BODY COMPOSITION AND NUTRITIONAL STATUS AMONG THE AO ADULTS

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DECLARATION

I, **Temsutola**, hereby declare that the subject matter of this thesis entitled, "Body Composition and Nutritional Status among the Ao Adults" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the North Eastern Hill University for the degree of Doctor of Philosophy in Anthropology.

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Temsutola

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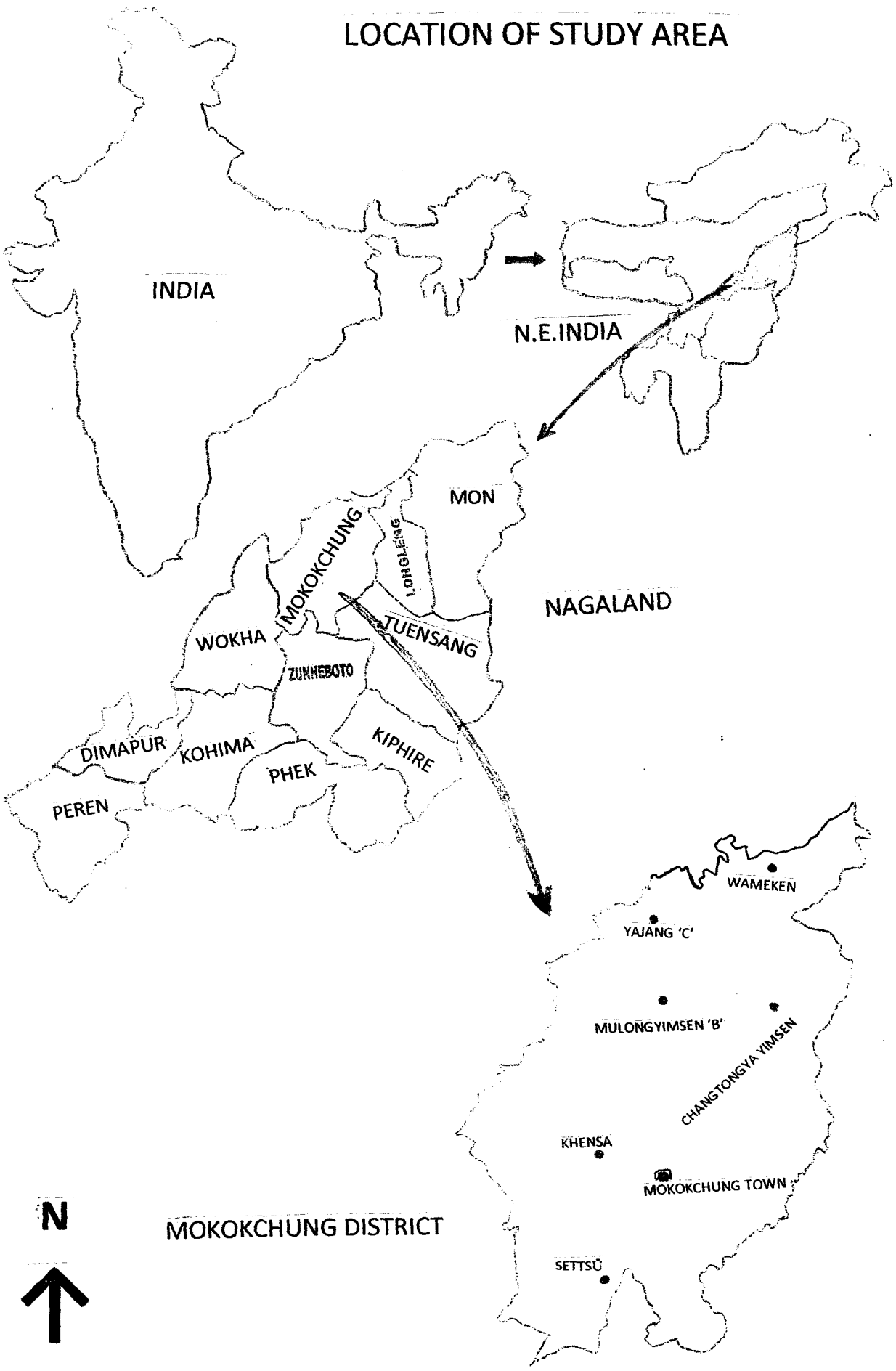
LOCATION OF STUDY AREA
INDIA
N.E.INDIA
MON
MOKOKCHUNG
LONGLENG
NAGALAND
WOKHA
JUENSANG
ZUNHEBOTO
DIMAPUR
KOHIMA
PHEK
KIPHIRE
PEREN
WAMEKEN
YAJANG 'C'
MULONGYIMSEN 'B'
CHANGTONGYA YIMSEN
KHENSA
MOKOKCHUNG TOWN
SETTSÜ
N
MOKOKCHUNG DISTRICT

CHAPTER-I

INTRODUCTION

Body composition is defined as "the make-up of the body in terms of the absolute and relative amounts of adipose tissue, muscle mass, skeletal mass, internal organs and other tissues" (Bogin, 1999). It may also be defined as the proportional amount of different body components in terms of water, masses, bones and tissues relative to the total body mass or body weight. In body composition research, body mass is considered as the sum of all components at each of the five levels namely, atomic, molecular, cellular, tissue-organ and whole-body (Wang *et al.*, 1992). This five-level model is considered as the central model in the study of body composition. The interest is at the molecular level, because a number of models are created that ranges from two to six components (Shen *et al.*, 2005). The earliest attempt for describing body composition and the most common method today is the two-component model that includes Fat Mass (FM) and Fat Free Mass (FFM). The unquestioning popularity of this method is because of the apparent simplicity, speed and low cost techniques for large field studies and therefore it is one of the most widely applied models in body composition research (Norgan, 2005). The two-component model is also used in the field of clinical nutrition for over four decades (Pietrobelli *et al.*, 2001). Models that include three or more components are referred to as multicomponent models. In multicomponent models, FFM is further sub-divided into several components.

In general, body composition is divided into major components, namely, FFM and FM. FFM refers to "body mass minus ether-extractable fat, and hence includes the stroma of adipose tissue" (Forbes, 1987). Thus, FFM includes water, muscles, bones, minerals, proteins and other tissues of the body; whereas FM includes essential and energy stores or storage fat. Essential fat is part of body structure found in nervous tissue, bone marrow, cell membranes that are associated with reproductive organs in females (Gibson, 1990). The remaining fat is usually known as energy stores which waxes and wanes with changes in nutritional status and

other physiological conditions (Poskitt, 1995). About one-third of energy stores in adults are deposited subcutaneously or externally.

Nevertheless, the main interest is to understand the relative proportion of body fat or FM to the total body mass of a person because FM has many medical and nutritional implications. The relationships among body weight, obesity and health are mediated by the increase in protein production, which is the metabolic characteristic of the Adipose Tissue (AT) and in turn results in several health problems (Sardinha and Teixeira, 2005). AT is a specialized connective tissue of loose lipid-filled cells or adipocytes, which functions as the major storage site for fat in the form of triglycerides (Albright and Stern, 1998). Excess body fat may lead to obesity and increases the risk of getting many diseases. On the other hand, inadequate body fat is indicative of deficiency in energy stores, which is often associated with morbidity and mortality (James *et al.*, 1988). In sports, excess body fat hinders performance because it does not contribute to muscular force production, and it is an additional weight that requires energy to move about.

The study of body composition has its origin about 440 BC when Hippocrates postulated his idea about the four components of human body (skeletal, muscle, fat and liquid). The mid-19th and early 20th centuries saw the beginning of the modern era of body composition research, when some important conceptual advances are prepared (Shen *et al.*, 2005). By the 1930s, body composition research has rapidly gained importance with the introduction of new sophisticated ideas and concepts for measuring body mass. Nowadays, it has become a very important field of research in Biological Anthropology and Medical Sciences and Sports. There are various methods for measuring and estimating FM and FFM. The common methods include anthropometry (especially skinfold thickness), bioelectrical impedance (i.e., an electrical analyser by which an electric resistance of FFM can be measured), X-rays, ultrasound, water displacement methods, computed axial tomography (CAT), magnetic resonance imaging (MRI), etc. Anthropometry, which includes measurements of body weight, height, body mass index (BMI), mid upper arm circumference (MUAC) and skinfold thickness, and bioelectrical analysis (BIA) are the most widely used methods for measuring body composition (Norgan, 2005). The measurement of body composition is essential for studying human variation and adaptation, and it is being used increasingly in the assessment of growth and nutritional status, fitness, work capacity, disease and its treatment (Norgan, 1995).

One of the major interests of current research on body composition is the health problems of obesity, or an excess body fat due to over-nutrition, which has been declared as an epidemic in developed countries (WHO/FAO, 2003). In country like United States, obesity is one of the leading causes of death and thereby has a large impact on public health (Stein and Colditz, 2004; Grundy, 2004). Health risk diseases are the consequence of obesity. Although under-nutrition remains a major health problem in many developing countries, obesity is also emerging with the improvement in socio-economic condition and increasing urbanization (Popkin, 1998, 2002). Many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing urbanization, changes in standards of living, dietary patterns and occupational work patterns are the key factors to risks of obesity and associated morbidity, such as diabetes mellitus, cardiovascular disease, hypertension and stroke, osteoporosis, and some forms of cancer (WHO/FAO, 2003). Obesity is not only a problem among adults but it is also very common among children. Studies have shown that there is a high prevalence of pediatric or childhood obesity in both developed and developing countries (Reilly *et al.*, 2002; Sung *et al.*, 2002; Riberio *et al.*, 2003).

In India, most of the body composition studies are concerned with the problem of under-nutrition, although there is evidence of socio-economic and nutrition transition that is likely to increase the epidemic of chronic diseases and obesity, particularly in the urban areas (Rao, 2001; Shetty, 2002). There is also lack of specific population information about factors associated with obesity and its associated morbidity, except for some studies (Misra *et al.*, 2001; Kaur and Morga, 2006; Sidhu and Prabhjot, 2007). Little is also known about the relationship between adult body composition and undernutrition, except those studies carried by Shetty (1984) and Ferro-Luzzi *et al.* (1997) in South India. There is also dearth of information on the relationship between body composition and morbidity patterns (Campbell and Ulijaszek, 1994; Khongsdier, 2002), although many studies were carried out on the relationship between body mass index and socio-economic conditions (Bharati, 1989; Reddy, 1998; Khongsdier, 2002, 2005a; Chakraborty *et al.*, 2006; Bose *et al.*, 2007). In addition, little works have been done on the relationship between body composition and body form (i.e., size and shape), except one study on the correlation between body mass index and cormic index in Northeast India (Khongsdier, 2001). Therefore, we undertook a study of

body composition and nutritional status in relation to biosocial factors among the Ao adults aged 18-70 years in the Mokokchung district of Nagaland.

OBJECTIVES OF THE STUDY

In view of the brief backdrop above and the overview of literature in Chapter – II, different research questions and objectives of study can be formulated with different research designs ranging from exploratory to explanatory types. In the present study, we are mainly concerned with the cross-sectional design of rural-urban differences that are by and large exploratory in nature to address the following objectives:

1. To assess the body composition and nutritional status of adults aged 18-70 years from rural and urban areas, using anthropometric indices and electrical impedance analysis.
2. To understand the relationship of body composition and nutritional status in relation to age, sex, anthropometric variables, self-reported morbidity, blood pressure and socio-economic variables.
3. To analyze the effects of socio-economic factors, such as physical activity, occupation, income, education and family size on adult body dimensions, nutritional status, self-reported morbidity and blood pressure.

STUDY AREA

"Nagaland" literally means the land of the Nagas. The Nagas belong to the mongoloid group of people occupying the present place. Nagaland state is situated in the northeastern part of India. The state lies between 26°20'N and 27°40' N latitude and 93°20'E and 95°15'E longitude. It covers an area of 16,579 square kilometers with a total population of 19, 88,636 (Census of India, 2001). Myanmar country and Arunachal Pradesh state bound Nagaland on the East, Assam state on the West and North and Manipur state on the South. Nagaland got its statehood on December 1st 1963. thereby becoming the Sixteenth State under the Indian Union. Kohima is the capital of Nagaland and is located at a height of about 1,444 meters above sea level. Nagaland is divided into eleven districts namely, Mokokchung, Dimapur, Kiphire, Kohima, Longleng, Mon, Peren, Phek, Tuensang, Wokha and Zunheboto. Nagaland state is the home of fifteen major tribes, they are, Angami, Ao, Chakhesang, Chang, Khiamniungan, Lotha, Konyak, Phom, Rengma, Sumi, Sangtam, Yimchungru, Zeliang, Kuki and Pochury. The variations in the physical feature of the land have given rise to a widely

varied range of flora and fauna. Exotic species of orchids, rhododendrons as well as wild fauna such as *Mithun*, tragopan and hornbill are found in the forests.

The present study was conducted among the Ao adults in the Mokokchung district of Nagaland. It became a full-fledged district in 1957.The district is situated in the north western part of the state, between 25°45' N and 26°30' N latitude and between 94°0'E and 94°45'E longitude. It covers an area of 1615 square kilometers with a total population of 2, 27,230 (Census of India, 2001). The district is divided into three development blocks, namely, Ongpangkong, Changtongya and Mangkolemba. Longleng and Tuensang districts bound Mokokchung on the East, Wokha district on the West, Assam state on the North and Zunheboto district on the South. Mokokchung Town is the district headquarters and it is located at a height of about 1,326 meters above sea level.

Mokokchung is the home of the Ao-Nagas. Besides the Ao tribe, a good number of other Naga tribes and also other communities reside in the district, especially in the district headquarter, Mokokchung town. Some of the Nagas who reside in this district include the Sumi, Lotha, Sangtam, Phom, Chang, Khiamniungan and Chakhesang, while those from other communities include the Nepalis, Biharis, Bengalis, Marwaris, Assamese, etc. All these different groups have taken residence in the district because of various socioeconomic reasons such as employment both in Central and State Governments, private institutions, as labourers, as businessmen and also because of marital reasons.

Topography

Mokokchung district occupy a territorial land of long unbroken ranges of hills. Geographically, the entire territory is divided into six ranges, namely, *Ongpangkong, Langpangkong, Asetkong, Changkikong, Japukong and Tsurangkong*. There are glens or valleys between these ranges. Two such valleys are *Changki* and *Tuli*. Mokokchung is comparatively less elevated. Nonetheless, there are wild chaos of spurs and ridges, deep gorges and steep terrains. The vertical corrosion or down-cutting through soft and loose geological strata by heavy rainfall have resulted in the formation of numerous valleys. The soil is a mixture of sandy loam and clay loam in the hills, and as it goes down towards the valleys, the soil is silt loam and clay loam. The soil is acidic in nature, and the average pH content varies from 5.61 to 5.83. Rampant deforestation, exploitation of land and prolonged erosion has made the soil barren and the hardest strata of the soil are exposed. Landslides occur more as a result of this, especially during heavy rainfall. The area is also affected by

minor shocks and occasional earthquakes. Important rivers are *Milak, Dikhu*, and *Tsurang*. There are two natural lakes, *Omoklushi* and *Yimyu Awatsung*. Natural minerals such as coal, iron, sand and sandstones, glass sand, petroleum, etc. are found in some pockets of the district.

Climate

The district, like the rest of the state enjoys a sub-tropical humid and temperate climate with monsoon as a dominating factor. It receives an average rainfall between 200 cm and 250 cm. The rainfall is at its maximum during the months of July and August or in other words, during the monsoon season. The lower ranges and valleys become swampy and foggy during rainy season. The temperature differs locally with the variation of altitude, whereby the low lying valleys are comparatively hot and humid. The average relative humidity is about 90 per cent. During summer, the temperature varies from 20°C to 38°C. While during winter it drops to 2°C. Longkhum village, located at a height of about 1,500 meters above sea level is the only inhabited place where frost falls during winter. As such the summers are mildly hot and winters are cold.

Flora

Mokokchung district has a well suited geographical position and climatic condition to support good natural flora and fauna. Vegetation falls under sub-tropical semi evergreen type. The forest floor is dense and covered with a variety of herbs and shrubs. However, the centuries old practice of *Jhum* cultivation by the people as well as the introduction of artificial fertilizers and inorganic farming have destroyed much of the valuable forests leading to soil erosion, thereby making the hilly land less porous to retain the rain water. Also, the extreme cold during the winter season result in drying up of the vegetations. Under these circumstances, both deciduous and tropical evergreen forests exist. Some of the important floras commonly found in this district are teak, alder, sal, *champa*, bonsom, hollock, *golmohar, chakranda,* etc. Plantations of fast growing tree species such as *golmohar, chakranda, Eucalyptus,* etc. are presently being planted in patches of land throughout the district. *Rhododendron* grows only in the forest of Longkhum village because of the higher altitude. A variety of tall grasses like bamboo, reeds and even ferns and orchids are also found. Seasonal fruits such as pear, plum, peach, passion fruit, jackfruit, cherry, mulberry, blackberry, gooseberry, papaya, grapes, oranges and banana are found abundantly both in the forests and in fields and garden. In the fields, besides paddy crop, a variety of vegetables and

tubers are cultivated. Some of which are, chilli, maize, brinjal, tapioca, bean, cabbage, cauliflower, carrot, sweet potato, potato, tomato, ginger and cucumber. Cash crops such as tea, coffee, sugarcane and rubber tree are also grown.

Fauna

As the major part of the district is covered by thick forest, a number of wild animals and birds are found. However, indiscriminate and illegal hunting of these animals have led many species to extinction. Animals that are found include wild boar, deer, Himalayan black bear, porcupine, tiger, python, elephant, monkey, jackal, fox, wild dog, wild cat, buffalo, *mithun*, toad, land tortoise, etc. Birds such as vulture, black partridge, grey partridge, eagle, jungle fowl, common pea fowl, owl, pigeon, hornbill, sparrow, spotted dove, etc. are found. Livestock plays a very important role especially for economic purposes. Goat, pig, buffalo, cattle and poultry are reared.

THE PEOPLE

Origin and Characteristics

The Ao people call themselves *Aor* which means, *going or gone* from the parent Chungliyimti village crossing over the Dikhu River. Chungliyimti Village is located in Sangtam-Naga area of Tuensang district. There is no specific evidence regarding the origin of the Ao tribe and it is still a matter of debate. According to a popular myth, the Aos are believed to have emerged out from six stones or *Longterok* at Chungliyimti. However, cultural traits indicate that they may have come from the South east in different succession of migration. Ao (1970), suggests that they first migrated towards north touching the outskirt of the present Chakesang area and entered Yimchung area, from which they went still northward through Sangtam area and reached Chungliyimti. According to Yonuo (1974), the Ao tribe comprised the second migratory wave of migrants, whose migration route is believed to be from Burma (Myanmar) through the Tangkhul, Chakhesang and Tuensang areas to the present Ao villages.

The Ao tribe belongs to Mongoloid race. Waddel (1900) reported that the Ao mean cephalic index (C.I.) is 80.11 and possess equal frequency of A and B genes according to the ABO blood group system. In his monograph, *the Ao Nagas*, Mills (1926) has described the general physical characteristics of the Ao people. According to him, the average height of men is about 5 feet and 8 inches, women being some 2 inches shorter. Their skin colour varies from light to dark brown. The face is broad with prominent cheek bones, low bridged

nose and broad nostrils, eyes are slanting and dark brown in colour, and hair type ranges from slightly straight to curled hair, with wavy hair as the prominent type. Their average cephalic index is 78.88 and average nasal index is 81.42. Their body is well proportioned and neither slight nor stocky. He further describes, "...the whole tribe gives one the impression of being well nourished." Thus, physically they are medium statured, with Mongoloid physical features such as light to dark brown skin colour, broad face, flat to medium broad nose, black hair colour, with dark brown and epicanthic folded eyes.

The Ao people are one of the dominant tribal groups in Nagaland. Presently, they are distributed in about 106 villages in the Mokokchung district (Census of India, 2001). Ao-O is the language of the Ao tribe. They speak the Tibeto-Burman language. Ao-O has two distinct dialects, which are Chungli and Mongsen. The Chungli dialect is the standard Ao dialect and as such it is used for all official communications. According to Ao (1999), this is because the first American missionaries settled in a Chungli-speaking village and introduced the Roman scripture for translating the Chungli dialect. However, the folksongs are preserved and transmitted through the Mongsen dialect. Major clans of Chungli are Pongener, Longkumer and Jamir, while major clans of Mongsen are Imchen, Longchar and Walling.

The Aos live is an egalitarian or classless society. The structure of the society is democratic in principle. A well articulated laws and customs govern the Ao social and domestic life. An Ao by birth inevitably becomes a member of the society. To be a part of the society means to be a member of a particular village. Therefore no matter in which place in the world he settles, he is by tradition a *bona fide* member of his clan and of his village. The Village Council or *Putu Menden* administers the respective village life. *Putu Menden* consists of the representatives of each clan. It looks after the welfare of the people, ensures security by maintaining friendly relations with the neighbouring villages. In fact, it is the sole duty of the *Putu Menden* to oversee the affairs of the village and to frame the rules and regulations.

Ao people follow the patrilineal system of society where lineage is traced from the male. Family is regarded as the most important social institution and it is a nuclear unit, where the father is the head of the family. Marriage is exogamous, in the sense that inter-clan marriage is prohibited. Therefore marriage among clan members is considered as incestuous and strict rules are laid down to the offenders. Marriage between cousins is even prohibited though they may belong to a different clan. Divorce or *bala*, is permissible, and it can be done for reasons such as incompatibility, adultery, barrenness, mutual dislike and impotency

(Das, 1994). Dowry or bride price is absent. In the Ao society, women do not play any important role in the social, political, religious and economic aspects. Nevertheless, although deprived of some fundamental rights, Ao women are always playing a significant partnership role and their contribution towards the well being of the society are always recognized and honoured (Aier, 1998). One unique character of Ao people is that an Ao woman retains her original clan name even though she marries to a man of another clan (Ao, 1999).

Moatsü and *Tsüngrem-mong* are the two major festivals of the Aos and they are celebrated to observe certain important stages in the yearly agricultural cycle. *Moatsü* is celebrated in the first week of May after the sowing is done in the fields. *Tsüngrem-mong* is celebrated in the first week of August or before harvesting. These festivals are observed to express their gratitude to the supreme God, for His blessing on their work. Such celebrations are occasions of singing, dancing and feasting by wearing their finest traditional costumes.

Occupation

Land and forest are the backbone of sustenance for the Ao tribe and forms the major source of economy. Originally land belongs to the clan. Therefore each clan member has a share of the clan land. Such land is not transferable and is inherited from one generation to the next. As a result of this land clan nexus, Ao people never face the problem of landlessness and therefore enjoys guaranteed hereditary rights to land and forests, which is ultimately linked with the kinship and descent groups (Das, 1994). However, lands are also owned by individuals. The main occupation of the Aos in rural area is agriculture, mainly practicing shifting or *jhum* cultivation. Terrace cultivation is also done in certain places such as in the foothills and valleys. Besides paddy, they grow a variety of vegetables in the field for consumption. Seasonal vegetables such as millet, maize, potato, sweet potato, bean, ginger. chilli, cucumber, pumpkin, bitter gourd, squash, tomatoes, mustard leaf, yam, etc. are grown along with the paddy in the field. Tea plantation in the foothills and valleys is presently a growing economy. Along with tea, seasonal fruits like orange, banana, pear, peach, passion fruit, etc, are grown for economic purposes. Apart from agriculture, the Aos engage themselves in handworks such as spinning and weaving, painting on cloth, pottery, woodwork, metalwork, stonework and basketry (Mills, 1926). These economic activities are still practiced by them.

Weaving is an important source of income and usually womenfolk are engaged in this work. Shawls and wrap around or *lungi* are woven with traditional motifs and designs.

Earlier, cotton was grown in the field and yarns were spun out of it to make the clothes. Nowadays the yarns are sold in the urban markets. Hand woven clothes are slowly disappearing as they are being replaced by modern weaving and sewing machines.

Creative wood works such as furniture, basket weaving and various handicrafts are made out of teak wood, bamboo and reeds. These are sold in the markets within and outside the district. Besides these, Aos are also engaged in various professions, both government and private sectors. Presently, many of the younger generations, who live in the town are also opting for private entrepreneurship by setting up modern restaurants and cybercafés, and a good number of shops, which sells groceries, household goods, electronics, cosmetics, foot wears and clothes.

Food habit

Rice is the stable food. The Aos are non-vegetarian. Pork, beef, mutton, chicken, fish and a variety of wild animals and birds are relished by them. Meat, especially pork, beef and fish are also smoked or dried in the fire-place. In a day, they consume two main meals, which is in the morning and in the evening. Meals include rice along with vegetables or meat. *Yam* vegetable is an essential source of food. The leaf, stalk and tuber are eaten. A traditional dish called *Anüshi* is made out of the *yam* leaves, which can be preserved throughout the year. Tender bamboo shoots are also another delicacy and this also can be preserved for a long period. It is both fermented and dried for consumption. Meat dishes are always seasoned either with *Anüshi*, fermented bamboo shoots or dried bamboo shoots, along with green chillies or dried chillies. Forest not only provides wild game but also a wide variety of tubers, roots, leafy vegetables and bamboo-shoots. They also domesticate and rear pigs, cattle, and chicken for the purpose of consumption as well as for economic purposes.

Local rice beer or *Yi* is still consumed by some people especially in the villages; although it is prohibited now. Tea is the most popular beverage. It is consumed with or without milk and sugar. Popular beverages such as soft drinks or cold drinks are increasingly in demand especially among the younger generations. Some Aos chew *tamul*, which is basically a concoction of betel leaf, areca nut, lime and dried tobacco leaves. Smoking of dried tobacco leaves, which is smoked through a wooden pipe, is still practiced by some people, particularly in the villages. Tobacco chewing, cigarette smoking and *paan* are also consumed by some, and these are readily available in the shops.

All the above mentioned activities are still practiced, although there has been a drastic change in tradition as a result of introducing a new religion, which is Christianity. They gave up their old belief and worship for the new one. A sense of consciousness to educate oneself and catch up with the rest of the world spread throughout the length and breadth of the Ao region. Dress code, economic status or way of living, profession and food habits underwent a drastic change as the people came in contact with the outside modern world. Market places in the town have opened an opportunity for the Ao people from different villages to come in contact with other communities. It has enabled them to trade their goods such as vegetables, wooden crafts, wild game, etc, for ready-made products and branded goods, especially food products. Traditional food habits are now more or less given up and are being replaced by protein rich processed food particularly in the town. In other words, the traditionally maintained Aos have emerged out of their social barriers and are mixing with the people of various communities. Migration from outside the district as well as within the district has been an important factor in this process. Aos staying in the rural villages are choosing to settle in the urban town, for the need to have a better lifestyle.

At present, almost all the villages are well linked to the main town, neighbouring state of Assam and districts of Nagaland by road. Basic amenities such as electricity and drinking water are provided. Institutions like schools, colleges, hospitals, dispensaries, etc are also being set up for the benefit of the people. Various Government aided development programmes such as Integrated Rural Development Programme (IRDP), Village Development Board (VDB), etc. have opened opportunities for the village people towards self-employment. Mokokchung town has a Government hospital, a military hospital and a private nursing hospital which caters to the need of the people. Nonetheless, not many of the villages have access to all the above mentioned facilities. Generally, most of the people choose to go for medical treatments to the better equipped private hospitals in big cities in various parts of the country.

Detailed statistics of the health status among the Ao people is not available to the general public as of now, except for the report by National Family Health Survey for the state of Nagaland as a whole. It is reported that in Nagaland state, less than one-third of the children are fully vaccinated, provision of iron and folic acid (IFA) supplement is far below the national average and only 51% to 52% of women have received tetanus toxoid injections (NFHS-3, 2007). This report also shows that in every 100,000 males, 1217 suffer from diabetes, 2464 from asthma and 725 from goitre or other thyroid disorders. While in every

100,000 females, 577 suffer from diabetes, 1414 from asthma and 629 from goitre or other thyroid disorders.

The survey also reports the nutritional status of adults in the state, and it shows that 15.9% of women and 10.8% of men have BMI below normal. BMI below normal is higher in urban men (11.3%) and urban women (16.9%) compared to rural men (9.6%) and rural women (13.1%). Also, 8.9% of women and 8.4% of men are either over-weight or obese. Rural men (16.8%) and rural women (17.5%) are more over-weight or obese compared to urban men (5.0%) and urban women (5.6%). General observation reveals that the Ao people are susceptible to air and water borne diseases such as malaria, typhoid, cholera, dysentery, influenza, etc. Nutritional deficiencies are also observed especially among some of the children in the rural areas or villages.

CHAPTER-II

REVIEW OF LITERATURE

In this brief review, an attempt will be made to make an overview of literature on how body composition is related to age, sex and nutritional status. An attempt will also be made to make a brief review of how body composition and nutritional status are related to morbidity, rural-urban setting and socioeconomic conditions. The overview is far from being exhaustive but its intension is to bring out some aspects that may be relevant to the present study.

Body composition in relation to age and sex

Body fat or FM varies with age and sex, especially during growth and development. This variation is apparent in early life and it is magnified during adolescent growth spurt and sexual maturation. There is a sex difference in changes in specific components of body composition with advancing age (Malina, 2005). As for adults, middle age (40-50 years) is commonly associated with increasing fatness due to increase in weight gain. In men, this may be a feature of fourth decade (Pierson *et al.*, 1974; Baumgartner *et al.*, 1995). In women, fatness is reported to increase following pregnancies or with the onset of menopause (Ben-Tovim and Walker, *1994*; Poskitt, *1995*; Kirchengast *et al., 1999*; Dittmar, *2001*; Winkvist *et al.*, 2003; Monisha *et al.*, 2007; Kulkarni *et al.*, 2010).

Various studies among the adults of both sexes in different populations show that FM increases slowly with age and that the rate of increase differs by sex. A study in a large multiethnic population comprising of Asians, Blacks, Puerto Ricans and Whites between the age group of 20 – 94 years reported that except among the Puerto Ricans, age was a significant predictor of body fat and fat percentage. Both FM and fat percentage were maximum between the age group of 49 – 61 years in both the sexes, and FM and fat percentage decreases with the increase in age (Mott *et al., 1999*). It is reported that the trends in FM and %FM by aging were different between males and females among the Japanese adults age 20 -79 years. Curvilinear changes peaking around 50 years of age were seen for

males, whereas linear increases in FM and %FM were seen for females (Ito *et al.*, 2001). Study among the elderly adults of Southeast Brazil reveal that underweight was significantly more common among men than women and increased directly with age in both the genders. It also revealed that obesity was more common among women, and prevalence decreased with age (Barreto *et al.*, 2003). A study in Albania showed clear gender differences in the prevalence of overweight and obesity, with women (30.9%) of all age groups being more likely to be more obese than men (22.0%) (Shapo *et al.*, 2003). Among adult Jamaicans of African origin, the prevalence of obesity is higher in women (30.7%) than in men (6.7%) (Jackson *et al.*, 2003). The highest proportions of overweight and obesity, 51.4% and 10.0%, respectively among Italian men are in the age group of 45-64 years, while the proportions of overweight and obesity, 38.8% and 13.8%, respectively among women are in the age group of ≥65 years (Gallus *et al.*, 2006). In the case of adults from Portugal, the prevalence of overweight and obesity is 33.5% and 18.8% in women, and 45.8% and 16% in men, respectively, and overweight and obesity increases with the increase in age in both genders (Santos *et al.*, 2008). Similar findings on the indigenous Suruí Indians of Southwest Brazil revealed that body fat or FM was higher in women (38.8%) than in men (13.6%) (Lourenco *et al.*, 2008).

Moreover, a review on a study of 19 populations reported that WC and WHR increased with the increase in age (Molarius *et al.*, 1999). A 10 years longitudinal study among the elderly revealed that waist circumference increased significantly in the women but not in the men, whereas hip circumference decreased significantly in the men (Hughes *et al.*, 2004). An increasing trend of the total FM and five anthropometric indices namely BMI, waist circumference (WC), hip circumference (HC), waist-hip ratio (WHR) and conicity index (CI) in successive older age groups was reported from a study among Chinese adults between the age group of 20 to 40 years (Lei *et al.*, 2006). A study reported that among the middle aged Polish population, males show a higher trend of increasing risk to obesity with increasing age compared to females (Kaezmarek, 2007).

Although such fat patterning seems to be physiological, it increases the risk of high morbidity and mortality (Timperio *et al.*, 2000; WHO/FAO, 2003; Kruger *et al.*, 2005). The association of fat distribution with coronary heart diseases has been reported in many middle aged adult populations (Chang *et al.*, 2000; Yasmin and Mascie-Taylor, 2000; Park *et al.*, 2006). Its association with diabetes (Olinto *et al.*, 2004) and with blood pressure and hypertension (Zhou *et al.*, 2008) has also been reported from the middle-aged adults. An

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analysis of anthropometric measures among women aged 20-49 years, in 36 developing countries reported that overweight exceeded underweight in both rural and urban areas (Mendez *et al.*, 2005).

In India, a study of urban population in Mumbai (Shukla *et al.*, 2002) also indicated that the prevalence of overweight was higher in women (30%) than in men (19%). Study among the urban elderly Bengalee Hindus in Calcutta reported that there exists a significantly decrease in adiposity or FM with increase in age (Ghosh *et al.*, 2001). Similar finding was reported by Tyagi *et al.* (2005) in a study among the urban elderly females of Delhi. Bose (2006) described changes with age in three measures of abdominal obesity, WC, WHR and CI and suggested that the relationship between WC and BMI is influenced by age and sex. Das and Bose (2006) described that the prevalence of FM and fat percentage was greater in females than in males from 20 to 75 years of age in a Marwari population in West Bengal. A study among the elderly from Delhi reported that non-institutionalized senior citizens of both sexes have higher percentages of overweight as compared to institutionalized elderly (Tyagi, 2007). Another study among post menopausal women in Chandigarh reported that there is a general increase in body weight in these women (Monisha *et al.*, 2007). A study among urban slum dwellers in India also reported that menopausal status is associated with lower lean mass and high obesity or body fat (Kulkarni *et al.*, 2010). However, age was found to be significantly negatively related with anthropometric and body composition variables and indices in a study among the men (Bose *et al.*, 2006a), and women of Bathudis tribe in Orissa (Bose *et al.*, 2007b). A study among the Kora Mudi tribe of West Bengal revealed that there exist significant age and sex variation in anthropometry and body composition (Bisai *et al.*, 2008).

FFM is also known to vary systematically with changes in age and sex. It is reported that FFM is usually greater in male adults than in female adults (Gallagher *et al.*, 1997; Wang *et al.*, 2001). It is generally observed that older people tend to have less FFM than young adults, and this age effect is more pronounced after 60 years of age, especially among post-menopausal women (van Loan, 1996; Forbes, 1999). A study among the white adults in the United States reported that mean FFM was greater in males (60.8 kg) than females (41.7 kg) and that the greater amount of FFM in males was due to broad shoulders, wrists and knees (Chumlea *et al.*, 2002). Similarly, an analysis of FFM in urban Gambia reported that FFM was significantly higher in males than females (Siervo *et al.*, 2006). The decline in FFM is also more rapid in aged men than in women (Gallagher *et al.*, 1997; Ito *et al.*, 2001). This

decline in FFM is associated with weakness, disability and morbidity (Frontera *et al.*, 1991; Hughes *et al.*, 2002). It is, however, suggested that low FFM can be improved by increased physical activity (Guo *et al.*, 1999; Hughes *et al.*, 2004). Little is known about such information on Indian populations, although a study carried out in a South Indian population indicated that FFM was higher in men than in women aged 22-38 years (Ferro-Luzzi *et al.*, 1997). A recent study among the Marwaris in West Bengal also reported that males have higher FFM compared to females (Das and Bose, 2006).

Body composition in relation to body dimensions and body shape

Anthropometric measurements and indices are widely used for the assessment of body composition and nutritional status of children and adults. For example, skinfold thicknesses are used in estimating body fat with the help of mathematical equations. The most widely used skinfold-thickness equations are those developed by Durnin and Womersley (1974) and Jackson and Pollock (1978). These equations were developed on the basis of a two-compartment model, which separates the body composition (body weight) into FM and FFM. It is, however, criticized that skinfold thicknesses may not provide accurate information about body fat because visceral fat cannot be measured (Friedl *et al.*, 2001). Moreover, skinfold thicknesses cannot be used to assess changes in body FM because of age-related fat redistribution (Hughes *et al.*, 2004). Nevertheless, skinfold thicknesses measurement is still used to understand the nutritional status and in epidemiologic research (Andrade *et al.*, 2001).

Body weight and height are another anthropometric measurements commonly used for the assessment of body composition and nutritional status. Both weight and height are correlated with FM and FFM. However, FM is more correlated to body mass index (BMI) developed by Quetelet in 1869 and is suggested to use as an index of FM. This index is derived as weight (in kg) divided by height squared in meters (weight/height^2). Since BMI is more correlated with FM (Norgan and Ferro-Luzzi, 1985; Willett, 1990), it is widely used as a good indicator of body fat and also recommended for use by the World Health Organization (WHO, 1983, 1995). Several studies have therefore been done to describe the relation of adult BMI to body fat distribution or obesity (Banegas *et al.*, 2001; Torrance *et al.*, 2002; Kant, 2003; Freedman *et al.*, 2004). Studies have also been carried out to assess the nutritional status of adults by using BMI in several countries (Belahsen *et al.*, 2003; Vorster *et al.*, 2005; Bergman and Hauser, 2006; Lourenco *et al.*, 2008) as well as in India (Reddy, 1998; Khongsdier, 2001; Bose *et al.*, 2006; Bose *et al.*, 2007a; Bose *et al.*, 2007b; Gautam, 2007; Gautam, 2008).

However, recent studies have questioned the validity of BMI as an indicator of fatness (Deurenberg *et al.*, 2001; Frankenfield *et al.*, 2001; Kyle *et al.*, 2003; Goh *et al.*, 2004; Cook *et al.*, 2005; Khongsdier, 2005a; Flint and Rimm, 2006) because it lacks specificity to the variation in body composition, and the confounding effects of various factors such as age, sex, body shape, ethnicity, etc. (Wagner and Heyward, 2000; Prentice and Jebb, 2001; Shiwaku *et al.*, 2004). It is recently proposed to split BMI into two components: body fat mass index (BFMI) and fat-free mass index (FFMI) in which the skinfold thicknesses were correlated (Khongsdier, 2005a), using the predicted equations of Durnin and Womersley (1974) and Siri (1961). The cut-off points are also proposed for both developed countries (Schutz *et al.*, 2002; Kyle *et al.*, 2003) and Asian countries (Khongsdier, 2005) due to wide variation in body fat composition between Asian and European populations (Norgan, 1990; Gallagher *et al.*, 2000). In India, Bose *et al.* (2008) have reported data on body composition using the equations of BFMI and FFMI among the adults of Bathudis.

Body composition is correlated not only with body dimensions (such as skinfold thickness, body weight and height), but also with body shape, i.e., relative dimensions such as the ratio of sitting height to height known as cormic index. It is suggested that BMI is correlated with sitting height, BMI is lower in those populations with higher sitting height, which is a general characteristic of populations in Asian and pacific regions (Norgan, 1990, 1994). A recent study in the United States among the adults of three groups, *viz.*, white, black and Mexican-American ethnicity shows that BMI is significantly influenced by sitting height ratio (Bogin and Beydoun, 2007). Prior to that, an analysis of BMI for 12 population groups in Northeast India seems to support such a contention (Khongsdier, 2001). Another analysis for 38 different population groups in Central India report that there is a positive but statistically insignificant correlation between BMI and cormic index (Adak *et al.*, 2006). Again in Central India, a study among the caste populations by Gautam (2008) has reported that the adult males within the same occupational group have the same cormic index and BMI. Nevertheless, there is limited literature on the relationship between body composition and cormic index from other Indian populations.

Conicity index (CI), waist-hip ratio (WHR) and waist circumference (WC) also measures the body shape and are correlated with body composition. These indices measure the abdominal or central adiposity i.e., it measures the FM and central fat distribution of the body. It is reported that abdominal circumferences, namely waist and hip circumferences, are more susceptible to environmental changes (i.e., diet and exercise) and therefore provide

better estimates of body fat than BMI for women (Friedl *et al.*, 2001). Moreover CI, WHR and WC are widely used in body composition studies because of its association with various obesity related problem such as hypertension, cardiovascular disease (CVD) or coronary heart disease (CHD), diabetes type II, etc. (Valdez *et al.*, 1993; Han *et al.*, 1995; Bose and Mascie-Taylor, 1998; Grundy, 2004; Pitanga and Lessa, 2004; Stein and Colditz, 2004; Swinburn *et al.*, 2004; Neufeld *et al.*, 2007; Welborn and Dhaliwal, 2007). A 10 year long study in a remote Aboriginal community in Australia report that WC, BMI and hip circumference were highly correlated and have a positive association with cardiovascular risk factors (Wang and Hoy, 2004). Among middle aged women in France, WC and WHR have been reported to be important for screening of diabetes and obesity-associated dyslipidaemia (Balkau *et al.*, 2006). Biosocial factors such as age, socioeconomic status, and lifestyles, which included dietary habits and physical activity, have a great influence on the WC, WHR and CI (Laitinen *et al.*, 2004; Suder, 2008; Lourenco *et al.*, 2008). A study in Bangladesh reports that the prevalence of high CI increases with increasing age and better education, and females are 7.5 times more likely to have a high CI than males (Flora *et al.*, 2009). Also, recent review of twenty-eight studies based on WC and WHR among adults, aged 18 to 74 years report that WC and WHR values vary across different ethnic groups, and that there are no universal optimal cutoff values (Qiao and Nyamdorj, 2010).

In India, the association of these indices and measures with overweight, blood pressure, diabetes, heart diseases, etc. has been reported from some adult populations (Das and Bose, 2006; Kaur and Mogra, 2006; Monisha *et al.*, 2007). A comparative study among adult Hindu and Muslim females, aged 18-23 years was reported that Hindu females have significantly higher BMI, WC and WHR compared to Muslim females (Ghosh *et al.*, 2005). An analysis among the elderly in Kolkata reports that WC is preferred over WHR and CI in measuring abdominal fat (Bose, 2006). A study in South India has reported on the relationship between BMI, WHR and CI to age, sex and socioeconomic conditions (Kusuma *et al.*, 2008). Only a limited study has been reported in India with regard to the relationship between WHR, CI and WC with body composition.

Body composition in relation to nutritional status and associated morbidity

The influence of nutrition on body composition is a well-established fact. However, the relative proportion of changes in FM and FFM during nutritional deprivation and over-nutrition is not fully understood (Frankenfield *et al.*, 2001; Khongsdier, 2005a). Over-nutrition is characterized by obesity and it is associated with morbidity, such as diabetes

mellitus, cardiovascular disease, hypertension and stroke, osteoporosis, and some forms of cancer (WHO/FAO, 2003). As noted earlier, obesity has become an epidemic in developed countries. It is believed to be a result of an excess accumulation of fat in the body, although it is not clear whether the total amount of fat deposited in the body, or the relative proportion of FM to FFM, that determines health and fitness (Poskitt, 1995; Khongsdier, 2005a). In fact it is without doubt that overweight and obesity are the leading nutrition-related disorders of clinical and public health concern (Kuczmarski and Flegal, 2000). This burden of overweight and obesity is growing fast in developing countries and is shifting towards groups who are from lower socioeconomic status (Monterio *et al.*, 2004).

The association of obesity and morbidity has been reported in a number of body composition studies from various populations. Stene and colleagues (2001) have reported that adult BMI is highly correlated with blood pressure. Similarly, Tawfeek (2002) report that 13.3% of men and 22.5% of women in Baghdad with WCs 94cm and 80cm respectively have hypertension. Olinto *et al.* (2004) reported that the prevalence of hypertension and diabetes was 25.6% and 6.2%, respectively among Brazilian women. The study showed that increase in WC and BMI is associated with hypertension and diabetes. A similar study among the adult Mexicans show that the prevalence of abdominal obesity, 46.3% of men and 81.4% of women, is associated with increased prevalence of diabetes type II mellitus and hypertension (Sànchez-Castillo *et al.*, 2005). It is reported that there is a strong positive correlation between obesity and hypertension in adult men and women in Uzbekistan, and that obese adults are about 3.1 times more likely to suffer from hypertension than those adults with normal BMI (Mishra *et al.*, 2006). Percent body fat was associated with metabolic and cardiovascular diseases in both men and women (Gregory *et al.*, 2007). In women, measures of body fatness by BMI and WC have reported to identify diabetes and hypertension risks (Neufeld, 2007). Study in a Chinese population has shown that the best indicator of hypertension was BMI for women (Zhou *et al.*, 2008).

In addition, although obesity is declared an epidemic in developed countries and developing countries undergoing rapid nutrition transition, fatness is actually considered desirable in some cultures as it enhances social prestige of the individuals (Wagner and Heyward, 2000). It is also considered to be beneficial for the survival of some tribal groups during the "feast and famine" conditions in the past, but becomes detrimental in a modern society with abundance of food and less physical activity (Neel, 1962). In fact, there is a population variation in perceptions about obesity. A social definition of obesity is related to

fatness beyond the socially accepted norms for a given society, while a medical definition relates the level of fatness (i.e., BMI of > 30.0 kg/m^2) to morbidity and mortality, which varies across populations (Ulijaszek, 1999). A worldwide overview from a range of body composition and disease studies report that Asians, Africans and Latin Americans are more likely than whites in the USA and Europe to have greater body fat and central fat for the same BMI and therefore likely to experience morbidity at lower BMI levels (Popkin, 2002). For example, the level of fatness associated with morbidity in Asian populations is lower than that in European populations (Deurenberg-Yap *et al.*, 2000).

Although some studies in urban cities in India have reported the prevalence of obesity or overweight (Ghosh *et al.*, 2001; Shukla *et al.*, 2002; Das and Bose, 2006; Monisha *et al.*, 2007) among adults, the report on its relation to morbidity is limited. Misra *et al.* (2001) studied the adults of a slum area in urban South Delhi and reported that there is a high prevalence of obesity, diabetes and dyslipidaemia among the middle aged, which is associated with a high BMI, WHR and percent body fat. A study among the postmenopausal women in Udaipur city show a high correlation between body FM measured by BMI and WC in relation to hypertension (Kaur and Morga, 2006). A study in Malda town of West Bengal revealed that adults with higher BMI are at significantly higher risk of hypertension (Das *et al.*, 2005). It is suggested that an increase in body fatness in healthy adults may be responsible for the association between blood pressure and weight (Sidhu and Prabhjot, 2007). Similarly, it is reported that among diabetes mellitus patients in Punjab, percent body fat is highly correlated with weight, BMI and WHR (Arora *et al.*, 2007). It is reported from Bikaner, Rajasthan, that 46.65% patients with type-2 diabetes are overweight or obese by BMI measures, and also WHR measure shows a high rate of abdominal obesity in both male (40.70%) and female (84.84%) patients (Sharma and Jain, 2009). Another study also reported that the means of BMI, WHR, WC and %BF are significantly higher in adults who are patients of type-2 diabetes and coronary artery disease (Kaur *et al.*, 2010). This study also suggested that %BF may be an improved phenotypic characteristic than BMI and WHR when studying obesity related health risks.

As for under-nutrition, the BMI < 18.5 kg/m^2 is widely used as a practical measure of chronic energy deficiency (CED) i.e. a "steady" underweight in which an individual is in energy balance irrespective of a loss in body weight, or body energy stores. Such a "steady" underweight is likely to be associated with morbidity, or other physiological and functional impairments (James *et al.*, 1988; Shetty and James, 1994; WHO, 1995). However, it is

unclear whether the associated morbidity or mortality with low BMI, especially in developing countries, also depends upon the variation in body composition. Studies of dietary-induced weight loss revealed that both body fat mass (BFM) and fat-free mass (FFM) decreased but in different proportions (Keys *et al.*, 1950). Empirical evidence from Asian populations indicated that low BMI was associated with low FM and FFM, although there were differences in the proportion of FM and FFM (Ferro-Luzzi *et al.*, 1997; Strickland and Tuffrey, 1997). Of course, some studies of the relationship between low BMI and morbidity in developing countries produced inconsistent results (Garcia and Kennedy, 1994; Khongsdier, 2002), despite certain evidence of a curvilinear relationship (de Vanconcellos, 1994). In fact, there is lack of information on the relationship between adult body composition and under-nutrition in relation to morbidity from developing countries, especially from India (Campbell and Ulijaszek, 1994; Khongsdier, 2002, 2005a), although there is considerable evidence that undernourished children are more susceptible to infectious diseases and poor growth and development (Khongsdier, 2005b).

In India, a high prevalence of under-nutrition (57.9%) was reported from the Bathudis, a tribal population in Orissa (Bose and Chakraborty, 2005). A study among the adult males in Central India has suggested that the high prevalence of CEDs may be due to their low BMI (Adak *et al.*, 2006). Relation between low BMI and CEDs are also reported from the backward populations in the districts of Madhya Pradesh and Chhattisgarh (Gautam *et al.*, 2006), from the Saharia tribe of Rajasthan (Rao, *et al.*, 2006), from the slum dwellers in Midnapore, West Bengal (Bose *et al.*, 2007), and from low socioeconomic tribal populations from South India (Kusuma *et al.*, 2008). A study among War Khasis in North-East India have found a significant association between BFMI and morbidity, compared to those with normal BFMI, suggesting that individuals with low BFMI are about 4.7 times more likely to become sick, and individuals with a high BFMI are about 3.9 times more likely to become sick (Khongsdier, 2005a). Further studies are needed to test the relationship between morbidity/mortality and the two components of BMI, namely, BFMI and FFMI, in both developed and developing countries.

Nutritional Status in relation to socio-cultural evolution and urbanization

Despite controversy on the proportion of vegetable and animal foods, it is widely accepted that the types of food and basic nutrients required for humans are relatively constant through different stages of human evolution. Also, there were no major morphological changes, except upright posture and development of brain capacity during the *Homo erectus* stage. The

ways of acquiring foods remained relatively constant till about 10,000 years ago when agricultural revolution started. "The absence of evidence for significant change in technology suggests that each generation had to solve the problems of survival and reproduction with a similar set of behaviours and tools" (Baker, 1984). However, the widespread of agriculture has a profound impact on nutritional and socio-cultural conditions of the people. They started consuming large amounts of grain, milk, and meat of domesticated animals and becoming more sedentary. Population growth started increasing and societies became larger. Thus the shift from foraging to farming was one of the major changes ever seen in the dietary history of humans since the time of *Homo erectus*. This transition has taken place only within the last 10,000 years, which is but a tiny part of our evolutionary history (Larsen, 1998).

With the advent of industrial revolution about 200 years ago in high-income countries, human populations have experienced dramatic changes in food production, processing, storage and distribution. These have brought about major changes in the nutritional composition of the diets. The traditionally plant-based diets have been quickly replaced by high-fat, energy-dense diets with high content of animal-based foods (WHO/FAO, 2003). Although under-nutrition remains a major health problem in many developing countries, there is evidence of rapid changes in dietary patterns compounded by changes in nature of work (lifestyles), often referred to as "nutrition transition" due to increasing urbanization, industrialization and market globalization (Popkin, 1998, 2002; Khongsdier, 2005b). Studies have reported of the influence of such transition from many developing countries (Noor, 2002; Du *et al.*, 2002; Maletnlema, 2002; Benjelloun, 2002; Shapo *et al.*, 2003; Rivera *et al.*, 2004; Lourenco *et al.*, 2008). These dramatic and rapid changes are believed to have a great impact on health and nutritional status of the people in developing countries. The rise in national incomes in developing countries and increased 'westernization' will lead to increase in the levels of obesity in the future (Martorell *et al.*, 2000).

Deficiency of nutrition in early fetal life has been found to have a great impact on the health of the individual during adult life, which is now known as fetal origins hypothesis. The basic principle of this hypothesis is that all human beings are 'plastic' and molded by the environment so as to adapt to different environmental conditions (Barker, 1999; Khongsdier, 2008). For a human fetus it means that when nutrition is less, the fetus can alter the metabolism and slow down the growth process. This kind of adaptation during the early developmental stage leads to permanent changes in the structure and function of the body.

Various studies by Barker and colleagues (1992, 1995, 1998; Barker *et al.*, 2001) have suggested that individuals who were disproportionately thin or small with low birth weight tend to have a higher rate of type-2 diabetes and associated coronary heart diseases including hypertension and stroke in their adult life. A study reported that mothers who are short stature, from low social class and those who smoke during pregnancy influence the development of adult chronic diseases (Power *et al.*, 2003). Another study show a strong positive associations between birth weight and bone mineral content which led to the evidence that the risk of osteoporosis in later life might be programmed by genetic and/or environmental influences during gestation (Gale *et al.*, 2001). Expectant mother nutritional status therefore influences the association of birth weight and certain adult chronic diseases. A cohort study in a high birth weight population in Iceland has reported that high birth weight is related to high BMI, truncal fat and high blood pressure during adulthood without any risk of having coronary heart disease (Gunnarstottir *et al.*, 2004).

In fact studies have found that even childhood BMI have a positive association with BMI during young adulthood. A report based on studies from rural Guatemala suggests that BMI should be measured between the age of 3 and 7 years as increase in BMI between these years have a strong association with fat mass and abdominal fat during adulthood (Corvalán *et al.*, 2007). In another recent study, it is reported that a 5.6 cm increase in childhood height is associated with a unit increase in childhood BMI, and a unit increase in BMI during childhood is associated with about 1.3 units increase in BMI during adulthood (Stovitz *et al.*, 2008). Recent study in Jamaica by Nelson (2009) reported that those individuals who are born between 1959 and 1968, a period when the country was experiencing political and economic instability, have higher BMI and skinfold thickness values. Nutritional stress due to fluctuations in the sociopolitical environment during the critical developmental period is also suggested to contribute to the poor health during adulthood.

Reviews of epidemiological studies in different populations with regard to the fetal origins of diseases have suggested that there is a need to improve the nutritional status of mothers, so as to reduce the prevalence of these diseases (Barker, 1999; Godfrey and Barker, 2001; Fall, 2001; Sachdev, 2004; Khongsdier, 2008). It is also suggested that even chronic under-nutrition during early childhood reduces the ability to burn fat during adulthood, and predisposes the individuals to adult obesity (Frisancho, 2003). According to Leonard (2009), early life under-nutrition and adult obesity are simply two sides of the same coin.

In India, a study by Stein and colleagues (1996) revealed that short height and small size babies whose mothers had with low weight were affected by coronary heart diseases during adulthood. Yajnik and colleagues (2002) have reported that hyperinsulinemia or increase in insulin resistant level is present at birth. Higher insulin resistance is a common feature in Indians, which make them susceptible to type-2 diabetes. It is also reported that the body composition of Indians show a very high amount of central fat and percent body fat for a given BMI, which is responsible for the high insulin resistant level. Also a cohort study in Delhi reported that a high BMI gain during infancy and early childhood is associated with a high increase in lean mass in adulthood, while a high BMI gain in late childhood and adolescence is strongly associated with adult adiposity and central adiposity (Sachdev *et al.*, 2005). More studies pertaining to this hypothesis are needed in India to understand nutritional status and its association with obesity and its related health diseases.

Some studies in Indian urban areas have revealed the increasing trend of obesity, which is likely to exert a great impact on the health and socio-economic systems in the next two decades (Shetty, 2002; Shukla *et al.*, 2002). In the meanwhile, under-nutrition still remains a major health problem in rural areas (Khongsdier, 2005b). There is also evidence that the prevalence of obesity in many developing countries is not only in the higher socio-economic groups (Ball and Crawford, 2005), but also in the lower ones especially in urban areas (Monteiro *et al.*, 2005), which is the common phenomenon in developed countries. More studies are needed to explore the bio-social factors responsible for under- and over-nutrition, which may vary from one population to another, especially in India with diverse socio-cultural and ecological conditions (Khongsdier, *2001*, *2002*). A better understanding of the biosocial variation in nutritional status is urgently needed not only for scientific interest, but also for policy implementation to reduce the double burden of under- and over-nutrition in the country.

Body composition and nutrition in relation to rural and urban differences

Urbanization is an important global phenomenon which has brought about drastic changes such as increase in population size, changes in dietary habits, lifestyle, etc. Urban areas are the place of economic growth and the home for the majority of humanity (Forbes and Lindfield, 1997). In the context of any developing country undergoing rapid nutrition transition, it is necessary to consider the rural-urban difference. It is observed that the shifts in diet, activity patterns and body composition are occurring more rapidly in developing countries (Popkin, 1998, 2004). The emergence of obesity is attributed to the increasing

intake of protein rich and fat rich diets with lessened physical activity. Khongsdier (2008) has pointed that the increase in rural-urban migration along with changes in dietary and physical activity patterns is likely to condition many individuals to obesity and its associated diseases such as diabetes, hypertension, etc. He has further pointed that rural to urban migration and transforming rural settlements to cities in developing countries are the major cause for the rapid growth of population, and that these changes will lead to the decline in rural population. A study among the black adults from a less developed and a developed nation, Nigeria and the United States, respectively revealed that the former have a significantly lower body weight, height, BMI, FFM and FM than the latter, which is due to the different level of physical activity (Luke *et al.*, 2002). Amoah (2003) studied obesity among the adults in Ghana and reported that the rate of overweight and obesity is higher in the urban areas than the rural areas. The study revealed that socio-demographic variables such as older age, female gender, urban, high-class residence, sedentary occupation and tertiary education are associated with higher prevalence of obesity. Study among the rural villagers and urban migrants of Huli-speaking group in Papua New Guinea reported that urban migrants have higher BMI and body fat or FM, and therefore better nutritional status compared to the rural counterparts (Yamauchi and Umezaki, 2005). They concluded that urbanization, especially reduced physical activity, affected the increase in the anthropometric measures and nutritional status. A rural-urban comparison in Eastern China reports that urban dwellers are highly associated with metabolic syndrome, which is a result of high dietary fat intake and lower occupational physical activity (Weng *et al.*, 2007). Also, an extensive study in 26 sub-Saharan countries in Africa reported that rural women were 68% more likely to be malnourished compared to their urban counterparts (Uthman and Aremu, 2008). Thus, differences in nutrition and lifestyle factors seem to contribute for the differences in the body composition between rural and urban populations.

Although generally urban dwellers are considered to be at risk to obesity, studies have reported that obesity does occur in rural dwellers. A very high prevalence of overweight and obesity have been reported from poor and relatively isolated communities of Mexico, the cause of which have been pointed on to less physical activity, sedentary life and intake of fat rich food (Sànchez-Castillo *et al.*, 2001). Torun *et al.* (2002) reported that a high proportion of young Guatemalan women in both rural and urban areas are overweight and sedentary with a mean body fat of 29.8%, both rural men and women have high abdominal fat, and that migration to a city is the main factor for such increase in both men and women. In another study, it is reported that occupation is the factor among the Guatemalan adults which causes

the prevalence of overweight and abdominal obesity in both rural and urban women; whereby women in both rural and urban areas lead a sedentary life, while the prevalence of overweight and abdominal obesity is higher among adult men from urban area and non-agricultural rural, compared to their agricultural rural counterparts (Gregory *et al.*, 2007). An analysis of body composition in Korean population report that a high abdominal obesity (46.9%) and high blood pressure (45.2%) are prevalent in the rural community and hypertriglyceridemia (37.6%) and low HDL-cholesterolemia (37%) in the urban community, which is attributed to the improving economic conditions (Lim *et al.*, 2006). In Turkey, it has been reported that there is a high prevalence of abdominal obesity and metabolic syndrome, especially among females in both rural and urban areas (Oğuz *et al.*, 2008).

In India, a study in South India on BMI and abdominal fat report that obesity or overweight, hypertension, sedentary lifestyle, etc, are more prevalent among urban population as compared to the rural population and therefore the cardiovascular risk factors are higher in urban population (Venkatramana and Reddy, 2002). In a review of various rural-urban studies in India, Shetty (2002) has described that the prevalence of CHD or coronary heart disease was found to be higher in the urban population as compared to rural population. He suggested that the increase in CHD resulted because of internal migration, urbanization and exposure to changing diet and lifestyle. Also, a study on body fat or FM among middle aged Indian men in rural and urban Pune reported on the high prevalence of FM in men, and has suggested that to assess risk for chronic diseases, adiposity should be measured by anthropometry and bioelectrical impedance (BIA), rather than relying only on BMI (Bhat *et al.*, 2005). Study among the adults of Calcutta and a village about 80 km away from the city was undertaken to investigate the rural-urban differences in the prevalence of cardiovascular diseases (Das *et al.*, 2008). This study showed that significant differences existed for anthropometric, metabolic and blood pressure variables between rural and urban areas. It also revealed that urban population was more susceptible to cardiovascular diseases and that this was due to the influence of effective urbanization and modernization. A study of the body fat distribution among the Meitei women in Manipur showed that body fat composition is higher among urban women. It further reported that dietary habit, physical activity and socioeconomic status are the factors behind the fat distribution difference between rural and urban women (Devi *et al.*, 2008).

Body composition in relation to socioeconomic status

Socioeconomic status is an important factor which has a high impact on the prevalence of obesity. Several studies have reported that obesity differs not only by age and sex, but also by socioeconomic status. A study in Spain shows that older women with low educational level and low income were the most susceptible group to gain weight (Aranceta *et al.*, 2001). Hakeem (2001), reported that in Karachi, Pakistan the relative proportion of overweight males and females increased with age at all income levels. It also reported that in young female adults (19-41 years), overweight decreased with increasing income whereas in the older females (41-60 years) the prevalence of overweight increased significantly with income level. It is reported that in the United States, Hispanic women have FM 9% higher and FFM 5% lower than in white women, and these differences occur in early adulthood among women of similar high educational status (Casas *et al.*, 2001). A study from Brazil reported that there is a linear association between socioeconomic status and body composition (BMI, %BF, lean body mass) for males, and a curvilinear association for females, and this variation in the pattern of association is not only by gender differences but also by caloric demand of labour and social value attached to food (Dos-Santos *et al.*, 2001). The increasing trend in the rate of overweight and obesity among adults in Canada varies by sex, education and smoking status (Torrance *et al.*, 2002).

It is also reported that women from affluent societies or from better socioeconomic background are overweight or obese, and they tend to retain more weight after each pregnancy (Winkvist *et al.*, 2003). A population based study in Sweden revealed that education with the influence of lifestyle factors such as physical inactivity and excess consumption of alcohol has a positive association with obesity, and that it is greater in men than in women (Molarius, 2003). Study also show that marital status influences the high rate of BMI, whereas BMI is lower among cigarette smokers (Jackson *et al.*, 2003). Socioeconomic status such as income, education, social class and lifestyle factors such as TV viewing, are reported to be associated with the risk of overweight and obesity among Peruvian adults living in cities (Jacoby *et al.*, 2003). A 15 year longitudinal study in Denmark has indicated that it is obesity which has lead to physical inactivity in both sexes of adults (Petersen *et al.*, 2004). It is reported that among Balinese women, fatness measured by anthropometry is found to be significantly associated with household wealth and educational level (Huntsman, *et al.*, 2005). Yoon *et al.* (2006) examined the relationship between socioeconomic status and obesity among Korean adults and reported that in men, as income increased there was a linear increase in mean BMI and mean WC but not in women. They

also found out that in women, higher levels of education were significantly associated with lower BMI and WC. A similar finding was reported by Gallus *et al.* (2006) in a study among Italian adults. The study showed that underweight was higher (6.7%) in more educated women as compared to less educated women (3.7%). Study in Portugal revealed that women from low socioeconomic status have significantly higher prevalence of overweight (37.6%) and obesity (24.5%) compared with those from middle and high socioeconomic status (Santos *et al.*, 2008). It is also reported that body fat distribution, especially WC is influenced by lifestyle factors, socioeconomic factors and age among working males in Poland (Suder, 2008). Study in a multiethnic population in Hawaii have also revealed that among the pacific islanders group the high rate of obesity was a result of socioeconomic status and lifestyle (Brown *et al.*, 2009).

Obesity related diseases are also found to be strongly determined by socioeconomic status. Winkleby and colleagues (1992), studied adults in the age group of 25-64 years in the United States and reported that there is a positive correlation between education, income and occupation. It is also reported that education was the only measure of socioeconomic status that was significantly associated with disease risk factors. Based on this finding they have further suggested that education should be used to indicate good health. In a longitudinal cohort study consisting of elderly adults (70-79 years) from both black and white community in the United States reveal that low family income is strongly associated with cardiovascular diseases (Rooks *et al.*, 2002). A similar longitudinal cohort study also revealed that elderly adults' from low socioeconomic status have a high risk to suffer from heart disease, cerebro-vascular disease, diabetes mellitus and even depression (Koster *et al.*, 2006).

In India, study on the relationship between socioeconomic status and body composition is very limited. One study among the adults of Mahishyas in West Bengal reported that values of anthropometric measurements and indices, skinfold thickness and body fat are higher as income increases (Bharati, 1989). Anthropometric measures show that adults are taller and heavier who are from upper middle income group compared to the lower income group (Rao *et al.*, 1990). Landless agricultural labourers and low income groups are reported to have a lower mean BMI values (Naidu and Rao, 1994). It is also reported that in urban areas of Hyderabad, the prevalence of overweight and obesity are higher in the higher income groups whereby, 21.8% and 27.4% of males and females, respectively are overweight, and 2.1% and 8.9% of males and females, respectively are obese (Rao *et al.*, 1995). Similarly, a study in a heterogeneous population of Andhra Pradesh also revealed that

in both male and female adults BMI increases with the increase in income (Reddy, 1998). A study among women from urban slum with low income earning reported that their occupational work which involve high physical labour, is associated with higher lean mass (Kulkarni *et al.*, 2010). In the Northeast India, a study among the War Khasis in Meghalaya has reported that BMI along with morbidity are significantly associated with income (Khongsdier, 2002).

In summary, the present overview has clearly revealed that body composition is associated with age, sex, body shape, morbidity and different demographic and socioeconomic factors. However, there are limited studies from India in general and Northeast India in particular. It is, therefore, important to carry out more studies especially in areas related to causes and prevention of obesity, which is an emerging health problem in many developing countries including India. The rural-urban migration and socioeconomic transition are likely to bring about many changes including those that may be influencing the nutritional and health problems in our country.

CHAPTER-III

MATERIALS AND METHODS

In this chapter, we shall describe the materials and methods used in the present study. These materials and methods are related to those used for collection, analysis and interpretation of data.

Sampling

The present study was conducted among the Ao adults in the Mokokchung district of Nagaland between the months of September 2006 to April 2006. Mokokchung is the home of the Ao-Naga tribe.

The data were collected from both urban and rural areas of the Mokokchung district. For the urban sample, Mokokchung town was the universe of study and two localities or wards, namely, Alempang and Kumlong were selected randomly using random numbers given in Snedecor and Cochran (1967). For rural sample, villages were stratified according to three Rural Development Blocks, namely, Ongpangkong, Mangkolemba and Changtongya. The villages are Khensa and Settsü (Ongpangkong Block), Mulongyimsen 'B' Loyong and Yajang 'C' (Mangkolemba Block), and, Changtongya Yimsen and Wameken (Changtongya Block). The primary sampling units for each of the three strata are six villages randomly selected by using random numbers as given in Snedecor and Cochran (1967). The required number of villages for collecting data from each stratum was determined independently, following the optimum allocation method as suggested by Snedecor and Cochran (1967), which may be substituted as follows:

$R_h = (N_h \sigma_h / \sum N_h \sigma_h)$ ..... (I)

Where R_h = relative sample size of villages in the *h* stratum, N_h = number of villages in h stratum, σ_h = standard deviation of the population size per village in h stratum.

Then, the required sample villages (n_h) to be selected from each stratum will be estimated as follows:

$$n_h = (R_h / \sum R_h)N \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where N = required number of villages to be covered from all three strata (i.e., about 5 or 6 villages), and $\sum R_h$ = sum of relative sample size for all strata.

An attempt was made to cover more than 30% of the total households from each selected sampling unit (i.e., village or locality). No statistical sampling of individuals was applied for collection of data from each selected village or locality to avoid operational difficulties in the field. Instead, an attempt was made to include in our sample all those adults (aged 18-70 years) who are willing to co-operate with the present work. An attempt was also made to cover as many as 30 individuals for each age group. Table 3.1 shows the number of households and number of individuals covered for the present study. Altogether a total of 405 households and 1002 individuals were covered from rural area, and a total of 252 households and 802 individuals were covered from urban area.

Village or Ward	Number of households	Number of individuals
Khensa Village	134	302
Settsü Village	77	160
Wameken Village	43	127
Changtongya Yimsen Village	27	61
Mulongyimsen 'B' Loyong Village	77	191
Yajang 'C' Village	47	161
Alempang Ward	95	461
Kumlong Ward	157	341

Table 3.1. Number of villages and wards covered

DATA ON ADULT BODY DIMENSIONS AND BODY COMPOSITION

A cross-sectional method of anthropometric study was adopted for assessing the body composition and nutritional status of adults aged 18-70 years of age. Some selected anthropometric measurements from the basic list of measurements, which was recommended by the International Biological Programme (Weiner and Lourie, 1981) was taken into consideration for the purpose of the present study. Following are the anthropometric measurements taken on the selected subjects of both sexes wearing light apparel:

Weight (Kg)

Height (cm)

Sitting Height (cm)

Mid Upper Arm Circumference (MAUC) (cm)

Chest Circumference (cm)

Waist Circumference (cm)

Hip Circumference (cm)

Skinfold thickness:

Biceps (mm)

Triceps (mm)

Subscapular (mm)

METHODS OF TAKING MEASUREMENTS

Standard techniques of taking the anthropometric measurements as described in Weiner and Lourie (1981) and Sen (1994) were followed while taking the anthropometric measurements of adults. They may be briefly described as follows:

Weight

The body weight was taken with a spring weighing machine, asking the subject to stand on it bare foot with an erect posture and light apparel. The weighing machine was checked from time to time with a known standard weight. No deduction was made for the weight of light apparel while taking the final reading.

Height

It measures the vertical distance from the floor to the vertex. The subject was made to stand as erect as possible with his/her arms hanging at the sides with thumbs forward, heels holding together and eyes directing towards the horizon (Hooton, 1946). The anthropometer was

placed at the back and between the heels of the subject, taking care that it is kept absolutely vertical. The sliding sleeve of the anthropometer was then lowered down towards the middle of the head (Sagital line) so that it would touch the vertex lightly. Reading in centimeter and its fractions were recorded.

Sitting height

It measures the vertical distance from the vertex to the sitting surface of the subject. The subject was made to sit on the stool, or a flat wooden chair, or at the end of a wooden bench. Then the subject was positioned in an erect sitting posture, with ankles crossed, knees spread at about 20 cm apart and hands rested on the thighs. The anthropometer was placed at the back and between the two buttocks, taking care that the lumbar curve of the subject was not flattened, but concave from behind. The sliding sleeve was the lowered down to touch the vertex lightly.

Mid Upper Arm Circumference (MUAC)

The measurement was taken with a steel tape at the middle (midway between acromion and elbow) part of the left upper arm on the naked skin (Sen, 1994), while the arms were hanging at the sides of the body.

Chest Circumference

It measures the circumference of the chest of the adult subject when he/she was breathing normally. This measurement was taken with a steel tape (Precision – 1mm) at the level of the meso-sternale and at the right angle to the axis of the body when the subject exhaled normally.

Waist Circumference

Waist circumference was measured midway between the lower rib margin and the superior anterior iliac spine. This measurement was taken with a steel tape at the right angle to the axis of the body when the subject exhaled normally.

***Hip* Circumference**

Hip circumference was taken at the widest point over the greater trochanters. This measurement was taken with a steel tape at right angle to the axis of the body when the subject exhaled normally.

Biceps

The skinfold was picked up between the thumb and forefinger and the caliper jaws was applied at exactly the level marked. The measurement was read after the full pressure of the caliper jaws was applied to the skinfold. Harpenden Skinfold Caliper was used for taking the skinfold thickness. The skinfold was picked up on the front of the upper arm directly above the centre of the cubital fossa and the level marked on the skin for the arm circumference.

Triceps

The skinfold was picked up at the back of the upper arm about 1 cm above the level marked on the skin for the arm circumference and directly in line with the olecranon process.

Subscapular

The skinfold was picked up under the inferior angle of the left scapula. According to the natural cleavage of the skin, the fold was measured either vertical or slightly inclined downward and laterally.

Anthropometric Indices and ratios

Besides the above measurements, following indices and ratio were computed for both adult males and females for correlating with body composition.

1. Body mass index or BMI = weight (kg)/height $(m)^2$

2. Fat free mass index or FFMI = FFM (kg)/height $(m)^2$

3. Body fat mass index or BFMI = BFM (kg)/ height $(m)^2$

4. Cormic index or relative-sitting height = sitting height (cm)/height (cm)

5. Conicity index or CI = waist circumference (m)/$0.109\times\sqrt{\{}$weight (kg)/height (m)$\}$

6. Waist-to-Hip ratio or WHR = waist circumference (cm)/ hip circumference (cm)

Anthropometric measurements were used to estimate the body composition (FM and FFM), using the prediction equations of Durnin and Womersley (1974) and Siri (1961) based on age, weight, height, and skinfold thickness. Body density was calculated according to Durnin and Womersley formula, which was in turn used to estimate the percent body fat (PBF) or percent BFM by using Siri's equation:

%BFM = (4.95/density-4.50) × 100

BFM was calculated as body weight multiplied by percent FM and then divided by 100:

BFM = weight (kg) × %BFM/100

FFM was then calculated as body weight minus BFM:

FFM = weight (kg) – BFM (kg)

The BMI (body weight in kg divided by the square of height in meters) was separated into two components: body fat mass index (BFMI = BFM in kg divided by the square of height in meters) and fat-free mass index (FFMI = FFM in kg divided by the square of height in meters) to test the relationship between body composition in terms of BFMI and FFMI with morbidity and other parameters.

Bioelectrical Impedance Analyzer

The body composition was also estimated using Bioelectrical Impedance Analyzer with four-point tactile electrodes (HBF–302, Omron Healthcare, Co. Ltd., Japan). This device measures the electrical signals of undetectably low voltage as they passed through the body fat via handheld device. Since fat is a very poor conductor of electricity, a greater fat accumulation in the body would impede the flow of the current. By measuring the resistance to the current, the device estimates the percent body fat, which can be used for estimating fat-free mass (FFM) by subtracting from body weight.

Blood pressure

Mercury sphygmomanometer was used to measure blood pressure of the individuals included in the present study. All measurements were taken on left hand when subjects were being seated position. Each participant was asked to relax and take rest for 10 minutes before taking the measurement. Systolic blood pressure was recorded as the first Korotkov sound (phase 1). Distolic blood pressure was taken as the disappearance of the Korotkov sounds (Phase V). Measurements were recorded for three times, and the average of the three was taken as recorded measurement. Digital blood pressure monitor (M2 Model, Omron Health Care Co. Ltd., Japan) was also used to cross-check the measurement. However, mercury type of measurement was reported for the present study.

Data on Morbidity

Data on morbidity were collected on the basis of "self reported illness" of the information taking into consideration the timeframe of two-week, three-week and four-week recalls of illness prior to the survey. Structured schedules were prepared by taking into consideration those described in different health studies conducted in India and abroad (IIPS and Macro International, 2000; Strickland and Tuffrey, 1997). Such schedules took into consideration the informant's perception of illness rather than the Western medical definition of a specific disease. In order words, the present study did not include a clinician thereby morbidity is referred to as an "illness" rather than a "disease". The self-reported symptoms of illness were grouped into different categories as followed by many studies (Strickland and Ulijaszek, 1993; Strickland and Tuffery, 1997; Sadana, 2000). The categories include: **(1) Cold/respiratory disorders:** *cough + runny nose + headache + fever, fever + cough, cough* alone, swollen glands + cold, ear problem, breathing problem, chest pain, sore throat, tuberculosis. **(2) Diabetes** – Type I and Type II. **(3) Cardiovascular problems** including *hypertension.* ***(4) Miscellaneous disorders:*** *sores/boils, fever alone, chicken pox, malaria,* typhoid, scabies, jaundice, all body pain, osteoarthritis, rheumatism, headache alone, malnutrition, weakness, don't know/unknown.

Socio-economic and demographic data

Rural and Urban

In the present study, the terms rural and urban were based on the definitions and concepts as given in Census of India, 2001. An urban area is defined as all places with a Municipality, Municipal Corporation, Cantonment Board, Notified Area/Town Committee, etc., and which satisfies the criteria such as a minimum population of 5000, at least 75% of the working population is engaged in non-agricultural pursuits and the population density is at least 400 per square kilometre. It also states that a town, whether statutory or non-statutory is an urban unit with a population below 100,000. Any place i.e., inhabited villages, which do not fulfil the criteria to be treated as urban units are treated as rural areas.

Thus, basing on this, Mokokchung town was classified as an urban area. While the six villages were classified as rural areas.

Education

The data on education of the individuals were classified into three broad educational levels, *namely, primary, secondary and higher secondary and above. In the present study, the* number of illiterates, i.e., those individuals who were not able to read or write, was negligible especially in urban areas. Therefore, we pooled some illiterate individuals in the category of ***primary level*** *of education, which includes lower primary and upper primary, i.e., up to* standard VIII. In the **secondary level** of education, we included those individuals who attended standard VIII to X. **Higher Secondary level and above** included other individuals *who attended standard XI and other higher levels of education. This educational classification* is highly arbitrary. However, our purpose is simply to examine the trend of body composition and nutritional status according to educational levels of the individuals. It is assumed that if *education is really important in regulating body composition and nutritional status like in the* western countries, its effects can be observed even if the individuals were dichotomized only into two categories, say, lower and higher levels of education.

Household Income

Data on monthly income were directly collected from the heads of the households and were *cross-checked taking into consideration some aspects of socio-economic conditions like* housing condition; house type, ownership of house, number of rooms, etc., household possession, sanitation, types of occupation, land holding, and monthly expenditure. Income *groups were classified into three categories, namely, Low, Middle and High Income groups* based on the per capita monthly income as follows:

Above 75^{th} percentile (>Rs.2200) = High income group (HIG)

50^{th} to 75^{th} percentile (Rs.1500-2200) = Middle income group (MIG)

Below 50^{th} percentile (<Rs. 1500) = Low income group (LIG)

Family size

Data on family size was classified into three groups: **(1) Ideal or Small** – family consisting *of four or less members.* ***(2) Medium*** *– family consisting of five or six members.* **(3) Large** – family consisting of more than seven members.

Physical Activity

Physical activity level was classified on the basis of occupations of the individuals, as described by the Indian Council of Medical Research (ICMR, 1991). The physical activity was classified into the following three categories for both males and females: **(1) Sedentary** – teacher, barber, housewife, student, nurses, executives, retired personnel, land-lord, tailor, peon, postman, pastor or priest, salesperson, shopkeeper, etc. **(2) Moderate** – agricultural labourer, farmer, fisherman, potter, fitter, tuner, welder, industrial labour, *cooli, beedi*-maker, carpenter, weaver, driver, plumber, electrician, basket-maker, maid servant, etc. **(3) Heavy** – stone-cutter, wood-cutter, blacksmith, etc. Due to limited sample size with respect to Heavy category from females, the physical activity level in the present study was classified into two categories, sedentary and moderate.

Statistical analyses

The basic design of the study is to analyse and present comparative data between urban and rural areas. In addition, the main focus of analysis was on the relationship between body composition and nutritional status, and their relationship with biosocial variables, such as age, sex, anthropometric variables, self-reported morbidity, blood pressure, physical activity, occupation, household income, education and family size.

All data was managed and analysed using SPSS/PC Software. The analysis was first carried out to present the basic descriptive statistics of anthropometric variables, blood pressure and morbidity prevalence in relation to socio-economic characteristics of the study samples for both rural and urban areas. The nutritional status was assessed, using the cut-off points for body mass index as recommended by the World Health Organization (WHO, 1995, 2000). The relationship between body composition and nutritional status was tested, using analysis of covariance (ANCOVA) and multiple regression analysis. For example, the differences in mean FM and FFM values according to nutritional groups by age and sex was determined, using ANCOVA after adjusting for socio-economic variables. Multiple regression analysis was used for testing the nature of such relationship, if any. Special attention was given to the relationship of body composition/nutritional status with morbidity, blood pressure and socio-economic conditions by applying appropriate statistical analyses. For example, the relationship between body composition/nutritional status and morbidity was tested, using odds ratios with 95% confidence interval from different models of logistic regression analysis after adjusting for socio-economic variables that would be quantified in

terms of appropriate dummy numbers to fit the logistic models. On the other hand, the relationship between nutritional status and blood pressure was determined, using ANCOVA and multiple regression analysis because blood pressure is a continuous trait.

CHAPTER IV

BODY COMPOSITION AND NUTRITIONAL STATUS

In the present Chapter, we shall describe our findings on adult body dimensions, body composition and nutrition status of the study population. Since our design of study is to compare the rural and urban differences in these characteristics, the chapter segregates the total sample size into rural and urban areas in order to examine the differences and the causes of such differences.

SOCIOECONOMIC BACKGROUND

Table 4.1 shows the percentage distribution of males and females according to background characteristics for both rural and urban areas. It is seen that the proportion of males and females is more or less similar in all age groups, especially in rural areas. Considering the sex and urban-rural differences, literacy is almost 100% in urban areas. In rural areas, on the other hand, the proportion of illiterate persons was about 10%, which is greater in females (15.28%) than in males (5.45%). It is also observed that the proportion of individuals with higher secondary level of education was much higher in urban than in rural areas. Therefore, it is difficult to analyze the data if we follow the educational level as classified in **Table 4.1** due to limited sample size with respect to illiteracy for urban areas and with regard to the higher secondary level for rural areas. Accordingly, for further analysis, our data on educational level were classified into three categories, namely, primary (i.e., illiterates plus lower and upper primary), secondary and higher secondary & above.

Table 4.1. Percentage distribution of males and females according to background characteristics

Background characteristics	Rural				Urban			
	Males (N =485)		Females (N=517)		Males (N =405)		Females (N=397)	
	N	%	N	%	N	%	N	%
Age group (years)								
≤ 34	211	43.51	245	47.39	210	51.85	202	50.88
35-54	179	36.91	181	35.01	127	31.36	145	36.52
≥ 55	95	19.58	91	17.60	68	16.79	50	12.60
Education								
Primary	420	50.12	345	66.73	20	4.94	68	17.13
Secondary	164	33.18	111	21.47	47	11.60	75	18.89
Higher secondary & above	81	16.70	61	11.80	338	83.46	254	63.98
Income group								
Low	385	79.38	417	80.66	61	15.06	65	16.38
Middle	60	12.37	57	11.02	157	38.77	160	40.30
High	40	8.25	43	8.32	187	46.17	172	43.32
Family income earning								
Yes	78	16.08	112	21.66	181	44.69	277	69.77
No	407	83.92	405	78.34	224	55.31	120	30.23
Family size								
Small (<4)	168	34.64	200	38.68	148	36.54	145	36.52
Middle (5-6)	239	49.28	237	45.84	237	58.52	230	57.93
Large (> 7)	78	16.08	80	15.48	20	4.94	22	5.54

With respect to income groups or levels, **Table 4.1** shows that there are differences between rural and urban areas in the proportion of participants belonging to three income levels. It is seen that the percentage of participants with low income level is much higher in rural areas than in urban areas. On the other hand, the proportion of participants with high income level in urban area is much higher than that in rural areas. Therefore, it is clearly evident that urban areas are more advanced in both education and economic condition. It is also observed that the proportion of participants with small family size is higher in urban than in rural areas, and a large proportion of women in urban area contributed to family income.

ANTHROPOMETRIC CHARACTERS

It is evident from **Table 4.1** that there are differences in socioeconomic conditions between rural and urban areas. Therefore, it is expected that such differences could have an effect on the anthropometric characters of both males and females. Therefore, an attempt has been made to show in **Tables 4.2** and **4.3** the differences in anthropometric characters between rural and urban areas for males and females, respectively. It is seen from **Table 4.2** that urban

males are significantly heavier and taller than rural males. Urban males have also greater hip circumference, biceps, cormic index, conicity index and waist-hip ratio. It is also interesting to note that although there is no significant difference in body mass index (BMI) between rural and urban males, the fat free mass index was significantly greater in rural males than in urban males. This indicates that the greater muscle mass in rural males might be due to greater physical activity in rural areas.

Table 4.2: Anthropometric characters of rural and urban males

Anthropometric characters	Rural (N=485)		Urban (N = 405)		t-value
	Mean	SD	Mean	SD	
Anthropometric measurements					
Weight (Kg)	54.98	6.87	56.85	7.03	3.988**
Height (cm)	162.70	4.64	166.25	3.91	12.373***
Sitting height (cm)	83.38	3.24	83.86	2.28	2.582**
MUAC (cm)	24.15	2.02	24.21	2.18	0.422
Chest circumference (cm)	80.54	4.62	80.76	4.08	0.753
Hip circumference (cm)	79.31	5.12	80.15	4.69	2.549*
Waist circumference (cm)	69.51	6.56	68.61	9.72	1.584
Biceps (mm)	3.42	1.28	3.59	1.39	1.939*
Triceps (mm)	7.69	2.29	7.91	2.82	1.290
Subscapular (mm)	12.42	4.03	12.86	5.17	1.399
Sum of 3 skinfold thicknesses (mm)	23.53	7.05	24.37	9.06	1.524
Anthropometric indices & ratios					
Body mass index (kg/m^2)	20.76	2.36	20.58	2.54	1.098
Fat-free mass index (kg/m^2)	17.29	1.38	17.06	1.39	2.438*
Fat-mass index (kg/m^2)	3.47	1.25	3.52	1.49	0.493
Cormic index	0.50	0.02	0.51	0.02	7.128***
Conicity index	1.08	0.07	1.10	0.11	3.783***
Waist-hip ratio	0.85	0.06	0.88	0.08	4.867***

*p<0.05, **p<0.001, ***p<0.0001

Table 4.3: Anthropometric characters of rural and urban females

Anthropometric characters	Rural (N=517)		Urban (N = 397)		t-value
	Mean	*SD*	*Mean*	*SD*	
Anthropometric measurements					
Weight (Kg)	47.74	6.84	49.10	8.09	2.688*
Height (cm)	152.72	4.01	153.30	3.13	2.453*
Sitting height (cm)	78.41	3.66	79.21	2.76	3.763***
MUAC (cm)	22.26	2.18	22.78	2.30	3.461***
Chest circumference (cm)	78.68	6.06	80.02	5.43	3.511***
Hip circumference (cm)	78.71	6.97	81.00	6.40	5.152***
Waist circumference (cm)	65.29	7.08	66.83	10.36	2.538*
Biceps (mm)	4.65	2.03	4.83	1.92	1.335
Triceps (mm)	10.73	3.56	10.98	3.57	1.039
Subscapular (mm)	15.04	5.99	16.64	6.93	3.677***
Sum of 3 skinfold thicknesses (mm)	30.42	10.53	32.45	11.63	2.720**
Anthropometric indices & ratios					
Body mass index (kg/m^2)	20.46	2.76	20.89	3.37	2.079*
Fat-free mass index (kg/m^2)	15.39	1.33	15.50	1.65	1.095
Fat-mass index (kg/m^2)	5.07	1.66	5.39	1.92	2.664**
Cormic index	0.51	0.02	0.52	0.02	2.846**
Conicity index	1.07	0.07	1.08	0.09	1.652
Waist-hip ratio	0.83	0.07	0.82	0.07	1.974*

*p<0.05, **p<0.001, ***p<0.0001

As for adult females, **Table 4.3** shows that almost all the anthropometric characters were significantly greater in urban than in rural areas. This clearly indicates that there are considerable differences between rural and urban areas with respect to body dimensions and composition among adult females in the present study.

In view of these findings on socioeconomic and anthropometric characters, it is clear that we cannot pool the rural and urban data without proper adjustment. Therefore, our design of study to segregate the rural and urban data seems to be well-fit as far as the present study is concerned. Accordingly, in the following sections, we shall present our data separately for both males and females in order to address the objectives of the present study.

BODY COMPOSITION AND NUTRITIONAL STATUS

One of the main objectives of this study is to address the relationship between body composition and nutritional status, and how body composition is related to age, sex, anthropometric variables, self-reported morbidity, blood pressure, and socio-economic variables. In order to address this objective, we shall look into these following aspects:

(i) Body composition in terms of 2-compartment model, i.e., body fat mass (BFM) and fat-free mass (FFM) derived from anthropometric measurements and measured by Omron bioelectrical impedance analyzer (OBIA);

(ii) Nutritional status as defined by BMI including its components, namely, body fat mass index (BFMI) and fat-free mass index (FFMI);

(iii) The relationship between body composition and nutritional status shall be described in terms of the above mentioned variables;

(iv) The relationship between body composition and body shape in relation to age, sex, anthropometric variables, self-reported morbidity, blood pressure, and socioeconomic variables.

Body Composition

Table 4.4 shows the body composition of males as measured by anthropometry and OBIA. Following a 2-compartment model, body composition is divided into major components, namely, fat free mass (FFM) and body fat mass (BFM). FFM includes water, muscles, bones, minerals, proteins, and other tissues of the body; whereas BFM includes essential and energy stores or storage fat. The formula for obtaining FM was described in Chapter III.

As for the body composition derived from anthropometry, **Table 4.4** shows that when BFM and FFM are expressed in kg, the urban males have significantly greater BFM and FFM than their rural counterparts. However, when both BFM and FFM are expressed as percentage of the body weight, the differences between rural and urban males disappeared. As a matter of fact, there is no difference between rural and urban males with respect to BMI. But when the BMI is split into two components, namely, BFMI and FFMI, we find that the differences between rural and urban males are significant only with respect to FFMI. It indicates the fat-free mass derived from anthropometry is significantly greater in urban than in rural males. Although it may be expected that BFM should be greater among urban males, the present findings indicates the absence of such differences between rural and urban areas. It is also seen that FFM measured by OBIA is about 0.90 kg different from that estimated

from anthropometry. Further, although FFM is greater among the urban males, there are no differences between rural and urban males with respect to BMI and its components. Therefore, it is possible that these discrepancies are due to technical error including instrumental errors. It may be mentioned that the standard error of estimate (SEE) in FFM according to OBIA is reported to be ≤ 3.5 kg for men and ≤ 2.8 kg for women (Heyward and Wagner, 2004). Considering these values of SEE, we may suggest that the body fat estimated from anthropometry is by and large similar to that measured by OBIA.

Table 4.4: Body composition of males as measured by anthropometry and impedance analyzer

Parameters	Rural (N=485)		Urban (N = 405)		t-value
	Mean	SD	Mean	SD	
Anthropometric measures					
Body fat mass (kg)	9.20	3.32	9.70	4.00	2.000*
Body fat mass (%)	16.38	4.06	16.62	5.05	0.752
Fat free mass (kg)	45.79	4.42	47.16	4.24	4.708***
Fat free mass (%)	83.62	4.06	83.38	5.05	0.752
Body mass index (kg/m^2)	20.76	2.36	20.58	2.54	1.098
Fat-free mass index (kg/m^2)	17.29	1.38	17.06	1.39	2.438*
Fat-mass index (kg/m^2)	3.47	1.25	3.52	1.49	0.493
By impedance analyzer					
Body fat mass (kg)	10.23	4.10	10.59	5.00	1.157
Body fat mass (%)	18.22	5.97	18.17	7.19	0.100
Fat free mass (kg)	44.75	5.02	46.26	4.67	4.635***
Fat free mass (%)	81.78	5.97	81.83	7.19	0.100
Body mass index (kg/m^2)	20.76	2.36	20.58	2.54	1.098
Fat-free mass index (kg/m^2)	16.88	1.45	16.72	1.46	1.552
Fat-mass index (kg/m^2)	3.89	1.60	3.86	1.86	0.255

*p<0.05, **p<0.001, ***p<0.0001

Table 4.5: Body composition of females as measured by anthropometry and impedance analyzer

Parameters	Rural (N=517)		Urban (N = 397)		t-value
	Mean	*SD*	*Mean*	*SD*	
Anthropometric measures					
Body fat mass (kg)	11.84	3.92	12.68	4.55	2.940**
Body fat mass (%)	24.26	4.60	25.11	5.09	2.586*
Fat free mass (kg)	35.91	3.51	36.43	4.00	2.047*
Fat free mass (%)	75.74	4.60	74.89	5.09	2.586*
Body mass index (kg/m^2)	20.46	2.76	20.89	3.37	2.079*
Fat-free mass index (kg/m^2)	15.39	1.33	15.50	1.65	1.095
Fat-mass index (kg/m^2)	5.07	1.66	5.39	1.92	2.664**
By impedance analyzer					
Body fat mass (kg)	12.39	4.73	13.37	5.90	2.697**
Body fat mass (%)	25.20	6.18	26.11	7.55	1.947*
Fat free mass (kg)	35.35	3.15	35.73	2.99	1.879
Fat free mass (%)	74.80	6.18	73.98	7.55	1.947*
Body mass index (kg/m^2)	20.46	2.76	20.89	3.37	2.079*
Fat-free mass index (kg/m^2)	15.14	1.06	15.20	1.17	0.800
Fat-mass index (kg/m^2)	5.32	2.03	5.69	2.50	2.419*

*p<0.05, **p<0.001, ***p<0.0001

Unlike the case of males, the rural-urban differences in body composition of females are significant in almost all the indicators considered under the present study. **Table 4.5** shows that the BFM and FFM, expressed in kg and percentage of body weight, among urban women are significantly greater than those among rural women. It holds good for BFM and FFM derived from anthropometry and OBIA. The same is true with respect to BMI and its component BFMI. This is clearly evident that urban females had greater fatness than their rural counterparts. It is likely that the prevalence of obesity would be greater among urban females than rural females. In the following sections, we shall look into this aspect.

NUTRITIONAL STATUS

The nutritional status of participants in this study was assessed by using BMI, taking into consideration the cut-off points recommended for the Asia pacific region (WHO, 2000). As described in Chapter II, the WHO (1995) has recommended the BMI cut-offs of 25.0 kg/m^2

and 30.0 kg/m^2 for defining overweight and obesity, respectively. But there is considerable evidence that these cut-off values are not applicable across ethnic groups, especially among Asian populations. Accordingly, the new BMI cut-off points of 23·0 kg/m^2 and 25·0 kg/m^2 have been recommended for Asian populations (WHO, 2000) and other populations (WHO, 1995), respectively. In order to test the validity of these recommended cut-off points, we used the ROC curve analysis and the results are given in **Table 4.6** and **Figures 4.1-4.4.**

Table 4.6 shows sensitivity and specificity values according to selected threshold values of BMI against the reference PBF>25% for men and >30% for women derived from anthropometry and OBIA. On the basis of anthropometry, the BMI cut-off points of ≥ 23 and ≥22 kg/m^2 would be most appropriate for detecting obesity among males and females, respectively. The area under ROC curve (AUC) was 0.934±0.017, $p < 0.0001$ for males (**Figure 4.1**), and 0.959±0.011, $p < 0.0001$ for females (**Figure 4.2**). On the other hand, if %BF is based on OBIA, the BMI cut-off points for males and females would be ≥ 21 and ≥22 kg/m^2, respectively. The AUC was found to be 0.820±0.021, $p < 0.0001$ for males (**Figure 4.3**), and 0.974±0.001, $p < 0.0001$ for females (**Figure 4.4**). On the basis of these ROC curve analysis, we may conclude that the BMI cut-off point for defining overweight in the present population lies between 21.0 and 23.0 kg/m^2.

If the BMI cut-off point is increased up to ≥ 25 kg/m^2 against the reference PBF >25%, the amount of sensitivity decreased substantially, while the amount of specificity increased marginally. For example, on the basis of anthropometric estimate of %BF, the amount of specificity in males was 56.73% (95% CI: 46.7-66.4) with 99.87% specificity (95% CI: 99.3-100.0). Compared with the values for the cut-off point 23.12 kg/m^2, there is a decrease of 28 percentage point in sensitivity, and an increase of about 6 percentage points in specificity. Similarly, the positive predicted value increased from 14% to 446% and the negative predicted value decreased from about 0.16% to 0.43%. Therefore, the cut-off points recommended for the Asia-pacific regions (WHO, 2000) would be more appropriate than those international cut-off points recommended by the WHO (1995) so far as the nutritional status in the present population is concerned. However, it is also important to report the findings as per the international cut-off points for the purpose of comparative analysis. In the following sections, we shall look into the nutritional status of the adult males and females, taking into consideration both the recommended cut-off points.

Table 4.6: Sensitivity and specificity of BMI thresholds in detection of obesity against the PBF reference value of > 25% for males and > 30% for females

BMI cut-off	Sensitivity (95% CI)	Specificity (95%CI)	Positive predicted value	Negative predicted value
Anthropometry				
Males = >25.0	56.73(46.7-66.4)	99.87(99.3-100.0)	445.90	0.43
Females = >25.0	49.43(41.8-57.1)	98.92(97.9-99.5)	45.60	0.51
OBIA				
Males = >25.05	33.14(26.2-40.7)	99.58(98.8-99.9)	79.31	0.67
Females = >25.0	*42.22(37.5-49.0)*	*100(99.5-100.0)*	*0.00*	*0.58*
Anthropometry				
Males = >23.12	84.62 (76.2 - 90.9)	93.89 (92.0 - 95.5)	13.86	0.16
Females = >21.95	91.48 (86.3 - 95.2)	86.86 (84.2 - 89.2)	6.96	0.10
OBIA				
Males = >21.35	76.16 (69.1 - 82.3)	75.49 (72.2 - 78.6)	3.11	0.32
Females = >21.90	91.56 (87.1 - 94.8)	91.44 (89.1 - 93.4)	10.69	0.09

OBIA – Omron bioelectrical impedance analyzer

Figure 4.1: ROC curve of sensitivity and specificity by BMI against reference PBF derived from anthropometry (Males)

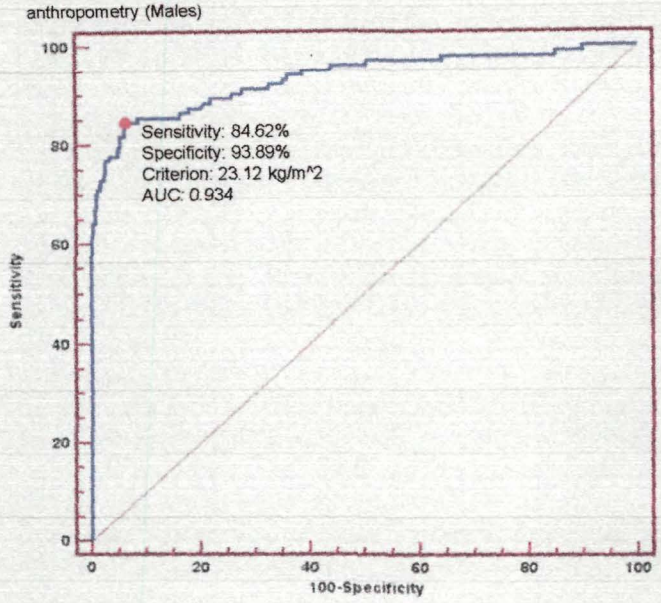


Figure 4.2: ROC curve of sensitivity and specificity by BMI against reference PBF derived from anthropometry (Females)

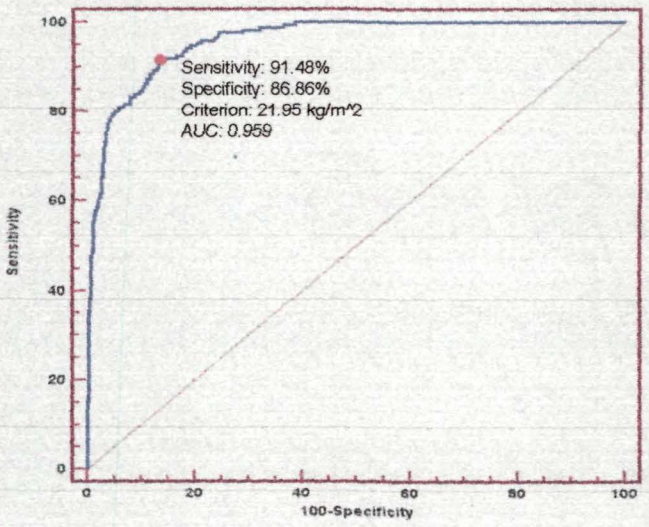


Figure 4.3: ROC curve of sensitivity and specificity by BMI against reference PBF derived from OBIA (Males)

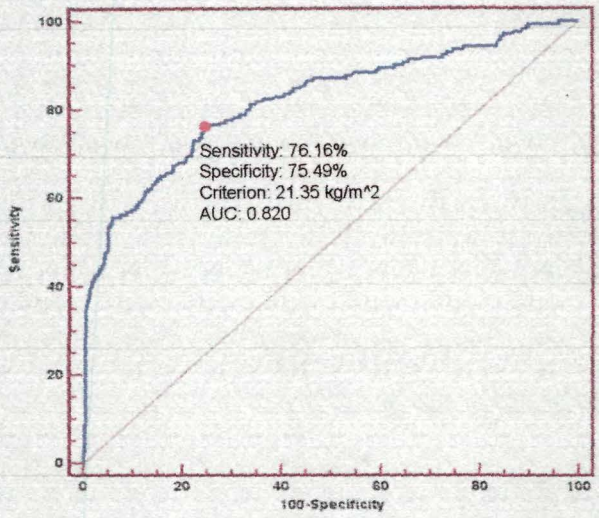
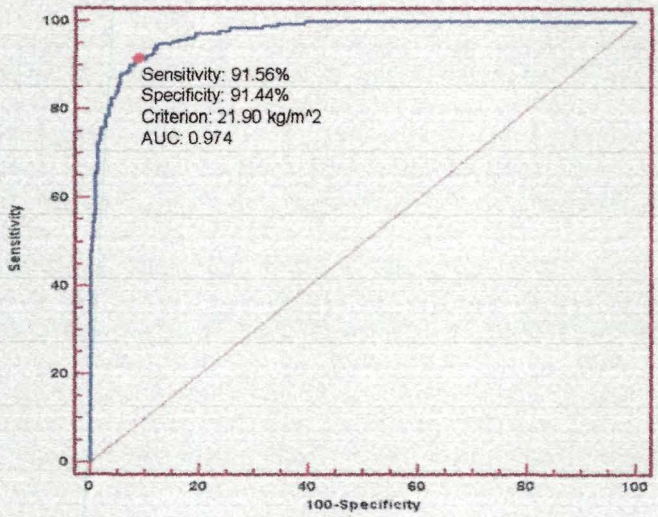


Figure 4.4: ROC curve of sensitivity and specificity by BMI against reference PBF derived from OBIA (Females)



Nutritional status according to BMI

Table 4.7 shows the nutritional status of participants according to BMI categories. It is found that about 17.11%, 76.91% and 5.98% of rural males were in the categories of underweight, normal and overweight & obesity, respectively. In urban areas, these frequencies are 24.94%, 67.16% and 7.90%, respectively. These rural-urban differences in the distribution of adult males with regard to their nutritional status are highly significant ($\chi^2 = 10.62$, $df = 2$, $p < 0.005$). It is also found that that the higher prevalence of underweight in urban areas as compared to rural areas was also highly significant ($\chi^2 = 8.24$, $df = 1$, $p < 0.004$). This finding is somewhat contrary to the general observation that the nutritional status is better in urban than rural areas. As for women, the rural-urban difference in the prevalence of underweight among women was not statistically significant ($\chi^2 = 1.01$, $df = 1$, $p > 0.05$), although it appears to be higher in urban (31.49%) than in rural (28.43%) areas.

With respect to the prevalence of overweight and/or obesity, it is observed that are three aspects of differences, namely, (i) differences due to BMI cut-off points, (ii) rural-urban differences, and (iii) differences between the sexes. As mentioned above, the cut-off points recommended for the Asia-pacific regions (WHO, 2000) would be more appropriate in the present population than those international cut-off points recommended by the WHO (1995). However, we have presented our data according to international cut-off points (WHO, 1995) for not only for comparative purposes (WHO Consultation Group, 2004), but also for understanding the possible underestimation of the prevalence of overweight/obesity in the present population. This is important because many studies in India and other developing countries have paid more attention to the problem of under-nutrition as compared to that of over-nutrition. **Table 4.7** shows that the prevalence of overweight/obesity in rural males, for example, was 5.98% according to the international cut-off points, but it was about 15.26% according to the cut-off points recommended for the Asia-pacific regions (WHO, 2000). It shows that the difference in estimation of overweight and/or obesity is about 9 percentage points. This sort of underestimation of the prevalence of overweight and/or obesity holds true for both males and females in both rural and urban areas. We shall further discuss this issue in chapter on discussion.

Table 4.7: Nutritional status according to BMI

Nutritional Status	Rural (n = 1002)		Urban (n = 802)	
	Number	%	*Number*	%
According to International Cut-offs (WHO, 1995)				
Males (N for rural= 485, urban = 405)				
Underweight (< 18.5 kg/m^2)	83	17.11	101	24.94
Normal (18.5 – 24.9 kg/m^2)	373	76.91	272	67.16
Overweight and obesity (≥ 25 kg/m^2)	29	5.98	32	7.90
Females (N for rural= 517, urban =397)				
Underweight (< 18.5 kg/m^2)	147	28.43	125	31.49
Normal (18.5 – 24.9 kg/m^2)	326	63.06	220	55.42
Overweight and obesity (≥ 25 kg/m^2)	44	8.51	52	13.10
According to Asia Pacific Cut-offs (WHO, 2000)				
Males (N for rural= 485, urban = 405)				
Underweight (< 18.5 kg/m^2)	83	17.11	101	24.94
Normal (18.5 – 22.9 kg/m^2)	328	67.63	228	56.30
Overweight and obesity (≥ 23 kg/m^2)	74	15.26	76	18.77
Females (N for rural= 517, urban =397)				
Underweight (< 18.5 kg/m^2)	147	28.43	125	31.49
Normal (18.5 – 22.9 kg/m^2)	281	54.35	173	43.58
Overweight and obesity (≥ 23 kg/m^2)	89	17.21	99	24.94

Note: Overall prevalence of underweight is 22.95% in rural and 28.18% in urban areas

With respect to the rural-urban differences in overweight and/or obesity, **Table 4.7** shows that it is higher in urban than in rural areas, irrespective of cut-off points and sexes. According to the cut-off points recommended for the Asia-pacific regions (WHO, 2000), the prevalence of overweight was 15.26% and 18.77% in rural and urban males, respectively. This difference between rural and urban males is, however, not statistically significant (χ^2 = 1.01, df = 1, $p > 0.05$). In other words, although the prevalence of overweight appears to be greater in urban than rural males, such differences may be due to sampling variation or chance errors. In the case of women, the situation is however different. It is found that the urban women are significantly higher in the prevalence of overweight when compared with the rural women (χ^2 = 8.20, df = 1, $p < 0.02$). With respect to sex differences, **Table 4.7** indicates that women had a greater prevalence of overweight than men in both rural and

urban areas. However, from the statistical point of view, the differences are significant only in urban areas where the prevalence of overweight was 18.77% and 24.94% in men and women, respectively ($\chi^2 = 4.48$, df = 1, $p < 0.03$).

Overall, the present findings on nutritional status indicate that the prevalence of underweight among urban adult males is higher than that among rural adult males. This rural-urban difference was statistically absent in the case of adult females. As normally expected, the prevalence of overweight and/or obesity was greater if we follow the cut-off points recommended for the Asia-pacific regions (WHO, 2000). Although the prevalence of overweight appears to be greater in urban than rural areas, the differences are significant only in adult females. The sex differences in the prevalence of overweight and/or obesity was highly significant in urban areas, i.e., women had greater prevalence of overweight and/or obesity than men.

Relationship between Body Composition and Nutritional Status

In the preceding sections of the present chapter, we have described the body composition and nutritional status of the present population. In this section, we shall describe and analyze the relationship between body composition and nutritional status in relation to age, sex, self-reported morbidity, hypertension and socioeconomic variables for both rural and urban areas. As mentioned earlier, the body composition is defined in terms of PBF and FFM; whereas the nutritional status is defined in terms of BMI categories.

Table 4.8 shows the adjusted means of PBF according to BMI categories among males and females in both rural and urban areas. The unadjusted means according to BMI categories are presented in **Figure 4.5**. It is seen from the figure that the mean PBF increases with increasing BMI levels for both males and females in both rural and urban areas. Both rural males and females had greater PBF except in the case of BMI categories of about 22 to 25 kg/m in which the PBF is greater in rural females. Adjusting for age, morbidity, hypertension, household income and education; the rural-urban differences in PBF were also not significant across levels of BMI.

A similar trend in observed in the case of means of FFM adjusted for age, morbidity, hypertension, household income and education (**Table 4.9 and Figure 4.6**). However, the rural-urban differences are significant especially among males. It is very interesting to note here that the urban males have a higher FFM than the rural males across levels of BMI. Among females, there are significant differences only in the normal category of BMI, i.e., 18.5-22.9 kg/m^2 (***Table 4.9***).

It is evident from these findings that it is difficult to conclude whether BMI is more related to PBF or FFM. The results indicate that both PBF and FFM have significantly increased with the increase in BMI levels. Secondly, it indicates that the urban males have a higher FFM than the rural males across levels of BMI, although it is expected that greater physical activity may increase FFM in rural areas.

Table 4.8. Adjusted means of PBF according to BMI categories*

BMI categories	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 18.5 kg/m^2	83	13.53	0.32	101	13.25	0.32	0.663
18.5-22.9 kg/m^2	328	15.78	0.16	228	16.18	0.21	1.326
> 23.0 kg/m^2	74	22.26	0.35	76	23.38	0.38	0.648
ANCOVA-F ratio	*180.41, p < 0.0001*			*167.44, p < 0.0001*			
Females							
< 18.5 kg/m^2	147	20.98	0.23	125	20.77	0.28	0.800
18.5-22.9 kg/m^2	281	23.66	0.16	173	24.80	0.22	3.897***
> 23.0 kg/m^2	89	31.59	0.31	99	31.11	0.34	0.529
ANCOVA-F ratio	370.85, p < 0.0001			224.03, p < 0.0001			

*** Adjusted for age, household income, education, morbidity and hypertension**

Table 4.9. Adjusted means of fat free mass (kg) according to BMI categories*

BMI categories	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 18.5 kg/m^2	83	40.74	0.36	101	42.86	0.30	5.143***
18.5-22.9 kg/m^2	328	45.86	0.18	228	47.28	0.20	5.426***
> 23.0 kg/m^2	74	51.14	0.39	76	52.51	0.36	2.347*
ANCOVA-F ratio	185.03, p < 0.0001			202.54, p < 0.0001			
Females							
< 18.5 kg/m^2	147	32.53	0.21	125	32.34	0.22	0.888
18.5-22.9 kg/m^2	281	36.37	0.15	173	37.04	0.18	2.731**
> 23.0 kg/m^2	89	40.05	0.28	99	40.52	0.28	1.645
ANCOVA-F ratio	225.29, p < 0.0001			239.24, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

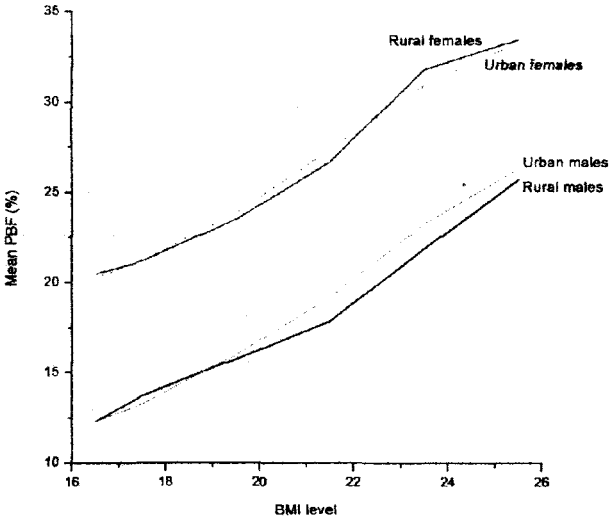


Figure 4.5. Mean percent body fat by BMI levels

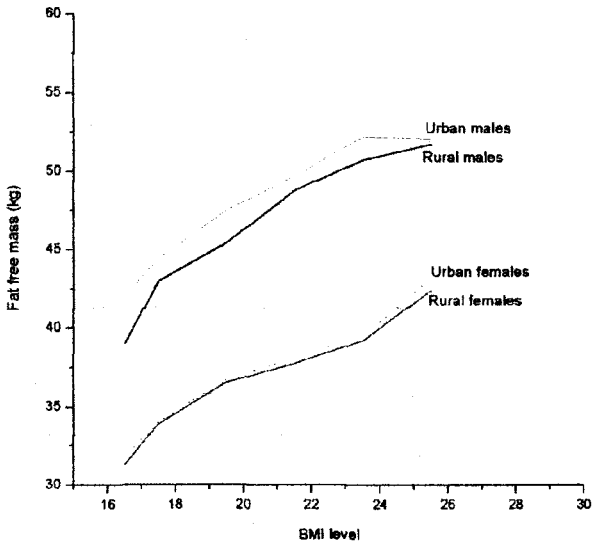


Figure 4.6. Mean fat free mass by BMI levels

In order to have a better understanding of the relationship between BMI and body composition, an attempt has been made to give in **Table 4.10** the results on the relationship nutritional indices (BMI and its components – BFMI and FFMI) and body composition. It is found that the overall correlation between PBF and BMI in males was similar in both rural ($r = 0.77$, $p < 0.001$) and urban ($r = 0.79$, $p < 0.001$). The same is true for females (r for rural = 0.83, $p < 0.001$, and urban = 0.86, $p < 0.001$). However, the correlation coefficient is greater in

females than males. The same trend is observed in the case of FFM. Nevertheless, it is clear that both PBF and FFM are highly correlated with BMI. It is somewhat difficult to conclude whether BMI is more correlated to PBF or FFM, although the correlation coefficient seems to be smaller with FFM. It may be noted that the major nutritional problem is the correlation between excess body fat and other chronic diseases. Secondly, BMI is a crude measure of both body fat and fat free mass. High BMI may also be due to high muscle mass, not necessarily because of high body fat. Therefore, it has been suggested to split the BMI into two parts, body fat mass index (BFMI) and fat free mass index (FFMI) to understand the relationship between body composition and nutritional status especially in relation to morbidity (Khongsdier, 2005). Having split the BMI into BFMI and FFMI, **Table 4.10** shows that BFMI is more correlated with PBF, whereas FFMI is more correlated with FFM for both the sexes in rural and urban areas. For example, following the z-score test for the difference between two correlations (Blalock, 1972), the z-score conversions for the correlation coefficients (r) between BMI and PBF (0.77) versus BFMI and PBF (0.97) among rural males were 1.0203 and 2.0923, respectively, giving a difference of 1.2773 [the formula for z-score = $\{\ln(1+r)/(1-r)\}/2$]. The standard error (SE) of difference between the two correlations is $\{\sqrt{1/(n_1-3)} + 1/(n_2-3)\} = \{\sqrt{1/(485-3)} + 1/(485-3)\} = 0.0644$. Therefore, the z-value of difference is 1.0720/0.0644 = 16.65, which is highly significant ($p < 0.0001$), i.e., much higher than 1.96 at 0.05 level. The differences in scatter plots of PBF on BMI and BFMI in rural males can also be clearly seen in **Figures 4.7 and 4.8**, respectively. It shows the *relationship of PBF is more curvilinear with BMI but more linear with BFMI.*

Thus, it suggests that information may be more accurate if the nutritional status is defined in terms of both BFMI and FFMI, especially in a situation where the information on *the relative importance of body fat and fat free mass is important to understand the nutritional* status.

Table 4.10: Correlation between nutritional indices and body composition in terms of PBF and FFM

Variables	Rural		Urban	
	Males	Females	Males	Females
BMI				
PBF	0.77, $p < 0.001$	0.83, $p < 0.001$	0.79, $p < 0.001$	0.86, $p < 0.001$
FFM	0.73, $p < 0.001$	0.78, $p < 0.001$	0.70, $p < 0.001$	0.78, $p < 0.001$
BFMI				
PBF	0.97, $p < 0.001$	0.97, $p < 0.001$	0.98, $p < 0.001$	0.97, $p < 0.001$
FFM	0.48, $p < 0.001$	0.63, $p < 0.001$	0.40, $p < 0.001$	0.76, $p < 0.001$
FFMI				
PBF	0.43, $p < 0.001$	0.53, $p < 0.001$	0.39, $p < 0.001$	0.62, $p < 0.001$
FFM	0.81, $p < 0.001$	0.84, $p < 0.001$	0.86, $p < 0.001$	0.93, $p < 0.001$

Figure 4.7: Relationship between BMI and PBF in rural males

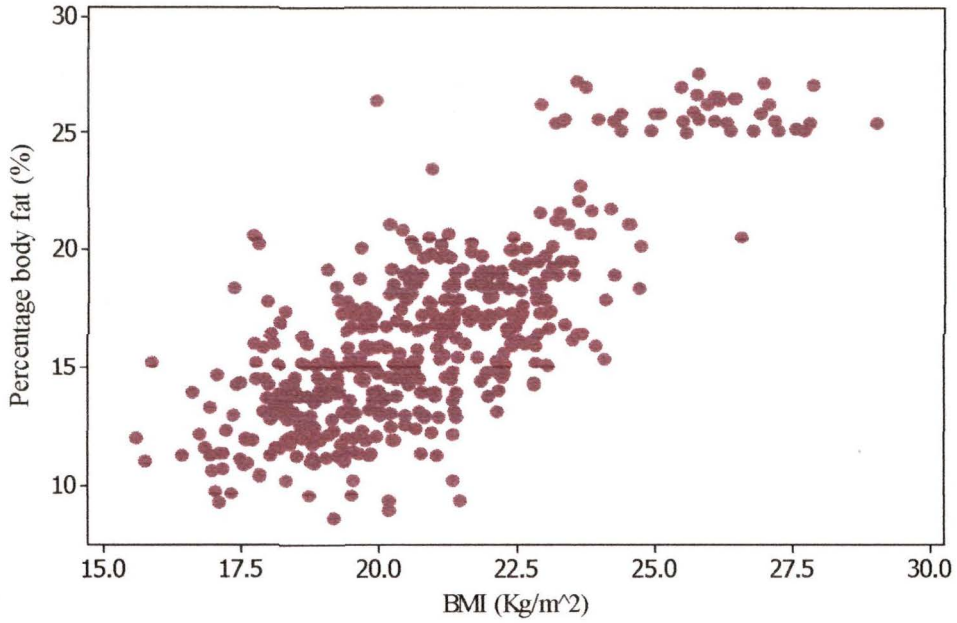
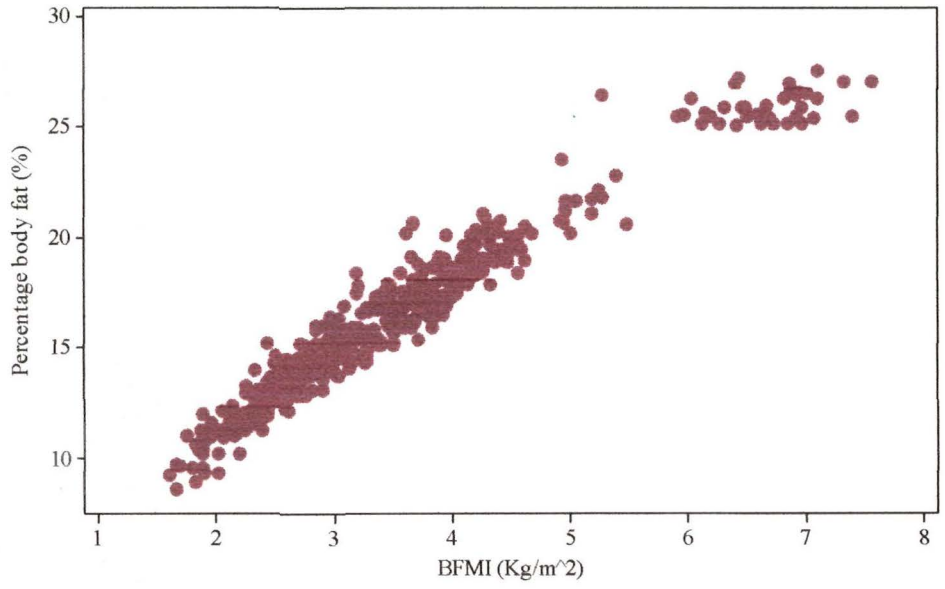


Figure 4.8: Relationship between BFMI and PBF in rural males



Body composition and anthropometric indices/ratios

In this section, we shall deal with relationship between body composition and body shape in terms of selected anthropometric indices and ratios. In other words, body shape is used here to refer to the relative body dimensions that are commonly expressed as indices or ratios. As mentioned earlier, our premise is to understand the relationship between body composition and body shape in relation to age, sex, self-reported morbidity, blood pressure, and socioeconomic variables. In doing so, we have taken into consideration four important indices and ratios, namely, cormic index, conicity index and waist-hip ratio. These indices and ratios are anthropometric reflections of body shape, which may also be considered as indicators of nutritional status.

Table 4.11: Adjusted means of PBF according to cormic index*

Cormic index	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 0.52	275	16.19	0.23	309	16.37	0.25	0.559
≥0.52	210	16.63	0.26	96	17.41	0.45	1.462
ANCOVA-F ratio	1.78, p > 0.05			3.98, p < 0.01			
Females							
< 0.52	238	23.66	0.28	179	24.18	0.32	1.223
≥0.52	279	24.78	0.26	218	25.87	0.29	2.799**
ANCOVA-F ratio	8.54, p < 0.004			15.81, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

Table 4.12. Adjusted means of fat free mass (kg) according to cormic index*

Cormic index	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 0.52	275	45.49	0.26	309	47.27	0.24	5.031***
≥0.52	210	46.18	0.30	96	46.79	0.44	1.127
ANCOVA-F ratio	3.13, p > 0.05			0.93, p > 0.05			
Females							
< 0.52	238	35.70	0.23	179	36.07	0.26	1.066
≥0.52	279	36.08	0.21	218	36.72	0.23	2.055*
ANCOVA-F ratio	1.50, p > 0.05			3.52, p > 0.05			

***Adjusted for age, household income, education, morbidity and hypertension**

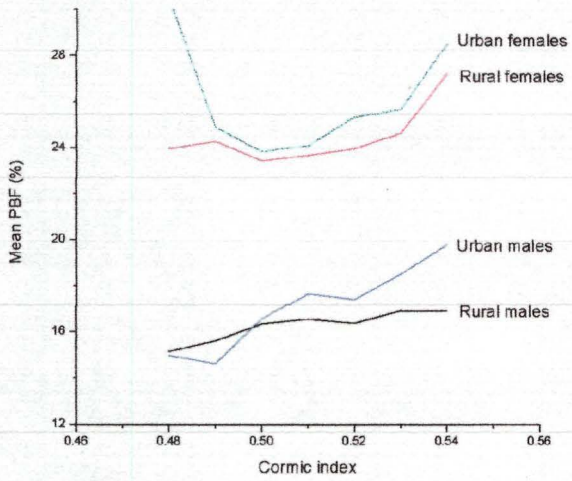


Figure 4.9: Cormic index and mean PBF

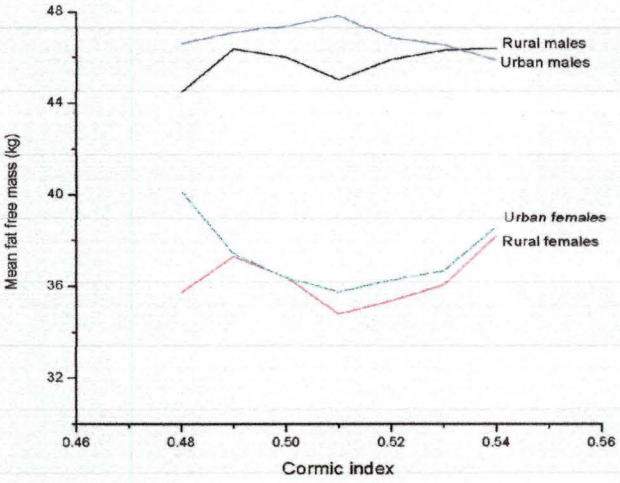


Figure 4.10: Cormic index and mean fat free mass

Cormic Index and Body Composition: **Table 4.11** shows the means of PBF according to cormic index categories after adjusting for age, household income, education, morbidity and hypertension. The adjusted means were higher in urban than in rural areas (**Figure 4.9**), although the rural-urban differences in PBF were significant only in females for higher cormic index (**Table 4.11**). However, it is obvious that the mean PBF is significantly greater in both the sexes with greater cormic index for both rural and urban areas. The only exception is that the mean PBF at comic index 0.48 appears to be very high among females (**Figure 4.9**). Nevertheless, the present findings indicate that persons with shorter leg length would have a greater PBF than those with longer leg length.

The means of FFM adjusted for age, morbidity, hypertension, household income and education are presented in **Table 4.12**. Similar to the case of PBF, urban females with greater cormic index had greater FFM than their rural counterparts. Among males, these urban-rural differences are significant in the category of lower cormic index. Overall, the present study indicates that FFM is by and large greater in urban than in rural areas (**Figure 4.10**). However, the sex differences are absent in both rural and urban areas.

Table 4.13. Adjusted means of PBF according to conicity index*

Conicity index	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 1.10	275	15.57	0.24	258	15.12	0.27	1.246
≥1.10	210	17.44	0.27	147	19.24	0.38	3.861***
ANCOVA-F ratio	24.59, p < 0.0001			66.14, p < 0.0001			
Females							
< 1.10	347	23.38	0.24	266	23.72	0.25	0.981
≥1.10	170	26.06	0.36	131	27.92	0.37	3.603***
ANCOVA-F ratio	35.13, p < 0.0001			78.53, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

Conicity Index and Body Composition: **Table 4.13** shows the means of PBF according to two categories of conicity after adjusting for age, household income, education, morbidity and hypertension. With respect to the rural-urban differences, it is found that there are significant differences in the higher conicity level ≥1.10 for both males (F-ratio= 3.86, p < 0.0001) and females (F-ratio= 3.60, p < 0.0001). However, ***Figure 4.11*** shows that both rural

and urban females are similar in mean PBF up to about 1.10 level of conicity index, and thereafter it is higher in urban females. As for males, the mean PBF is greater in rural areas up to about 1.0 level of conicity index, and thereafter it is higher in urban males. Both urban and rural males are, however, similar in PBF at 1.15 level of conicity index (**Figure 4.11**). As in the case of cormic index, the mean PBF is significantly greater in both the sexes with greater conicity index for both rural and urban areas. Therefore, it is obvious from the present findings that the mean PBF varies according to conicity level and rural-urban setting. In other words, it is likely that persons with greater conicity index would have greater PBF in both rural and urban areas. In addition, both urban males and females with greater level of conicity index (≥1.10) are likely to have greater PBF than their rural counterparts.

Table 4.14. Adjusted means of fat free mass (kg) according to conicity index*

	Rural			Urban			t-test
Conicity index	N	Mean	SE	N	Mean	SE	
Males							
< 1.10	275	45.80	0.27	258	46.73	0.29	2.347*
≥1.10	210	45.77	0.32	147	47.91	0.37	4.375***
ANCOVA-F ratio	0.01, p > 0.05			5.04, p < 0.025			
Females							
< 1.10	347	35.51	0.19	266	35.49	0.22	0.069
≥1.10	170	36.73	0.29	131	37.46	0.32	1.690
ANCOVA-F ratio	11.07, p < 0.001			14.04, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

As for FFM, **Table 4.14** shows that the rural-urban differences are significant only in males, i.e., urban males had greater FFM at both levels of conicity index. However, the differences between lower and greater conicity levels are significant for both males and females except in rural males. The mean FFM according to conicity levels by sex and rural-urban setting is also presented in **Figure 4.12**. It is seen that that the mean FFM is by and large greater in urban than in rural for both the sexes. However, rural females seem to have greater FFM than urban females from 0.90 to 1.02 levels of conicity index. Nevertheless, it is clear that persons with greater conicity index are likely to have greater mean FFM than those with lower conicity index. Therefore, on the basis of these findings, we may conclude that both PBF and FFM are significantly correlated with conicity index.

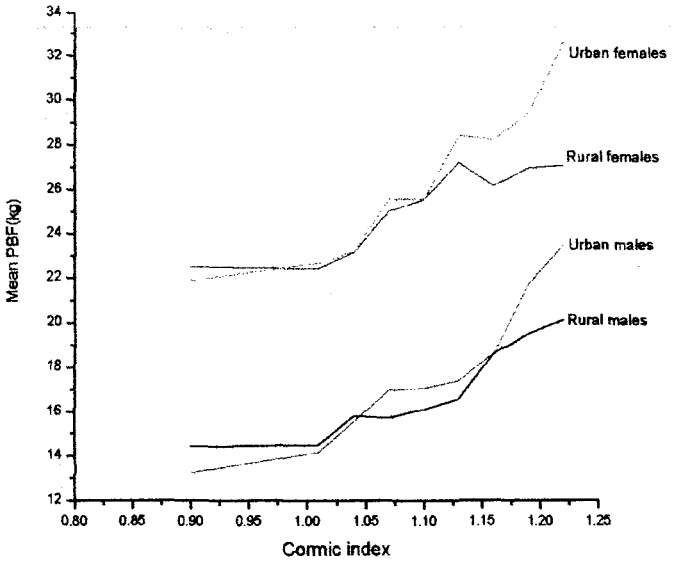


Figure 4.11: Conicity index and mean percen body fat mass

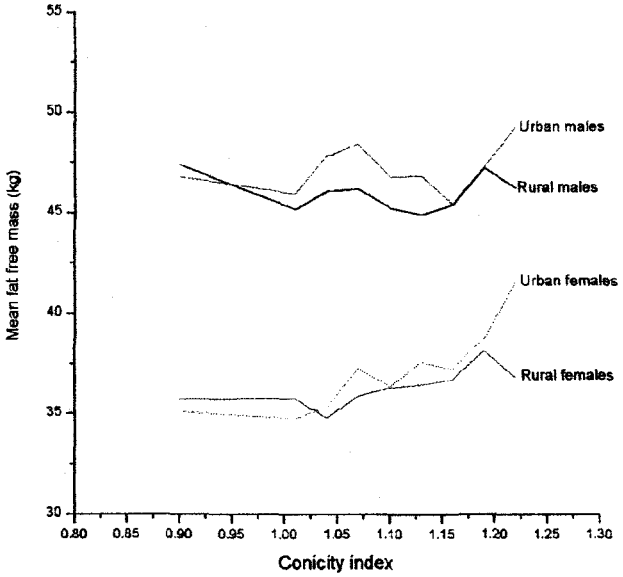


Figure 4.12: Conicity index and mean fat free mass

Table 4.15. Adjusted means of PBF according to waist-hip ratio*

Waist-hip ratio	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 0.92	382	15.89	0.19	312	15.44	0.22	1.548
≥0.92	103	18.21	0.38	93	20.57	0.42	4.167***
ANCOVA-F ratio	28.81, p < 0.0001			108.99, p < 0.0001			
Females							
< 0.82	214	23.46	0.30	217	22.94	0.27	1.288
≥0.82	303	24.83	0.25	180	27.71	0.30	7.375***
ANCOVA-F ratio	11.32, p < 0.001			125.52, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

Table 4.16. Adjusted means of fat free mass (kg) according to waist-hip ratio*

Waist-hip ratio	Rural			Urban			t-test
	N	Mean	SE	N	Mean	SE	
Males							
< 0.92	382	45.41	0.22	312	46.31	0.23	2.828**
≥0.92	103	47.19	0.43	93	49.99	0.43	4.604***
ANCOVA-F ratio	12.99, p < 0.001			53.89, p < 0.0001			
Females							
< 0.82	214	35.32	0.24	217	35.02	0.23	0.902
≥0.82	303	36.33	0.20	180	38.13	0.25	5.622***
ANCOVA-F ratio	9.78, p < 0.002			74.12, p < 0.0001			

***Adjusted for age, household income, education, morbidity and hypertension**

Waist-Hip Ratio and Body Composition: The relationship between body composition and waist-hip ratio is given in **Table 4.15**. Adjusting for age, household income, education, morbidity and hypertension; the rural-urban differences in mean PBD are significant only at the higher level of waist-hip ratio for both males (≥0.92) and females (≥0.82). As in the case of other indices, PBF is significantly higher among persons with greater waist-hip ratio compared with those having lower waist-hip ratio in both rural and urban areas. **Figure 4.13**

shows the sex differences for both rural and urban areas. The mean PBF is by and large greater in urban males and females compared with their rural counterparts.

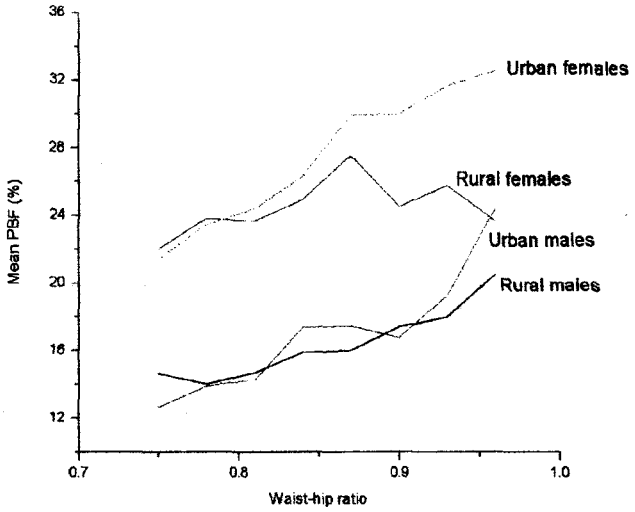


Figure 4.13: WHR and mean PBF

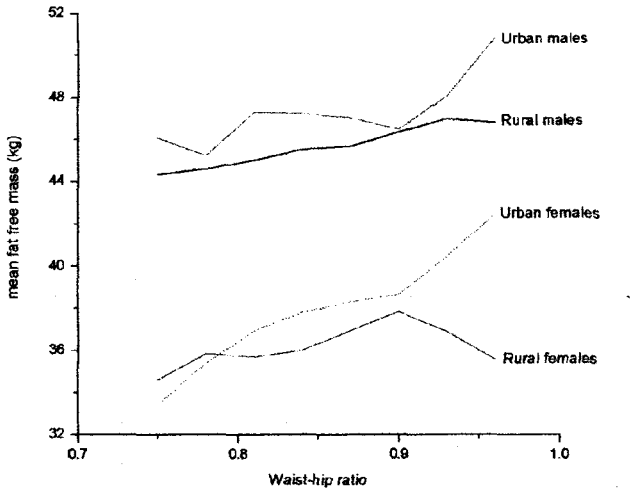


Figure 4.14: WHR and mean fat free mass

A similar trend is observed with respect to the FFM (**Table 4.16**). It is observed that the mean PBF is significantly higher in urban than rural areas, except among females for waist-hip ratio < 0.82. Also, the mean FFM is significantly higher in males and females with greater waist-hip ratio. The sex differences in mean FFM according to waist-hip ratio are also shown in **Figure 4.14**. It is observed that the mean FFM is by and large greater in urban males and females compared with their rural counterparts. On the basis of these findings, we may conclude that body composition among the Ao adult males and females is significantly correlated with waist-hip ratio.

Overall, the present study strongly indicates that body composition is significantly correlated with body shape in terms of cormic index, conicity index and waist-hip ratio. It is also observed that body composition is correlated with sex and rural-urban setting.

CHAPTER V

BIOLOGICAL AND SOCIOECONOMIC CHARACTERISTICS

In the present Chapter, we shall describe our findings on the effects of socioeconomic characteristics on adult body dimensions, body composition, nutritional status, blood pressure and self-reported morbidity. The adult body dimensions, body composition and nutritional status are described in terms of anthropometric measurements and indices; whereas the socioeconomic characteristics are described in terms of occupation, household income, education, family size. Since our design of study is to look into the rural and urban differences in these characteristics, the chapter segregates the total sample size into rural and urban areas in order to examine the differences and the causes of such differences.

ANTHROPOMETRIC TRAITS AND SOCIOECONOMIC FACTORS

In this section, we describe the relationship between adult body dimensions and socioeconomic factors.

Age Group

Table 5.1 shows the means and standard deviations of anthropometric traits for adult males by age groups. With the exception of chest girth, waist and hip circumferences the mean anthropometric traits are higher significantly in the lower age groups. The same is true for adult females as shown in Table 5.2. Perhaps, this may be due to secular trend other than chance factors such as sampling variation in sample size. By secular trend, we mean an increase in anthropometric measurements from one generation to another due to improvement in economic condition of a given population. With respect to chest girth, waist and hip circumferences, different explanations may be given, but it is likely to be associated with the increase in fat accumulation at the chest, waist and hip portion of the body with increasing age of the individuals. The point to be noted here is that the main purpose of data presentation in **Tables 5.1** and **5.2** is to understand whether or not age influences anthropometric

measurements of adult males and females in the present population. It is evident from the results presented in the Tables that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socioeconomic conditions on anthropometric traits, or while assessing the nutritional status of the study population in relation to socioeconomic conditions.

Table 5.1. Means and standard deviations of anthropometric traits for adult males by age groups

Anthropometric traits	Age groups in years (yrs)						ANOVA F-statistics
	<34 yrs (N for rural = 211 N for urban = 210)		35-54 yrs (N for rural = 179 N for urban = 127)		≥ 55 yrs (N for rural = 95 N for urban = 68)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	55.09	5.86	55.11	7.77	54.51	7.20	0.288
Height (cm)	164.41	4.19	162.15	4.18	159.91	4.85	37.792****
Sitting height (cm)	83.91	2.84	83.32	3.21	82.33	3.84	8.028***
MUAC (cm)	23.93	1.80	24.43	2.05	24.10	2.36	3.062**
Chest girth (cm)	79.73	3.84	81.05	5.29	81.37	4.62	6.024**
Waist cir. (cm)	67.02	4.60	70.79	7.22	72.66	6.97	33.571****
Hip cir. (cm)	78.14	4.30	79.53	5.59	81.48	5.16	15.018****
Sum 3 skinfolds(mm)	21.60	5.00	24.20	7.71	26.53	8.29	18.661****
Body mass index	20.38	2.06	20.92	2.51	21.30	2.57	5.774**
BFMI	3.16	0.93	3.59	1.36	3.96	1.45	15.272****
FFMI	17.22	1.37	17.34	1.42	17.35	1.34	0.459
Cormic index	0.51	0.02	0.51	0.02	0.51	0.02	2.943*
Conicity index	1.06	0.06	1.12	0.06	1.14	0.07	64.590****
Waist-hip ratio	0.86	0.05	0.89	0.06	0.89	0.05	22.001****
Urban							
Weight (kg)	56.10	5.77	57.14	7.87	58.63	8.51	3.517**
Height (cm)	167.83	3.38	165.15	3.61	163.41	3.71	49.744****
Sitting height (cm)	83.98	2.14	83.71	2.35	83.74	2.55	0.652
MUAC (cm)	23.39	1.80	25.13	1.99	24.99	2.63	35.527****
Chest girth (cm)	79.32	2.82	81.97	4.25	82.97	5.20	33.319****
Waist cir. (cm)	64.18	6.88	71.57	10.04	76.76	9.33	69.015****
Hip cir. (cm)	78.50	3.42	80.89	4.75	83.87	5.47	43.576****
Sum 3 sknfolds (mm)	21.38	5.47	24.44	9.69	33.47	10.61	58.915****
Body mass index	19.92	2.03	20.94	2.77	21.92	2.86	19.443****
BFMI	3.05	0.98	3.59	1.66	4.82	1.66	43.935****
FFMI	16.87	1.29	17.35	1.37	17.10	1.63	4.923**
Cormic index	0.50	0.01	0.51	0.02	0.51	0.02	17.853****
Conicity index	1.02	0.08	1.12	0.10	1.18	0.09	107.122****
Waist-hip ratio	0.82	0.07	0.88	0.08	0.91	0.06	62.463****

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 5.2. Means and standard deviations of anthropometric traits for adult females by age groups

Anthropometric traits	Age groups in years (yrs)						ANOVA F-statistics
	<34 yrs (N for rural = 245 N for urban = 202)		35-54 yrs (N for rural = 181 N for urban = 145)		≥ 55 yrs (N for rural = 91 N for urban = 50)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	46.31	5.66	49.88	7.84	47.36	6.59	15.141****
Height (cm)	153.54	4.08	152.62	3.76	150.68	3.54	18.090****
Sitting height (cm)	78.88	3.15	78.54	3.76	76.90	4.34	10.140****
MUAC (cm)	21.68	1.92	23.00	2.37	22.37	2.01	20.648****
Chest girth (cm)	77.10	4.65	80.83	7.07	78.68	6.00	21.183****
Waist cir. (cm)	62.11	5.04	67.68	7.38	69.15	7.43	59.603****
Hip cir. (cm)	76.61	5.74	80.48	7.39	80.85	7.52	23.103****
Sum 3 skinfolds(mm)	27.41	6.93	33.74	13.34	31.96	9.99	21.600****
Body mass index	19.62	2.10	21.39	3.12	20.86	2.89	24.617****
BFMI	4.57	1.11	5.61	2.04	5.34	1.67	23.699****
FFMI	15.05	1.21	15.78	1.33	15.52	1.39	17.401****
Cormic index	0.51	0.02	0.51	0.02	0.51	0.02	1.612
Conicity index	1.04	0.06	1.09	0.07	1.13	0.06	83.558****
Waist-hip ratio	0.81	0.07	0.84	0.06	0.86	0.04	19.171****
Urban							
Weight (kg)	44.92	5.28	52.37	8.02	56.54	8.08	85.542****
Height (cm)	153.87	3.20	152.58	2.73	153.12	3.54	7.469***
Sitting height (cm)	79.56	2.23	79.00	2.39	78.42	4.80	4.133**
MUAC (cm)	21.55	1.76	23.88	2.07	24.57	2.06	87.570****
Chest girth (cm)	77.36	3.09	82.24	5.52	84.32	6.86	70.167****
Waist cir. (cm)	61.05	5.64	71.26	9.79	77.29	12.19	107.983****
Hip cir. (cm)	77.39	4.18	83.94	5.68	87.06	6.92	107.277****
Sum 3 skinfolds(mm)	26.66	5.96	37.32	13.51	41.71	10.71	73.127****
Body mass index	18.97	2.13	22.48	3.27	24.07	3.01	109.816****
BFMI	4.35	1.02	6.25	2.09	7.12	1.75	94.132****
FFMI	14.62	1.28	16.23	1.44	16.95	1.50	90.652****
Cormic index	0.52	0.01	0.52	0.01	0.51	0.03	2.599*
Conicity index	1.04	0.06	1.12	0.09	1.17	0.13	68.265****
Waist-hip ratio	0.79	0.05	0.85	0.07	0.88	0.09	64.238****

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Household Income

Table 5.3 shows the means and standard deviations of anthropometric traits for adult males by income groups for both rural and urban areas. The table shows that the differences

between income groups are highly significant in almost all anthropometric traits. Most of the mean anthropometric traits are significantly higher in the higher income groups in both rural and urban areas. The same is true for females (**Table 5.4**). Thus, we may conclude that anthropometric traits in the present study are to a great extent influenced by household income in both rural and urban areas for both the sexes.

Table 5.3. Means and standard deviations of anthropometric traits for adult males by income groups

Anthropometric traits	Income groups						ANOVA F-statistics
	Low (N for rural = 385 N for urban = 61)		Middle (N for rural = 60 N for urban = 157)		High (N for rural = 40 N for urban = 187)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	54.28	6.44	58.12	7.78	57.10	7.87	10.572****
Height (cm)	162.60	4.69	163.68	4.45	162.11	4.29	1.761
Sitting height (cm)	83.37	3.23	83.93	3.41	82.64	2.93	1.942
MUAC (cm)	23.91	1.91	25.15	2.28	24.92	2.05	13.639****
Chest girth (cm)	80.08	4.41	82.71	4.87	81.73	5.21	10.262****
Waist cir. (cm)	68.91	6.18	71.80	7.92	71.94	6.74	8.239***
Hip cir. (cm)	78.89	4.70	81.11	6.35	80.65	6.20	6.514***
Sum 3 skinfolds (mm)	22.81	6.50	26.39	8.40	26.08	8.28	9.887****
Body mass index	20.52	2.23	21.68	2.70	21.68	2.53	9.938****
BFMI	3.34	1.16	4.00	1.47	3.95	1.39	10.878****
FFMI	17.18	1.33	17.68	1.51	17.73	1.53	5.749***
Cormic index	0.51	0.02	0.51	0.02	0.51	0.01	0.587
Conicity index	1.10	0.07	1.11	0.07	1.11	0.06	1.710
Waist-hip ratio	0.87	0.06	0.88	0.05	0.89	0.05	2.839*
Urban							
Weight (kg)	53.69	6.76	56.82	6.84	57.91	6.99	8.619***
Height (cm)	165.96	3.68	166.37	3.73	166.23	4.14	0.256
Sitting height (cm)	83.00	2.21	84.25	2.17	83.80	2.32	6.918***
MUAC (cm)	23.93	2.02	24.23	2.28	24.28	2.16	0.584
Chest girth (cm)	79.85	3.46	80.69	4.26	81.12	4.07	2.306*
Waist cir. (cm)	66.14	8.57	68.47	10.13	69.54	9.61	2.865*
Hip cir. (cm)	78.00	3.31	80.30	5.00	80.73	4.50	8.230***
Sum 3 skinfolds (mm)	19.81	7.55	24.09	8.51	26.09	9.44	11.793****
Body mass index	19.49	2.38	20.54	2.52	20.97	2.52	8.004***
BFMI	2.74	1.33	3.50	1.49	3.79	1.44	12.134****
FFMI	16.75	1.30	17.04	1.45	17.17	1.34	2.129
Cormic index	0.50	0.02	0.51	0.02	0.50	0.02	3.353**
Conicity index	1.07	0.10	1.07	0.11	1.08	0.11	0.400
Waist-hip ratio	0.85	0.08	0.85	0.08	0.86	0.08	0.790

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 5.4. Means and standard deviations of anthropometric traits for adult females by income groups

Anthropometric traits	Income groups						ANOVA F-statistics
	Low (N for rural = 417 N for urban = 65		Middle (N for rural = 57 N for urban = 160)		High (N for rural = 43 N for urban = 172)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	47.12	6.45	49.37	7.27	51.60	8.37	10.551***
Height (cm)	152.71	4.08	152.81	3.86	152.62	3.53	0.027
Sitting height (cm)	78.39	3.57	78.78	3.16	78.12	5.03	0.434
MUAC (cm)	22.07	2.11	22.87	2.29	23.37	2.29	9.723***
Chest girth (cm)	78.12	5.63	80.03	6.32	82.34	8.08	11.456***
Waist cir. (cm)	64.77	6.55	66.30	7.22	69.10	10.09	8.153***
Hip cir. (cm)	78.20	6.43	79.72	7.48	82.33	9.72	7.718***
Sum 3 skinfolds (mm)	29.33	9.63	33.46	12.15	36.97	13.33	13.539***
Body mass index	20.19	2.55	21.12	2.84	22.17	3.70	12.406***
BFMI	4.89	1.52	5.52	1.84	6.15	2.16	14.267***
FFMI	15.30	1.27	15.60	1.21	16.02	1.78	6.728**
Cormic index	0.51	0.02	0.52	0.02	0.51	0.03	0.539
Conicity index	1.07	0.07	1.07	0.06	1.09	0.09	1.308
Waist-hip ratio	0.83	0.06	0.83	0.05	0.84	0.09	0.626
Urban							
Weight (kg)	44.69	6.08	49.25	7.72	50.63	8.52	13.585***
Height (cm)	152.37	3.35	153.67	3.42	153.32	2.68	4.066**
Sitting height (cm)	78.82	2.66	79.47	2.20	79.13	3.22	1.421
MUAC (cm)	21.65	2.01	22.87	2.32	23.13	2.26	10.420***
Chest girth (cm)	77.53	4.19	80.26	5.51	80.73	5.53	8.751***
Waist cir. (cm)	62.21	6.86	67.02	10.48	68.39	10.88	8.754***
Hip cir. (cm)	78.48	4.95	81.03	6.48	81.93	6.59	7.050**
Sum 3 skinfolds (mm)	25.70	9.29	32.75	11.33	34.72	11.78	15.313***
Body mass index	19.25	2.52	20.87	3.26	21.54	3.56	11.478***
BFMI	4.28	1.46	5.42	1.85	5.79	1.99	15.826***
FFMI	14.97	1.34	15.45	1.61	15.75	1.74	5.443**
Cormic index	0.52	0.01	0.52	0.01	0.52	0.02	0.254
Conicity index	1.05	0.07	1.08	0.09	1.09	0.10	3.510**
Waist-hip ratio	0.79	0.05	0.83	0.07	0.83	0.07	7.369**

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Education and Family Size

Table 5.5 shows the means and standard deviations of anthropometric traits for adult males by educational level. In rural areas, the differences between educational groups are significant only in respect of height, MUAC and waist-hip ratio. It indicates that these anthropometric characters are greater in adult males with higher educational level. In general, it indicates that

there was an absence of statistical differences between educational groups of rural men with respect to many anthropometric characters. A similar trend can be observed among the urban adult males (**Table 5.5**). It shows that the effect of education is significant only with respect to height and conicity index.

Table 5.5. Means and standard deviations of anthropometric traits for adult males by educational level

Anthropometric traits	Educational levels						ANOVA F-statistics
	Primary (N for rural = 240 N for urban = 20)		Secondary (N for rural = 164 N for urban = 47)		≥Higher Secondary (N for rural =81 N for urban =338)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	54.29	6.78	55.78	7.00	55.42	6.76	2.506
Height (cm)	161.73	4.79	163.14	4.14	164.65	4.41	13.775***
Sitting height (cm)	83.18	3.40	83.31	3.00	84.12	3.13	2.645
MUAC (cm)	23.94	1.86	24.45	2.14	24.15	2.18	3.137**
Chest girth (cm)	80.34	4.52	80.99	4.70	80.21	4.75	1.199
Waist cir. (cm)	69.38	6.43	70.26	7.10	68.42	5.65	2.243
Hip cir. (cm)	79.58	4.91	79.36	5.54	78.40	4.82	1.626
Sum 3 skinfolds (mm)	23.44	6.97	24.07	7.65	22.67	5.86	1.106
Body mass index	20.73	2.24	20.96	2.53	20.43	2.33	1.383
BFMI	3.46	1.23	3.58	1.34	3.32	1.08	1.232
FFMI	17.27	1.30	17.38	1.45	17.11	1.48	1.018
Cormic index	0.51	0.02	0.51	0.02	0.51	0.02	2.635
Conicity index	1.10	0.07	1.10	0.07	1.08	0.06	2.369
Waist-hip ratio	0.87	0.05	0.89	0.06	0.87	0.05	3.361**
Urban							
Weight (kg)	54.75	7.35	55.37	7.39	57.18	6.93	2.327
Height (cm)	164.66	3.77	164.86	4.12	166.53	3.83	5.627**
Sitting height (cm)	83.28	2.42	83.46	2.38	83.94	2.25	1.619
MUAC (cm)	24.27	2.46	24.83	2.04	24.12	2.18	2.249
Chest girth (cm)	81.25	4.25	81.22	4.44	80.67	4.02	0.521
Waist cir. (cm)	69.57	9.15	69.80	10.47	68.39	9.66	0.531
Hip cir. (cm)	79.58	5.45	80.36	4.80	80.16	4.63	0.195
Sum 3 skinfolds (mm)	24.22	11.03	22.50	9.29	24.64	8.89	1.157
Body mass index	20.20	2.72	20.37	2.64	20.63	2.52	0.439
BFMI	3.39	1.80	3.23	1.57	3.57	1.46	1.142
FFMI	16.81	1.28	17.14	1.38	17.06	1.40	0.399
Cormic index	0.51	0.02	0.51	0.02	0.50	0.02	0.460
Conicity index	1.11	0.09	1.10	0.11	1.07	0.11	2.998*
Waist-hip ratio	0.87	0.07	0.87	0.09	0.85	0.08	1.274

*p<0.05 **p<0.01, ***p<0.001

Table 5.6. Means and standard deviations of anthropometric traits for adult females by educational level

Anthropometric traits	Educational levels						ANOVA F-statistics
	Primary (N for rural = 345 N for urban = 68)		Secondary (N for rural = 111 N for urban = 75)		Higher Secondary + (N for rural =61 N for urban =254)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	47.21	6.73	49.06	7.19	48.34	6.53	3.357**
Height (cm)	152.37	4.03	152.89	3.74	154.38	3.94	6.813***
Sitting height (cm)	78.27	3.62	78.26	3.87	79.49	3.39	3.033*
MUAC (cm)	22.13	2.12	22.69	2.26	22.20	2.32	2.784*
Chest girth (cm)	78.33	5.91	79.76	6.70	78.71	5.53	2.343
Waist cir. (cm)	65.52	6.83	65.63	8.21	63.43	5.96	2.437
Hip cir. (cm)	78.58	6.66	79.75	8.32	77.58	5.74	2.105
Sum 3 skinfolds (mm)	29.89	10.38	31.80	10.77	30.93	10.83	1.472
Body mass index	20.33	2.73	20.98	2.95	20.26	2.46	2.539
BFMI	4.98	1.64	5.34	1.75	5.07	1.55	2.001
FFMI	15.35	1.33	15.64	1.39	15.19	1.14	2.798
Cormic index	0.51	0.02	0.51	0.02	0.51	0.02	0.593
Conicity index	1.08	0.07	1.06	0.08	1.04	0.06	9.677****
Waist-hip ratio	0.83	0.06	0.82	0.07	0.82	0.07	2.218
Urban							
Weight (kg)	50.13	7.30	48.29	7.61	49.07	8.42	0.927
Height (cm)	151.86	3.05	152.08	2.77	154.05	3.01	22.452****
Sitting height (cm)	78.71	2.33	78.48	2.11	79.56	2.97	5.969***
MUAC (cm)	23.48	2.11	22.51	2.32	22.67	2.31	4.000**
Chest girth (cm)	80.86	4.79	79.40	5.71	79.97	5.50	1.317
Waist cir. (cm)	70.03	9.96	66.92	10.26	65.94	10.37	4.262**
Hip cir. (cm)	82.36	5.62	81.03	6.10	80.63	6.65	1.948
Sum 3 skinfolds (mm)	34.18	11.79	31.16	12.45	32.37	11.32	1.220
Body mass index	21.74	3.12	20.87	3.17	20.68	3.47	2.694*
BFMI	5.76	1.92	5.23	1.97	5.34	1.91	1.639
FFMI	15.98	1.40	15.64	1.44	15.33	1.74	4.499**
Cormic index	0.52	0.01	0.52	0.01	0.52	0.02	0.470
Conicity index	1.12	0.10	1.09	0.10	1.07	0.09	6.937***
Waist-hip ratio	0.85	0.07	0.82	0.07	0.81	0.07	5.870***

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

As for females, the results are presented in **Table 5.6** for both rural and urban areas. Among rural females, the differences between educational groups are significant in respect of weight, height, sitting height, MUAC and conicity index. In urban areas, the differences between educational groups of adult females are significant in respect of height, sitting

height, MUAC, waist circumference, BMI, FFMI, conicity index and waist-hip ratio. In view of the results presented in **Table 5.5** and **5.6**, we may suggest that that the role of education in patterning anthropometric traits is more important in females than in males. It holds true for both rural and urban areas.

Table 5.7. Means and standard deviations of anthropometric traits for adult males by family size

Anthropometric traits	Family size						ANOVA F-statistics
	Small (N for rural = 168 N for urban = 148)		Medium (N for rural = 239 N for urban = 237)		Large (N for rural = 78 N for urban = 20)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	55.31	6.40	55.12	7.28	53.88	6.52	1.245
Height (cm)	162.78	4.24	162.93	4.73	161.78	5.10	1.864
Sitting height (cm)	83.12	2.97	83.90	3.08	82.34	3.92	7.904***
MUAC (cm)	24.30	1.94	24.19	2.03	23.67	2.11	2.730*
Chest girth (cm)	80.54	4.83	80.68	4.54	80.09	4.44	0.476
Waist cir. (cm)	69.49	6.63	69.43	6.76	69.81	5.83	0.097
Hip cir. (cm)	79.29	4.74	79.15	5.55	79.83	4.56	0.510
Sum 3 skinfolds (mm)	23.59	7.30	23.37	7.09	23.85	6.37	0.144
Body mass index	20.87	2.25	20.74	2.43	20.59	2.39	0.392
BFMI	3.49	1.24	3.45	1.28	3.51	1.19	0.068
FFMI	17.38	1.37	17.29	1.39	17.08	1.38	1.260
Cormic index	0.51	0.02	0.52	0.02	0.51	0.02	5.381**
Conicity index	1.09	0.07	1.10	0.07	1.11	0.06	1.697
Waist-hip ratio	0.88	0.06	0.88	0.06	0.87	0.05	0.076
Urban							
Weight (kg)	57.07	7.27	56.59	6.83	58.33	7.62	0.671
Height (cm)	166.33	4.04	166.18	3.87	166.41	3.52	0.076
Sitting height (cm)	83.77	2.29	83.93	2.27	83.61	2.36	0.370
MUAC (cm)	24.36	2.20	24.12	2.19	24.15	2.05	0.580
Chest girth (cm)	80.87	3.99	80.67	4.13	81.10	4.20	0.178
Waist cir. (cm)	68.51	9.31	68.50	9.87	70.70	11.04	0.482
Hip cir. (cm)	79.94	4.31	80.24	4.80	80.68	6.01	0.310
Sum 3 skinfolds (mm)	24.73	9.27	24.04	8.76	25.63	11.05	0.467
Body mass index	20.63	2.52	20.51	2.55	21.06	2.69	0.476
BFMI	3.56	1.48	3.48	1.47	3.73	1.78	0.359
FFMI	17.07	1.46	17.03	1.36	17.33	1.26	0.429
Cormic index	0.50	0.02	0.51	0.02	0.50	0.01	0.519
Conicity index	1.07	0.10	1.07	0.11	1.09	0.12	0.358
Waist-hip ratio	0.85	0.08	0.85	0.08	0.87	0.09	0.721

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 5.7 shows the means and standard deviations of anthropometric traits by family size among adult males in both rural and urban areas. It is seen that the effect of family size in rural males was significant only for sitting height, MUAC and cormic index. In urban areas, none of the differences was significant. Thus, it indicates that the effect of family size is not clearly perceptible in respect of many anthropometric variables, especially among urban males.

Table 5.8. Means and standard deviations of anthropometric traits for adult females by family size

Anthropometric traits	Family size						ANOVA F-statistics
	Small (N for rural = 200 N for urban =145)		Medium (N for rural = 237 N for urban = 230		Large (N for rural = 80 N for urban = 22)		
	Mean	SD	Mean	SD	Mean	SD	
Rural							
Weight (kg)	47.45	6.74	48.02	6.92	47.65	6.89	0.379
Height (cm)	152.95	4.09	152.65	3.74	152.32	4.53	0.764
Sitting height (cm)	78.53	3.94	78.57	3.33	77.66	3.84	2.002
MUAC (cm)	22.01	2.13	22.45	2.21	22.35	2.20	2.276*
Chest girth (cm)	78.36	6.18	78.94	5.98	78.75	6.02	0.507
Waist cir. (cm)	64.99	7.12	65.29	7.15	66.07	6.79	0.656
Hip cir. (cm)	78.67	6.66	78.74	6.90	78.72	7.93	0.006
Sum 3 skinfolds (mm)	30.01	10.55	30.64	10.88	30.82	9.44	0.260
Body mass index	20.28	2.81	20.59	2.73	20.53	2.73	0.680
BFMI	4.98	1.66	5.12	1.69	5.14	1.57	0.440
FFMI	15.30	1.37	15.47	1.28	15.38	1.34	0.892
Cormic index	0.51	0.02	0.51	0.02	0.51	0.02	1.876
Conicity index	1.07	0.07	1.07	0.07	1.09	0.08	1.737
Waist-hip ratio	0.83	0.06	0.83	0.06	0.84	0.08	1.731
Urban							
Weight (kg)	49.76	8.55	48.58	7.84	50.27	7.35	1.201
Height (cm)	152.96	2.90	153.54	3.16	153.03	4.06	1.617
Sitting height (cm)	78.90	3.48	79.38	2.20	79.56	2.62	1.515
MUAC (cm)	22.89	2.25	22.68	2.34	23.11	2.20	0.599
Chest girth (cm)	80.27	5.37	79.78	5.48	80.88	5.42	0.656
Waist cir. (cm)	67.70	10.42	66.14	10.27	68.17	10.82	1.203
Hip cir. (cm)	81.72	6.13	80.43	6.51	82.28	6.64	2.305*
Sum 3 skinfolds (mm)	33.15	12.16	31.89	11.24	33.67	12.20	0.643
Body mass index	21.25	3.46	20.62	3.33	21.47	3.02	1.893
BFMI	5.55	2.02	5.27	1.86	5.63	1.87	1.104
FFMI	15.70	1.63	15.35	1.66	15.84	1.49	2.536*
Cormic index	0.52	0.02	0.52	0.01	0.52	0.01	0.797
Conicity index	1.09	0.09	1.08	0.10	1.09	0.11	0.632
Waist-hip ratio	0.82	0.07	0.82	0.07	0.83	0.08	0.350

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 5.8 also shows the differences in anthropometric traits by family size among rural and urban females. As in the case of males, the effect of family size was not clearly perceptible, except in respect of MAUC in rural females, and hip circumference and FFMI in urban females. Thus, it is clearly evident that family size has little role to play in the variation of anthropometric traits in the present study.

Table 5.9. Means and standard deviations of anthropometric traits for adult males by physical activity

Anthropometric traits	Physical activity				ANOVA F-statistics
	Sedentary (N for rural = 142 N for urban = 336)		Moderate (N for rural = 343 N for urban = 69)		
	Mean	SD	Mean	SD	
Rural					
Weight (kg)	55.82	6.97	54.64	6.81	2.955
Height (cm)	163.45	4.93	162.38	4.48	5.355*
Sitting height (cm)	83.37	3.57	83.39	3.10	0.001
MUAC (cm)	24.32	2.19	24.08	1.95	1.415
Chest girth (cm)	80.52	4.89	80.55	4.51	0.005
Waist cir. (cm)	69.58	6.81	69.49	6.47	0.021
Hip cir. (cm)	79.42	5.20	79.26	5.10	0.098
Sum 3 skinfolds (mm)	24.04	7.39	23.31	6.90	1.052
Body mass index	20.91	2.60	20.70	2.25	0.764
BFMI	3.57	1.31	3.43	1.22	1.208
FFMI	17.34	1.54	17.27	1.32	0.250
Cormic index	0.51	0.02	0.51	0.02	4.205*
Conicity index	1.09	0.07	1.10	0.07	1.056
Waist-hip ratio	0.88	0.05	0.88	0.06	0.037
Urban					
Weight (kg)	57.24	6.99	54.99	6.96	5.944**
Height (cm)	166.46	3.94	165.19	3.60	6.183**
Sitting height (cm)	83.90	2.27	83.64	2.34	0.708
MUAC (cm)	24.12	2.25	24.63	1.81	3.144*
Chest girth (cm)	80.81	4.17	80.56	3.62	0.211
Waist cir. (cm)	68.66	10.01	68.37	8.20	0.054
Hip cir. (cm)	80.33	4.71	79.29	4.51	2.812
Sum 3 skinfolds (mm)	24.96	9.08	21.50	8.41	8.467**
Body mass index	20.67	2.56	20.14	2.42	2.460
BFMI	3.61	1.48	3.07	1.45	7.795**
FFMI	17.06	1.42	17.07	1.24	0.010
Cormic index	0.50	0.02	0.51	0.02	1.255
Conicity index	1.07	0.11	1.09	0.09	1.056
Waist-hip ratio	0.85	0.08	0.86	0.07	0.697

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Table 5.10. Means and standard deviations of anthropometric traits for adult females by physical activity

Anthropometric traits	Physical activity				ANOVA F-statistics
	Sedentary (N for rural = 157 N for urban = 384)		Moderate (N for rural = 380 N for urban = 17)		
	Mean	SD	Mean	SD	
Rural					
Weight (kg)	47.70	7.18	47.76	6.70	0.009
Height (cm)	152.92	4.12	152.63	3.96	0.583
Sitting height (cm)	78.09	3.96	78.56	3.52	1.786
MUAC (cm)	22.34	2.43	22.23	2.06	0.285
Chest girth (cm)	78.48	6.56	78.77	5.84	0.264
Waist cir. (cm)	64.65	7.74	65.58	6.76	1.915
Hip cir. (cm)	78.16	7.71	78.95	6.62	1.417
Sum 3 skinfolds (mm)	30.95	10.69	30.19	10.46	0.564
Body mass index	20.38	2.90	20.49	2.69	0.167
BFMI	5.11	1.69	5.05	1.64	0.148
FFMI	15.27	1.41	15.44	1.28	1.777
Cormic index	0.51	0.02	0.51	0.02	4.763**
Conicity index	1.06	0.08	1.08	0.07	4.215**
Waist-hip ratio	0.83	0.08	0.83	0.06	0.173
Urban					
Weight (kg)	49.26	6.70	45.62	6.79	3.318**
Height (cm)	153.38	3.96	151.49	2.77	6.007**
Sitting height (cm)	79.27	3.52	77.85	2.10	4.341**
MUAC (cm)	22.80	2.06	22.31	1.84	0.734
Chest girth (cm)	80.10	5.51	78.25	3.02	1.888
Waist cir. (cm)	67.06	10.48	61.64	4.91	4.495**
Hip cir. (cm)	81.07	6.48	79.61	4.37	0.846
Sum 3 skinfolds (mm)	32.89	11.66	22.64	4.27	13.040****
Body mass index	20.94	3.39	19.86	2.75	1.659
BFMI	5.45	1.93	4.10	1.05	8.224**
FFMI	15.49	1.64	15.76	1.82	0.464
Cormic index	0.52	0.02	0.51	0.01	0.567
Conicity index	1.08	0.10	1.03	0.04	4.820**
Waist-hip ratio	0.82	0.07	0.77	0.04	7.854**

*p<0.05, **p<0.01, ***p<0.001, ****p<0.0001

Physical Activity

Table 5.9 shows the means and standard deviations of anthropometric traits for adult males by physical activity level for both rural and urban areas. In rural areas, the differences in mean anthropometric traits by physical activity are not clearly perceptible except in sitting height and BFMI. However, the effect of physical activity is more pronounced among urban

males, and it is significant in weight, height, MUAC, sum of 3 skinfold thicknesses and BFMI. As normally expected, sedentary urban males have greater body fat as indicated by body weight, Skinfold thickness and BFMI.

The effect of physical activity on anthropometric traits that are related to fatness is more pronounced among urban females (**Table 5.10**). Therefore, on the basis of the results presented in **Table 5.10**, we may suggest that physical activity is very important in regulating the body dimensions especially among the adult females of the present population.

In view of the results presented above, we may conclude that anthropometric traits in the present study are to a great extent influenced by age, household income and physical activity. The effect of education and family size was not clearly perceptible in males, although it is likely to have an effect on the anthropometric characteristics of females. The family size also seemed to have little to do with the variation of anthropometric traits in the present study.

SELF-REPORTED MORBIDITY

In this section, we shall present our data on self-reported morbidity. We shall also analyse our data to understand how self-reported morbidity may be associated with anthropometric and socioeconomic factors.

Table 5.11 shows the prevalence of self reported morbidity by sex in both rural and urban areas. These self reported symptoms of illness are broadly classified into two categories. They are: **1.Cold/respiratory disorders** – cough + runny nose + headache + fever, fever + cough, cough alone, swollen glands + cold, ear problem, breathing problem, chest pain, sore throat, tuberculosis, and **2.Cardiovascular and other problems**- including hypertension, diabetes type 2, etc. It is observed that in rural area, cold and respiratory disorders are more prevalent than cardiovascular and other problems. It is slightly higher in females (9.86%) than males (9.28%). The prevalence of cardiovascular and other problems is slightly higher in males (5.15%) than females (4.26%). Overall morbidity is slightly higher in females (9.28%) than in males (8.25%). However, the chi-square test indicates that these slight sex differences in the prevalence of morbidity are not statistically significant.

It is also observed from table 5.11 that in urban area, the prevalence of cardiovascular and other problems is greater compared to cold and respiratory disorders, and the prevalence is more or less similar in both males (9.38%) and females (9.07%). The prevalence of cold and respiratory disorders is also more or less similar in both males (6.42%) and females (6.30%). The prevalence of overall morbidity is slightly higher in males (9.63%) than in females (9.07%). However, the chi-square test indicates that these sex differences in the prevalence of morbidity are not statistically significant for both rural and urban areas.

Table 5.11. prevalence of self reported morbidity by sex

Categories	*Cold and respiratory* disorders	*Cardiovascular and* other problems	*Overall morbidity**
Rural			
Males (N = 485)	45(9.28%)	25(5.15%)	40 (8.25%)
Females (N= 517)	51(9.86%)	22(4.26%)	48 (9.28%)
χ^2 - value for sex difference	0.10, df=1,p > 0.05	0.45, df = 1, p >0.05	0.34, df = 1, p > 0.05
Urban			
Males (N= 405)	26(6.42%)	38(9.38%)	39(9.63%)
Females (N = 397)	25(6.30%)	36(9.07%)	36(9.07%)
χ^2 - value for sex difference	0.01, df = 1, p >0.05	0.02, df = 1, p >0.05	0.07, df = 1, p > 0.05

*Based on number of those who reported for at least one type of morbidity

Self-Reported Morbidity in Relation to Anthropometric and Socioeconomic Factors

Table 5.12 shows the prevalence of morbidity by anthropometric and socioeconomic parameters in both rural and urban areas. The prevalence of morbidity is based on the number of those individuals who reported for at least one type of morbidity. It is observed that the overall prevalence of morbidity in rural area is higher in females (9.28%) than in males (8.25%). The situation is, however, reversed in urban area where the prevalence of morbidity is higher in males (9.63%) than in females (9.07%). Nevertheless, the chi-square test indicates that the sex difference is not statistically significant in both rural (χ^2=0.34, df=1, p>0.05) and urban (χ^2=0.07, df=1, p>0.05) areas. The same is true for the rural-urban differences that are not statistically significant in both males (χ^2=0.52, df=1, p>0.05) and females (χ^2=0.01, df=1, p>0.05). Therefore, it is likely that morbidity in the present study is not associated with sex or rural-urban setting.

Table 5.12. Prevalence of morbidity by anthropometric & socioeconomic parameters

Parameters	Rural (N=1002)		Urban (N=802)		χ^2 for urban-rural difference
	N	Prevalence (%)	N	Prevalence (%)	
Sex					
Males	485	40 (8.25)	405	39 (9.63)	0.52, p>0.05
Females	517	48 (9.28)	397	36 (9.07)	0.01, p>0.05
χ^2 with df=1	0.34, p>0.05		0.07, p>0.05		
Age (years)					
<34	456	21 (4.61)	412	13 (3.16)	1.21, p>0.05
35-54	360	24 (6.67)	272	23 (8.46)	5.19, p<0.02
≥55	186	43 (23.12)	118	39 (33.05)	3.62, p>0.05
χ^2 with df=2	59.66, p<0.0001		97.10, p<0.0001		
Education					
Primary	585	58 (9.91)	88	11 (12.50)	0.56, p>0.05
Secondary	275	24 (8.73)	122	8 (6.56)	0.54, p>0.05
≥Higher Secondary	142	6 (4.23)	592	56 (9.46)	4.06, p<0.05
χ^2 with df=2	4.62, p>0.05		2.16, p>0.05		
Household Income					
Low	802	73 (9.10)	126	6 (4.76)	2.63, p>0.05
Middle	117	12 (10.26)	317	39 (12.30)	0.35, p>0.05
High	83	3 (3.61)	359	30 (8.36)	2.19, p>0.05
χ^2 with df=2	3.19, p>0.05		6.81, p<0.05		
Family Size					
Small	368	20 (5.43)	293	22 (7.51)	1.18, p>0.05
Medium	476	50 (10.50)	467	50 (10.71)	0.01, p>0.05
Large	158	18 (11.39)	42	3 (7.14)	0.64, p>0.05
χ^2 with df=2	8.25, p<0.01		4.23, p>0.05		
Nutritional Status					
Underweight	230	18 (7.83)	226	15 (6.64)	0.24, p>0.05
Normal	609	58 (9.52)	401	18 (4.49)	8.81, p<0.002
Overweight	163	12 (7.36)	175	42 (24.00)	17.40, p<0.001
χ^2 with df=2	1.09, p>0.05		57.45, p<0.0001		
Cormic Index					
<0.52	513	50 (9.75)	488	38 (7.79)	1.20, p>0.05
≥0.52	489	38 (7.77)	314	37 (11.78)	7.45, p<0.006
χ^2 with df=1	1.22, p>0.05		3.60, p>0.05		
Conicity Index					
<1.10	622	40 (6.43)	524	24 (4.58)	1.85, p>0.05
≥1.10	380	48 (12.63)	278	51 (18.35)	4.10, p<0.04
χ^2 with df=1	11.32, p<0.001		40.60, p<0.0001		
Waist-Hip Ratio					
Lower	596	43 (7.21)	529	26 (4.91)	2.57, p>0.05
Greater	406	45 (11.08)	273	49 (17.95)	6.45, p<0.01
χ^2 with df=1	4.51, p<0.05		30.09, p<0.0001		

It is further observed from **Table 5.12** that the prevalence of morbidity increases with the increase in age groups in both rural and urban areas. The chi-square tests indicate that the age differences in the prevalence of morbidity are highly significant in both rural (χ^2=59.66, df=2, p<0.0001) and urban (χ^2=97.10, df=2, p<0.0001). Thus, age may be an important factor

in influencing the prevalence of morbidity, suggesting that the older persons are likely to have higher morbidity. In addition, the chi-square tests indicate that the rural-urban differences are statistically significant in the age group of 35-54 years (χ^2 = 5.19, df=1, $p<0.02$). Thus, the prevalence of morbidity seems to be higher among the urban individuals compared to the rural individuals especially in the age group of 35-54 years.

As for education, **Table 5.12** shows the absence of statistical differences between educational groups with respect to the prevalence of morbidity in both rural (χ^2=4.62, df=2, $p>0.05$) and urban (χ^2=2.16, df=2, $p>0.05$) areas. However, the rural-urban difference in the prevalence of morbidity was statistically significant among the individuals with educational level of higher secondary and above (χ^2=4.06, df=1, $p<0.05$). Thus, the differences between rural and urban areas among the higher educational groups cannot be totally ruled out in the present study.

Table 5.12 further shows the prevalence of morbidity by income groups in both rural and urban areas. It is observed that the difference in the prevalence of morbidity by income group was statistically significant only in urban areas (χ^2=6.81, df=2, $p<0.05$). It is also observed that the rural-urban differences are not statistically significant in all the income groups. Therefore, household income seems to influence the prevalence of morbidity among urban individuals, although the rural-urban difference is not statistically significant.

With respect to family size, **Table 5.12** shows that the prevalence of morbidity by family size groups are statistically significant only in rural (χ^2=8.25, df=2, $p<0.01$) but not in urban (χ^2=4.23, df=2, $p>0.05$) areas. However, the rural-urban differences are not statistically significant for all the three categories of family size. Therefore, the relationship between morbidity and family size is not clear in urban areas, but it is highly significant in rural areas.

The relationship between morbidity and nutritional status is highly significant in urban areas (χ^2=57.45, df=2, $p<0.0001$) but not in rural areas (χ^2=1.09, df=2, $p>0.05$). Thus, we may suggest that the nutritional status is likely to be associated with morbidity, especially in urban areas. Further, the rural-urban differences seem to be mainly because of the differences in the distribution of individuals with normal and overweight categories of nutritional status.

The relationship between morbidity and cormic index is not clearly perceptible in the present study (**Table 5.12**). However, the rural-urban difference is highly significant among the individuals with greater cormic index (χ^2=7.45, df=1, $p<0.006$). Thus, despite the absence of statistical difference in morbidity between individuals with lower and greater cormic

index, it is likely that the rural-urban difference in morbidity may be attributed to the variation in greater cormic index.

With respect to conicity index, **Table 5.12** shows that conicity index is significantly associated with morbidity in both rural (χ^2=11.32, df=1, p<0.001) and urban (χ^2=40.60, df=1, p<0.0001) areas. The chi-square test also indicates that the rural-urban differences in the prevalence of morbidity is statistically significant among the individuals with greater conicity index (χ^2=4.10, df=1, p<0.04). Thus, it is clear that morbidity is higher among the individuals with greater conicity index, which is also attributable to rural-urban differences.

The relationship between morbidity and waist-hip ratio (WHR) is statistically significant in both rural (χ^2=4.51, df=1, p<0.05) and urban (χ^2=30.09, df=1, p<0.0001). As in the case of conicity index, the prevalence of morbidity is higher among the individuals with greater WHR (**Table 5.12**). The rural-urban differences is also statistically significant among the individuals with greater WHR (χ^2=6.45, df=1, p<0.01). Therefore, it is likely that morbidity is associated with greater WHR, which may also bring about the rural-urban differences in morbidity.

Hypertension in Relation to Anthropometric and Socioeconomic Factors

Table 5.13 shows the prevalence of hypertension by anthropometric and socioeconomic parameters in both rural and urban areas. It is observed that in rural area, the prevalence of hypertension is higher in males (25.15%) than in females (21.08%). Similarly, in urban area, it is higher in males (28.40%) than in females (16.12%). However, the chi-square tests indicate that the sex difference is statistically significant only in urban (χ^2=17.42, df=1, p<0.0001). It is also observed that the overall prevalence of hypertension is higher in urban males compared to rural males, and on the other hand, it is higher in rural females than in urban females. But the chi-square tests indicate that the rural-urban differences in the prevalence of hypertension are not statistically significant. Although there is no rural-urban difference in hypertension, the sex difference is significant in urban areas.

It is further observed from **Table 5.13** that the prevalence of hypertension increases with the increase in age groups, in both rural and urban areas. The chi-square tests also indicate that these differences in the prevalence of hypertension by age groups are statistically very significant both in rural (χ^2=67.41, df=2, p<0.0001) and in urban (χ^2=134.18, df=2, p<0.0001). Therefore, age may be an important factor in influencing the prevalence of hypertension, suggesting that older people are likely to be more hypertensive.

In addition, chi-square tests indicate that the rural-urban differences in the prevalence of hypertension by age group is statistically significant only in the age group of ≥55 years (χ^2=7.86, df=1, p<0.01). Thus, the prevalence of hypertension also seems to be higher among urban individuals compared to rural individuals especially in the age group of ≥55 years.

Table 5.13. Prevalence of hypertension by anthropometric & socioeconomic parameters

Parameters	Rural (N=1002)		Urban (N=802)		χ^2 for urban-rural difference
	N	Prevalence (%)	N	Prevalence (%)	
Sex					
Males	485	122 (25.15)	405	115 (28.40)	1.19, p>0.05
Females	517	109 (21.08)	397	64 (16.12)	3.60, p>0.05
χ^2 with df=1	2.34, p>0.05		17.42, p<0.0001		
Age (years)					
<34	456	55 (12.06)	412	34 (8.25)	3.41, p>0.05
35-54	360	101 (28.06)	272	78 (28.68)	0.03. p>0.05
≥55	186	75 (40.32)	118	67 (56.78)	7.86, p<0.01
χ^2 with df=2	67.41, p<0.0001		134.18, p<0.0001		
Education					
Primary	585	130 (22.22)	88	18 (20.45)	0.14, p>0.05
Secondary	275	65 (23.64)	122	30 (24.59)	0.04, p>0.05
≥Higher Secondary	142	36 (25.35)	592	131 (22.13)	0.68, p>0.05
χ^2 with df=2	0.70, p>0.05		0.55, p>0.05		
Household Income					
Low	802	157 (19.58)	126	18 (14.29)	1.99, p>0.05
Middle	117	44 (37.61)	317	69 (21.78)	11.13, p<0.0007
High	83	30 (36.14)	359	92 (25.63)	3.73, p<0.05
χ^2 with df=2	27.46, p<0.0001		7.01, p<0.03		
Family Size					
Small	368	82 (22.28)	293	55 (18.77)	1.22, p>0.05
Medium	476	107 (22.48)	467	116 (24.84)	0.73, p>0.05
Large	158	42 (26.58)	42	8 (19.05)	1.00, p>0.05
χ^2 with df=2	1.32, p>0.05		4.10, p>0.05		
Nutritional Status					
Underweight	230	32 (13.91)	226	19 (8.41)	3.48, p>0.05
Normal	609	11 (1.81)	401	76 (18.95)	90.30, p<0.0001
Overweight	163	80 (49.08)	175	84 (48.00)	0.04, p>0.05
χ^2 with df=2	267.59, p<0.0001		94.42, p<0.0001		
Cormic Index					
<0.52	513	122 (23.78)	488	103 (21.11)	1.03, p>0.05
≥0.52	489	109 (22.29)	314	76 (24.20)	0.39, p>0.05
χ^2 with df=1	0.31, p>0.05		1.06, p>0.05		
Conicity Index					
<1.10	622	93 (14.95)	524	66 (12.60)	1.32, p>0.05
≥1.10	380	138 (36.32)	278	113 (40.65)	1.28, p>0.05
χ^2 with df=1	60.69, p<0.0001		82.44, p<0.0001		
Waist-Hip Ratio					
Lower	596	107 (17.95)	529	81 (15.31)	1.40, p>0.05
Greater	406	124 (30.54)	273	98 (35.90)	2.13, p>0.05
χ^2 with df=1	21.57, p<0.0001		44.01, p<0.0001		

As for education, **Table 5.13** shows the absence of statistical differences between educational groups with respect to the prevalence of hypertension in both rural (χ^2=0.70, df=2, p>0.05) and in urban (χ^2=0.55, df=2, p>0.05) areas. In addition, the chi-square tests indicate that the rural-urban differences in the prevalence of hypertension by education are not statistically significant. Thus, education does not seem to be important in regulating blood pressure in the present study.

Table 5.13 further shows the prevalence of hypertension by income groups in both rural and urban areas. It is observed that the differences in the prevalence of hypertension are statistically significant in both rural (χ^2=27.46, df=2, p<0.0001) and urban (χ^2=7.01, df=2, p<0.03) areas. It is also observed that the rural-urban differences are statistically significant in the middle income group (χ^2=11.13, df=1, p<0.0007) and high income group (χ^2=3.73, df=1, p<0.05). Therefore, household income seems to influence the prevalence of hypertension in both rural and urban individuals. In addition, the rural-urban differences suggest that prevalence of hypertension is higher in urban compared to rural, especially among middle and high income groups.

With respect to family size, **Table 5.13** shows that the prevalence of hypertension by family size groups are not statistically significant in both rural and urban areas. The same is true that for the rural-urban differences, there is no statistical significance in all the three categories of family size. Therefore, there seem to be no indication of a relationship between family size and hypertension.

The relationship between hypertension and nutritional status is highly significant in both in rural (χ^2=267.59, df=2, p<0.0001) and in urban (χ^2=94.42, df=2, p<0.0001). Thus, we may suggest that the nutritional status is likely to be associated with hypertension. Further, the rural-urban differences in the prevalence of hypertension by nutritional status is statistically significant only in the normal weight category (χ^2=90.30, df=1, p<0.0001). This indicates that the prevalence of hypertension is different between rural and urban individuals even in the normal category of nutritional status. Thus, it suggests that hypertension is associated not only with nutritional status but also with rural-urban setting.

The relationship between hypertension and cormic index is not clearly perceptible in the present study (**Table 5.13**). In addition, the rural-urban differences show no statistical significance in any of the categories of cormic index. Therefore, it is likely that hypertension in the present study is not associated with cormic index or rural-urban setting.

With respect to conicity index, **Table 5.13** shows that conicity index is significantly associated with hypertension in both rural (χ^2=60.69, df=1, p<0.0001) and urban (χ^2=82.44, df=1, p<0.0001) areas. It is observed that the prevalence of hypertension is higher among the individuals with greater conicity index. The chi-square tests indicate that the rural-urban differences in the prevalence of hypertension by conicity index are not statistically significant. Thus, it is clear that hypertension is higher among the individuals with greater conicity index, irrespective of rural-urban setting.

Similarly, the relationship between hypertension and waist-hip ratio (WHR) is statistically significant in both rural (χ^2=21.57, df=1, p<0.0001) and urban (χ^2=44.01, df=1, p<0.0001). As in the case of conicity index, the prevalence of hypertension is higher among the individuals with greater WHR. Also, the chi-square tests indicate that the rural-urban differences in the prevalence of hypertension by WHR are not statistically significant. Therefore, it is likely that morbidity is associated with greater WHR, irrespective of rural-urban setting.

Underweight in Relation to Anthropometric and Socioeconomic Factors

Table 5.14 shows the prevalence of underweight by anthropometric and socioeconomic parameters in both rural and urban areas. It is observed that in rural area, the prevalence of underweight is higher in females (28.43%) than in males (17.11%). Similarly in urban area, the prevalence is higher in females (31.49%) than in males (24.94%). The chi-square tests also indicate that the sex differences are statistically significant in both rural (χ^2=18.13, df=1, p<0.0001) and urban (χ^2=4.25, df=1, p<0.05). It is also observed that the prevalence of underweight is higher among urban males and urban females compared to rural males and rural females, it is statistically significant only among adult males (χ^2=8.24, df=1, p<0.004). Thus, sex may be an important factor in influencing underweight, while rural-urban setting is important only among males.

It is further observed from **Table 5.14** that the prevalence of underweight decreases with increasing age groups. The chi-square tests also indicates that the prevalence of underweight by age groups is statistically highly significant in both rural (χ^2=22.34, df=2, p<0.0001) and urban (χ^2=44.55, df=2, p<0.0001). Thus, age may be an important factor in influencing the prevalence of under-weight, suggesting that younger adults are more underweight. In addition, the chi-square tests indicate that the rural-urban differences in the prevalence of underweight is statistically significant in the age group of <34 years (χ^2=7.02, df=1, p<0.01).

Therefore, we may suggest that age is important factor in patterning underweight in the present study, and it is likely to contribute to the rural-urban differences especially in the age group of <24 years.

Table 5.14. Prevalence of underweight by anthropometric & socioeconomic parameters

Parameters	Rural (N=1002)		Urban (N=802)		χ^2 for urban-rural difference
	N	Prevalence (%)	N	Prevalence (%)	
Sex					
Males	485	83 (17.11)	405	101 (24.94)	8.24, p<0.004
Females	517	147 (28.43)	397	125 (31.49)	1.00, p>0.05
χ^2 with df=1	18.13, p<0.0001		4.25, p<0.03		
Age (years)					
<34	456	136 (29.82)	412	158 (38.35)	7.02, p<0.01
35-54	360	62 (17.22)	272	52 (19.12)	0.38, p>0.05
≥55	186	32 (17.20)	118	16 (13.56)	0.72, p>0.05
χ^2 with df=2	22.34, p<0.0001		44.55, p<0.0001		
Education					
Primary	585	140 (23.93)	88	20 (22.73)	0.06, p>0.05
Secondary	275	52 (18.91)	122	37 (30.33)	6.34, p<0.01
≥Higher Secondary	142	38 (26.76)	592	169 (28.55)	0.18, p>0.05
χ^2 with df=2	4.02, p>0.05		1.61, p>0.05		
Household Income					
Low	802	202 (25.19)	126	58 (46.03)	23.46, p<0.0001
Middle	117	19 (16.24)	317	93 (29.34)	7.66, p<0.005
High	83	9 (10.84)	359	75 (20.89)	4.42, p<0.03
χ^2 with df=2	12.13, p<0.002		29.47, p<0.0001		
Family Size					
Small	368	89 (24.18)	293	75 (25.60)	0.17, p>0.05
Medium	476	105 (22.06)	467	143 (30.62)	8.92, p<0.002
Large	158	36 (22.78)	42	8 (19.05)	0.27, p>0.05
χ^2 with df=2	0.53, p>0.05		4.07, p>0.05		
Cormic Index					
<0.52	513	129 (25.15)	488	156 (31.97)	5.71, p<0.02
≥0.52	489	101 (20.65)	314	70 (22.29)	0.31, p>0.05
χ^2 with df=1	2.86, p>0.05		8.84, p<0.002		
Conicity Index					
<1.10	622	175 (28.14)	524	196 (37.40)	11.16, p<0.0001
≥1.10	380	55 (14.47)	278	30 (10.79)	1.94, p>0.05
χ^2 with df=1	24.89, p<0.0001		63.56, p<0.0001		
Waist-Hip Ratio					
Lower	596	159 (26.68)	529	207 (39.13)	19.80, p<0.0001
Greater	406	71 (17.49)	273	19 (6.96)	15.74, p<0.0001
χ^2 with df=1	11.53, p<0.001		92.08, p<0.0001		

As for education, **Table 5.14** shows the absence of statistical differences between educational groups with respect to the prevalence of underweight in both rural (χ^2=4.02, df=2, p>0.05) and urban (χ^2=1.61, df=2, p>0.05). In addition, the chi-square tests indicate that the rural-urban differences is statistically significant only in the secondary level

of education (χ^2=6.34, df=1, p<0.01). Thus, although education does not seem to be important in regulating underweight, there exists a rural-urban difference in the prevalence of underweight among individuals with secondary level of education.

Table 5.14 further shows the prevalence of underweight by income groups in both rural and urban areas. It is observed that the prevalence of underweight decreases with the increase in the income groups. These differences in the prevalence of underweight are statistically significant in both rural (χ^2=12.13, df=2, p<0.002) and urban (χ^2=29.47, df=2, p<0.0001) areas. It is also observed that the rural-urban differences are statistically significant in all the income groups. Therefore, household income seems to influence the prevalence of underweight in both rural and urban individuals. In addition, the rural-urban differences suggest that prevalence of underweight is higher in urban compared to rural al all income levels.

With respect to family size, **Table 5.14** shows that the prevalence of underweight by family size groups are not statistically significant in both rural and urban areas. However, the rural-urban differences show that it is statistically significant only in the medium family size (χ^2=8.92, df=1, p<0.002). Thus, the prevalence of underweight by family size is not clear, although there is indication that underweight is more prevalent among urban adults than rural adults especially in medium family size.

The prevalence of underweight by cormic index is shown in **Table 5.14**. It is observed that underweight is highly prevalent among individuals with lower cormic index in both rural and urban. However, the chi-square tests indicate that the prevalence of underweight by cormic index is statistically significant only in urban (χ^2=8.84, df=1, p<0.002). In addition, the chi-square tests again indicate that the rural-urban differences are statistically significant only in lower cormic index category (χ^2=5.71, df=1, p<0.02). Thus, it seems that the prevalence of underweight is higher among individuals with lower cormic index, especially among urban individuals. Also, the rural-urban differences suggest that underweight is higher among urban individuals with lower cormic index.

With respect to conicity index, **Table 5.14** shows that conicity index is significantly associated with underweight in both rural (χ^2=24.89, df=1, p<0.0001) and urban (χ^2=63.56, df=1, p<0.0001) areas. It is observed that the prevalence of underweight is higher among the individuals with lower conicity index. In addition, the chi-square tests indicate that the rural-urban differences is statistically significant only in lower conicity index (χ^2=11.16, df=1,

$p<0.0001$). Therefore, individuals with lower conicity index seem to have a greater risk of being underweight, and it is greater among urban individuals.

Table 5.14 shows that the relationship between underweight and waist-hip ratio (WHR) is statistically significant in both rural ($\chi^2=11.53$, df=1, $p<0.001$) and urban ($\chi^2=92.08$, df=1, $p<0.0001$) areas. It is observed that the prevalence of underweight is higher among individuals with lower WHR. Further, the rural-urban differences is also statistically significant among the individuals with both lower WHR ($\chi^2=19.80$, df=1, $p<0.0001$) and greater WHR ($\chi^2=15.74$, df=1, $p<0.0001$). Therefore, the prevalence of underweight is greater among those individuals with lower WHR, and the rural-urban differences are significant for both lower and greater WHR.

Overweight in Relation to Anthropometric and Socioeconomic Factors

Table 5.15 shows the prevalence of overweight by anthropometric and socioeconomic parameters in both rural and urban areas. It is observed that in both rural and urban, the prevalence of overweight is higher among females compared with males. However, the chi-square tests indicate that these sex differences are statistically significant only in urban area ($\chi^2=4.48$, df=1, $p<0.03$). It is also observed that the prevalence of overweight is higher among urban males (18.77%) and females (24.94%) compared to their rural counterparts, although it is statistically significant only for females ($\chi^2=8.20$, df=1, $p<0.004$). Thus, females are likely to have greater prevalence of overweight than males in both rural and urban areas, and urban females are greater in risk of being overweight compared with rural females.

Table 5.15 also shows that the prevalence of overweight by age groups are statistically significant in both rural ($\chi^2=49.81$, df=2, $p<0.0001$) and urban ($\chi^2=143.01$, df=2, $p<0.0001$) areas. It is also observed that the rural-urban differences in the prevalence of overweight by age groups are statistically significant only in the age groups of 35-54 years ($\chi^2=5.96$, df=1, $p<0.01$) and ≥ 55 years ($\chi^2=29.06$, df=1, $p<0.0001$). Thus, age may be an important factor in influencing the prevalence of over-weight, suggesting that older adults are more over-weight. In addition, the rural-urban differences suggest that the prevalence of overweight is higher among urban individuals compared to rural individuals, especially among the age groups of 35-54 and ≥ 55 years.

Table 5.15. Prevalence of overweight by anthropometric & socioeconomic parameters

Parameters	Rural (N=1002)		Urban (N=802)		χ^2 for urban-rural difference
	N	Prevalence (%)	N	Prevalence (%)	
Sex					
Males	485	74 (15.26)	405	76 (18.77)	1.94, p>0.05
Females	517	89 (17.21)	397	99 (24.94)	8.20, p<0.004
χ^2 with df=1	0.70, p>0.05		4.48, p<0.03		
Age (years)					
<34	456	34 (7.46)	412	23 (5.58)	1.24, p>0.05
35-54	360	91 (25.28)	272	93 (34.19)	5.96, p<0.01
≥55	186	38 (20.43)	118	59 (50.00)	29.06, p<0.0001
χ^2 with df=2	49.81, p<0.0001		143.01, p<0.0001		
Education					
Primary	585	86 (14.70)	88	26 (29.55)	12.16, p<0.004
Secondary	275	55 (20.00)	122	28 (22.95)	0.45, p>0.05
≥Higher Secondary	142	22 (15.49)	592	121 (20.44)	1.79, p>0.05
χ^2 with df=2	3.93, p>0.05		3.83, p>0.05		
Household Income					
Low	802	100 (12.47)	126	12 (9.52)	0.89, p>0.05
Middle	117	33 (28.21)	317	72 (22.71)	1.41, p>0.05
High	83	30 (36.14)	359	91 (25.35)	3.95, p<0.05
χ^2 with df=2	44.81, p<0.0001		13.94, p<0.001		
Family Size					
Small	368	60 (16.30)	293	67 (22.87)	4.53, p<0.03
Medium	476	81 (17.02)	467	97 (20.77)	2.17, p>0.05
Large	158	22 (13.92)	42	11 (26.19)	3.62, p>0.05
χ^2 with df=2	0.83, p>0.05		0.96, p>0.05		
Cormic Index					
<0.52	513	68 (13.26)	488	85 (17.42)	3.35, p>0.05
≥0.52	489	95 (19.43)	314	90 (28.66)	9.20, p<0.002
χ^2 with df=1	7.00, p<0.008		14.16, p<0.001		
Conicity Index					
<1.10	622	56 (9.00)	524	48 (9.16)	0.01, p>0.05
≥1.10	380	107 (28.16)	278	127 (45.68)	21.52, p<0.0001
χ^2 with df=1	63.54, p<0.0001		143.03, p<0.0001		
Waist-Hip Ratio					
Lower	596	58 (9.73)	529	33 (6.24)	4.60, p<0.03
Greater	406	105 (25.86)	273	142 (52.01)	48.24, p<0.0001
χ^2 with df=1	46.13, p<0.00001		221.19, p<0.0001		

As for education, **Table 5.15** shows the absence of statistical differences between educational groups with respect to the prevalence of overweight in both rural and urban areas. In addition, the chi-square tests indicate that the rural-urban differences is statistically significant only in the primary level of education (χ^2=127.72, df=1, p<0.0001). Thus, the role of education in the prevalence of over-weight is not clear, although there is an indication that overweight is more prevalent among urban individuals, especially among those individuals who have attained primary education.

Table 5.15 further shows the prevalence of overweight by income groups in both rural and urban areas. It is observed that the prevalence of overweight increases with the increase in the income groups, and it is statistically significant in both rural (χ^2=44.81, df=2, p<0.0001) and urban (χ^2=13.94, df=2, p<0.001). It is also observed that overweight is more prevalent among rural individuals than urban individuals in all the income groups. However, these rural-urban differences is statistically significant only in the high income group (χ^2=3.95, df=1, p<0.05). Thus, income may be an important factor in influencing overweight, suggesting that over-weight is more prevalent as income level improves. In addition, the rural-urban differences suggest that the prevalence of overweight is higher among rural individuals than in urban individuals, especially in the high income group.

With respect to family size, **Table 5.15** shows that the prevalence of overweight by family size groups are not statistically significant in both rural and urban areas. However, the rural-urban differences show that it is statistically significant in small family size (χ^2=4.53, df=1, p<0.03). Thus, the prevalence of overweight by family size is not clear, although there is indication that overweight is more prevalent among urban individuals than rural individuals, especially in small family size.

The prevalence of overweight by cormic index is shown in **Table 5.15**. It is observed that overweight is highly prevalent among individuals with greater cormic index in both rural and urban, and this prevalence of overweight by cormic index is statistically significant in both rural (χ^2=7.00, df=1, p<0.008) and urban (χ^2=14.16, df=1, p<0.001) areas. It is also observed that the prevalence of overweight is higher among urban individuals than in rural individuals in both the categories of cormic index. However, the chi-square tests indicate that the rural-urban difference is statistically significant only among individuals with greater cormic index (χ^2=9.20, df=1, p<0.002). Thus, it seems that the prevalence of overweight is higher among individuals with greater cormic index. Also, the rural-urban differences suggest that overweight is higher among urban individuals especially with greater cormic index.

With respect to conicity index, **Table 5.15** shows that conicity index is significantly associated with overweight in both rural (χ^2=763.54, df=1, p<0.0001) and urban (χ^2=143.03, df=1, p<0.0001). It is observed that the prevalence of overweight is higher among the individuals with greater conicity index. In addition, the chi-square tests indicate that the rural-urban differences is statistically significant only among individuals with greater conicity index (χ^2=21.52, df=1, p<0.0001). Therefore, individuals with greater conicity index seem to have greater overweight, and the rural-urban differences indicate that overweight is more

prevalent among urban individuals than rural individuals, especially among those individuals with greater conicity index.

Table 5.15 shows that the relationship between overweight and waist-hip ratio (WHR) is statistically significant in both rural (χ^2=46.13, df=1, p<0.0001) and urban (χ^2=221.19, df=1, p<0.0001). It is observed that the prevalence of overweight is higher among individuals with greater WHR. The rural-urban differences are also statistically significant among the individuals with both lower WHR (χ^2=4.60, df=1, p<0.03) and greater WHR (χ^2=48.24, df=1, p<0.0001). Therefore, overweight seems to be more prevalent among those individuals with greater WHR. In addition, there are also rural-urban differences in overweight among individuals with both lower and greater WHR.

RURAL-URBAN DIFFERENCES

Since our basic design of our study is to understand the rural-urban differences and the causes of such differences, the logistic regression analysis was carried out in this section by considering underweight and overweight as dependent variables and rural-urban setting as independent variable in relation to other anthropometric and socioeconomic covariates. Morbidity and hypertension were not analyzed because of the absence of statistical differences between rural and urban areas.

Rural-Urban Differences in Underweight

Table 5.16 shows that the prevalence of underweight is higher in urban than in rural areas, which is not according to general expectation. As per model-1 of the regression analysis, i.e., when rural-urban setting is considered alone in the analysis, the odds ratio (OR) was found to be 1.31 with a confidence interval (CI) of 1.06-1.63. This OR is highly significant, thereby suggesting that the urban persons are about 1.31 times greater in risk of being underweight compared with the rural persons. On the basis of this finding, we may also hypothesize that the above rural-urban difference in underweight may be because of the differences in age, sex and socioeconomic conditions between rural and urban areas. However, such a hypothesis can be rejected if we take into consideration the model-2 of the regression analysis in which age, sex, and socioeconomic factors were included as covariates. It is found that the urban adults had about 2.06 times higher in risk of being underweight than the rural adults. Therefore, we may conclude that, on the basis of the present analysis, the differences between rural and urban areas in underweight are not because of the above socioeconomic variables considered in the present study. Factors (including biological factors) other than those

considered in the present analysis may be responsible for the rural-urban differences in underweight.

Table 5.16: Odds ratio (OR) derived from logistic regression analysis for the risk factors of underweight

Models	N	Prevalence (%)	Odds ratio (95% CI)	B	p-level
Model-1					
Rural	1002	22.95	-	-	-
Urban	802	28.18	1.31(1.06-1.63)	0.275	0.011
Model-2					
Urban	1002	22.95	-	-	-
Rural	802	28.18	2.06(1.52-2.79)	0.723	0.001
Model-3					
Urban	1002	22.95	-	-	-
Rural	802	28.18	3.58(1.96-6.54)	1.275	0.001
Model-4					
Urban	1002	22.95	-	-	
Rural	802	28.18	0.99(0.64-1.53)	-0.011	NS

***Model-1** includes underweight as dependent variable and rural-urban setting as covariate*

***Model-2** includes underweight as dependent variable and rural-urban setting, age, sex, family size, household income, education and morbidity as covariates*

***Model-3** includes underweight as dependent variable and rural-urban setting, age, sex, family size, household income, education, morbidity and FFMI as covariates*

***Model-4** includes underweight as dependent variable rural-urban setting, age, sex, family size, household income, education, morbidity and BFMI as covariates*

Conclusions: Rural-urban differences in underweight are not due to differences in age, sex, family size, household income, education and morbidity, but because of differences in BFMI.

NS – not significant

In this connection, we may take into consideration the relative contribution of BFMI and FFMI in bringing about the rural-urban differences in underweight that was classified on the basis of BMI. In doing so, we included in model-3 the FFMI along with age, sex and other socioeconomic covariates that were included in model-2. It is found that the rural-urban difference in underweight is still significant. This indicates that rural-urban difference in underweight is not because of FFMI. When FFMI is excluded but BFMI is included in model-4, we found that the difference is not significant. Therefore, we may conclude that the rural-urban difference in underweight is mainly because of the differences in BFMI, which may be in turn influenced by different factors.

Rural-Urban Differences in Overweight

Table 5.17: Odds ratio (OR) derived from logistic regression analysis for the risk factors of overweight

Models	N	Prevalence (%)	Odds ratio (95% CI)	B	p-level
Model-1					
Rural	1002	16.27	-	-	-
Urban	802	21.82	1.44(1.13-1.82)	0.362	0.003
Model-2					
Urban	1002	16.27	-	-	-
Rural	802	21.82	1. 63(1.27-2.10)	0.488	0.001
Model-3					
Urban	1002	16.27	-	-	-
Rural	802	21.82	0.88(0.63-1.24)	-0.125	NS
Model-4					
Urban	1002	16.27	-	-	
Rural	802	21.82	1.52(1.13-2.05)	0.417	0.006
Model-5					
Urban	1002	16.27	-		
Rural	802	21.82	0.76(0.55-1.05)	-0.279	NS

Model-1 includes overweight as dependent variable and rural-urban setting as covariate

Model-2 includes overweight as dependent variable and rural-urban setting, age, sex, family size, and morbidity as covariates

Model-3 includes overweight as dependent variable and rural-urban setting, household income, education and physical activity as covariates

Model-4 includes overweight as dependent variable rural-urban setting and education as covariates

Model-5 includes overweight as dependent variable rural-urban setting, household income and physical activity as covariates

Conclusions: Rural-urban differences in overweight are not due to differences in age, sex, family size, education and morbidity, but mainly because of differences in household income and physical activity.

NS – not significant

Table 5.17 shows that the prevalence of overweight is higher in urban than in rural areas, giving the OR of 1.44 with CI of 1.06-1.63 ($p < 0.0001$). In other words, it suggests that the urban persons are about 1. 44 times greater in risk of being overweight compared with the rural persons. When age, sex, family size, and morbidity are included as covariates in model-2, the OR was 1.63(CI: 1.27-2.10, $p < 0.001$). Therefore, it is clear that the differences between rural and urban areas in overweight are not because of age, sex, family size, and morbidity. In model-3, an attempt was made to include household income, education and

physical activity as covariates. The results indicate that the differences between rural and urban areas disappeared. This indicates that the rural-urban differences are mainly because of the differences in household income, education and physical activity. In order to have a better understanding of the relative importance of these three factors, we assumed that education was an important factor by including it as the only covariate in model-4. However, the results indicate that the urban persons were about 1.52 (CI: 1.13-2.05, $p < 0.006$) times greater in risk of being overweight compared with the rural persons, thereby indicating that education alone was not an important factor for bringing about the rural-urban differences in overweight. When physical activity and household income were included in model-5, the significant differences between rural and urban areas disappeared (OR: 0.76(CI: 0.55-1.05, $p > 0.05$). Similarly, the rural-urban difference in overweight disappeared even when only physical activity or only household income was included in the model – not shown in **Table 5.17**. Therefore, we may conclude that the difference in the prevalence of overweight between rural and urban people was mainly due to the differences in household income and physical activity, although the role of other factors not included in the present study cannot be ruled out.

CHAPTER VI

DISCUSSION AND CONCLUDING REMARKS

In this Chapter, we shall briefly discuss our findings in the context of other findings on other populations including those from Northeast India. We shall also look into the implications of the present findings.

Rural-Urban Difference in Socioeconomic Conditions

It is clearly evident from the present study that urban areas are more advanced in both education and economic condition. Therefore, it is consistent with the earlier reports. For example, the National Family Health Survey-3 (IIPS and Macro International, 2009) revealed that more than one-third of households (35%) in urban areas of Nagaland belonged to the highest wealth index as compared to only 7% of households in rural areas. The same is true with regard to literacy rates, which were 63% and 85% in rural and urban areas, respectively (Census of India, 2001). Although data on wealth index are not available for Mokokchung district of Nagaland, 2001 census data indicated that the literacy rate was higher in urban (92%) than in rural (85%) areas. Nevertheless, on the basis of the present findings on education and household income, it is likely that urban areas are more advanced than rural areas.

It is further observed that there were significant differences between rural and urban areas in respect of anthropometric characters. With the exception of few cases, anthropometric characters are significantly greater in urban than in rural areas. Our findings, therefore, corroborate with earlier studies have also reported such findings from several countries such as in Mexico (Sànchez-Castillo *et al.*, 2001), Guatemala (Torun *et al.*, 2002), Papua New Guinea (Yamauchi and Umezaki, 2005), Eastern China (Weng *et al.*, 2007), 26 sub-Saharan countries in Africa (Uthman and Aremu, 2008), India (Venkatramana and Reddy, 2002), Pune (Bhat *et al.*, 2005), Calcutta (Das *et al.*, 2008) and Northeast India among the Meitei women in Manipur (Devi *et al.*, 2008).

In view of these findings on socioeconomic and anthropometric characters, it is clear that we cannot pool the rural and urban data without proper adjustment. Therefore, our

segregation of rural and urban data seems to be justified as far as the present study is concerned.

Body Composition and Nutritional Status

One of the main objectives of this study is to address the relationship between body composition and nutritional status, and how body composition is related to age, sex, anthropometric variables, self-reported morbidity, blood pressure, and socio-economic variables. Our findings with respect to this objective are presented in Chapter IV. The 2-compartment model was followed for estimating the body composition by using both anthropometric measurements and Omron bioelectrical impedance analyzer (OBIA-306). It is found that FFM measured by OBIA is about 0.90 kg different from that estimated from anthropometry. The standard error of estimate (SEE) in FFM according to OBIA is reported to be ≤ 3.5 kg for men and ≤ 2.8 kg for women (Heyward and Wagner, 2004). Considering these values of SEE, we may suggest that the body fat estimated from anthropometry is by and large similar to that measured by OBIA-306. Therefore, we have used in this thesis the body composition estimated from anthropometry not only because the estimation is similar to that obtained through OBIA, but also to make our studies comparable with other anthropological studies of body composition.

Body Composition

It is found that the mean values of BFM and FFM were 9.20 kg and 45.79 kg for rural males, and 9.70 kg and 47.16 kg for urban males, respectively. Therefore, both BFM and FFM are greater in urban males compared to their rural counterparts. It holds true from the statistical point of view also. These values of BFM and FFM among adult males are lower than those reported for adult males from Pune (Bhat *et al.*, 2005), Marwaris of West Bengal (Das and Bose, 2006), but are higher than those reported for adult males of the Kora Mudi (Bisai *et al.*, 2008), the Bathudis and Savars (Bose *et al.*, 2008), and the War Khasis (Khongsdier, 2005a).

As for females, it is observed that the mean values of BFM were 11.48 kg and 12.68 kg in rural and urban areas, respectively. And the mean values of FFM were 35.91 kg and 36.43 kg in rural and urban areas, respectively. These values of body composition variables in the present study is higher than those reported for females from the tribes of the Kora Mudi (Bisai *et al.*, 2008) and the Bathudis and Savars (Bose *et al.*, 2008).

Nutritional status

The nutritional status of participants in this study was assessed by using BMI, taking into consideration the cut-off points recommended for the Asia pacific region (WHO, 2000). The reason for this is given in chapter IV on the basis of the ROC curve analysis. According to this analysis, the BMI cut-off point for defining overweight lies between ≥ 21 kg/m^2 and ≥ 23 kg/m^2 against the reference PBF > 25% for men and >30% for women (Deurenberg *et al.*, 1998, 1999). It may be noted that the World Health Organisation (WHO) has recommended the BMI cut-offs of 25.0 kg/m^2 and 30.0 kg/m^2 for overweight and obesity, respectively (WHO, 1995) But there is considerable evidence that these cut-off values are not applicable across ethnic groups, especially among Asian populations. It has been reported that Asian Indians, for example, have higher PBF, waist-to-hip ratio (WHR) and abdominal fat at a lower level of BMI compared with the Caucasian populations (Ramachandran *et al.*, 1997; Deurenberg-Yap *et al.*, 2000). Among Asian populations, the risk of association with diabetes and CVD occurs at lower levels of BMI compared with the Caucasians (McKeigue and Shah, 1991; Banerji *et al.*, 1999; Chandalia *et al.*, 1999) Accordingly, The WHO Regional Office for Western Pacific Region, along with the International Association for the Study of Obesity (IASO) and the International Obesity Task Force (IOTF), has recommended new BMI cut-off points of 23·0 kg/m^2 and 25·0 kg/m^2 for defining overweight and obesity, respectively, in Asian populations (WHO, 2000). Considering the results of ROC curve analysis and this recommendation for the Asian populations, we propose to use the BMI-cutoff ≥ 23.0 kg/m^2 for defining overweight and obesity in the present population. However, we have also presented our results as per the international cut-off points (WHO, 1995) for comparative purposes (WHO Expert Consultation, 2004).

It is found that the prevalence of underweight in males was significantly lower in rural (17.11%) than in urban (24.94%) areas. The rural-urban difference in the prevalence of underweight among women was not statistically significant, although it appears to be higher in urban (31.49%) than in rural (28.43%) areas. Pooling males and females, the overall prevalence of underweight is 22.95% in rural and 28.18% in urban areas These values are lower than those reported from other tribal populations of Northeast India such as Boro-Kacharis, Lalungs, Miris and Pnars (Khongsdier, 2001) and War Khasi (Khongsdier, 2002). They are also lower than that reported for caste groups like Brahmins and Jogis (Khongsdier, 2001). Moreover, the prevalence of underweight is also lower compared to those reported from other populations in the country such as the Bathudis in Orissa (Bose and Chakraborty, 2005), adult males in Central India (Adak *et al.*, 2006), Saharia tribe of Rajasthan (Rao, *et al.*,

2006), backward populations in the districts of Madhya Pradesh and Chhattisgarh (Gautam *et al.*, 2006), from the slum dwellers in Midnapore, West Bengal (Bose *et al.*, 2007), and from low socioeconomic tribal populations from South India (Kusuma *et al.*, 2008). Thus, from these comparisons the nutritional status of the present population is better than most of the populations in the North-East and also most of the tribal populations in the country.

Following the international cut-off points (WHO, 1995), the prevalence of overweight (including obesity) was 5.98% and 7.90% in rural and urban adult males, respectively. These frequencies were 8.51% and 13.10% in rural and urban adult females, respectively. These results suggest the prevalence of overweight was higher in urban than rural areas, and also among females compared to males. Further, the prevalent rate increases considerably according to the cut-off points recommended for the Asia-pacific regions (WHO, 2000). It is found that the prevalence of overweight was 15.26% and 18.77% in rural and urban adult males, respectively. In the case of adult females, these frequencies were 17.21% and 24.94%, respectively. The prevalence of overweight among rural males was lower compared with those studies from rural Pune (Bhat *et al.*, 2005), but it was higher compared to the Bhil tribe of Maharashtra (Adak *et al.*, 2006). The prevalence of overweight among urban males was also lower compared to urban Mumbai (Shukla *et al.*, 2002), urban slum dwellers and urban middle class of Pune (Bhat et al., 2005), Marwaris of Howrah (Das and Bose, 2006) and slum dwellers of West Bengal (Chakraborty *et al.*, 2006). For rural females, the prevalence of overweight was lower compared to the rural females of Delhi (Reddy *et al.*, 2002). The prevalence of overweight among urban females was higher compared to the female Muslims of West Bengal (Ghosh *et al.*, 2005). However, the prevalence of overweight among urban females were lower compared to those females of urban Mumbai (Shukla *et al.*, 2002), Hindus of West Bengal (Ghosh *et al.*, 2005), Bengalee Hindu women, Kolkata (Bhadra *et al.*, 2005), female Marwaris of Howrah (Das and Bose, 2006) and females of Jalandhar, Punjab (Khokhar *et al.*, 2010).

These findings on nutritional status have clearly indicated three major aspects, namely, (i) differences due to BMI cut-off points, (ii) differences between the sexes, and (iii) rural-urban differences.

Different prevalence due to BMI cut-off points: Earlier studies in India and other developing countries have paid more attention to the problem of under-nutrition as compared to that of over-nutrition. However, during the last decade or so, there has been a shift of attention from meeting nutritional needs to the biological effects of nutrition on lifetime health, especially

with the emerging trend of obesity that has been declared an epidemic in developed countries (WHO/FAO, 2002). Recent studies from India have also revealed that overweight is very high, especially in urban areas (e.g., Sidhu and Tatla, 2002; Tiwari *et al.*, 2010). What we need to mention with respect to the present findings is that the prevalence of overweight (including obesity) seems to increase significantly when we use the cut-off points recommended for the Asia-pacific regions (WHO, 2000). It may be noted that the health ministry of the Government of India has also recommended the use of BMI $\geq$ 23.0 kg/m^2 as the cut-off point for defining obesity in the country (The Times of India, 26 Nov'08). However, many studies have still used the international cut-off point of $\geq$ 25.0 kg/m^2 (WHO, 1995), showing that the prevalence of overweight was very high in some urban areas of India. For example, Tiwari *et al.* (2010) have reported that reported that 34.4% of males and 31.3% of females aged 30 years and above were either overweight or obese in Gwalior city. Other studies have reported even higher rates, e.g., a study conducted by Sidhu and Tatla (2002) has revealed that the prevalence of overweight was about 45.3% among Punjabi females aged $\geq$30 years in Amritsar and Ludhiana cities. The point is that these studies have used the international cut-off point of $\geq$ 25.0 kg/m^2 for defining overweight and/or obesity. If the cut-off point of $\geq$ 23.0 kg/m^2 is used, it is likely that the prevalence of overweight would increase considerably in the above mentioned studies. Although future studies on risk factors of BMI cut-offs are needed in India, it is likely that the prevalence of overweight in India increased considerably during the last decade or so (IIPS and Macro International, 2009). In Northeast India, under-nutrition still remains as the major nutritional problem but over-nutrition is also emerging rapidly as indicated in the present study.

Sex differences: According to the WHO Global Infobase (WHO 2010), the estimated prevalence of overweight ($\geq$ 25.0 kg/m^2) in India was higher in men (20.1%) than in women (18.1%) who are in the age group 15 years and above. In the present study, the overall prevalence of overweight was 6.85% in men and 10.50% in women according to the international cut-off point of $\geq$ 25.0 kg/m^2. This sex difference is observed in both rural and urban areas, although the prevalence is higher in urban than rural areas. Therefore, our findings are inconsistent with the WHO estimate for the whole country. It is also inconsistent with a study reported from Gwalior city (Tiwari *et al.*, 2010), which indicated higher prevalence of overweight among males. However, some other studies from India indicated that the prevalence of overweight is higher in females than in males (e.g., Kaur *et al.*, 2010). A study of urban population in Mumbai (Shukla *et al.*, 2002) also indicated that the

prevalence of overweight was higher in women (30%) than in men (19%). It may be noted that the sex differences in the prevalence of overweight and obesity are different from one country to another. In South Africa, Puoane *et al.* (2002) reported that about 60% of African women in 1998 were either overweight or obese, which was about five times higher than for African men. Therefore, it is likely to be associated with different biological and environmental factors. It is generally reported that although both the sexes are susceptible to obesity, women and men differ in the proportion and distribution of body fat. Women have greater adipose store than men irrespective of cultures and races (Power and Schulkin, 2008). These differences begin early in life, and are more pronounced during puberty due to differences in metabolic and hormonal processes. However, it is reported that the prevalence of cardiovascular disease is greater in obese men than obese women (Wingard *et al.*, 1983; Lerner and Kannel, 1986), and the reason for this gender difference is not fully understood. The point to be made here is that the sex differences in overweight and obesity in India may vary from one region to another or from one culture to another. Future studies are needed to understand the etiology of such differences.

Rural-urban differences: In the present study, the prevalence of underweight is lower in rural than in urban areas, although it was not significant for females. On the other hand, the prevalence of overweight is higher in urban than rural areas. As for the prevalence of overweight, it is according to the general expectation that urbanization may predispose the people to overweight due to greater degree of changes in diet and lifestyles. As described in Chapter II, various factors are associated with overweight and non-communicable chronic diseases (NCDs). Nutritionally related factors associated with increasing urbanization and sedentary lifestyles are generally considered to be responsible for the increasing prevalence of overweight/obesity and NCDs in developing countries. According to WHO/FAO Expert Consultation (WHO/FAO, 2003), "Increasing urbanization will distance more people from primary food production, and in turn have a negative impact on both the availability of a varied and nutritious diet with enough fruits and vegetables, and the access of the urban poor to such a diet." It may be mentioned that Nagaland is one of the states in Northeast India with very high rate of migration from rural to urban area (Khongsdier, 2008). This increasing rural-urban migration in the state could be associated with various factors especially in search of better jobs, education and living conditions (DPC, 2004). Consequently, there are changes in economic conditions, dietary intakes, physical activity and lifestyles, which may be

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responsible for overweight and obesity among urban individuals of the present study. Future studies should pay more attention on how to prevent overweight and obesity.

Another major concern with respect to the findings of the present study is that underweight is also still high among the urban adults compared to their rural counterparts. This is also consistent with the report of the 3rd National Family Health Survey (IIPS and Macro International, 2009). Although it is difficult to explain the reason of this phenomenon, it is clearly obvious that there exists a double burden of under- and over-nutrition, especially in urban areas. One possible explanation of the lower prevalence of underweight in rural area may be related to the egalitarian nature of economic life in Nagaland. There is a strong community spirit and social responsibility to look after the poor as well as to provide an access to equal opportunities, because the kinship bond is very strong among the Ao villages. According to Nagaland Human Development Report (DPC, 2004), "Due to strong community spirit and social capital, the poor are looked after, and cared for, by kith and kin and the community. As a result, there is no case of starvation deaths and no one is shelterless." This may have implication if we take into consideration the way of life in urban areas where the degree of social stratification in terms of education, income and other socioeconomic factors is more prevalent. The Nagaland Human Development Report (DPC, 2004) has pointed out that the increased migration from rural to urban or town areas has "put a strain on the limited urban services and infrastructure in these towns and has resulted in increased urban poverty and unemployment levels." Another possible explanation of the lower prevalence of underweight in rural areas may be related to natural resources of nutrients. In rural areas, many types of fruits, vegetables and animal foods are gathered from jungles. The combination of forest resources of foods with the egalitarian aspects of the Ao society may be responsible for the better nutritional status in rural areas compared to urban areas. We hope that future studies will throw much more light on this area of rural-urban differences in nutritional status of the Ao Nagas. As far as the present study is concerned, we can only suggest that there exists a double burden of underweight and overweight, which are indicative of differential resources especially in urban areas.

Relationship between Body Composition and Nutritional Status

Our findings in Chapter IV have clearly indicated that it is difficult to conclude whether BMI is more related to PBF or FFM. It is found that both PBF and FFM have significantly increased with the increase in BMI levels. It also indicates that the urban males have a higher FFM than the rural males across levels of BMI, although it is expected that greater physical

activity may increase FFM in rural areas. It may be noted that the major nutritional problem is the correlation between excess body fat and other chronic diseases. Secondly, BMI is a crude measure of both body fat and fat free mass. High BMI may also be due to high muscle mass, not necessarily because of high body fat. Accordingly, it has been suggested to split the BMI into two parts, body fat mass index (BFMI) and fat free mass index (FFMI) to understand the relationship between body composition and nutritional status (Van Itallie, 1990). The present study indicated that BFMI was more correlated with PBF, whereas FFMI is more correlated with FFM for both the sexes in rural and urban areas. Therefore, the present findings suggest that BFMI can also be used to detect changes in fat and fat-free body stores (Schutz *et al.*, 2002; Wells *et al.*, 2004; Khongsdier, 2005). The split of BMI into BFMI and FFMI may be important in understanding the relationship between body composition and morbidity, especially in a population with high prevalent of overweight and obesity.

Body composition and body shape

In the present study, body shape refers to the relative body dimensions that are commonly expressed as indices or ratios. We have taken into consideration four important indices and ratios, namely, cormic index, conicity index and waist-hip ratio. In Chapter IV, we have presented our findings on the relationship between body composition and body shape in relation to age, sex, self-reported morbidity, blood pressure, and socioeconomic variables.

Cormic Index and Body Composition: Cormic index or relative sitting height is one of the most common bivariate indices of body shape. It has been suggested that the variation in cormic index between and within populations may be associated with variations in BMI and body composition (Norgan, 1994). For example, Africans have proportionately longer leg (average of 0.51), whereas Asians have shorter legs with means of 0.52 to 0.54, although there exists considerable variation within each group (Norgan, 1994; Khongsdier, 2001). It has been suggested that a change of 0.88 kg/m in BMI for the variation of 0.01 in cormic index (Norgan, 1994). Therefore, the variation in cormic index may have certain implication for the differences in BMI and body composition between and within populations. In the present study, we have observed that persons with shorter leg length would have a greater percentage body fat body (PBF) than those with longer leg length. However, shorter leg length does not seem to play a major role in bringing about the differences in FFM. Therefore, we may conclude that the effect of cormic index on body composition of the

present population is significant only with respect of PBF, but it is not clearly perceptible in the case of FFM.

Abdominal obesity measures and Body Composition: In the present study, we have considered two abdominal obesity measures, namely, conicity index and waist-hip ratio (WHR) that are commonly used in assessing the nutritional status of population. Our purpose is to see how these measures are related to body composition in terms of PFB and FFM. We have observed that both PBF and FFM are significantly correlated with conicity index. In addition, both urban males and females with greater level of conicity index ($\geq$1.10) are likely to have greater PBF than their rural counterparts. Similarly, PBF and FFM are significantly higher among persons with greater waist-hip ratio compared with those having lower waist-hip ratio in both rural and urban areas. Also, the means of PBF and FFM are by and large greater in urban males and females compared with their rural counterparts.

Conicity index is one of the measures of abdominal obesity. It is derived from height and weight of the individual relative to waist circumference. It describes the deviation of the abdomen from the circumference of an imaginary cylindrical shape with constant body density (Valdez et al. 1993). The more central a person is in fat distribution, the higher the value of conicity index (Mueller *et al.*, 1996), ranging from 1.00 (perfect cylinder) to perfect double cone of 1.73 (Valdez, 1991). The conicity index has been shown to be associated with various risk factors for CHD to a similar extent as the waist to hip ratio (Valdez *et al.*, 1993; Mueller *et al.*, 1996). Similarly, many studies have indicated that WHR is associated with increased risk of hypertension, diabetes mellitus and coronary heart disease (e.g., Cassano *et al.*, 1992; Valdez *et al.*, 1993; Han *et al.*, 1995). As a matter of fact, it is not yet fully understood whether conicity index or WHR is more important in prediction of abdominal obesity and its associated morbidity and mortality risks. Some studies from India suggested that waist circumference should be preferred over WHR and conicity index (e.g., Bose, 2006). With respect to the relative importance of conicity index and WHR, many studies have indicated that the former is no better than the latter (e.g., Mantzoros *et al.*, 1996; Bose and Mascie-Taylor, 1998; Heyward and Wagner, 2004).

In the present study, our objective is not to find out the relative importance of conicity index and WHR in prediction of risk factors. Our study is mainly concerned with the relationship between these measures and body composition as well as to analyse the differences in the prevalence of self-reported morbidity and hypertension according to these measures. What we can suggest is that both conicity index and WHR are positively correlated

with body composition in terms of body fat and fat-free mass. We have also observed that the prevalence of morbidity and hypertension is greater in those individuals with higher levels of conicity index and WHR for both rural and urban areas.

Anthropometric Traits and Socioeconomic Factors

In Chapter V, we analyzed the effects of socioeconomic factors on adult body dimensions, body composition, nutritional status, blood pressure and self-reported morbidity. The adult body dimensions, body composition and nutritional status are described in terms of anthropometric measurements and indices; whereas the socioeconomic characteristics are described in terms of occupation, household income, education, family size. Since our design of study is to look into the rural and urban differences in these characteristics, total sample size was segregated into rural and urban areas in order to examine the differences and the causes of such differences.

The means and standard deviations of anthropometric traits by age group in the present study show that with the exception of chest girth, waist and hip circumferences the mean anthropometric traits are higher significantly in the lower age groups for both adult males and females. Therefore, the present findings may be related to secular trend. By secular trend, we mean an increase in anthropometric measurements, particularly height and weight, from one generation to another due to improvement in economic condition of a given population (Damon, 1968; Tanner, 1992; Ulijaszek, 1999; Bogin, 1999; Cole, 2003). The secular trend may be positive or negative. Since human growth and body size are highly sensitive to environmental conditions, positive secular trend is considered to be largely influenced by improved nutrition and health conditions, whereas negative secular trend can be observed in a situation where the environmental conditions are deteriorated (Eveleth and Tanner, 1990; Ulijaszek, 1999a; Roche and Sun, 2003; Ozer, 2008). Secondly, the present findings clearly indicate that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socioeconomic conditions on anthropometric traits, or while assessing the nutritional status of the study population in relation to socioeconomic conditions.

It is observed that the differences between income groups are highly significant in almost all anthropometric traits in both males and females. Most of the mean anthropometric traits are significantly higher in the higher income groups in both rural and urban areas. This observation is similar to those reported for other populations in India from West Bengal (Bharati, 1989), South India (Rao, *et al.*, 1990; Naidu and Rao, 1994; Rao *et al.*, 1995; Reddy, 1998; Kulkarni *et al.*, 2010) and Northeast India (Khongsdier, 2002). Thus,

anthropometric traits in the present study are to a great extent influenced by household income in both rural and urban areas for both the sexes.

In addition to household income, the present findings indicate that education has certain role in patterning anthropometric traits. In general, it indicates anthropometric characters are greater in adults with higher educational level, especially among females. However, household income seems to be more influential than education especially among males. Nevertheless, the findings of present study corroborated to some extent with those reported for other Asian populations including India (e.g., Yoon *et al.*, 2006; Khongsdier, 2002; Kulkarni *et al.,* 2010). It may, however, be mentioned that the effect of family size was not clearly perceptible, except in respect of MUAC in rural females, and hip circumference and FFMI in urban females. Thus, it is clearly evident that family size has little role to play in the variation of anthropometric traits in comparison with household income and education.

Physical activity is another important factor that affects anthropometric characters in the present study. As normally expected, sedentary individuals have greater body fat as indicated by body weight, skinfold thickness and BFMI, especially among urban females. Although the present study failed to identify different levels of physical activity, our findings suggest that anthropometric indicators of overweight and obesity are negatively influenced by physical activity. Therefore, the present study is consistent with many cross-sectional studies that have generally shown the inverse effect of physical activity on body mass (Miller *et al.*, 1990; Tremblay *et al.*, 1990; Klesges *et al.*, 1991; Fitzgerald *et al.*, 1997; Weng *et al.*, 2007; Gregory *et al.*, 2007; Nicklas *et al.*, 2009). In addition, physical activity is reported to improve glucose tolerance even in the absence of weight loss (Oshida *et al.*, 1989; DiPietro *et al.*, 1998). Some studies have even suggested that physical activity would also reduce the risk of cancer (Michaud *et al.*, 2001; Bao and Michaud, 2008).

Self-reported Morbidity

The overall prevalence of morbidity in rural and urban areas is 8.78% and 9.35%, respectively. This prevalence of morbidity in the present study is lower than those reported from the War Khasis (Khongsdier, 2002). In rural areas, it is higher in females (9.28%) than in males (8.25%). The situation is, however, reversed in urban area where the prevalence of morbidity is slightly higher in males (9.63%) than in females (9.07%). It is found that the prevalence of morbidity increases with the increase in age groups in both rural and urban areas, suggesting that the older persons are likely to have higher morbidity. However, the

effects of sex, education, income and family size on morbidity are not clearly perceptible in the present study.

It is found that the nutritional status is likely to be associated with morbidity, especially in urban areas where the prevalence of self-reported morbidity among overweight individuals was greater than that among the underweight individuals. Although self-reported morbidity refers here to different types of morbidity during the last one month, our findings suggest to certain extent the association between morbidity and overweight or obesity. Therefore, the present study supports the general observation that overweight or obesity is associated with different types of morbidity (e.g., WHO/FAO, 2003; Sullivan *et al.*, 2005; Janssen, 2007). The positive relationship between self-reported morbidity and obesity was also observed in the individuals with greater conicity index and WHR as mentioned earlier, i.e., individuals with greater conicity index and WHR were likely to have a greater risk of morbidity. This justifies the need for taking appropriate action in preventing the emerging trend of obesity in the state.

Hypertension

In addition to self-reported morbidity, nutritional status in the present study is associated with hypertension in both rural and urban areas. It is also observed that the prevalence of hypertension associated with greater conicity index and greater waist-hip ratio as suggested by many scholars (e.g., Venkatramana and Reddy, 2002; Shetty, 2002; Das *et al.*, 2008). In other words, the present findings confirmed that overweight and obesity is associated with hypertension.

We have also observed that the prevalence of hypertension is higher in males than in females in both rural and urban areas. Further, it is observed that the prevalence of hypertension increased with the increase in age groups in both rural and urban areas, suggesting that older people are likely to be more hypertensive. It is also found that household income is positively associated with hypertension. However, the effect of education and family size on hypertension is not clearly perceptible in the present study. It may be mentioned that studies in developed countries have revealed that hypertension is negatively associated with socioeconomic conditions, showing that higher socioeconomic status was associated with lower blood pressure or a lower prevalence of hypertension (for review see Colhoun *et al.*, 1998). In developing countries, the relationship between blood pressure and socioeconomic status is not clearly understood. Some studies have revealed that

that blood pressure was positively associated with social class for men, but negatively for women (e.g., Dressler *et al.*, 1989; Abdo and Leon, 2009). Other studies have shown that there was a U-shaped relationship between income and blood pressure, women with either high or low incomes had higher blood pressures than those with middle incomes (Mendez *et al.*, 2003). Nevertheless, the present study indicated a positive relationship between hypertension and household income.

Underweight and Overweight

The prevalence of underweight and overweight in the present study is correlated with urbanization and household income. Individuals in the lower income groups are likely to have greater prevalence of underweight as observed in other populations (Khongsdier, 2002; Roy *et al.*, 2004; Bose and Chakraborty, 2005, Kusuma *et al.*, 2008). It is found that the prevalence of underweight decreases with increase in the age groups. It is also found that females are more underweight than males especially among low economic groups. In addition, the prevalence of underweight decreases with increase in the age groups. However, the effects of education and family size on underweight are not clearly perceptible in the present population.

As for overweight, it is found that the overall prevalence of overweight is higher among females compared to the males, in both rural and urban areas. This difference in sex is similar to that reported from other populations (Shukla *et al.*, 2002, Das and Bose, 2006). The rural-urban differences suggest that the risk of being overweight is greater in urban than in rural areas, especially among males. This is similar to the findings reported from other populations in India (Venkatramana and Reddy, 2002; Shetty, 2002; Bhat *et al.*, 2005). It is found that older adults had greater prevalence of overweight. The effect of education and family size is not clear. However, the prevalence of overweight increases with the increase in the income groups, in both rural and urban areas. This association between overweight and income is also reported from other Indian populations (Bharati, 1989; Rao, *et al.*, 1990; Rao *et al.*, 1995; Reddy, 1998). It is also found that overweight is associated with greater cormic index, conicity index and waist-hip ratio.

Concluding Remarks

The main purpose of the present study is to understand the relationship between body composition and nutritional status, and how certain demographic and socioeconomic factors

could influence the body composition and nutritional status of the Ao Nagas. The findings clearly indicated that the relationship between body composition and nutritional status is compounded by different factors including urbanization, demographic and socioeconomic factors. In other words, body composition and nutritional status are just like two sides of the same coin, which are greatly influenced by urbanization, demographic and socioeconomic factors. These findings can be interpreted differently from different perspectives. From the anthropological point of view, the study of body composition and nutritional status is biocultural in nature within the framework of evolutionary perspective. From the nutritional and health points of view, the present study clearly reflects that the Ao population is under the double burden of underweight and overweight. The convergence between anthropological and nutritional perspectives is clearly reflected by the present study, which indicates how body composition and nutritional status are associated with different demographic and sociocultural characteristics of the study population. Although this study is cross-sectional in nature, it has evolutionary implications for understanding the health and nutritional status of the population.

From the evolutionary point of view, basic nutrients required for humans are relatively constant through different stages of human evolution, and there were no major morphological changes, except upright posture and development of brain capacity during the *Homo erectus* stage. However, there are two major stages of nutritional transition since the time of *Homo erectus*. Firstly, the widespread of agriculture during the last 10,000 years has a profound impact on nutritional and socio-cultural conditions of the people. They started consuming large amounts of grain, milk, and meat of domesticated animals and becoming more sedentary. Population growth started increasing and societies became larger. Secondly, with the advent of industrial revolution about 200 years ago in high-income countries, human populations have experienced another dramatic change in food production, processing, storage and distribution. These have brought about major changes in the nutritional composition of the diets. The traditionally plant-based diets have been quickly replaced by high-fat, energy-dense diets with high content of animal-based foods. These dramatic and rapid changes are believed to have a great impact on the health and nutritional status of the people all over the world, although the rates of changes vary considerably within and among populations depending upon technological, demographic, social and economic conditions.

The major health implication of such rapid changes is the emergence of obesity and its associated morbidities (co-morbidities) in both developed and developing countries. In

developed countries, obesity has become an epidemic. The situation is more serious in developing countries, where both underweight and overweight co-exist. This contention is clearly supported by the findings of the present study. It is observed that both underweight and overweight among the Ao Nagas are associated with urbanization and socioeconomic status.

It may be recalled that Popkin (1994, 1998) has called attention to the `nutrition transition' in developing countries, or the shift from traditional diets and lifestyles to `Western' diets (ie high in saturated fats, sugar and refined foods), and the combination of reduced levels of physical activity and increased stress, particularly in the rapidly growing urbanization. The feared outcomes of the nutrition transition are increased levels of obesity and chronic and degenerative diseases. In Nagaland, increasing rural-urban migration in the state could be associated with various factors especially in search of better jobs, education and living conditions. Consequently, there are changes in economic conditions, dietary intakes, physical activity and lifestyles, which may be responsible for overweight and obesity among urban individuals.

The lower prevalence of underweight in rural area compared to urban area is very interesting from the biocultural point of view. The egalitarian nature of society with a strong kinship bond and social responsibility to look after the poor in Ao villages may be one of the possible factors for the lower prevalence of underweight in rural areas. Therefore, the policy implication for reducing underweight in rural areas should be integrated with the cultural system of the society. In addition, the policy implication is not only to reduce underweight but also to prevent overweight and obesity especially in urban areas.

Another remark to be made with regard to the present study is the use of the BMI cut-offs for defining overweight and obesity. If the cut-off points for the Asia-pacific regions (WHO, 2000) are used, the prevalence of overweight increased about 9 to 12 percentage points. The ROC curve analysis on the basis of the risk factor like hypertension seemed to support the cut-off points recommended for Asian population. Consequently, the burden of overweight and obesity would increase in the population. This may have implication not only for the emerging health problems of the present population but for the entire Indian population. Some studies in central and western India have shown that the prevalence of overweight according to the international cut-off points (WHO, 1995) ranges from 30 to 45% (Sidhu and Tatla, 2002; Tiwari *et al.*, 2010). If the cut-off points for the Asia-pacific regions

(WHO, 2000) are used, the prevalence of overweight and obesity would increase to the level equivalent or greater than that reported for western countries. In other words, overweight might have exceeded underweight in many Indian populations especially in urban areas. Accordingly, the health problems of underweight have been replaced with those relating to overweight and obesity in such populations. Future studies in India should pay more attention on how to identify the health risk factors of BMI at different levels, keeping in view the two recommended cut-off points mentioned above. In addition, the measures of central obesity in relation to BMI and risk factors are not clearly understood in Indian populations. More studies are needed to study the relationship between body composition and nutritional status. In the present study, we suggest to split BMI into fat mass and fat-free mass components to have a better understanding of the risk factors associated with obesity and overweight in Indian populations.

The present study has supported that body dimensions, nutritional status, self-reported morbidity and hypertension are associated with certain demographic and socioeconomic factors. However, the effect of economic status on the above measures seemed to be more pronounced. While it is negatively associated with underweight, on the one hand, household income is positively associated with overweight, hypertension and self-reported morbidity, on the other hand, especially in urban areas. These findings may have certain implications for understanding the dynamics and extent of socioeconomic disparity and its impact on health and nutritional status not only among the Ao Nagas, but also in our country as a whole. On the one hand, India with a population of more than one billion, the poverty has remained the greatest challenge related to health problems. On the other hand, recent studies have indicated that the country is facing with nutrition-related problems among the affluent, predominantly affecting the urban population. There is no denying the fact that the middle class and the affluent segments of the India's population are increasing in recent years. As a result, India is faced with the double burden of under- and over-nutrition. Therefore, the policy implication is not only to reduce underweight due to poverty, but also to prevent the spread of overweight and obesity due to economic transition.

CHAPTER VII

SUMMARY

This thesis is concerned with the body composition and nutritional status of Ao adults in the Mokokchung district of Nagaland. Body composition is defined as "the make-up of the body in terms of the absolute and relative amounts of adipose tissue, muscle mass, skeletal mass, internal organs and other tissues" (Bogin, 1999). In body composition research, body mass is considered as the sum of all components at each of the five levels namely, atomic, molecular, cellular, tissue-organ and whole-body (Wang *et al.*, 1992). The earliest attempt for describing body composition and the most common method today is the two-component model that includes Fat Mass (FM) and Fat Free Mass (FFM). This method is commonly used because of simplicity, speed and low cost techniques for large field studies, and therefore it is one of the most widely applied models in body composition research (Norgan, 2005). Under this model, body composition can be assessed by using either anthropometry or other techniques like the bioelectrical impedance analysis (BIA). Anthropometry, which includes measurements of body weight, height, body mass index (BMI), mid upper arm circumference (MUAC) and skinfold thickness, is widely used in anthropological and biomedical studies for the assessment of body composition by using certain prediction equations.

The measurement of body composition is essential for studying human variation and adaptation, and it is being used increasingly in the assessment of growth and nutritional status, fitness, work capacity, disease and its treatment (Norgan, 1995). Recently, one of the major interests of research on body composition is the health problems of obesity, or an excess body fat due to over-nutrition, which has been declared as an epidemic in developed countries (WHO/FAO, 2003). In country like the United States, obesity is one of the leading causes of death and thereby has a large impact on public health (Stein and Colditz, 2004). In developing countries, although under-nutrition remains a major health problem, obesity is also emerging with the improvement in socio-economic condition and increasing urbanization (Popkin, 2002). Many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing

urbanization, changes in standards of living, dietary patterns and occupational work patterns are the key factors to risks of obesity and associated morbidity, such as diabetes mellitus, cardiovascular disease, hypertension and stroke, osteoporosis, and some forms of cancer (WHO/FAO, 2003).

In India, most of the body composition studies are concerned with the problem of under-nutrition, although there is evidence of socio-economic and nutrition transition that is likely to increase the epidemic of chronic diseases and obesity, particularly in the urban areas (Rao, 2001; Shetty, 2002). When this study was proposed about 6 years ago, there was a lack of specific population information about factors associated with obesity and its associated morbidity. Little was also known about the relationship between adult body composition and under-nutrition, except those studies carried by Shetty (1984) and Ferro-Luzzi *et al.* (1997) in South India. There was also dearth of information on the relationship between body composition and morbidity patterns (Campbell and Ulijaszek, 1994), although many studies were carried out on the relationship between body mass index and socio-economic conditions (Bharati, 1989; Reddy, 1998; Khongsdier, 2002). In addition, little works have been done on the relationship between body composition and body form (i.e., size and shape), except one study on the correlation between body mass index and cormic index in Northeast India (Khongsdier, 2001). Therefore, we undertook a study of body composition and nutritional status in relation to biosocial factors among the Ao adults aged 18-70 years in the Mokokchung district of Nagaland.

Chapterization

The thesis has been divided into seven chapters. The first chapter gives a general introduction relating to the scope and importance of the study. The objectives and statement of problem are also given in this chapter along with a brief description of the study population and study area. The II Chapter deals with the review of literature. Chapter III describes the materials and methods of data collection. The methods of data analyses are also presented in this chapter. Chapter IV gives the findings on adult body dimensions, body composition and nutrition status of the study population. Since our design of study is to compare the rural and urban differences in these characteristics, the chapter segregates the total sample size into rural and urban areas in order to examine the differences and the causes of such differences. In Chapter V, we described our findings on the effects of socioeconomic characteristics on adult body dimensions, body composition, nutritional status, blood pressure and self-reported morbidity. Chapter VI discusses the findings of the study in the light of

other studies. It also discusses the social and biological implications of the findings. Chapter VII gives the summary and conclusions.

OBJECTIVES OF THE STUDY

The study is more exploratory rather than testing hypotheses based on previous studies especially among the Ao population where no study has so far been carried out. The objectives of the study are as follows:

1 To assess the body composition and nutritional status of adults aged 18-70 years from rural and urban areas, using anthropometric indices and electrical impedance analysis.
2 To understand the relationship of body composition and nutritional status in relation to age, sex, anthropometric variables, self-reported morbidity, blood pressure and socio-economic variables.
3 To analyze the effects of socio-economic factors, such as physical activity, occupation, income, education and family size on adult body dimensions, nutritional status, self-reported morbidity and blood pressure.

MATERIALS AND METHODS

Study Area and Population

The present study was conducted among the Ao adults in the Mokokchung district of Nagaland between the months of September 2005 to April 2006. The present study was conducted among the Ao adults in the Mokokchung district of Nagaland. It became a full-fledged district in 1957.The district is situated in the north western part of the state, between 25°45' N and 26°30' N latitude and between 94°0'E and 94°45'E longitude. It covers an area of 1615 square kilometers with a total population of 2, 27,230 (Census of India, 2001). Longleng and Tuensang districts bound Mokokchung on the East, Wokha district on the West, Assam state on the North and Zunheboto district on the South. Mokokchung Town is the district headquarters and it is located at a height of about 1,326 meters above sea level.

Mokokchung is the home of the Ao-Nagas. Besides the Ao tribe, a good number of other Naga tribes and also other communities reside in the district, especially in the district headquarters, i.e., Mokokchung town. Some of the Nagas who reside in this district include the Sumi, Lotha, Sangtam, Phom, Chang, Khiamniungan and Chakhesang, while those from other communities include the Nepalis, Biharis, Bengalis, Marwaris, Assamese, etc. All these different groups have taken residence in the district because of various socioeconomic

reasons such as employment both in Central and State Governments, private institutions, as labourers, as businessmen and also because of marital reasons.

The data were collected from both urban and rural areas of the Mokokchung district. For the urban sample from Mokokchung town, two localities or wards, namely, Alempang and Kumlong were selected randomly by lottery method. For rural sample, six villages were randomly selected from three Rural Development Blocks, namely, Ongpangkong, Changtongya and Mangkolemba according to stratified random sampling. The required number of villages for collecting data from each stratum was determined independently, following the optimum allocation method as suggested by Snedecor and Cochran (1967) based on the population size. An attempt was made to cover more than 30% of the total households from each selected sampling unit (i.e., village or locality). No statistical sampling of individuals was applied for collection of data from each selected village or locality to avoid operational difficulties in the field. Instead, an attempt was made to include in our sample all those adults (aged 18-70 years) who were willing to co-operate with the present work. Altogether a total of 405 households and 1002 individuals were covered from rural area, and a total of 252 households and 802 individuals were covered from urban area.

Data on adult body dimensions and body composition

A cross-sectional method of anthropometric study was adopted for assessing the body composition and nutritional status of adults aged 18-70 years of age. Standard techniques of taking the anthropometric measurements were followed (Weiner and Lourie, 1981; Heyward and Wagner, 2004). The anthropometric measurements included weight (kg), height (cm), sitting height (cm), mid upper arm (MUAC), chest, hip and waist circumferences (cm), skinfold thickness at biceps, triceps and subscapular (mm).

Anthropometric measurements were used to estimate the body composition (BFM and FFM), using the prediction equations of Durnin and Womersley (1974) and Siri (1961) based on age, weight, height, and skinfold thickness. Anthropometric indices and ratios, such as body mass index (BMI), cormic index, conicity index, waist-hip ratio, etc. were also calculated, following standard methods. The nutritional status was assessed, using the cut-off points for body mass index as recommended by the World Health Organization (WHO, 1995, 2000).

Bioelectrical Impedance Analyzer

The body composition was also estimated using Bioelectrical Impedance Analyzer (BIA) with four-point tactile electrodes (HBF–302, Omron Healthcare, Co. Ltd., Japan). This device

measures the electrical signals of undetectably low voltage as they passed through the body fat via handheld device. Since fat is a very poor conductor of electricity, a greater fat accumulation in the body would impede the flow of the current. By measuring the resistance to the current, the device estimates the percent body fat, which can be used for estimating fat-free mass (FFM) by subtracting from body weight.

Blood pressure

Mercury sphygmomanometer was used to measure blood pressure of the individuals included in the present study. All measurements were taken on left hand when subjects were being in seated position. Each participant was asked to relax and take rest for 10 minutes before taking the measurement. Systolic blood pressure was recorded as the first Korotkov sound (phase I). Diastolic blood pressure was taken as the disappearance of the Korotkov sounds (Phase V). Measurements were recorded for three times, and the average of the three was taken as recorded measurement.

Data on Morbidity

Data on morbidity were collected on the basis of "self reported illness" of the information taking into consideration the timeframe of two-week, three-week and four-week recalls of illness prior to the survey. Structured schedules were prepared by taking into the informant's perception of illness rather than the Western medical definition of a specific disease. The self-reported symptoms of illness were grouped into different categories as followed by many studies (Strickland and Ulijaszek, 1994; Strickland and Tuffery, 1997; Sadana, 2000).

SOCIO-ECONOMIC CATEGORIES

In the present study, certain socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on body composition and nutritional status. Our classification may be briefly described as follows:

Income groups

Data on household income were collected directly from the heads of the households and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The per capita monthly income of the households was classified as follows:

Above 75^{th} percentile (>Rs.2200) = High income group (HIG)

50^{th} to 75^{th} percentile (Rs.1500-2200) = Middle income group (MIG)

Below 50^{th} percentile (<Rs. 1500) = Low income group (LIG)

Educational Level

Data on educational attainment of individuals in the present study were arbitrarily classified into three broad educational levels, namely, primary, secondary and higher secondary and above. In the present study, the number of illiterates, i.e., those individuals who were not able to read or write, was negligible especially in urban areas. Therefore, we pooled some illiterate individuals in the category of **primary level** of education, which includes lower primary and upper primary, i.e., up to standard VIII. In the **secondary level** of education, we included those individuals who attended standard VIII to X. **Higher Secondary level and above** included other individuals who attended standard XI and other higher levels of education. This educational classification is highly arbitrary. However, we assumed that if education is really important in regulating body composition and nutritional status like in the western countries, its effects can be observed even if the individuals were dichotomized only into two categories, say, lower and higher levels of education.

Family Size

The family size was classified into three categories. The individuals who lived in a household with less than 4 family members were considered as having a **Small Family Size.** The **Average/Medium Family Size** includes those individuals who lived in a household with 5-6 family members. The individuals who lived in a household with more than 7 family members were grouped in the category of **Large Family Size**.

Physical Activity

Two types of physical activity level were classified according to occupations of the individuals as described by the Indian Council of Medical Research (ICMR, 1991). These are: **(1) Sedentary** includes teacher, barber, housewife, student, nurses, executives, retired personnel, land-lord, tailor, peon, postman, pastor or priest, salesperson, shopkeeper, etc. **(2) Moderate** – agricultural labourer, farmer, fisherman, potter, fitter, tuner, welder, industrial labour, *cooli, beedi*-maker, carpenter, weaver, driver, plumber, electrician, basket-maker, maid servant, etc.

Statistical analyses

The basic design of the study is to analyse and present comparative data between urban and rural areas. In addition, the main focus of analysis was on the relationship between body composition and nutritional status, and their relationship with biosocial variables, such as

age, sex, anthropometric variables, self-reported morbidity, blood pressure, physical activity, occupation, household income, education and family size.

All data was managed and analysed using SPSS/PC Software. The analysis was first carried out to present the basic descriptive statistics of anthropometric variables, blood pressure and morbidity prevalence in relation to socio-economic characteristics of the study samples for both rural and urban areas. The relationship between body composition and nutritional status was tested, using analysis of covariance (ANCOVA) and multiple regression analysis. For example, the differences in mean FM and FFM values according to nutritional groups by age and sex was determined, using ANCOVA after adjusting for socio-economic variables. Multiple regression analysis was used for testing the nature of such relationship, if any. Special attention was given to the relationship of body composition/nutritional status with morbidity, blood pressure and socio-economic conditions by applying appropriate statistical analyses. For example, the relationship between body composition/nutritional status and morbidity was tested, using odds ratios with 95% confidence interval from different models of logistic regression analysis after adjusting for socio-economic variables that would be quantified in terms of appropriate dummy numbers to fit the logistic models. On the other hand, the relationship between nutritional status and blood pressure was determined, using ANCOVA and multiple regression analysis because blood pressure is a continuous trait.

FINDINGS OF THE PRESENT STUDY

As already mentioned, the findings of the present study were presented in chapters IV and V. Since our design of study is to compare the rural and urban differences, the chapter segregates the total sample size into rural and urban areas in order to examine the differences and the causes of such differences. I shall briefly present them as follows:

Socioeconomic characteristics

The findings on the important socioeconomic characteristics show that urban areas are more advanced in both education and economic condition. It is also observed that the proportion of participants with small family size is higher in urban than in rural areas, and a large proportion of women in urban area contributed to family income.

Anthropometric traits

1. The findings on anthropometric traits indicate that urban males are significantly heavier and taller than rural males. Urban males have also greater hip circumference

and biceps. Rural males have greater cormic index, conicity index and waist-hip ratio. It is also interesting to note that although there is no significant difference in body mass index (BMI) between rural and urban males, the fat free mass index was significantly greater in rural males than in urban males. This indicates that the greater muscle mass in rural males might be due to greater physical activity in rural areas.

2. As for females, almost all the anthropometric characters are significantly greater in urban than in rural areas. This clearly indicates that there are considerable differences between rural and urban areas with respect to body dimensions and composition among adult females in the present study.

Body Composition

In the present study, the body composition follows a 2-compartment model, and it is therefore divided into two major body components, namely, fat free mass (FFM) and body fat mass (BFM). Anthropometry and Omron bioelectrical impedance analyzer (OBIA) are used to measure the body composition.

1. It is found that FFM measured by OBIA is about 0.90 kg different from that estimated from anthropometry. The standard error of estimate (SEE) in FFM according to OBIA is reported to be $\leq$ 3.5 kg for men and $\leq$ 2.8 kg for women (Heyward and Wagner, 2004). Considering these values of SEE, we suggested that the body fat estimated from anthropometry is by and large similar to that measured by OBIA.
2. The mean values of BFM and FFM were 9.20 kg and 45.79 kg for rural males, and 9.70 kg and 47.16 kg for urban males, respectively. Therefore, both BFM and FFM are greater in urban males compared to their rural counterparts, despite the absence of statistical significance in respect of BMI and percentage of BFM and FFM. The rural-urban differences are more pronounced among females, which indicated that BFM and FFM, expressed in kg and percentage of body weight, are significantly greater in urban than in rural females.

Nutritional Status

The nutritional status of participants in this study was assessed by using BMI, taking into consideration the cut-off point of 23·0 kg/m^2 for defining overweight among Asian populations (WHO, 2000). On the basis of ROC curve analysis, we also found that this cut-off point is more appropriate in the present study. It is found that the BMI cut-off point for defining overweight among the Ao Nagas lies between $\geq$ 21 kg/m^2 and $\geq$ 23 kg/m^2 against the reference PBF > 25% for men and >30% for women (Deurenberg *et al.*, 1998, 1999).

It is found that the prevalence of underweight in males was significantly lower in rural (17.11%) than in urban (24.94%) areas. The rural-urban difference in the prevalence of underweight among women was not statistically significant, although it appears to be higher in urban (31.49%) than in rural (28.43%) areas. Pooling males and females, the overall prevalence of underweight is 22.95% in rural and 28.18% in urban areas These values are lower than those reported from other tribal populations of Northeast India such as Boro-Kacharis, Lalungs, Miris and Pnars (Khongsdier, 2001) and War Khasi (Khongsdier, 2002). They are also lower than that reported for caste groups like Brahmins and Jogis (Khongsdier, 2001). In short, the nutritional status of the Ao Nagas is better than most of the tribal populations in Northeast India.

Following the international cut-off points (WHO, 1995), the prevalence of overweight (including obesity) was 5.98% and 7.90% in rural and urban adult males, respectively. These frequencies were 8.51% and 13.10% in rural and urban adult females, respectively. These results suggest the prevalence of overweight was higher in urban than rural areas, and also among females compared to males. Further, the prevalent rate increases considerably according to the cut-off points recommended for the Asia-pacific regions (WHO, 2000). It is found that the prevalence of overweight was 15.26% and 18.77% in rural and urban adult males, respectively. In the case of adult females, these frequencies were 17.21% and 24.94%, respectively.

Relationship between Body Composition and Nutritional Status

1. It is found that both PBF and FFM have significantly increased with the increase in BMI levels. It also indicates that the urban males have a higher FFM than the rural males across levels of BMI, although it is expected that greater physical activity may increase FFM in rural areas. In short, it is difficult to conclude whether BMI is more related to PBF or FFM.
2. It may be noted that the major nutritional problem is the correlation between excess body fat and other chronic diseases. Secondly, BMI is a crude measure of both body fat and fat free mass. High BMI may also be due to high muscle mass, not necessarily because of high body fat. Accordingly, it has been suggested to split the BMI into two parts, body fat mass index (BFMI) and fat free mass index (FFMI) to understand the relationship between body composition and nutritional status (Van Itallie, *et al.*, 1990). The present study indicated that BFMI was more correlated with PBF, whereas FFMI is more correlated with FFM for both the sexes in rural and urban areas. For example, the differences in scatter plots of PBF on BMI and BFMI in rural males

shows the relationship of PBF is more curvilinear with BMI but more linear with BFMI. Therefore, the present findings suggest that the split of BMI into BFMI and FFMI may be important in understanding the relationship between body composition and morbidity, especially in a population with high prevalent of overweight and obesity.

Body composition and body shape

In the present study, body shape refers to the relative body dimensions that are commonly expressed as indices or ratios. We have taken into consideration three important indices and ratios, namely, cormic index, conicity index and waist-hip ratio.

1. Cormic index or relative sitting height is one of the most common bivariate indices of body shape. It has been suggested that the variation in cormic index between and within populations may be associated with variations in BMI and body composition (Norgan, 1994). In the present study, we have observed that the effect of cormic index on body composition of the present population is significant only with respect of PBF, but it is not clearly perceptible in the case of FFM.
2. Both urban males and females with greater level of conicity index ($\geq$1.10) are likely to have greater PBF than their rural counterparts. Similarly, PBF and FFM are significantly higher among persons with greater waist-hip ratio compared with those having lower waist-hip ratio in both rural and urban areas. In addition, the means of PBF and FFM are by and large greater in urban males and females compared with their rural counterparts.

Overall, the present study strongly indicates that body composition is significantly correlated with body shape in terms of cormic index, conicity index and waist-hip ratio. It is also observed that body composition is correlated with sex and rural-urban setting.

Anthropometric Traits and Socioeconomic Factors

In Chapter V, we analyzed the effects of socioeconomic factors on adult body dimensions, body composition, nutritional status, blood pressure and self-reported morbidity. The adult body dimensions, body composition and nutritional status are described in terms of anthropometric measurements and indices; whereas the socioeconomic characteristics are described in terms of occupation, household income, education, family size. Since our design of study is to look into the rural and urban differences in these characteristics, total sample size was segregated into rural and urban areas in order to examine the differences and the causes of such differences. Some of the major findings are as follows:

1. The means and standard deviations of anthropometric traits by age group in the present study show that with the exception of chest girth, waist and hip circumferences the mean anthropometric traits are higher significantly in the lower age groups for both adult males and females. Therefore, the present findings may be related to secular trend. By secular trend, we mean an increase in anthropometric measurements, particularly height and weight, from one generation to another due to improvement in economic condition of a given population. Nevertheless, the present findings clearly indicate that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socioeconomic conditions on anthropometric traits, or while assessing the nutritional status of the study population in relation to socioeconomic conditions.
2. It is observed that the differences between income groups are highly significant in almost all anthropometric traits in both males and females. Most of the mean anthropometric traits are significantly higher in the higher income groups in both rural and urban areas. This observation is similar to those reported for other Indian populations (e.g., Bharati, 1989, Reddy, 1998; Khongsdier, 2002). Thus, anthropometric traits in the present study are to a great extent influenced by household income in both rural and urban areas for both the sexes.
3. In addition to household income, the present findings indicate that education has certain role in patterning anthropometric traits. In general, it indicates anthropometric characters are greater in adults with higher educational level, especially among females. However, household income seems to be more influential than education especially among males. However, the effect of family size was not clearly perceptible, except in respect of MUAC in rural females, and hip circumference and FFMI in urban females. It indicates that family size has little role to play in the variation of anthropometric traits in comparison with household income and education.
4. Physical activity is another important factor that affects anthropometric characters in the present study. As normally expected, sedentary individuals have greater body fat as indicated by body weight, skinfold thickness and BFMI, especially among urban females. Although the present study failed to identify different levels of physical activity, our findings suggest that anthropometric indicators of overweight and obesity are negatively influenced by physical activity as suggested by many studies.

Self-reported Morbidity

1. The overall prevalence of morbidity in rural and urban areas is 8.78% and 9.35%, respectively. It is found that the prevalence of morbidity increases with the increase in age groups in both rural and urban areas, suggesting that the older persons are likely to have higher morbidity. However, the effects of sex, education, income and family size on morbidity are not clearly perceptible in the present study.
2. It is found that the nutritional status is likely to be associated with morbidity, especially in urban areas where the prevalence of self-reported morbidity among overweight individuals was greater than that among the underweight individuals. Although self-reported morbidity refers here to different types of morbidity during the last one month, our findings suggest to certain extent the association between morbidity and overweight or obesity. Therefore, the present study supports the general observation that overweight or obesity is associated with different types of morbidity (e.g., WHO/FAO, 2003; Janssen, 2007). The positive relationship between self-reported morbidity and obesity was also observed in the individuals with greater conicity index and WHR as mentioned earlier, i.e., individuals with greater conicity index and WHR were likely to have a greater risk of morbidity. This justifies the need for taking appropriate action in preventing the emerging trend of obesity in the state.

Hypertension

1. In addition to self-reported morbidity, nutritional status in the present study is associated with hypertension in both rural and urban areas. It is also observed that the prevalence of hypertension associated with greater conicity index and greater waist-hip ratio as suggested by many scholars (e.g., Venkatramana and Reddy, 2002; Shetty, 2002; Das *et al.*, 2008). In other words, the present findings confirmed that overweight and obesity is associated with hypertension.
2. We have also observed that the prevalence of hypertension is higher in males than in females in both rural and urban areas. Further, the prevalence of hypertension increased with the increase in age groups in both rural and urban areas, suggesting that older people are likely to be more hypertensive. It is also found that household income is positively associated with hypertension. However, the effect of education and family size on hypertension is not clearly perceptible in the present study. It may be mentioned that studies in developed countries have revealed that hypertension is negatively associated with socioeconomic conditions, showing that higher socioeconomic status was associated with lower blood pressure or a lower prevalence

of hypertension (for review see Colhoun *et al.*, 1998). In developing countries, the relationship between blood pressure and socioeconomic status is not clearly understood. Some studies have revealed that that blood pressure was positively associated with social class for men, but negatively for women (e.g., Dressler *et al.*, 1988; Abdo and Leon, 2009). Other studies have shown that there was a U-shaped relationship between income and blood pressure, women with either high or low incomes had higher blood pressures than those with middle incomes (Mendez *et al.*, 2003). Nevertheless, the present study indicated a positive relationship between hypertension and household income.

Underweight and Overweight

1. The prevalence of underweight and overweight in the present study is correlated with urbanization and household income. Individuals in the lower income groups are likely to have greater prevalence of underweight as observed in other Indian populations (e.g., Bose and Chakraborty, 2005, Kusuma *et al.*, 2008). It is found that the prevalence of underweight decreases with increase in the age groups. It is also found that females are more underweight than males especially among low economic groups. In addition, the prevalence of underweight decreases with increase in the age groups. However, the effects of education and family size on underweight are not clearly perceptible in the present population.
2. As for overweight, it is found that the overall prevalence of overweight is higher among females compared to the males, in both rural and urban areas. This difference in sex is similar to that reported from other populations (Shukla *et al.*, 2002, Das and Bose, 2006). The rural-urban differences suggest that the risk of being overweight is greater in urban than in rural areas, especially among females. This is similar to the findings reported from other populations in India (Shetty, 2002; Bhat *et al.*, 2005). It is found that older adults had greater prevalence of overweight. The effect of education and family size is not clear. However, the prevalence of overweight increases with the increase in the income groups, in both rural and urban areas. This association between overweight and income is also reported from other Indian populations (e.g., Rao *et al.*, 1995; Reddy, 1998). It is also found that overweight is associated with greater cormic index, conicity index and waist-hip ratio.

Concluding Remarks

The main purpose of the present study is to understand the relationship between body composition and nutritional status, and how certain demographic and socioeconomic factors could influence the body composition and nutritional status of the Ao Nagas. The findings clearly indicated that the relationship between body composition and nutritional status is compounded by different factors including urbanization, demographic and socioeconomic factors. In other words, body composition and nutritional status are just like two sides of the same coin, which are greatly influenced by urbanization, demographic and socioeconomic factors. These findings can be interpreted differently from different perspectives. From the anthropological point of view, the study of body composition and nutritional status is biocultural in nature within the framework of evolutionary perspective. From the nutritional and health points of view, the present study clearly reflects that the Ao population is under the double burden of underweight and overweight. The convergence between anthropological and nutritional perspectives is clearly reflected by the present study, which indicates how body composition and nutritional status are associated with different demographic and sociocultural characteristics of the study population. Although this study is cross-sectional in nature, it has evolutionary implications for understanding the health and nutritional status of the population.

From the evolutionary point of view, basic nutrients required for humans are relatively constant through different stages of human evolution, and there were no major morphological changes, except upright posture and development of brain capacity during the *Homo erectus* stage. However, there are two major stages of nutritional transition since the time of *Homo erectus*. Firstly, the widespread of agriculture during the last 10,000 years has a profound impact on nutritional and socio-cultural conditions of the people. They started consuming large amounts of grain, milk, and meat of domesticated animals and becoming more sedentary. Population growth started increasing and societies became larger. Secondly, with the advent of industrial revolution about 200 years ago in high-income countries, human populations have experienced another dramatic change in food production, processing, storage and distribution. These have brought about major changes in the nutritional composition of the diets. The traditionally plant-based diets have been quickly replaced by high-fat, energy-dense diets with high content of animal-based foods. These dramatic and rapid changes are believed to have a great impact on the health and nutritional status of the

people all over the world, although the rates of changes vary considerably within and among populations depending upon technological, demographic, social and economic conditions.

The major health implication of such rapid changes is the emergence of obesity and its associated morbidities (co-morbidities) in both developed and developing countries. In developed countries, obesity has become an epidemic. The situation is more serious in developing countries, where both underweight and overweight co-exist. This contention is clearly supported by the findings of the present study. It is observed that both underweight and overweight among the Ao Nagas are associated with urbanization and socioeconomic status.

It may be recalled that Popkin (1994, 1998) has called attention to the `nutrition transition' in developing countries, or the shift from traditional diets and lifestyles to `Western' diets (ie high in saturated fats, sugar and refined foods), and the combination of reduced levels of physical activity and increased stress, particularly in the rapidly growing urbanization. The feared outcomes of the nutrition transition are increased levels of obesity and chronic and degenerative diseases. In Nagaland, increasing rural-urban migration in the state could be associated with various factors especially in search of better jobs, education and living conditions. Consequently, there are changes in economic conditions, dietary intakes, physical activity and lifestyles, which may be responsible for overweight and obesity among urban individuals.

The lower prevalence of underweight in rural area compared to urban area is very interesting from the biocultural point of view. The egalitarian nature of society with a strong kinship bond and social responsibility to look after the poor in Ao villages may be one of the possible factors for the lower prevalence of underweight in rural areas. Therefore, the policy implication for reducing underweight in rural areas should be integrated with the cultural system of the society. In addition, the policy implication is not only to reduce underweight but also to prevent overweight and obesity especially in urban areas.

Another remark to be made with regard to the present study is the use of the BMI cut-offs for defining overweight and obesity. If the cut-off points for the Asia-pacific regions (WHO, 2000) are used, the prevalence of overweight increased about 9 to 12 percentage points. The ROC curve analysis on the basis of the risk factor like hypertension seemed to support the cut-off points recommended for Asian population. Consequently, the burden of overweight and obesity would increase in the population. This may have implication not only

for the emerging health problems of the present population but for the entire Indian population. Some studies in central and western India have shown that the prevalence of overweight according to the international cut-off points (WHO, 1995) ranges from 30% to 45% (Sidhu and Tatla, 2002; Tiwari *et al.*, 2010). If the cut-off points for the Asia-pacific regions (WHO, 2000) are used, the prevalence of overweight and obesity would increase to the level equivalent or greater than that reported for western countries. In other words, overweight might have exceeded underweight in many Indian populations especially in urban areas. Accordingly, the health problems of underweight have been replaced with those relating to overweight and obesity in such populations. Future studies in India should pay more attention on how to identify the health risk factors of BMI at different levels, keeping in view the two recommended cut-off points mentioned above. In addition, the measures of central obesity in relation to BMI and risk factors are not clearly understood in Indian populations. More studies are needed to study the relationship between body composition and nutritional status. In the present study, we suggest to split BMI into fat mass and fat-free mass components to have a better understanding of the risk factors associated with obesity and overweight in Indian populations.

The present study has supported that body dimensions, nutritional status, self-reported morbidity and hypertension are associated with certain demographic and socioeconomic factors. However, the effect of economic status on the above measures seemed to be more pronounced. While it is negatively associated with underweight, on the one hand, household income is positively associated with overweight, hypertension and self-reported morbidity, on the other hand, especially in urban areas. These findings may have certain implications for understanding the dynamics and extent of socioeconomic disparity and its impact on health and nutritional status not only among the Ao Nagas, but also in our country as a whole. On the one hand, India with a population of more than one billion, the poverty has remained the greatest challenge related to health problems. On the other hand, recent studies have indicated that the country is facing with nutrition-related problems among the affluent, predominantly affecting the urban population. There is no denying the fact that the middle class and the affluent segments of the India's population are increasing in recent years. As a result, India is faced with the double burden of under- and over-nutrition. Therefore, the policy implication is not only to reduce underweight due to poverty, but also to prevent the spread of overweight and obesity due to economic transition.

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