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TRADITIONAL OCCUPATIONS AND NUTRITIONAL ADAPTATION AMONG CENTRAL INDIAN CASTE POPULATIONS

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Summary. The socioeconomic milieu has benefits and drawbacks for determining level of nutrition. The Indian population provides an excellent example of nutrition-driven adaptation. The present paper deals with the relationship between BMI (body mass index) and traditional occupation and process of adaptation among adult males of Central India. Anthropometric data collected by the Anthropological Survey of India on stature, sitting height and weight of 6663 adult males belonging to 22 castes were used for computation of BMI and Cormic index. The caste groups earning their living as labourers are found to be shortest (157·4 ± 6·5 cm), and the caste group practising priesthood are tallest (168·6 ± 6·6 cm). The prevalence of chronic energy deficiency is found to be highest (72%) among castes earning their living as daily wage labourers. The ANOVA on Cormic index and BMI suggests that people within the same occupational group are more homogeneous than those from different occupational groups. The *t* test also supports the homogeneity of the same occupational group.

Introduction

India is the homeland of Hinduism, whose followers are divided into four *varna* and various castes. A particular caste has to practise a definite kind of occupation, which is traditionally passed on from generation to generation. It is postulated that socioeconomic condition is shaped by occupation, which in turn influences level of nutrition. Among the poorer sections of a population, the intake of food is generally low because of poverty; adaptation to malnutrition during critical stages of growth is likely to induce a permanent reduction in body size, which in turn will reduce the energy needs of the body. People with a small body size will survive more easily on low-calorie diets and they will have some adaptive advantage in circumstances where scarcity conditions prevail. Anthropometry, despite its inherent limitations, still remains the most practical tool for assessing nutritional status (Ghosh *et al.*, 2001). The Quetlet or body mass index (BMI) is widely accepted as one of the best indicators of nutritional status in adults (James *et al.*, 1988; Ferro-Luzzi *et al.*, 1992; Shetty &

James, 1994; Naidu & Rao, 1994; Bailey & Ferro-Luzzi, 1995). It has been reported that the basic causes of undernutrition in developing countries are poverty, poor hygienic conditions and poor access to preventive health care (Mitra, 1985; WHO, 1990). Literature on the nutrition of Indians is limited to certain geographical areas or populations. Noteworthy among them are the study of BMI among the north-east Indian (Khongsdier, 2001), south Indian (Ferro-Luzzi *et al.*, 1992) and Central Indian population (Gautam *et al.*, 2006; Adak *et al.*, 2006a, b; Gautam, 2007). Some of the most notable work on nutritional adaptation of a population to certain socio-economic conditions was done by Frisancho (1973), Ganguly (1977, 1979), Waterlow (1990), Ulizaszek & Huss-Ashmore (1997) and Crooks (1999). But work on nutritional adaptation of Central Indian populations to socioeconomic conditions is not available. In this way the present investigation is unique.

Moreover, the term adaptation needs clarification as in biological and social sciences it has varied, vague and equivocal meanings (Mazess, 1975). Dubos (1965a, b) indicated that 'acclimatization, acclimation, adaptation, and habituation are often used interchangeably because the processes these words are supposed to denote usually overlap and because the fundamental mechanisms involved are poorly understood'. Prosser (1958, 1964) was among the most prominent in providing a conceptual framework for dealing with adaptation, and in particular 'physiological adaptation'. Eagan (1963) and Folk (1966) examined the problems of nomenclature, and both suggested that adaptation be kept as a generic (note not genetic) term. There has been a widespread tendency, especially in physical anthropology, to consider adaptation as genetic adaptation, with the implication that natural selection is involved. Dobzhansky (1968) attempted to clarify the concept of 'adaptedness'. He recognized that adaptation could refer to both individuals and populations, and he delineated adaptedness, fitness and persistence; all were applied at the population level. Most non-geneticists and non-anthropologists do not consider adaptation primarily as populational but rather as individual, although it is recognized that individual adaptation can contribute to population adaptation (McCutcheon, 1964). Adaptation is usually defined as the ability to survive, function and reproduce (McCutcheon, 1964; Prosser, 1958, 1964; Dobzhansky, 1968; Baker, 1966), without really noting, as does Lasker (1969), that the term is relative. Some scholars have tried to discriminate between adaptive responses of a population and that of individuals within a population. Hulse (1960) uses the terms adaptation and plasticity to denote these two categories; according to him selection is the means and adaptation is the end. Adaptation is the possession of a genetic system by a population resulting in phenotypic expressions that are favourable to the survival and reproduction of the population. Plasticity, on the other hand, is possession of a genetic system that is capable of varied expression in response of varied environmental stimuli. Alland (1975) also makes a distinction between evolutionary adaptation and physiological adaptation; according to him evolutionary adaptation is a trans-generational change in the direction of increased maximization in specific environments, and physiological adaptation is an organismic or systematic response to parametric variation that acts to maintain homeostasis.

In this way the concept of adaptation is a complex one and it has major theoretical implications. In a broader sense both biological as well as cultural

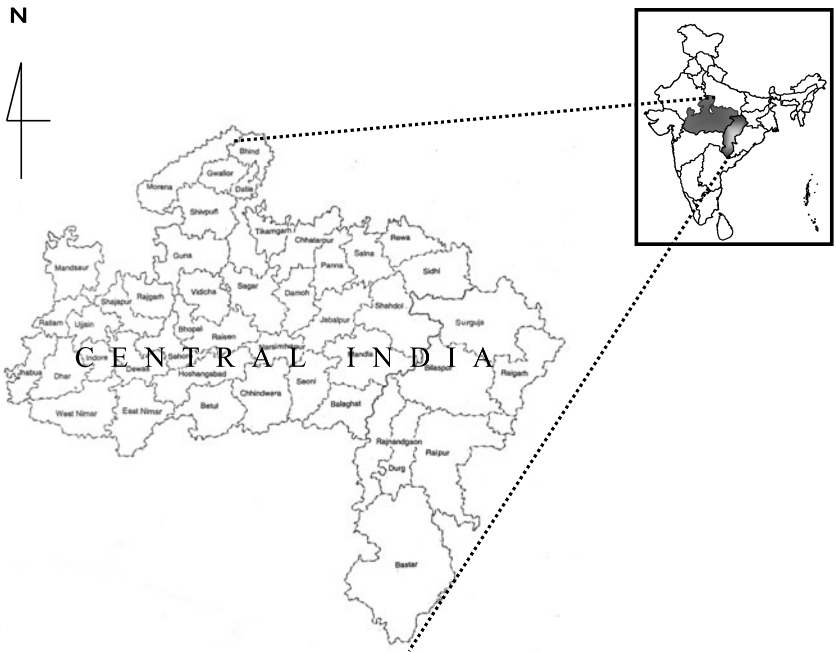

Fig. 1. Map showing location of Central India.

adaptation may be considered as complimentary to each other. There is no doubt that culture is a human attribute that interposes between someone and his environment in order to ensure his security and survival.

The poor socioeconomic condition is a result of a low-yielding occupation against a comparatively high input of labour. Certain occupations require more energy, time and labour, viz. daily wage earning, blacksmith, agriculture and weaving in comparison to others such as priesthood and so on. When these occupations are traditional, the populations practising occupations are in a constant socioeconomic condition over many generations. Therefore it is very natural that they are physically adapted to their respective occupational requirement and socioeconomic condition through changes in body structure. The Indian population (especially Hindu castes) provides a unique opportunity to analyse the impact of occupation on changes in bodily structure of its practitioners or adaptation of a population to a particular socioeconomic condition. Therefore the present investigation was carried out on a sub-sample of a total of 6663 male individuals 18–70 years of age belonging to 22 caste group of 38 districts of Central India (Fig. 1).

The area and its people

Area

India is an Asian country. It is the second largest country in the world from the point of view of population. Today every sixth individual in the world is an Indian.

Although the country has 16·6% of the world's population, the sub-continent is comparatively poor in natural resources as it has only 2% of the land, 1% of the rainfall and 0·5% of the forests. The erstwhile Madhya Pradesh or undivided Madhya Pradesh state as its name implies – Madhya means 'Central' and Pradesh means 'region' or 'state' – is the area of the present study and called Central India (Fig. 1). One new state, Chhattisgarh, was formed after division of this state in November 2000. The study area is situated between 18° to 26° and 30′ of latitude at the north of equator and 74° to 84° and 36′ of longitude east of the prime meridian.

People

The present study is confined to 22 caste groups of 38 districts of the erstwhile Madhya Pradesh state of India. These caste groups belong to thirteen traditional occupational groups. The information regarding traditional occupation of most of the caste groups is based on an official document of the Government of Madhya Pradesh (1997). A brief description of the occupational groups and castes is presented below.

i. Agriculture. A total of nine out of 22 castes are traditionally engaged in agriculture. These are Jat, Khati, Koli, Kulmi, Kurmi, Kurumbanshi, Lodha, Lodhi and Lora. The sample of Jat is taken from Gwalior district; they possibly immigrated from the Haryana and Punjab states of India. The rest of the sample is taken from different districts. The largest sample (349) is of Kurmi, followed by Lodhi (300) and so on. In this way a total of 1007 belong to this group. Though these castes are traditionally agriculturist, they are not large landholders. In general, the majority are medium landholders.

ii. Animal husbandry. Agriculture and animal husbandry have been locked together in the course of human evolution. In the present study there are two caste groups that are known as traditionally pastoralists. Their primary as well as traditional occupation is the domestication of cows and buffalo. A few of them also domesticate goats and sheep. Besides the domestication of animals they are also engaged in the production and marketing of milk and milk products. They also own small patches of land for cultivation.

iii. Blacksmith. The caste groups Lohar, Lohgadia and Agaria of Central India are traditionally engaged in the extraction of iron and manufacture and repair of iron implements. For the present investigation the sample are taken from the Lohar only.

iv. Fishing. In Central India, certain groups base their livelihood on fishing. This profession is also traditionally inherited. For the present investigation the sample are drawn from the Majhi of Surguja district, who are a scheduled tribe. In other districts the Majhi are considered as a caste.

v. Labourer. The caste group Panka is identified as labourer by the government. By and large members of this caste earn their living as daily wage labourers in the fields of agriculturists or landlords or at construction sites. Besides that they are engaged as labourers, informants or guides by the forest, revenue and police department. In many villages, a member of this caste is deputed as village guard. Recently a few of them have become priests among followers of *Kabirpanth* (a sect of Hinduism). Simultaneously, those who are deputed as village guards are allotted a small patch of barren land.

vi. Oil merchant: The members of the caste known as Teli are traditionally oil merchants. They are widely distributed in Central India. Up to the pre-industrial era, they were earning their living through the extraction and trading of oil. But with the advent and introduction of technology, gradually their traditional occupation has been forgotten by themselves and by society too. Now they have shifted to other business enterprises such as running general stores, grain merchants, middlemen, agriculture. For the present investigation a total sample of 1156 of the Teli caste are taken from 23 different districts of Central India.

vii. Potter. Pottery was possibly the first mark of the revolution of human culture and civilization. In the history of human evolution, potters would possibly have been regarded as technocrats. Still they are artisans, and their skill and occupation is socially patented for themselves only. Except Kumbhar, no other caste practises pottery. Besides water pots, they manufacture other kind of utensils for daily use as well as toys for children; they slightly changed their traditional occupation with the wave of change and modernity. Now, many of their artistically designed objects can be seen in modern drawing rooms.

viii. Priest. Brahmin is the only caste that has patented this luxurious job in Hinduism. After many waves of revolution, and sanskritization of many castes, the hold on priesthood is still lies in the hand of the Brahmin. In this way, the Brahmin are at the top of caste hierarchy of Hinduism. They have many privileges. They are regarded as second gods or godly souls. They have also exploited their high social rank. They have occupied most of the political, administrative, academic and other advantageous positions since long back and are continuing the tradition. They are also large landholders, but do not practise agriculture. They are landlords and hire labourers for the job of agriculture. A total of 1114 Brahmin were drawn from 22 districts for the present investigation.

ix. Shoemaker. The practitioners of this profession are traditionally regarded as untouchables. If the priests are at the top of Hindu caste hierarchy, the shoemakers are at the bottom. Although, after independence, the practice of untouchability was abolished by law in the country, it is still being practised in rural India. Besides shoemaking and repairing they also do scavenging. They are called Chamar. In Central India, they are also known as Ahirwar, Jatav and other names. To provide constitutional protection they are classified as a scheduled caste. By and large, they are landless. Therefore, besides their traditional occupation of leatherwork, they also earn their living as agricultural labourers. A total of 1062 Chamar belonging to 21 districts are included in the present investigation.

x. Vegetable cultivator. There are some caste groups who are exclusively dependent on vegetable cultivation. One of them is Kachi, who are traditionally vegetable cultivators. Their villages are generally on the bank of rivers and rivulets, where land and water is available for the cultivation of vegetable. Besides cultivation they also market their products. Generally they own small patches of lands on the banks of rivers or other water bodies.

xi. Warrior. The Rajput are traditionally warriors. They are also landlords. They were a sovereign part of the feudal kingdoms of historical India. Although, traditionally, they were prepared as guards of Hindu society, especially of Brahmins, later on they become rulers and established kingdoms. They still have a hold on Indian polity, in second position. They are large landholders; most of the advantageous positions and occupations lie with them. There are still regions that are governed in the traditional manner where law and order is in the hands of the descendents of kings and landlords. In modern India too, they are affluent and dominant. Now they are playing the role of politician, administrator, industrialist and so on. A total of 701 Rajput are considered for the present investigation; these were collected from fourteen districts of Central India.

xii. Weaver. In the course of human evolution, possibly the first technocrats were potters and second would have been weavers. Perhaps, weavers would have been in a better position than potters, as textile-making is more recent than pottery. But it is not clear at which stage of evolution they become untouchables. Now they are provided constitutional protection as a scheduled caste. For the present investigation, only Kori caste is considered, who are traditionally weavers. Although now they have forgotten their traditional occupation of weaving, they are still untouchables. Now they are engaged in different occupations, though their primary occupation is agriculture or agricultural labouring. Apart from in Central India, Kori are abundantly found in northern India.

xiii. Wine merchant. The Kaller are known traditionally as wine merchants. The caste Kaller is also spelt 'Kallar'. Many of them are still engaged in this business, although now it has lost its traditional form. Now, wine shops are very profitable businesses. Therefore, it has crossed the boundary of caste, and it is in the hands of dominant castes or individuals. The members of the Kaller caste are also engaged in different businesses.

It should be noted that the present analysis is based on data collected by the anthropological survey of India (Basu *et al.*, 1994); therefore it is not possible to make out the current occupation of samples. However, this is not important because the current occupation has only started being practised by the current generation or in the last two generations, so there is a least chance of complete absence of impact of traditional occupations.

Methods

The study sample is based on the basic anthropometric data collected on adult males aged 18–70 years by the Anthropological Survey of India (Basu *et al.*, 1994). For the present investigation altogether 22 caste group of 38 districts of Central India (Fig. 1) comprising the states of Madhya Pradesh and Chhattisgarh were taken into consideration. These caste groups are practising thirteen different traditional occupations. The information related to traditional occupation of castes is obtained from an official document, namely Part I of the Gazette (Government of Madhya Pradesh, 1997). Information related to landholding is based on observation and traditional occupation of the castes. The study sample consists of a total of 6663 adult males. Data were collected by the trained physical anthropologists of the Anthropological Survey of India, following standard techniques (Martin & Saller, 1956). The measurements were taken only on adult males who looked apparently normal. Efforts were also made to exclude closely related individuals such as brothers, fathers and sons; and those with any kind of physical deformities. Therefore the samples were free from any selection bias.

The data collected on stature (H), sitting height (SH) and body weight (W) were used for computation of Cormic index (SH/H) and body mass index (weight/height^2) for each individual. Calculation of central tendency (arithmetic mean), dispersion (standard deviation) and relative dispersion (coefficient of variation) for each caste and occupational group was done using MS Excel and SPSS software packages. Subsequent calculations were also done using both software. The average *t* distance among castes and occupational groups was calculated using following formula:

$$\text{Mean } t \text{ distance} = \frac{\Sigma t}{\Sigma N}$$

where Σt is the sum of *t* values calculated for pairs of caste and occupational groups, and this is divided by ΣN. The sum of *N* or ΣN is computed by the following formula:

$$\Sigma N = (2-1) + (3-1) + \ldots\ldots + (\eta_{max} - 1)$$

For caste groups η_{max} is 22 so $(\eta_{max} - 1) = 21$, whereas for occupational groups η_{max} is 13.

For screening chronic energy deficiency (CED) groups the value 18·5 is taken as a cut-off point following James *et al.* (1988), Ferro-Luzzi *et al.* (1992), Khongsdier (2001, 2002), Adak *et al*. (2006a, b), Gautam *et al.* (2006) and Gautam (2007).

Results

It is evident from Table 1 that among the 22 caste groups the Jat, with a mean height of 168·6 ± 6·6 cm, are tallest in stature while the Panka, with a mean value of 157·4 ± 6·5 cm, are shortest. The range of mean indicates that all the populations are short to medium in stature. The Kachi, Kaller, Koli, Kori, Majhi and Panka are short in stature, while the Gujar, Brahmin, Rajput, Kulmi, Kurmi, Lohar, Lodha, Lodhi, Lora, Kumbhar, Ahir, Chamar (Jat), Kurumbanshi, Khati, Teli are lower medium and the Jat are medium in stature. Occupation has a great role in shaping and sizing individuals and populations as a whole. The mean value of stature is found to be shortest (157·4 ± 6·5 cm) for occupational groups who are traditionally labourers, whereas the mean value of stature is found to be highest (166·4 ± 5·7 cm) for priests.

Table 1. Mean, standard deviation and coefficient of variation of stature, sitting height, weight, BMI and Cormic index among 22 caste groups (practising thirteen traditional occupations) of Central India

Occupation/caste group	Stature			Sitting height			Weight			BMI			Cormic index		
	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV	Mean	SD	CV
1. Agriculture															
Jat (50)	168·6	6·6	3·9	85·6	3·6	4·3	55·3	7·9	14·2	19·4	2·0	10·1	0·508	0·017	3·3
Khati (50)	163·6	6·0	3·7	81·4	3·1	3·8	49·0	4·2	8·7	18·4	1·5	8·0	0·498	0·014	2·7
Koli (50)	162·9	7·1	4·3	81·8	3·0	3·7	48·7	6·9	14·1	18·3	1·9	10·6	0·502	0·018	3·6
Kulmi (50)	166·0	6·8	4·1	83·9	4·1	4·9	52·9	6·3	12·0	19·2	1·9	10·0	0·506	0·017	3·3
Kurmi (349)	165·8	6·1	3·7	82·3	3·4	4·1	52·4	6·7	12·8	19·1	2·2	11·4	0·497	0·017	3·4
Kurumbanshi (51)	163·7	6·0	3·6	82·1	3·1	3·8	52·1	5·2	9·9	19·5	1·7	8·8	0·502	0·015	3·1
Lodha (51)	164·7	5·1	3·1	83·3	3·2	3·9	49·8	5·0	10·0	18·4	1·7	9·4	0·505	0·014	2·7
Lodhi (300)	164·4	5·5	3·3	81·4	3·5	4·3	50·9	6·4	12·6	18·8	2·0	10·7	0·495	0·017	3·4
Lora (56)	163·9	6·9	4·2	82·5	4·3	5·2	49·3	5·4	10·9	18·3	1·4	7·4	0·503	0·016	3·2
Total (1007)	165·0	6·1	3·7	82·3	3·6	4·4	51·4	6·5	12·6	18·9	2·0	10·6	0·499	0·017	**3·4**
2. Animal husbandry															
Ahir (600)	163·7	5·9	3·6	81·9	3·4	4·2	49·4	6·4	12·9	18·4	2·0	10·7	0·501	0·016	3·3
Gujar (100)	166·5	7·3	4·4	83·1	4·7	5·6	54·8	9·6	17·5	19·7	2·7	13·5	0·499	0·017	3·3
Total (700)	164·1	6·2	3·7	82·1	3·6	4·4	50·2	7·2	14·3	18·6	2·1	11·4	0·500	0·017	**3·3**
3. Blacksmith															
Lohar (50)	164·9	6·6	4·0	82·7	3·1	3·8	49·0	6·3	12·9	18·1	2·5	14·1	0·502	0·021	4·1
4. Fishing															
Majhi (50)	158·4	5·7	3·6	79·2	2·9	3·7	48·8	5·0	10·4	19·4	1·5	7·7	0·500	0·013	2·6
5. Labourer															
Panka (57)	157·4	6·5	4·1	78·2	3·6	4·6	44·4	4·7	10·6	17·9	1·6	9·0	0·497	0·014	2·9
6. Oil merchant															
Teli (1156)	163·3	5·7	3·5	81·9	3·4	4·2	49·7	6·8	13·7	18·6	2·2	11·8	0·502	0·017	3·4
7. Potter															
Kumbhar (413)	163·7	6·0	3·6	81·7	5·3	6·5	49·2	6·7	13·7	18·3	2·1	11·5	0·499	0·029	5·9
8. Priest															
Brahmin (1114)	166·4	5·7	3·4	84·6	3·4	4·0	54·0	8·1	15·0	19·5	2·6	13·3	0·508	0·017	3·3
9. Shoemaker															
Chamar (Jat) (1062)	163·7	6·1	3·7	81·9	3·9	4·8	48·5	6·1	12·6	18·1	1·9	10·6	0·501	0·019	3·8
10. Vegetable cultivator															
Kachi (253)	163·0	5·5	3·4	81·5	4·6	5·7	48·7	5·3	10·9	18·3	1·7	9·4	0·500	0·024	4·8
11. Warrior															
Rajput (701)	166·1	6·2	3·7	82·5	3·4	4·2	52·3	7·3	14·0	18·9	2·3	12·0	0·497	0·017	3·4
12. Weaver															
Kori (50)	162·0	6·8	4·2	81·9	3·2	3·9	46·7	5·8	12·5	17·8	1·7	9·6	0·506	0·014	2·8
13. Wine merchant															
Kaller (50)	163·0	6·8	4·2	80·3	3·9	4·9	51·8	8·2	15·7	19·5	2·5	12·9	0·492	0·014	2·9
F ratios															
13 occupational groups	34·41*			49·01*			45·79*			24·27*			20·34*		
22 caste groups	22·75*			32·12*			31·47*			16·49*			13·97*		

*$p<0{\cdot}001$.

Here it should be noted that as an individual caste the Jat, traditionally agriculturist, are on average taller, whereas as an occupational group priests are taller. Mean value of stature by traditional occupation is further illustrated in Fig. 2. The mean value of sitting height varies between 78·2 ± 3·6 cm among Panka and 85·6 ± 3·6 cm among Jat.

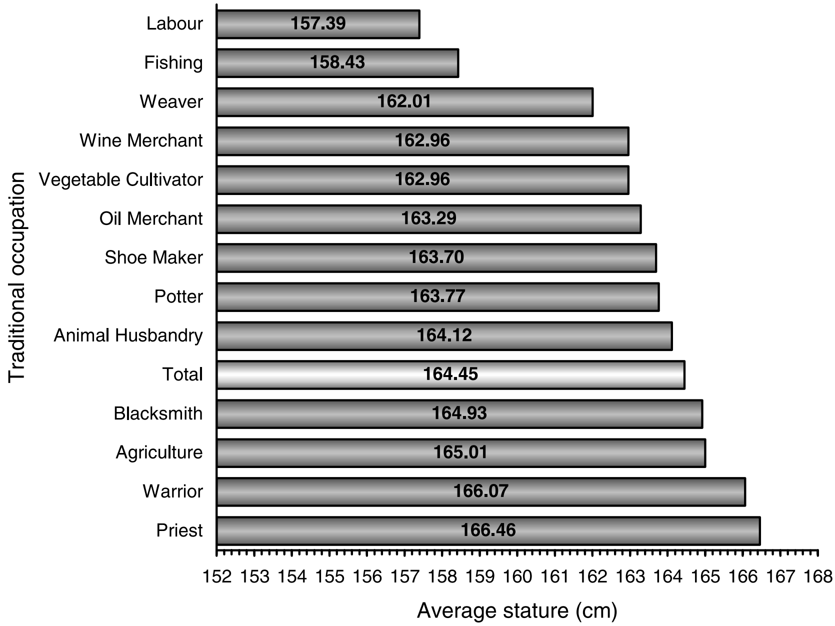

Fig. 2. Average stature of Central Indian population of 22 caste groups by traditional occupation.

The coefficient of variation shows the disparity of these anthropometric parameters within caste and occupational group. It is less within caste groups as compared with occupational groups, although it is highest for weight across the groups. The one-way analysis of variance (ANOVA) shows that the castes are comparatively more homogenous than occupational groups, as the *F* ratio is highly significant for occupational groups as compared with caste group. Stature is the length of the skeletal system, weight is a measurement of body mass including the skeleton and muscles, the BMI is a composite index of height and weight. Therefore, to find out the anthropometric difference between castes and occupational groups, paired *t* tests were computed for BMI, which are presented in Tables 2 and 3. It is apparent that the mean BMI varies significantly between the caste group practising different occupations. Among castes the highest *t* value (14·3) is found for Brahmin (priests) and Chamar (shoemakers), which is significant at the 1% level (p<0·001). The *t* value is found to be zero between Khati and Lodha, and Lora and Koli; all four castes are agriculturists. Apart from these two pairs, the *t* value is found to be zero between blacksmiths and potters also, both skilled occupations. Finally, mean *t* distance was computed among 22 castes and thirteen occupational groups, and was found to be 0·58 and 0·27 respectively.

Body mass index is one of the most widely used indicators for assessment of nutrition of individuals and populations. In the present study BMI was found to be lowest (17·8 ± 1·7) for the caste group practising weaving as a traditional occupation (i.e. Kori caste), and the highest mean BMI was recorded for priests (19·5 ± 2·6) among thirteen traditional occupational groups. Of individual castes, the Gujar have

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Table 2. Paired *t* test for BMI between 22 caste groups of Central India

Caste group	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1) Ahir		−8·7*	3·1*	−3·7*	−2·0†	1·2	−1·7	0·4	0·5	1·9†	−1·5	0·8	−3·6*	−2·1†	0·5	−2·1	0·9	1·1	−2·4†	2·8†	−4·6*	−1·1
(2) Brahmin			14·3*	−0·3	1·0	6·8*	0·7	3·0†	3·0†	4·2*	1·3	7·5*	2·6†	0·8	3·1†	4·1*	3·2†	3·4*	0·9	4·5*	4·6*	8·1*
(3) Chamar (Jat)				−3·8*	−2·1†	−0·9	−2·1†	0·6	0·8	2·3†	−1·3	−1·7	−6·5*	−2·5†	0·7	−4·0*	1·2	0·4	−2·0†	1·7	−8·2*	−6·4*
(4) Gujar					1·3	5·0*	1·0	3·9*	4·1*	5·0*	1·6	5·1*	2·3†	1·4	3·8*	3·0†	3·9*	4·2*	1·4	4·9*	2·7†	2·0†
(5) Jat						3·6*	−0·1	2·8†	2·7†	4·4*	0·5†	3·1	1·3	−0·3†	3·0	1·8†	3·0†	3·1†	−0·1	3·9*	1·1	0·7
(6) Kachi							−3·2†	2·7†	2·5†	4·1*	0·6	3·1†	1·2	−0·1	2·4†	1·5	2·7†	2·7†	0·1	3·3†	1·0	0·8
(7) Kaller								2·7†	2·5†	4·1*	0·6	3·1†	1·2	−0·1	2·4†	1·5	2·7†	2·7†	0·1	3·3†	1·0	0·8
(8) Khati									0·1	1·8	−2·4†	0·8	−1·9	−3·5*	0·0	−0·7	0·7	0·2	−3·5*	1·4	−1·6	−1·5
(9) Koli										1·4	−2·1†	0·5	−1·7	−3·5*	−1·1	−0·8	0·4	0·0	−3·3†	1·1	−1·6	−1·6
(10) Kori											−4·4*	−1·0	−3·4*	−5·7*	−1·5	−2·0†	−0·8	−2·1†	−5·4*	−0·5	−3·5*	−2·5†
(11) Kulmi												2·7†	0·6	−0·7	1·9†	1·2	2·3†	3·1†	−0·6	3·6*	0·5	0·3
(12) Kumbhar													−4·4*	−3·8*	−0·6	1·4	0·0	−0·9	−4·1*	0·4	−3·5*	−1·6
(13) Kurmi														−1·5	1·7	1·4	2·2†	1·8	−1·2	3·1†	1·3	3·2*
(14) Kurumbanshi															3·4*	1·9†	3·5*	4·0*	0·2	4·4*	1·2	0·8
(15) Lodha																0·6	0·6	0·3	−3·1†	1·2	−1·4	−1·3
(16) Lodhi																	1·3	1·0	−1·9	2·5†	−0·2	1·5
(17) Lohar																		−0·5	−2·8	0·3	−1·8	−1·8
(18) Lora																			−3·9*	1·4	−1·7	−1·7
(19) Majhi																				4·5*	1·2	0·8
(20) Panka																					−3·0†	−2·7
(21) Rajput																						3·1†
(22) Teli																						

$\Sigma t = 134{\cdot}3$; mean t distance $= 0{\cdot}58$.

Level of significance of difference in mean between caste groups: $*p < 0{\cdot}001$; $\dagger p < 0{\cdot}05$.

Table 3. Paired *t* test for BMI between thirteen occupational groups of Central India

Traditional occupation groups	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Agriculture		2·9†	3·0†	− 0·1	3·8*	2·3†	4·9*	− 5·9*	9·0*	3·2†	− 0·1	4·5*	− 0·2
(2) Animal husbandry			1·0	− 2·5†	2·8†	0·2	0·8	− 7·6*	4·7*	1·3	− 3·1†	2·0	− 1·8
(3) Blacksmith				− 2·8†	0·3	− 1·8	0·0	− 3·2$^{\Delta}$	− 1·2	0·1	− 1·9	0·8	− 2·7$^{\Delta}$
(4) Fishing					4·6*	0·9	4·1*	− 1·0	2·1†	4·6*	1·2	5·5*	− 0·1
(5) Labourer						− 2·8†	− 0·5	− 4·6*	− 1·7	− 0·5	− 3·1†	0·5	− 3·3†
(6) Oil merchant							1·6	− 8·1*	6·4*	0·7	− 3·1†	2·6†	− 0·8
(7) Potter								− 7·5*	1·8	− 0·8	− 3·5*	1·0	− 3·1†
(8) Priest									14·3*	6·9*	4·6*	4·2*	0·8
(9) Shoemaker										− 1·0	− 8·2*	2·3†	− 2·1†
(10) Vegetable cultivator											− 2·6†	0·8	− 3·2†
(11) Warrior												3·5$^{\Delta}$	− 1·0
(12) Weaver													− 4·1*
(13) Wine merchant													

Σt=21·2; mean *t* distance=0·27.
Level of significance of difference in mean between occupational groups: *p<0·001; †p<0·05.

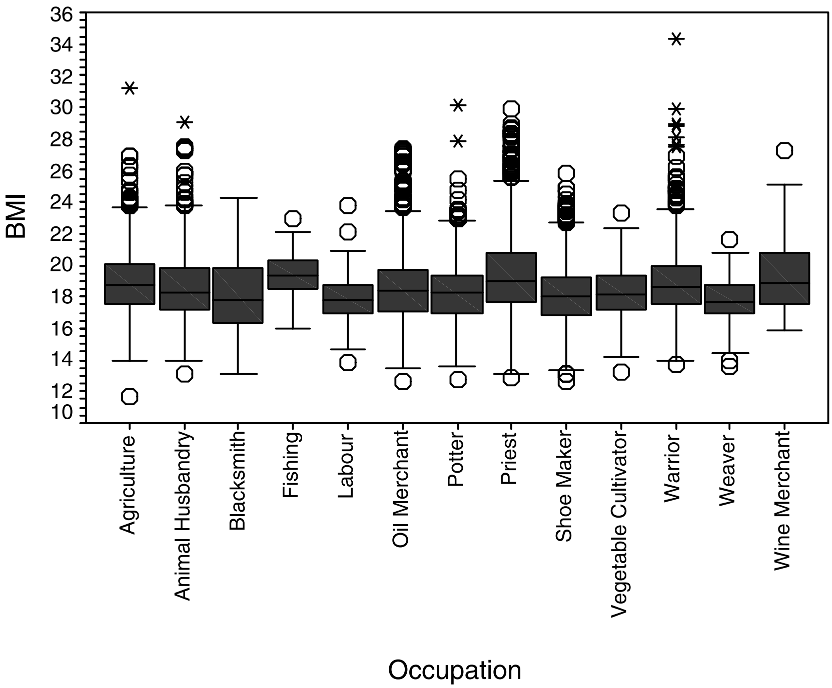

Fig. 3. Boxplot showing the median, quartiles and extreme values of BMI among thirteen occupational groups of Central India.

the highest mean BMI (19·7 ± 2·7). On the other hand, the mean BMI (18·7 ± 2·2) for all populations, irrespective of their caste and traditional occupation, is lower than that reported for the well-to-do individuals (Bharati, 1989; Visweswara Rao *et al.*, 1990, 1995; Khongsdier, 1997; Reddy, 1998), but it is not as low as that among the south Indian population (Ferro-Luzzi *et al.*, 1992). The traditional occupation-wise descending order of BMI is found to be: priest>wine merchant>fisherman>warrior> agriculturist>oil merchant>pastoralist (animal husbandry)>vegetable cultivator> potter>shoemaker>blacksmith>labourer>weaver. This is also evident from the box-plot diagramme in Fig. 3. The difference of mean of BMI between pairs of caste groups as well as occupational groups is also evident from the error bar chart in Fig. 4. The mean BMI is significantly higher among group of practitioners of certain luxurious traditional occupations such as priesthood, traditional businesses such as wine merchant, long-established dominator and landlords, i.e. warrior, as well as some well nourished occupational groups such as fisherman and agriculturists, whereas mean BMI is found to be significantly lower among weavers, labourers, shoemakers, blacksmiths, vegetable cultivators, potters, oil merchants and pastoralists (animal husbandry).

The percentage distribution of BMI according to different grades of chronic energy deficiency (CED) is given in Table 4, considering a cut-off point of 18·5 for screening the individuals into normal and CED groups. The prevalence of CED is found to be highest (72%) among castes earning their living traditionally as daily wage

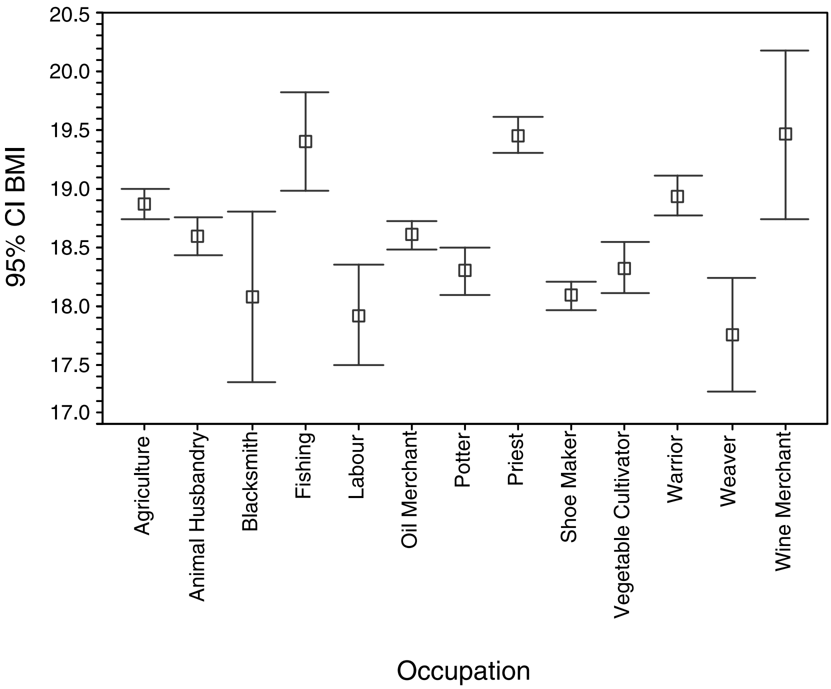

Fig. 4. Error bar chart showing 95% confidence intervals of mean BMI among individual groups as well as comparison of means between different occupational groups.

labourers. Weavers and blacksmiths are in second and third position, respectively, with 66% and 62% of the population in the chronic energy deficient categories. On the other hand, the prevalence of CED is found to be lowest among the fisherman population (24%) followed by priests (40·9%), wine merchants (44%), agriculture farmers (45·8%), warriors (46·3%) and so on. Irrespective of caste and occupational group, a total of 51·2% of the population of Central India are found to be chronic energy deficient. The difference between lowest and highest average weight, respectively, between labourers (44·4 kg) and priests (54·0 kg) is 9·6 kg, and this difference in weight between two occupational groups appears to have some adaptive significance.

However, variation in Cormic index is significant across the caste groups (F=13·97) and is augmented further among occupational groups (F=20·34). The mean value of Cormic index is lowest among wine merchants (0·492 ± 0·014) whereas it is highest among priests (0·508 ± 0·017). To find out the difference of mean Cormic index between pairs of caste groups as well as occupational groups ANOVA tests were computed, as shown in Table 5 and 6. It is apparent from these tables that there are non-significant differences of mean between most of the pairs of caste groups as well as occupational groups, but there are ten pairs of caste showing significant differences. Of these ten pairs, six pairs are practitioners of different occupations. These pairs are: Brahmin vs Kaller, Brahmin vs Majhi, Gujar vs Kachi, Koli vs Rajput, Kori vs Teli and Panka vs Rajput. In the same way there are five pairs of

Table 4. Percentage distribution of population as per categories of CED among thirteen occupational groups of Central India

		CED				BMI (grouped)			
S. No.	Traditional occupation	Grade III (severe) <16·0	Grade II (moderate) 16·0–16·99	Grade I (mild) 17·0–18·49	Low (18·5–19·99)	Normal (20·0–24·9)	Obese Grade I (25·0–29·99)	Obese Grade II (>30)	Total
1.	Agriculture	4·7	10·7	30·4	28·4	25·1	0·6	0·1	100
2.	Animal husbandry	7·6	13·4	32·9	23·6	21·4	1·1	0·0	100
3.	Blacksmith	16·0	22·0	24·0	14·0	24·0	0·0	0·0	100
4.	Fishing	2·0	4·0	18·0	42·0	34·0	0·0	0·0	100
5.	Labourer	5·3	21·1	45·6	22·8	5·3	0·0	0·0	100
6.	Oil merchant	8·6	14·1	30·8	26·2	18·8	1·6	0·0	100
7.	Potter	10·9	15·7	30·5	25·7	16·5	0·5	0·2	100
8.	Priest	5·2	9·7	26·0	23·3	31·8	4·0	0·0	100
9.	Shoemaker	12·2	15·6	33·8	23·7	14·6	0·1	0·0	100
10.	Vegetable cultivator	7·5	14·2	34·8	26·9	16·6	0·0	0·0	100
11.	Warrior	6·0	10·1	30·2	29·1	22·7	1·7	0·1	100
12.	Weaver	12·0	14·0	40·0	24·0	10·0	0·0	0·0	100
13.	Wine merchant	2·0	12·0	30·0	24·0	28·0	4·0	0·0	100
	Total	7·7	12·7	30·8	25·6	21·8	1·4	0·1	100

Table 5. One-way analysis of variance test for Cormic index among 22 caste group of Central India

Source	Sum of squares	df	Mean^2	F	Sig.
Between groups	0·101	21	0·005	13·974	<0·000
Within groups	2·277	6640	0·000		
Total	2·378	6661			

Caste group	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
(1) Ahir		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(2) Brahmin			—	—	—	—	*	—	—	—	—	—	—	—	—	—	—	—	*	—	—	—
(3) Chamar (Jat)				—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(4) Gujar					—	*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(5) Jat						—	—	—	—	—	*	—	—	—	—	—	—	—	—	—	—	—
(6) Kachi							—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(7) Kaller								—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
(8) Khati									*	—	—	—	—	—	—	—	—	—	—	—	—	—
(9) Koli										—	—	—	—	—	—	—	—	—	—	—	*	—
(10) Kori											—	—	—	—	—	—	—	—	—	—	—	*
(11) Kulmi												—	—	*	—	—	—	*	—	—	—	—
(12) Kumbhar													—	—	—	—	—	—	—	—	—	—
(13) Kurmi														—	—	—	—	—	—	—	—	—
(14) Kurumbanshi															—	—	—	—	—	—	—	—
(15) Lodha																—	—	—	—	—	—	—
(16) Lodhi																	—	—	—	—	—	—
(17) Lohar																		—	—	—	—	—
(18) Lora																			—	—	—	—
(19) Majhi																				—	—	—
(20) Panka																					*	—
(21) Rajput																						—
(22) Teli																						

Level of significance of difference in mean between caste groups: *$p<0·05$; –$p>0·05$.

Table 6. One-way analysis of variance test for Cormic index among thirteen occupational groups of Central India

Source	Sum of squares	df	Mean^2	*F*	Sig.
Between groups	0·084	12	0·007	20·344	<0·000
Within groups	2·294	6649	0·000		
Total	2·378	6661			

Traditional occupation groups	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Agriculture		—	—	—	—	—	—	—	—	—	—	—	—
(2) Animal husbandry			—	—	—	—	—	—	—	—	—	—	—
(3) Blacksmith				—	—	—	—	—	—	—	—	—	—
(4) Fishing					—	—	—	—	—	—	—	—	*
(5) Labourer						—	—	—	—	—	*	—	—
(6) Oil merchant							—	*	—	—	—	*	—
(7) Potter								—	—	—	—	—	—
(8) Priest									—	—	—	—	*
(9) Shoemaker										—	—	—	—
(10) Vegetable cultivator											—	—	—
(11) Warrior												—	—
(12) Weaver													—
(13) Wine merchant													

Level of significance of difference in mean between occupational groups: *$p<0{\cdot}05$; –$p>0{\cdot}05$.

occupational groups showing significant difference of mean for Cormic index, viz. fishermen vs wine merchants, labourers vs warriors, oil merchants vs priests, oil merchants vs weavers and priests vs wine merchants. The linear regression carried out also indicates that BMI is not independent of Cormic index across nine out of thirteen occupational groups, where the correlation coefficients are positively significant. The Cormic index accounts for no more than 19% variability on BMI (Table 7). As is apparent from Table 1, these castes as well as occupational groups differ more in BMI (F=24·27) than in Cormic index (F=20·34).

Table 8 shows regression analysis of BMI on age using raw data for different age groups, viz.<25 years, 26–40 years, 41–60 years, 61+ years and total (18–70 years), as well as using mean BMI for age groups 18–40 years and 41–70 years of age. It is evident from Table 8 that age accounts for more than 57·6% of variability in BMI for 18–40 years of age (Table 8). The correlation is positive and significant at the 1% level (p<0·001). After 40 years of age the correlation is negative as well as insignificant, as elucidated by the scattered plot diagrammes in Figs 6 and 7.

Discussion

The present form of human being is evolved from ancestors who constantly reformed through interaction between their inherent genetic characteristics and the environment. The study of the human genome propounded that the genetic variation among different human populations is meager but physical variation is apparent. During the

Table 7. Linear regression coefficient of BMI on Cormic index among thirteen occupational groups of Central India

Occupational group	R^2	β	SE	t	df	F	p
Agriculture	0·038	23·1	3·7	6·3	1006	39·6	*
Animal husbandry	0·050	28·9	4·7	6·1	699	37·1	*
Blacksmith	0·190	53·4	15·9	3·4	49	11·3	†
Fishing	0·005	7·7	16·5	0·5	49	0·2	ns
Labourer	0·006	8·7	15·0	0·6	56	0·3	ns
Oil merchant	0·042	26·3	3·7	7·1	1155	51·0	*
Potter	0·015	8·8	3·5	2·5	412	6·4	*
Priest	0·020	21·8	4·6	4·8	1113	23·0	†
Shoemaker	0·019	13·7	3·0	4·5	1061	20·5	*
Vegetable cultivator	0·012	7·9	4·5	1·8	252	3·1	ns
Warrior	0·047	28·9	4·9	5·9	700	34·6	*
Weaver	0·127	42·9	16·2	2·6	49	7·0	†
Wine merchant	0·001	− 6·5	25·5	− 0·3	49	0·1	ns
Total	0·033	21·2	1·4	15·0	6661	226·3	*

*p<0·001; †p<0·05.
ns, not significant.

Table 8. Linear regression analysis of BMI on age using raw data, and mean of BMI for age, for different age groups

Age group	R^2	β	SE	t	df	F	p
Raw data							
<25	0·013	0·094	0·022	4·2	1395	17·7	*
26–40	0·002	0·023	0·009	2·6	3175	7·2	†
41–60	0·000	0·003	0·011	0·2	2036	0·0	ns
61+	0·007	− 0·072	0·119	− 0·6	53	0·3	ns
Total (18–70)	0·003	0·011	0·002	4·4	6662	19·6	*
Mean of BMI for age data							
18–40	0·576	0·042	0·008	5·3	22	28·5	*
41–70	0·020	− 0·014	0·019	− 0·7	28	0·5	ns
Total (18–70)	0·020	0·007	0·006	1·0	51	1·0	ns

*p<0·001; †p<0·05.
ns, not significant.

course of evolution when agriculture and pastoralism started, after the hunting and food-gathering stage, society was stratified, and resources limited to the dominant few. The Industrial Revolution further nurtured the process of stratification. The establishment of democratic states and the rise of communalism in the 19th century slightly twisted this stratified form of society, and India still has a deep-rooted and intact caste system, which provides certain privileges to some castes (e.g. Brahmin) and many restrictions on lower castes (e.g. scheduled castes). The traditional occupation of an individual is decided by birth. In this study an attempt has been made to investigate how the body is shaped by occupation, which influences level of nutrition among 22 castes of Central India who practise thirteen different traditional occupations. On the basis of BMI it can be derived that most of the adult males in the studied populations are lean. Ganguly (1977) also reached the same conclusion on the basis of Pignet's constitutional index. He stated that the Indian body build is noticeably slender. Further, he stated that the weight of Indians is one of the lowest in the world, both absolutely and in relation to stature. In the present investigation a higher proportion (51·16%) of the studied population were found to be chronic energy deficient (CED), corroborating Ganguly's 1977 findings.

With regard to the lower value of BMI, a number of studies have suggested a higher mortality rate in individuals with a low BMI (Waaler, 1984; Harris *et al.*, 1993). It has been seen that the mortality rate is higher in men with a BMI below 16·0 compared with those with a BMI>18·5 (Reddy, 1991). On the other hand, Shetty (1984) mentioned that male Indian labourers with a BMI below 17·0 are physically fit according to standard texts, though their physical capacity is not known. Further, Henry (1994) suggested that a BMI below 13 in adult males and 11·0 in adult females may be considered the lowest thresholds of mortality risk. Of course, it has been reported that the relationship between BMI and mortality is U-shaped (Troiano *et al.*, 1996). It has been recognized by many observers (Roberts, 1953; Newman & Munro, 1955; Dobzhansky, 1962; Schreider, 1968) that a lean linear body build with low weight to surface area ratio is one of the general characteristic of the people living in tropical and sub-tropical climates. This may be one of the probable reasons behind the high presence of individuals with CED grade I in most of the populations in Central India. Whereas Satyanarayana *et al.* (1991) have shown that the difference in mortality rates between adult males with CED grade I and normal CED is only about 1% per year, it increases rapidly when the BMI is below 17. Thus in view of the above findings, it can be said that the apparently healthy individuals with CED grade I in the present study may be thin but are physically active and healthy. However, further intensive investigation into these populations is required, because the BMI as a measure of the CED should be analysed along with other aspects such as morbidity and the health status of the population. But it is clear from the present findings that the caste groups with poor means of livelihood or who are traditionally labourers are most affected. The better nutrition status of priests, wine merchants, agriculture farmers and warriors is corroborated by their inherent better means of livelihood and higher social and economic status; and the effect of the socioeconomic milieu has been found to persist throughout childhood. Mukherjee (1951) and Datta-Banik *et al.* (1970) have reported that children from relatively high social classes are heavier and taller than those from lower classes. There has been much research indicating a strong relationship between poverty or socioeconomic status and child growth (e.g. Bogin *et al.*, 1989; Cameron, 1992; Crooks, 1994; Islam *et al.*; 1994; Johnson & Low, 1995; Singh & Harrison, 1997). In the same way Crooks (1999) also reported poor growth and nutritional status among the children from high poverty areas of eastern Kentucky. Therefore, this discussion leads to the conclusion that among the poorer

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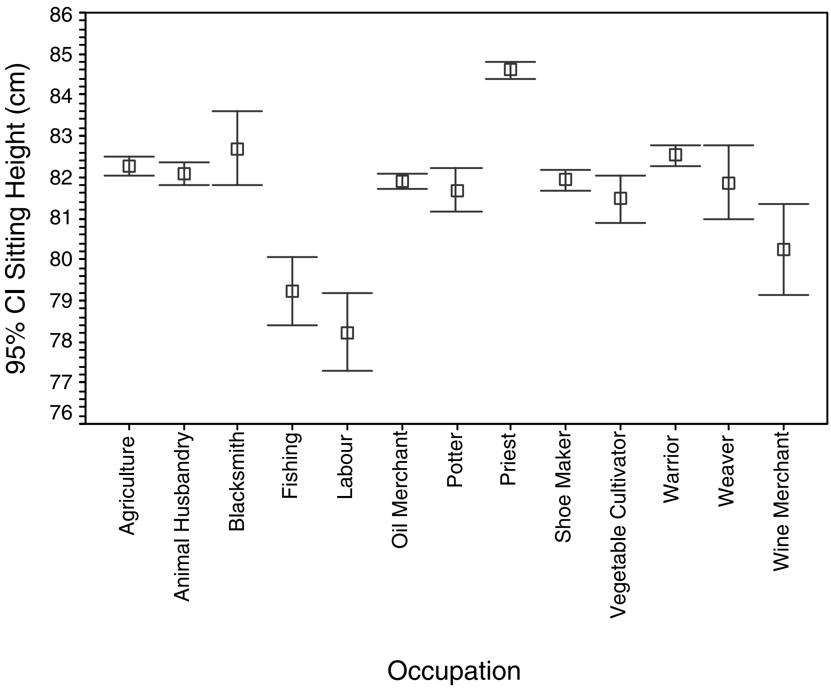

Fig. 5. Error bar chart showing 95% confidence intervals of mean sitting height among individual groups as well as comparison of means between different occupational groups.

sections of a population, the intake of food is generally poor because of poverty. Constant poor intake of food leads to adaptation to malnutrition during critical stages of growth and is likely to induce a permanent reduction in body size, which in turn will reduce the energy needs of the body.

Among the least affected populations is the fisherman. However, it is difficult to explain why the nutritional status is better among a population that is traditionally based on fishing for their subsistence, than the caste group practising more flexible and luxurious occupations such as the priesthood, warrior, business (wine merchant), agriculture and so on. There are two possible explanations. The first is their dietary habit and life style; a significant proportion of their foodstuff comes from aquatic animals such as fish, which are quite nutritious, and simultaneously, their life style is quite sedentary. The second explanation is based on their body structure. Norgan (1994) has suggested that BMI is correlated with sitting height, or BMI is lower in those populations with higher sitting height. As shown in Fig. 5, the mean sitting height is significantly low among fishermen. Again it is contradictory as the lowest mean sitting height is found among labourers, and among them the level of nutrition is worst. In this context it should be noted that Khongsdier (2001) also reported better nutritional status among north-east Indian tribal populations as compared with Hinduized and caste populations of higher social status, such as Brahmin, of the same region. A third explanation for the better nutritional status of fishermen lies in

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Ganguly's (1977) statement. He is of the opinion that primitive societies are away from the stratification of higher and lower socioeconomic classes of civilized societies, where these classes are usually characterized by different standards of living that have a strong relationship with their level of nutrition.

Nevertheless, although it is believed that BMI is largely independent of ethnic or genetic variation, its correlation with Cormic index (CI) may have certain implications as the latter may be subject to both genetical and environmental influences. In this regard it should be noted that sitting height is largely determined by genetics. It has been reported that BMI is correlated with sitting height, or that BMI is lower in those populations with a higher sitting height (Norgan, 1994; Strickland & Tuffrey, 1997; Khongsdier, 2001). However, in the present investigation the contrary was found. Sitting height is found to be significantly higher for priests or Brahmin, and these groups also have a higher BMI. Among the tribes of Maharastra State of India, Adak *et al.* (2006b) also found the same contradiction. For further elucidation, regression analysis was done keeping BMI as the dependent variable and Cormic index as independent variable for individual occupational groups. This showed that there is no uniformity in correlation of BMI and Cormic index across the thirteen occupational groups. As the correlation is positive and significant in nine out of thirteen groups, this leads to the conclusion that the BMI is dependent on sitting height as well as Cormic index, as postulated by previous research (Norgan, 1994; Strickland & Tuffrey, 1997; Khongsdier, 2001).

Briefly, the differences in BMI between castes as well as occupational groups in this study are not merely due to nutrition, but rather they are due to other environmental (e.g. occupational privileges and stress) and genetic factors as well. This can also be cited as a classical example of adaptation by permanent reduction in body size among the poorer sections of a population, viz. labourers (traditionally); among these the intake of food is generally poor because of poverty; so for generations they have been in the process of adaptation to malnutrition during critical stages of growth as well as adulthood, which ultimately resulted in a permanent reduction in body size, to reduce the energy needs of the body. People with a small body size can survive more easily on low-calorie diets and they will have some adaptive advantage in circumstances when scarcity conditions prevails (Frisancho *et al.*, 1970, 1973; Stini, 1972; Garn *et al.*, 1972; Thomas, 1972; Malcolm, 1969, 1970). Although practising a particular traditional occupation by a caste group is sufficient to explain the scarcity condition, in a country like India where, since conception of society, the generations of the masses have suffered from social, economic and political disparity, the gene pool has persisted in the same prevailing situation. The distribution of natural resources is unequal and limited to a sort of dominant caste or occupational group. So, in this context, the scarcity condition can be further illustrated by landholding. This is illustrated in Fig. 8, where no or little landholding prevails in a large proportion of the population, in chronic energy deficient categories. In other words, as landholding increases the proportion of the population with a poor level of nutrition (i.e. BMI$<18{\cdot}5$) decreases.

Another explanation is that the caste group who are traditionally labourers, do not require bigger and heavier bodies as such a body build is not quite compatible with their job. The lifting and carrying of heavy weights is easier with a short stature

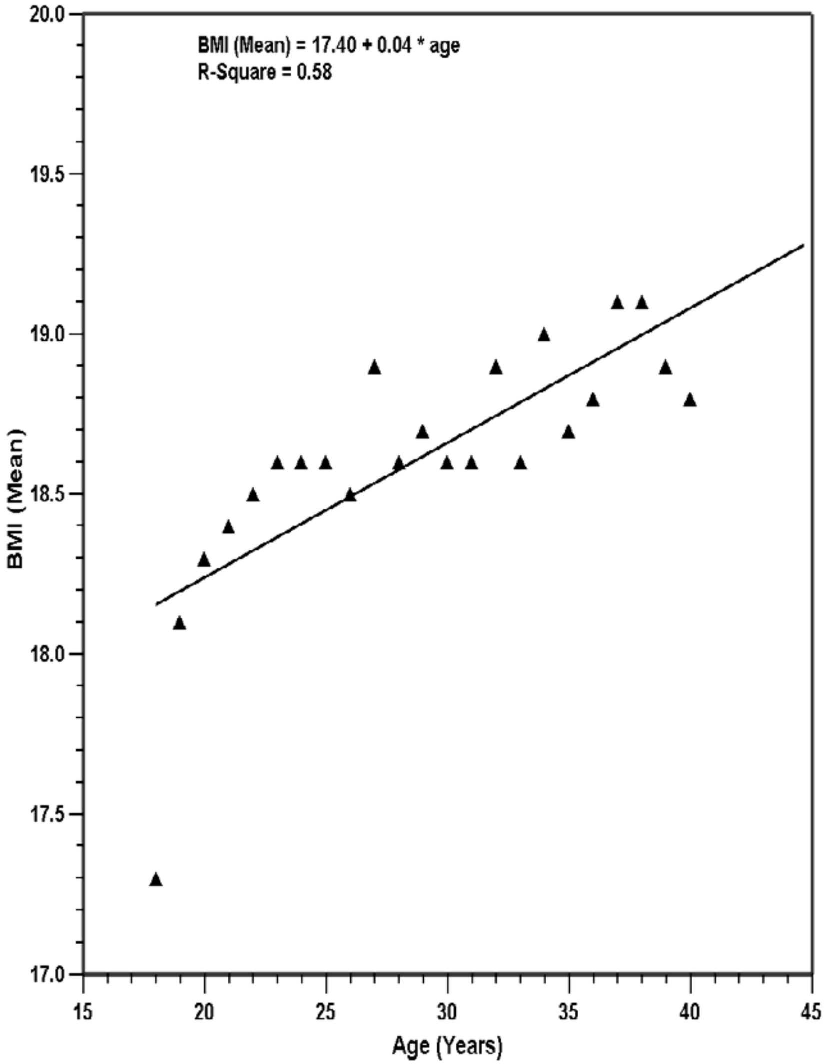

Fig. 6. Scattered plot diagram showing correlation and regression between mean BMI and age among Central Indian population 18–40 years of age.

and thin body build than with a taller and heavy one. Malville (1999) also concluded that one of the reasons why Nepali porters are able to carry heavy loads (>150% of body weight) is their small and thin body build (BMI<18·5). The productivity of a thin body build was also established among Bangladeshi tea pluckers (Gilgen & Mascie-Taylor, 1999) and Indian labourers (Shetty, 1984). However, little is known about endurance capacity in such thin individuals; and the issue remains highly contentious (Pelto & Pelto, 1989; Payne, 1992) and needs further investigation.

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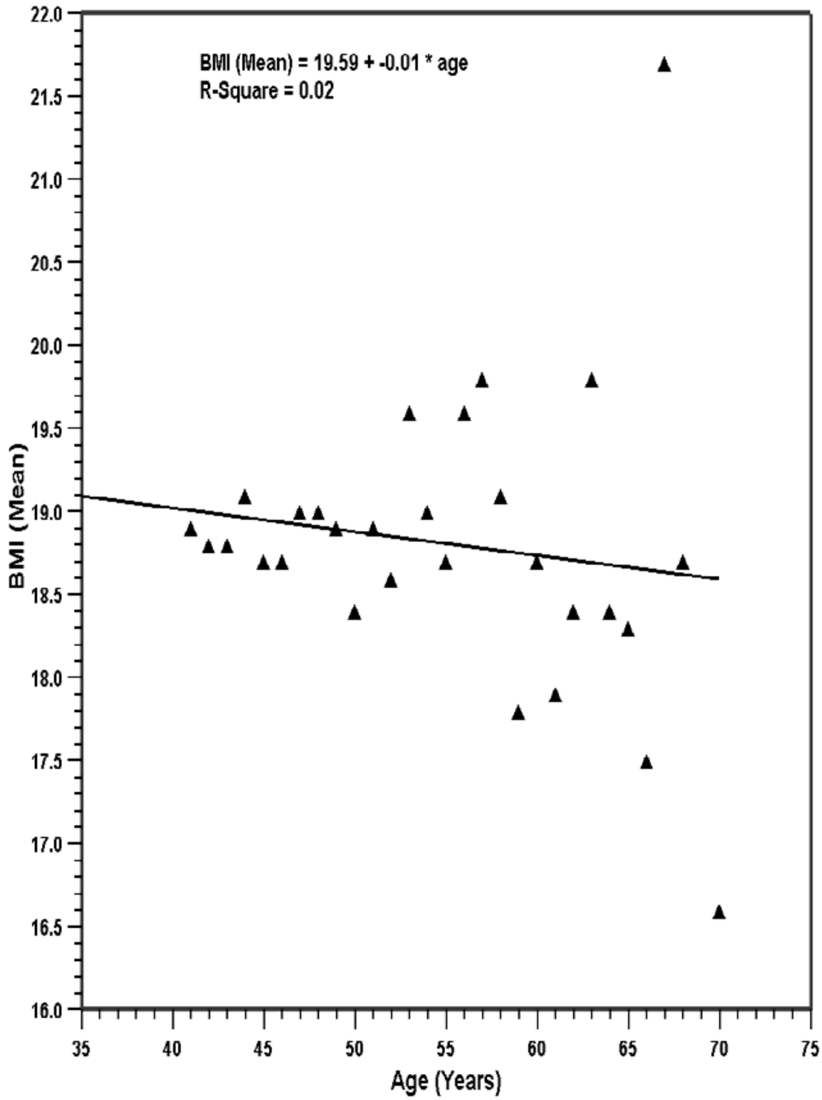

Fig. 7. Scattered plot diagram showing correlation and regression between mean BMI and age among Central Indian population 41–70 years of age.

Further, on the basis of studies on athletes, Tanner (1964) concluded that the nature and diversity of tasks to be performed in any specific economy will determine size and shape and this corroborates the present findings. Individuals of shorter stature and slender build are also quicker and faster.

In this way each occupational group has a different job profile so their body size and shape is transformed as per their job requirement as well as the socioeconomic status. For example, shoemakers have a comparatively sedentary job profile so their

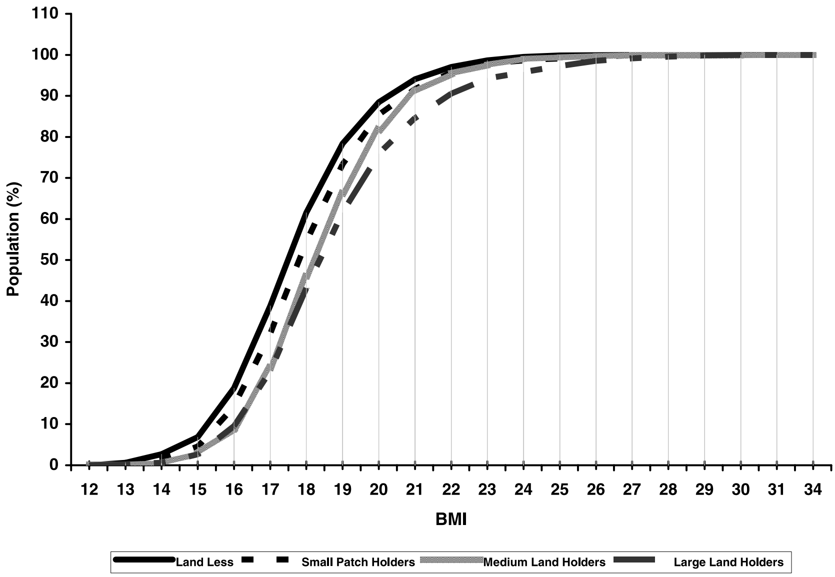

Fig. 8. Cumulative frequency distribution of adult BMI as per landholding among Central Indian populations.

stature is moderate, but due to poor socioeconomic conditions their mean BMI is significantly lower than others. As they are untouchables their morale is always down.

Beyond that, the present investigation establishes that the BMI has a positive correlation with age, particularly up to 40 years. The maximum growth of height in human beings is achieved within 20 years of age. The increment in height after 25 years has hardly been reported, or there is negligible increment after 25 years of age, but weight gain continues up to 40 years of age, which results in successive increments of BMI up to that age. After 40 years, a gradual decline in weight begins, because of a gradual loss of immunity and increment in various morbid conditions. Although until now, it has not been established that after 40 years of age BMI starts to gradually decline, because it could not be proved statistically, and this needs further investigation.

Hence, the present study postulates that the variation in BMI and Cormic index among the Central Indian population is due to the peculiar kind of socioeconomic structure of the country, where caste, traditional occupation and landholding are responsible for physical variation among various endogamous groups. At the same time, on the basis of correlation of age and BMI, it can be concluded that the Central Indian male is leading a healthy life, by and large, up to 40 years of age.

References

Adak, D. K., Gautam, R. K., Bharati, S., Gharami, A. K., 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.

Adak, D. K., Gautam, R. K. & Gharami, A. K. (2006b) Assessment of nutritional status through body mass index among adult males of 7 tribal populations of Maharashtra, India. *Malaysian Journal of Nutrition* **12**(1), 23–31.

Alland, A. J. (1975) Adaptation. In Siegel, B. J. (ed.) *Annual Review of Anthropology.* Annual Reviews Inc., Palo Alto, CA, Vol. 4, pp. 59–73.

Ayala, F. J. (1968) Genotype, environment and population numbers. *Science* **162**, 1453–1459.

Bailey, K. V. & Ferro-Luzzi, A. (1995) Use of body mass index of adults in assessing individual and community nutritional status. *Bulletin of the World Health Organization* **73**(5), 673–680.

Baker, P. T. (1960) Climate, culture and evolution. *Human Biology* **32**, 316.

Baker, P. T. (1966) Human biological variation as an adaptive response to the environment. *Eugenics Quarterly* **13**, 81–91.

Basu, A., Mukherjee, D. P., Dutta, P. C., Bose, D. K., Basu, M. P., Ghosh, G. C., Kumar, G. D. & Huq, F. (1994) *All India Anthropometric Survey: North Zone Basic Anthropometric Data, Vol. I.* Anthropological Survey of India, Madhya Pradesh, Calcutta.

Bharati, P. (1989) Variation in adult body dimensions in relation to economic condition among the Mahishyas of Howrah district, West Bengal, India. *Annals of Human Biology* **16**, 529–541.

Bogin, B., Sullivan, T., Hauspie, R. & MacVean, R. B. (1989) Longitudinal growth in height, weight and bone age of Guatemalan Ladino and Indian schoolchildren. *American Journal of Human Biology* **1**, 103–113.

Cameron, N. (1992) The monitoring of growth and nutritional status in South Africa. *American Journal of Human Biology* **4**, 223–234.

Crooks, D. L. (1994) Relationship between environment and growth for Mopan children in Belize. *American Journal of Human Biology* **6**, 571–584.

Crooks, D. L. (1999) Child growth and nutritional status in a high-poverty community in Eastern Kentucky. *American Journal of Physical Anthropology* **109**(1), 129–142.

Datta-Banik, N. D., Krishna, R., Mane, S. I. S., Raj, L. & Taskar, A. D. (1970) A longitudinal study of physical growth of children from birth up to 5 years of age in Delhi. *Indian Journal of Medical Research* **58**, 135–142.

Dobzhansky, T. (1962) *Mankind Evolving: The Evolution of Human Species*. Yale University Press, New Haven and London.

Dobzhansky, T. (1968) Adaptedness and fitness. In Lewontin, R. (ed.) *Population Biology and Evolution: Proceedings of an International Symposium.* Syracuse University Press, Syracuse, New York, pp. 109–121.

Dubos, R. (1965a) *Man Adapting.* Yale University Press, New Haven.

Dubos, R. (1965b) Humanistic biology. *American Scientist* **53**, 419.

Eagan, C. J. (1963) Introduction and terminology. *Federation Proceedings* **22**, 930–932.

Eveleth, P. B. & Tanner, J. M. (1990) *Worldwide Variation in Human Growth*, 2nd edn. Cambridge University Press, Cambridge.

Ferro-Luzzi, A., Sette, S., Franklin, M. & James, W. P. T. (1992) A simplified approach of assessing adult chronic energy deficiency. *European Journal of Clinical Nutrition* **46**, 173–186.

Folk, G. E. JR (1966) *Introduction to Environmental Physiology.* Lea and Febiger, Philadelphia.

Frisancho, A. R., Garn, S. M. & Ascoli, W. (1970) Childhood retardation resulting in reduction of adult body size due to lesser adolescent skeletal delay. *American Journal of Physical Anthropology* **33**, 325–336.

Frisancho, A. R., Sanchez, J., Pallardel, D. & Yanez, L. (1973) Adaptive significance of small body size under poor socio-economic conditions in southern Peru. *American Journal of Physical Anthropology* **39**, 255–261.

Ganguly, P. (1977) The problem of human adaptation: An overview. *Man in India* **57**(1), 1–22.

Ganguly, P. (1979) Progressive decline in stature in India: A study of sixty population groups. In Stini, M. A. (ed.) *Physical and Morphological Adaptation and Evolution.* World Anthropological Series, Mouton, The Hague, pp. 315–317.

Garn, S. M., Nagy, J. M., Poznanski, A. K. & McCann, M. B. (1972) Size reduction associated with brachymesophalangia-5: a possible selective advantage. *American Journal of Physical Anthropology* **37**, 267–270.

Gautam, R. K. (2007) Biosocial covariates of adult male body mass index in Central India. *Journal of Biosocial Science* **39**, 875–893.

Gautam, R. K., Adak, D. K., Gharami, A. K. & Datta, T. (2006) Body mass index in Central India: Inter district variation. *Anthropologischer Anzeiger* **64**(4), 447–461.

Ghosh, R., Das, P. K. & Bharati, P. (2001) Health and nutritional status of Ho preschool children of Orissa. *Journal of Human Ecology* **12**, 109–113.

Gilgen, D. & Mascie-Taylor, C. G. N. (1999) Intestinal helminth infections and labour productivity of female tea pluckers in Bangladesh. *Annals of Human Biology* **26**, 581.

Government of Madhya Pradesh (1997) Part I of the Gazette, notification No. F. 85-XXV-4–84 dated 26th December 1984. In *Gazette of Madhya Pradesh*, No. 205, Bhopal, Saturday 5th April 1997.

Harris, T. B., Ballard-Barbasch, R., Madan, J., Makuc, D. M. & Feldman, J. J. (1993) Overweight, weight loss and risk of coronary heart disease in older women. The NHANES I follow-up study. *American Journal of Epidemiology* **137**, 1318–1327.

Henry, C. J. K. (1994) Variability in adult body size: uses in defining the limits of human survival. In Ulijaszek, S. J. & Mascie-Taylor, C. G. N. *Anthropometry: The Individual and the Population.* Cambridge University Press, Cambridge, pp. 117–129.

Hulse, F. S. (1960) Adaptation, selection and plasticity in ongoing human evolution. *Human Biology* **32**, 63–79.

Islam, M. A., Rahman, M. M. & Mahalanabis, D. (1994) Maternal and socioeconomic factors and the risk of severe malnutrition in a child: a case control study. *European Journal of Clinical Nutrition* **48**, 416–424.

James, W. P. T., Ferro-Luzzi A. & Waterlow, J. C. (1988) Definition of chronic energy deficiency in adults. *European Journal of Clinical Nutrition* **42**, 969–981.

Johnston, F. E. & Low, S. M. (1995) *Children of the Urban Poor: The Socio-Cultural Environment of Growth, Development and Malnutrition in Guatemala City.* Westview Press, Boulder, CO, p. 189.

Khongsdier, R. (1997) The War Khasi of Meghalya: Implications of variation in adult body dimensions. *Journal of Human Ecology* (Special Issue) **6**, 299–305.

Khongsdier, R. (2001) Body mass index of adult males in 12 populations of Northeast India. *Annals of Human Biology* **28**, 374–383.

Khongsdier, R. (2002) Body mass index and morbidity in adult males of the War Khasi in Northeast India. *European Journal of Clinical Nutrition* **56**, 484–489.

Lasker, G. W. (1969) Human biological adaptability: The ecological approach in physical anthropology. *Science* **166**, 1480–1486.

McCutcheon, F. H. (1964) Organ systems in adaptation: the respiratory system. In Dill, D. B., Adolph, E. F. & Wilber, C. G. (eds) *Handbook of Physiology,* Vol. 4: *Adaptation to the Environment.* American Physiological Society, Washington DC, pp. 167–191

Malcolm, L. A. (1969) Growth and development of the Kaiapit children of the Markham valley, New Guinea. *American Journal of Physical Anthropology* **31**, 39–51.

Malcolm, L. A. (1970) Growth and development of the Bundi child of the New Guinea Highlands. *Human Biology* **42**, 293–328.

Malville, N. (1999) Porters of eastern Hills of Nepal: Body size and load weight. *American Journal of Human Biology* **11**, 1–11.

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

Mazess, R. B. (1975) Human adaptation to high altitude. In Damon, A. (ed.) *Physiological Anthropology*. Oxford University Press, New York, pp. 167–209.

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

Mukherjee, R. (1951) A study on difference in physical development by socio-economic strata. *Sankhya* **11**, 47–56.

Naidu, A. N. & Rao, N. P. (1994) Body mass index: a measure of nutritional situational situation in Indian populations. *European Journal of Clinical Nutrition* **48** (Suppl. 3), 131–140.

Newman, R. W. & Munro, S. H. (1955) The relation of climate and body size in US males. *American Journal of Physical Anthropology* **74**, 385–392.

Norgan, N. G. (1994) Relative sitting height and the interpretation of body mass index. *Annals of Human Biology* **21**, 79–82.

Payne, P. (1992) Assessing undernutrition: The need for a reconceptualization. In Osmani, S. (ed.) *Nutrition and Poverty.* Oxford University Press, Oxford.

Pelto, G. & Pelto, P. (1989) Small but healthy? An anthropological perspective. *Human Organisation* **48**, 11–15.

Prosser, C. L. (1958) General summary: the nature of physiological adaptation In Prosser, C. L. (ed.) *Physiological Adaptation.* American Physiological Society, Washington DC, pp. 167–180.

Prosser, C. L. (1964) Perspectives of adaptation: theoretical aspects. In Dill, D. B., Adolph, E. F. & Wilber, C. G. (eds) *Handbook of Physiology,* Vol. 4, *Adaptation to the Environment.* American Physiological Society, Washington DC, p. 1125.

Reddy, B. R. (1998) Body mass index and its association with socioeconomic and behavioural variables among socioeconomically heterogeneous populations of Andhra Pradesh, India. *Human Biology* **70**, 901–917.

Reddy, V. (1991) Body mass index and mortality rates. *Nutrition News* (National Institute of Nutrition, Hyderabad) **12**(1).

Roberts, D. F. (1953) Body weight, race and climate. *American Journal of Physical Anthropology* **11**, 533–558.

Rolland-Cachera, M. F. (1993) Body composition during adolescence: methods, limitations and determinants. *Hormone Research* **39** (Suppl. 3), 25–40.

Satyanarayana, K., Rao, S. S., Radhiah, G. & Reddy, V. (1991) Body mass index and mortality rates. *Nutrition Reviews* (National Institute of Nutrition, Hyderabad) **12**.

Schreider, E. (1968) Ecological rules, body-heat regulation, and human evolution. In Bresler, J. B. (ed.) *Environments of Man*. Addison-Wesley, Massachusetts, pp. 55–66.

Shetty, P. S. (1984) Adaptive changes in basal metabolic rate and lean body mass in chronic undernutrition. *Human Nutrition: Clinical Nutrition* **38**C, 443–451.

Shetty, P. S. & James, W. P. T. (1994) *Body Mass Index: A Measure of Chronic Energy Deficiency in Adults.* FAO Food and Nutrition Paper 56, Rome.

Singh, L. P. & Harrison, G. P. (1997) The impact of caste on the growth of male Sikh in Punjab, India. *Annals of Human Biology* **24**, 131–139.

Stini, W. A. (1972) Malnutrition, body size and proportion. *Ecology of Food and Nutrition* **1**, 121–126.

Strickland, S. S. (2002) Functional consequences of adult malnutrition in developing countries: A review. *Journal of Physiological Anthropology* **21**(1), 1–9.

Strickland, S. S. & Tuffrey, V. R. (1997) *Form and Function: A Study of Nutrition, Adaptation and Social Inequality in Three Gurung Villages of the Nepal Himalayas.* Smith-Gordon, London.

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Tanner J. (1964) *The Physique of the Olympic Athelete*. University Press, Cambridge.
Thomas, R. B. (1972) Human adaptation to a high Andean energy flow system. PhD Thesis, Pennsylvania State University, University Park, Pennsylvania.
Troiano, R. P., Frongillo, E. A., Sobal, L. & Levitsky, D. A. (1996) The relationship between body weight and mortality: a quantitative analysis of combined information from existing studies. *International Journal of Obesity and Related Metabolic Disorders* **20**, 63–75.
Ulijaszek, S. J. & Huss-Ashmore, R. (1999) *Human Adaptability: Past, Present, and Future*. Oxford University Press, New York.
Visweswara Rao, K., Balakrishna, N. & Shatrugna, V. (1995) Variation in forms of malnutrition in well-to-do adults and the associated factors. *Man in India* **75**, 241–249.
Visweswara Rao, K., Balakrishna, N., Thimmayama, B. V. S. & Rao, P. (1990) Indices and critical limits of malnutrition for use among adults. *Man in India* **70**, 351–367.
Waaler, H. T. (1984) Height, weight and mortality – the Norwegian experience. *Acta Medica Scandinavica* **679** (supplement), 556.
Waterlow, J. C. (1990) Nutritional adaptation in man: general introduction and concepts. *American Journal of Clinical Nutrition* **51**, 259–263.
WHO (1990) *Diet, Nutrition, and the Prevention of Chronic Disease*. WHO Technical Report Series No. 797. World Health Organization, Geneva.