, foetal loss, children surviving and child loss. The average number of pregnancies experienced by studied women was 4.20, varying slightly among women of different ethnic origin and ecology. Foetal loss was almost equal among women of the hills (0.13±0.63) and plains (0.11±0.37) but child loss was found to be higher among women of the plains (0.62±1.13) compared to the hills (0.34±0.92).

The mean and SD values for anthropometric characteristics viz. height, sitting height, weight, cormic index and body mass index for the studied women are shown in Table 1b. In stature, Brahmin women of Madhya Pradesh were tallest with 155.39 cm average height; in general, women of the plains were taller (154.29±5.10 cm) and heavier (47.46±8.81 kg) in comparison to women of middle altitude (Uttarakhand).

Table 1a. Mean and standard deviations of demographic characteristics

No.	*State/Caste*	*Current age*	*Age at menarche*	*Age at menopause*	*Reproductive life span*	*Number of pregnancies*	*Foetal loss*	*Children surviving*	*Child loss*	*Family size*
Uttarakhand		33.49±12.85	15.84±1.58	44.35±4.45	28.34±5.51	4.02±2.26	0.13±0.63	3.55±1.89	0.34±0.92	6.47 ± 2.48
1	Rajput	33.69±12.58	16.13±1.62	43.97±4.91	27.55±5.76	3.92±2.35	0.08±0.29	3.48±1.98	0.37±1.03	6.79 ± 2.41
2	Brahmin	32.33±13.57	15.61±1.45	46.58±4.23	32.00±6.19	4.62±2.24	0.38±1.24	3.69±1.62	0.54±0.96	6.53 ± 2.74
3	Arya	34.25±12.94	15.29±1.47	43.53±3.22	27.29±3.27	3.66±1.92	0.03±0.16	3.60±1.94	0.03±0.16	5.44 ± 2.13
Madhya Pradesh		33.76±12.69	14.50±1.32	46.22±4.00	31.91±4.72	4.44±2.52	0.11±0.37	3.61±1.86	0.62±1.13	9.51 ± 5.86
4	Thakur	31.20±11.46	14.95±1.36	43.30±5.59	28.00±5.83	4.09±2.19	0.06±0.24	3.38±1.64	0.65±1.09	9.38 ± 4.91
5	Ahirwar	37.12±12.03	14.44±1.05	46.22±2.27	31.22±2.53	4.91±2.96	0.18±0.56	3.70±1.97	1.00±1.59	8.56 ± 6.99
6	Brahmin	36.58±14.48	13.66±0.93	48.46±1.39	35.38±1.32	4.67±2.63	0.12±0.32	3.97±2.12	0.34±0.62	10.40 ± 6.74
Total		33.60±12.77	15.29±1.62	44.99±4.37	29.55±5.50	4.20±2.38	0.12±0.53	3.58±1.88	0.47±1.03	7.72 ± 4.47

Table 1b. Mean and standard deviations of age, anthropometric measurements and indices

No.	*State/Caste*	*No.*	*Height (cm)*	*Sitting height (cm)*	*Weight (kg)*	*Cormic Index*	*BMI*
Uttarakhand		262	153.46±5.26	79.26±3.21	45.49±7.94	0.516±0.017	19.31±3.22
1	Rajput	150	154.04±5.20	79.82±3.39	46.10±7.94	0.518±0.017	19.42±3.22
2	Brahmin	60	152.90±5.63	78.49±2.94	43.41±6.31	0.513±0.018	18.56±2.52
3	Arya	52	152.41±4.87	78.54±2.65	46.11±9.26	0.515±0.016	19.83±3.80
Madhya Pradesh		184	154.29±5.10	77.94±3.10	47.76±8.81	0.505±0.017	20.01±3.23
4	Thakur	100	154.76±5.22	78.85±2.91	47.90±9.72	0.509±0.017	19.94±3.55
5	Ahirwar	34	151.29±4.58	76.26±3.08	44.00±6.18	0.504±0.017	19.20±2.60
6	Brahmin	50	155.39±4.45	77.26±2.87	50.06±7.63	0.497±0.014	20.71±2.82
Total		446	153.80±5.20	78.72±3.22	46.43±8.38	0.512±0.018	19.60±3.24

The average height of women of Uttarakhand was found to be 8.3 mm shorter (153.46±5.26) and were 2.27 kg lighter (45.49±7.94) in weight. In contrary, in terms of sitting height, women of middle altitude (Uttarakhand) were found to be taller (79.26±3.21) by 1.32cm compared to women of the plains in Madhya Pradesh (77.94±3.10). On the basis of one way ANOVA analysis, it was found that the variation in mean BMI between populations is insignificant; simultaneously, none of the population fell below 18.5 kg m^{-2} of mean BMI, varying from 18.6 kg m^{-2} among Brahmin of Uttarakhand to 20.7 kg m^{-2} among Brahmin women of Madhya Pradesh. There is a difference of 0.7 kg m^{-2} between the women of middle altitude (i.e. Uttarakhand) and plains of Madhya Pradesh. As evident from Figure 2, the comparison of mean BMI of these women with south Indian women (Ferro-Luzzi *et al.*, 1992) indicates an increment of mean BMI of 1.6 kg m^{-2}. The estimation of mean BMI for Indian women by the National family Health Survey or NFHS-III (2007), that is, BMI 20.5 kg m^{-2} corroborate the present findings. Even in South Indian states (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu) the mean BMI was above 20.7 kg m^{-2}. The mean cormic index (CI) or proportion of sitting height to stature was found to vary between 0.497±0.014 among Brahmin of Madhya Pradesh to 0.518±0.017 among the Rajput of Uttarakhand. There is a significant difference in the cormic index between women of the plains and hills (middle altitude). This means that the proportion of trunk of hilly people is significantly larger in ratio to their stature compared to women of the plains [Figures 3(b) and (d)]; simultaneously, difference in stature and weight is insignificant among them [Figures 3(a) and (c)].

It is clear from the above findings that the studied Indian women were lower medium to medium in stature. Together, 42.1 % of them fall in the chronic energy deficient grades considering the BMI value of 18.5 as the cut-off point. As all these women had a rural background, they had to perform hard labour and depend on the poor subsistence of their livelihood.

The women having a BMI of below 18.5 kg / m^{-2} are considered as chronic energy deficient. Further, there are three categories

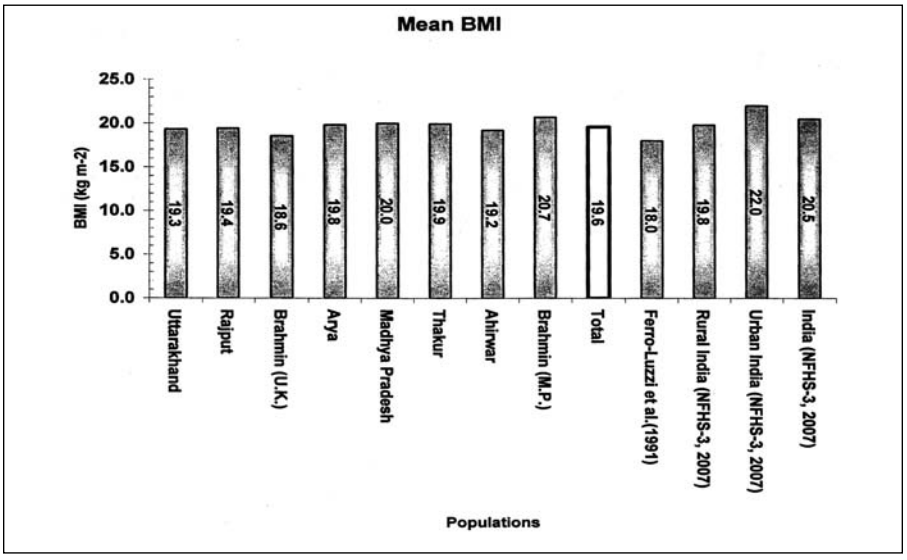

Figure 2. Mean BMI among Indian women

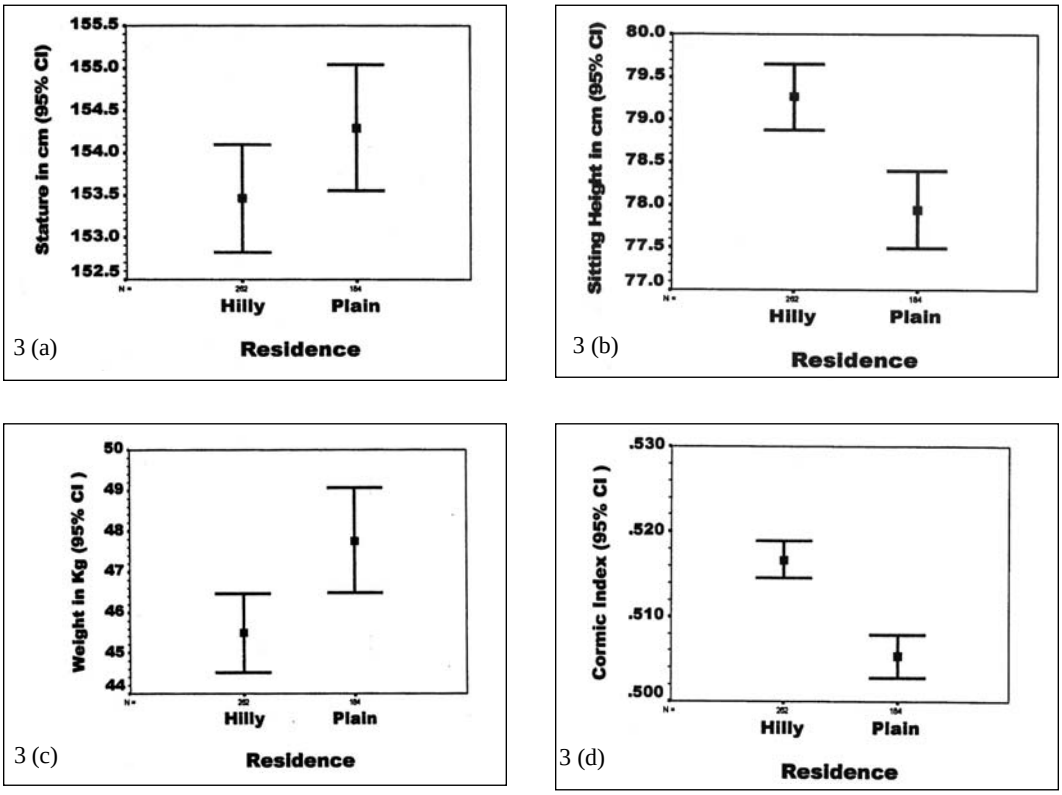

Figure 3. Error bar diagram showing insignificant difference of (a) stature and significant difference in (b) sitting height (c) weight and (d) Cormic Index among women of different ecologies

of CED, that is, severe, moderate and mild. As evident from Table 2, the prevalence of CED is highest (58.3 %) among the Brahmin of Uttarakhand, followed by Ahirwar (47.1 %) of Madhya Pradesh. It was found that the prevalence of CED is higher (45.9 %) among the hilly population of Uttrakhand, compared to the plains of Madhya Pradesh (36.9 %).

Cumulative distribution of adult BMI among women of middle altitude and plains is shown in Figure 4. It can be seen that the proportion of respondents with chronic energy deficiency is higher among women of middle altitude, compared to the plains.

The regression coefficient of BMI on CI is computed and shown in Table 3. The regression coefficient is found to be significant (p>0.05) among all the groups of Uttrakhand and one of the groups of Madhya Pradesh (i.e. Brahmin). It is also apparent from the bivariate plot diagram (Figure 5) that there is negative correlation between BMI and CI.

In order to identify the determinants of the nutritional status of the studied women, bivariate and multivariate regression analysis was carried out and is shown in Table 4. Initially, six anthropometric and nine demographic variables were selected as independent variables to ascertain their impact on BMI. It was found that six anthropometric variables taken together account for 99.5 % variability (R^2=0.995) in the BMI. The regression coefficient was found to be significant (p>0.001). The linear bivariate regression analysis was computed to find out the impact of each of the independent variables on the BMI which gave significant regression coefficient for five

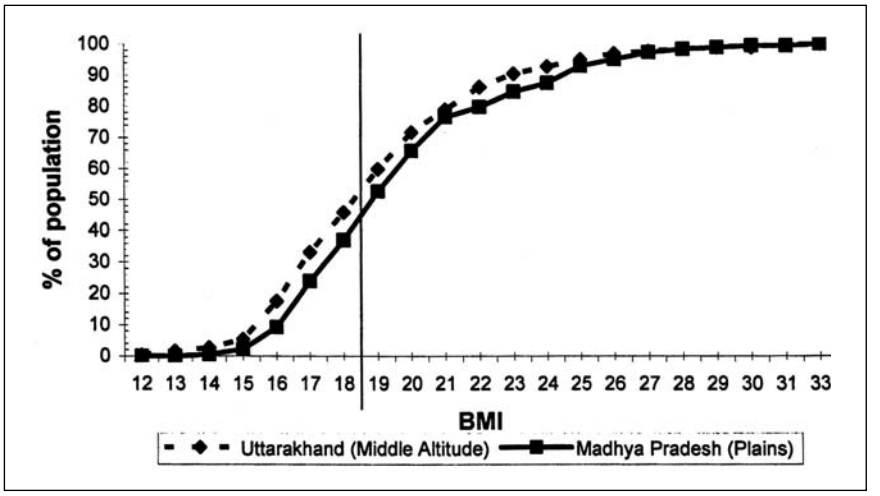

Figure 4. Cumulative frequency distribution of adult BMI among females of Middle altitude and Plains

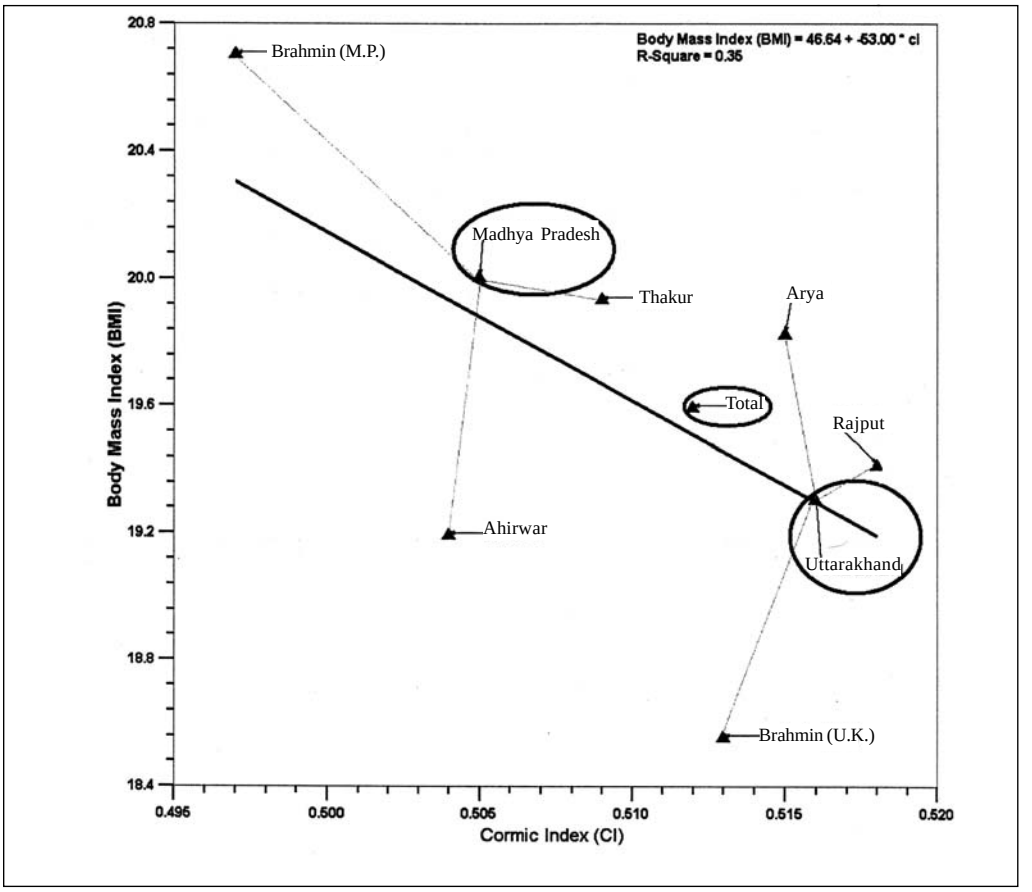

Figure 5. Bivariate scattered diagram of the populations with Cormic Index and Body Mass Index values.

Table 2. Percentage distribution of population as per chronic energy deficiency level

No.	State/Caste	Percentage distribution of population as per chronic energy deficiency level							
		CED Grade III (Severe) (<16.0)	*CED Grade II (Moderate) (16.0-16.99)*	*CED Grade I (Mild) (17.0-18.49)*	*Low weight Normal (18.5-19.99)*	*Normal (20.0-24.9)*	*Obese Grade-I (25.0-29.99)*	*Obese Grade II (>30)*	*Total*
Uttarakhand		11.5	13.0	21.4	20.6	28.2	4.2	1.1	
1	Rajput	13.3	10.0	18.0	24.0	29.3	4.7	0.7	100
2	Brahmin	13.3	13.3	31.7	16.7	23.3	1.7	-	100
3	Arya	3.8	21.2	19.2	15.4	30.8	5.8	3.8	100
Madhya Pradesh		4.3	10.9	21.7	23.9	29.3	8.7	1.1	
4	Thakur	5.0	14.0	21.0	24.0	24.0	10.0	2.0	100
5	Ahirwar	5.9	8.8	32.4	26.5	20.6	5.9	-	100
6	Brahmin	2.0	6.0	16.0	22.0	46.0	8.0	-	100
Total		8.5	12.1	21.5	22.0	28.7	6.1	1.1	100

Table 3. Regression coefficient and F-statistics of BMI on CI

Population groups	*Coefficients of regression*					*F-Statistics*	
	R	r^2	β	*SE*	*t- value*	*F Change*	*p-value*
Uttarakhand	0.313	0.098	56.4	10.6	5.3	28.2	0.001
Rajput	0.278	0.077	50.3	14.3	3.6	12.412	0.001
Brahmin	0.353	0.124	47.5	16.6	2.9	8.247	0.006
Arya	0.370	0.137	84.3	29.9	2.8	7.938	0.007
Madhya Pradesh	0.118	0.014	21.9	13.7	1.6	2.556	0.112
Thakur	0.093	0.009	19.4	20.9	0.9	0.861	0.356
Ahirwar	0.052	0.003	7.9	26.7	0.3	0.088	0.768
Brahmin	0.414	0.171	79.2	25.2	3.1	9.933	0.003
Total	0.189	0.036	33.1	8.1	4.0	16.415	0.001

anthropometric variables viz. weight, hip circumference, waist circumference, mid-arm circumference and sitting height. Only one anthropometric variable viz. stature was not found to have any impact on BMI as the regression coefficient was insignificant.

All the nine demographic variables hardly influenced the BMI together as the regression coefficient was found to be insignificant. But, when linear bivariate regression analysis was computed for each of independent demographic variables, it was found that age of respondent and family size certainly affected her level of nutrition and was found to have a significant low degree of impact on BMI. None of remaining demographic variables were found to have any significant impact on BMI.

For further elucidation, stepwise multivariate regression analysis was computed keeping all the anthropometric and demographic variables as independent variables (Table 4). The analysis provided four models. According to the first model, the body weight was the only determinant of BMI as it alone accounted for 89.9 % of variability on BMI. According to the second model, there were two predictors of BMI viz. body weight and stature; up to this point, body weight and stature have had strong correlation with BMI. But, the third and fourth models indicated two other predictors of BMI; these were hip circumference and mid-arm-circumference and these four predictors accounted for 99.8 % of variability in BMI.

In the next step, after removing the four variables of weight, stature, hip and mid arm circumference, the analysis left one model. According to this model, waist circumference can determine up to 65.7% of BMI. When waist circumference was removed from the analysis, none of the variables remained as predictors and were excluded automatically. Here, it should be noted that out of the 15 variables considered as predictors of BMI, only 5 variables viz. weight, stature, hip circumference, mid-arm circumference and waist circumference were found to have a strong correlation with BMI; none of the demographic variables remained as predictors during stepwise regression analysis.

Education and ecology (plain vs. hills) certainly affected level of nutrition as it is evident from the error bar diagrams[Figure 6 (a) and (c)], but showed insignificant difference. On the other hand, occupation imposed significant impact on the level of nutrition of individuals. The BMI of women enjoying sedentary occupation was found to be significantly higher than women engaged in laborious occupation. Like occupation, the marital status of women also influenced their level of nutrition as significant differences were found in BMI of married and unmarried women [Figure 6 (d)].

DISCUSSION

A comparison of mean BMI of Indian women from previous studies (Ferro-Luzzi *et al.*, 1992; NFHS-III, 2007) has led to the conclusion that the nutritional status of Indian women had improved over the last two decades. This has taken place because of the overall growth of socio-economic condition of the country, women empowerment, rural employment and improved educational attainment of women. The outcomes of welfare schemes launched after independence are now perceptible. The improved nutritional status of the studied women can be seen as outcomes of family welfare, maternal and child health and reproductive and child health programmes (RCH) launched all over the country. Emphasis has been given to improve schooling for children, at least up to 14 years of age. Lactating and pregnant women have been given special attention. They are being given supplementary nutrition through the *aganwadi* centres. Children enrolled in primary schools are being provided with a

Table 4. Bivariate and multivariate regression between BMI and anthropometric and demographic variables

Bivariate linear regression							
Dependent variable	*Independent variable*	R^2	$\beta \pm SE$	*df*	*F-value*	*t-value*	*P-value*
	Anthropometric variables	0.995	-	445	8469.0	-	0.001
BMI	1.Weight	0.855	0.358 ± 0.007	445	2610.4	51.0	0.001
	2.Stature	0.000	0.005 ± 0.030	445	0.033	0.18	0.857
	3.Hip circumference	0.626	0.339 ± 0.012	445	742.55	27.25	0.001
	4.Waist circumference	0.486	0.262 ± 0.030	83	77.47	8.8	0.001
	5. Mid arm circumference	0.647	1.046 ± 0.037	445	814.39	28.53	0.001
	6. Sitting height	0.030	0.173 ± 0.047	445	13.53	3.67	0.001
	Demographic variables	0.098	-	89	1.104	-	0.369
	1.Age	0.052	0.058 ± 0.012	445	24.42	4.94	0.001
	2.Age at menarche	0.003	-0.103 ± 0.095	442	1.166	-1.08	0.281
	3.Age at menopause	0.039	-0.181 ± 0.093	93	3.76	-1.94	0.055
	4.Reproductive life span (years)	0.030	-0.125 ± 0.074	93	2.80	-1.67	0.097
	5.Total number of pregnancies	0.001	0.032 ± 0.080	310	0.161	0.401	0.689
	6.Foetal loss	0.001	0.239 ± 0.345	328	0.482	0.694	0.488
	7.Number of surviving children	0.003	0.092 ± 0.102	310	0.820	0.906	0.366
	8.Number of child deaths	0.003	-0.178 ± 0.178	328	1.00	-1.00	0.317
	9.Family size	0.012	0.078 ± 0.034	445	5.22	2.28	0.023

Table 4. Continued

Stepwise multivariate regression						
Dependent variable	*Model*	*Predictors*	R^2	$\beta \pm SE$	*F-value*	*t-value*
BMI	1	Weight	0.899	0.356 ± 0.027	169.2	13.01
	2	Weight	0.996	0.425 ± 0.007	2069.9	62.77
		Stature		-0.273 ± 0.014		-20.04
	3	Weight	0.997	0.444 ± 0.011	1663.3	41.6
		Stature		-0.268 ± 0.013		-21.2
		Hip circumference		0.030 ± 0.014		-2.16
	4	Weight	0.998	0.422 ± 0.012	1715.1	35.0
		Stature		-0.264 ± 0.011		-24.1
		Hip circumference		-0.039 ± 0.012		-3.16
		Mid arm circumference		0.101 ± 0.037		2.71
After removing above 4 variables						
BMI	1	Waist circumference	0.657	0.306 ± 0.051	36.3	6.02

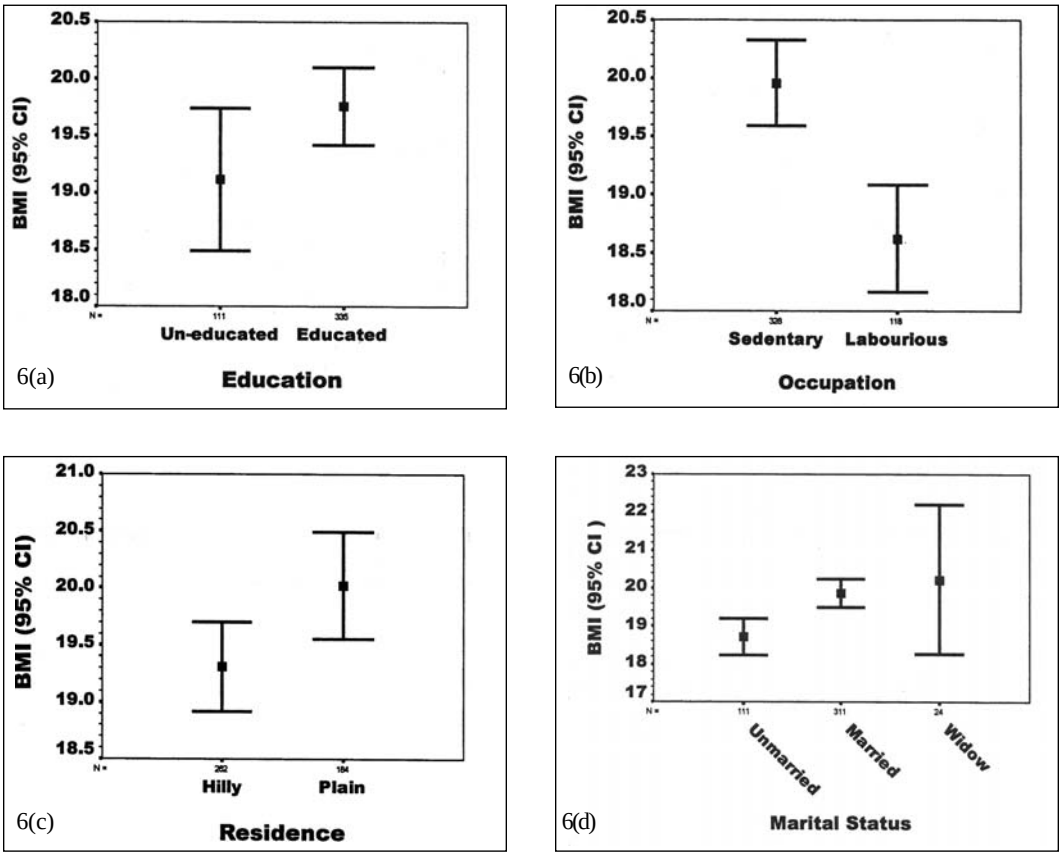

Figure 6. Error bar diagrams showing difference in BMI for (a) education, (b) occupation, (c) residence and (d) marital status of women

mid-day meal. In this way, continuous efforts being made to improve the health and nutrition of women and children of the country are reflected in the findings of the present study. However, the efforts are insufficient and require further improvement and monitoring. Simultaneously, the wide spread of corruption has seriously eroded the intention of the programmes.

The role of ecology in shaping the individuals is again established by this study. The significant differencs in sitting height and Cormic Index of women of the hills and plains show that the trunk of hilly people are longer in body proportion compared to people of the plains. People from the hills have to perform hard labour in their day-to-day activity. The larger trunk, comparatively short stature and light body weight allows for greater efficiency in surviving the tough ecological environment.

Ferro-Luzzi *et al.* (1991) proposed that BMI alone is sufficient to define CED in adults, irrespective of energy turnover as suggested earlier (James *et al.*, 1988). Furthermore, their findings on the distribution of BMI according to various grades of CED in a South Indian population seem to be corroborated by the present results, i.e. a large proportion of individuals (42.1%) belonged to CED grades. They suggest that the majority of the rural populations in India are likely to be undernourished.

The BMI is widely used as a measure of fatness, or the nutritional status of a population in both developed and developing countries (Khongsdier, 2001). Recent studies have, however, questioned the validity of BMI as an indicator of fatness (Frankenfield *et al*., 2001; Kyle *et al*., 2003) because it lacks specificity in terms of the variation in body composition, and the confounding effects of various factors such as age, sex, body shape and ethnicity (Norgan, 1994; Gurrici *et al*., 1998; Wagner and Heyward, 2000; Prentice and Jebb, 2001). It has also been suggested that body fat composition varies considerably between ethnic groups (Norgan, 1994; Gallagher *et al*., 2000). Norgan (1994) is of the opinion that BMI is correlated with sitting height, or BMI is lower in those populations with higher sitting height. It indicates that there exists an inverse relationship between BMI and CI; the present study corroborates the view of Norgan (1994). According to Khongsdier (2001), BMI is largely independent of ethnic or genetic variation; its correlation with CI may have certain implications as the latter may be subject to both genetical and environmental influences. So the differences in means of BMI between ethnic groups in the present study (Table 3) may not only be due to nutrition, but also due to impact of other environmental and genetic factors, as BMI is determined by both genetic as well as environmental factors, whereas CI is more of genetics and less determined by environment. But at the same time the manifestation of genetics is largely dependent on environment; therefore the role of environment cannot be underestimated. The regression analysis (Table 3) also supports that BMI is less dependent on CI as r^2-value varied from 0.171 to 0.137. However, it can be concluded that an improvement in socio-economic condition of these populations may lead to an increase in their BMI. The present study also indicates a need for effective implementation of nutrition programmes among the studied populations.

One of the important determinants of nutrition is occupation, which is already established (Gautam, 2007b). Education and ecology do not impose a significant impact on nutrition. The role of education cannot be underestimated as education has a key role in deciding the occupation, dietary habits and health consciousness of an individual. Similarly, the role of persistent stress and privileges of ecology cannot be ignored. The significant differences in sitting height and Cormic Index of women of the hills and plains establishes the role of ecology in shaping its habitants. The body of an individual takes shape as per level of nutrition; therefore different anthropometric measurements have significant correlations with BMI. In the same way the reproductive life span of women is decided by her level of nutrition. The difference in BMI of married and unmarried women is basically a positive correlation of age and weight as already postulated in the case of males (Gautam, 2007b). Married women generally fall into a higher age group as compared to unmarried women.

REFERENCES

Adak DK, Gautam RK & Gharami AK (2006b). Assessment of Nutritional status through Body Mass Index among adult males of 7 tribal populations of Maharashtra, India. *Mal J Nutr* 12 (1): 23-31.2006.

Adak DK, Gautam RK, Bharati S, Gharami AK, Pal M & Bharati P (2006a). Body Mass Index and chronic energy deficiency of adult males of Central Indian populations. *Human Biology* 78 (2): 201–218.

Bhatt SC (1997). The Encyclopaedic District Gazetteers of India, Gyan Publishing House, New Delhi. Vol. 6, 885-891.

Ferro-Luzzi A, Sette S, Franklin M & James WPT (1992). A simplified approach of assessing adult chronic energy deficiency. *Eur J Clin Nutr* 46:173-186.

Frankenfield, DC, Rowe WA, Cooney RN, Smith JS & Becker D (2001). Limits of body mass index to detect obesity and predict body composition. *Nutrition* 17: 26-30.

Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR & Sakamoto Y (2000). Healthy percentage body fat ranges: an approach for developing guidelines based on body mass index. *Am J Clin Nutr* 72: 694 –701.

Gautam RK (2007). Biosocial covariates of adult male body mass index in Central India. *J Biosoc Sci* 39: 875-893

Gautam RK (2008). Traditional occupation and nutritional adaptation among Central Indian caste populations. *J Biosoc Sci* 40: 697-723

Gautam RK & Adak DK (2007). Population, health and nutrition in Central India: a situational analysis. *Mal J Nutr* 13 (1): 55-70.

Gautam RK, Adak DK, Gharami AK & Datta T (2006). Body Mass Index in Central India: inter-district variation. *Anthropologischer Anzeiger* : 64(4) : 447-461.

Gordon JE, Ascoli W, Mata LJ, Guzman MA & Scrimshaw NS (1968). Nutrition and infection field study in Guatemalan villages 1959-1964. Acute diarheal disease and nutrition disorder in general disease incidence. *Archives of Environmental Health* 16: 424-437.

Gurrici S, Hartriyanti Y, Hautvast JG & Deurenberg P (1998). Relationship between body fat and body massindex: difference between Indonesians and Dutch Caucasians. *Eur J Clin Nutr* 52: 779-783.

James WPT, Ferro-Luzzi A & Waterlow JC (1988). Definition of chronic energy deficiency in adults. *Eur J Clin Nutr* 42: 969-981.

Khongsdier, R (2001). Body mass index of adult males in 12 populations of Northeast India. *Ann Hum Biol* 28: 374-383.

Kyle UG, Schutz Y, Dupertuis YM & Pichard C (2003). Body composition interpretation: contribution of the fat free mass index and the body fat mass index. *Nutrition* 19: 597-604.

Martin, R & Saller K (1956). *Lehrbuch der Anthropologie*, Vol.3, Stuttgart, G. Fisher.

Miller FJ, Billewicz WZ, Thomson AM (1972). Growth from birth to adult life of 442 Newcastle-upon-Tyne children. *Br J Prev Soc Med* 26: 224–230.

Mitra, A (1985). The nutrition situation in India. In: *Nutrition and Development*. M. Biswas & P. Andersen. (eds). Oxford, Oxford University Press, pp. 142-162.

Naidu AN & Rao NP (1994). Body mass index: a measure of nutritional situation in Indian populations. *Eur J Clin Nutr* 48 (Suppl. 3) : 131-140

Naidu, AN, Neela J & Rao NP (1991). Maternal body mass index and birth weight. *Nutrition News*, National Institute of Nutrition, Hyderabad 12, 2.

NFHS-III (2007). National Family Health Survey (NFHS-3) 2005-06. International Institute of Population Sciences, Deonar, Mumbai.

Norgan, NG (1994). Relative sitting height and the interpretation of body mass index. *Ann Hum Biol* 21: 79-82.

Osmani, SR (eds.) (1992). Nutrition and Poverty. Clarendon Press, Oxford.

Parsons T, Power C, Logan S & Summerbell CD (1999). Childhood predictors of adult obesity: a systematic review. *Int J Obes Relat Metab Disord* 23(suppl): S1–107.

Pierce, MB & Leon, DA (2005). Age at menarche and adult BMI in the Aberdeen Children of the 1950s Cohort Study. *Am J Clin Nutr* 82: 733-739.

Prentice AM & Jebb SA (2001). Beyond body mass index. *Obes Rev* 2: 141-147.

Rao, S (2001) . Nutritional status of the Indian Populsation. *J Biosci* 26(4): 481-489

Styne DM (2004). Puberty, obesity and ethnicity. *Trends Endocrinol Metab* 15:472–478.

Weigner DR & Heyward VH (2000). Measures of body composition in blacks and whites: a comparative review. *Am J Clin Nutr* 71: 1392-1402.

Wellens R, Malina RM, Roche AF, Chumlea WC, Guo S & Siervogel RM (1992). Body size and fatness in young adults in relation to age at menarche. *Am J Hum Biol* 4: 783–787.

World Health Organization (1990). Diet, nutrition, and the prevention of chronic disease. *WHO Technical Report Series,* No.797. Geneva, World Health Organization.