Introduction
1. INTRODUCTION

India made remarkable strides in food production recently and has attained the long pending goal of food security at national level. However, the household is not a homogenous unit and intrafamilial access to food and food distribution practices, in the context of socio-economic conditions prevailing are still not favourable to the females in the family. Hence, achieving food and nutrition security remains a goal yet to be achieved.

The lives of women in developing countries differ from those of men for cultural, biological and socio-economic reasons. These differences place women at significantly higher risk than men of malnutrition and mortality. The importance of women's nutritional status to their own health, productivity and quality of life and to the survival and healthy development of their children and other family members who depend on women's domestic and market work, warrant serious efforts to reduce malnutrition among women (Leslie, 1991).

Further, evidence shows that low birth weight continues to be a major contributor to the prevailing child malnutrition. Future projections reveal that about 1 in 4 children born in 2020 is expected to suffer from insufficient foetal growth result in low birth weight. Poor maternal nutrition both before conception and during pregnancy remains the prime causes of poor foetal growth and low birth weight.

Women constitute half of the countries population, in other words half of the country's human resource. Women in the Indian society are traditionally the providers of nutrition to the family. In India nearly 70 percent constitute rural area and remaining is urban and semirural areas. The life style of rural women reveals that 90 – 95 percent of the women work for the economic support in addition to the responsibility of
attending to the household chores. If one looks at the picture of any rural area it is
evident that it comprises of 5 – 10 percent elite families and the remaining major chunk
of families belong to middle, low and very poor income groups. This picture is true
throughout India. An examination of work and nutritional and health status of women in
relation to the conditions prevailing in the rural areas will throw light on not only the
nutritional and health risks of women but also those of the future generations.

Women are members of the households in which they acquire, cook, serve
consume and store food and their nutritional profile is also part of the household’s
nutritional profile. However, what sets these dimensions apart and makes them
particularly interesting is the apparent contradiction that while women are in a
commanding position over the household resources that determine individual nutrition,
they are themselves quite malnourished, often more so than other family members
(Meera Chatterjee, 1989).

Thus, women’s health has emerged as both a powerful political platform and a
dynamic public health issue. Women suffer more acute symptoms, chronic conditions
and short and long term disabilities resulting from health problems. Women are
vulnerable to several weight related health risks associated with being overweight,
losing weight and being underweight by choice or by circumstance. They have shorter
life expectancy, experience high maternal mortality and have a higher incidence of
chronic diseases and conditions such as chronic energy deficiency, obesity, nutritional
anaemia, osteoporosis, diabetes, hypertension and other cardiovascular diseases.
Women’s overall health status is further diminished by higher rates of poverty, lack of
education and limited or non-existent access to medical care.

The maintenance of homeostasis and health calls for dietary intakes situated
between a lower and an upper limit; as long as daily intakes stay within these limits,
adaptive processes can maintain homeostasis and normal physiological function of the body. Above or below these limits, chronic deficiencies or excesses of dietary intakes will have undesirable consequences.

CED and obesity are the two conditions, which are the two models for chronic energy deficiency and chronic energy excess respectively in the study of nutrition.

CED, according to Norgan (1994), refers to an intake of energy less than the requirement for a period of several months or years. He also stated that CED is the most widespread nutritional deficiency. It is observed to affect half the world's children and recent evidence reveal that as much adult population suffer from this nutritional deficiency.

According to the National Nutrition Monitoring Bureau in India (1994) the prevalence of CED among women was 47.57 percent with the severe degree being documented in 10 percent. The prevalence of CED in India was 48.6 per cent for women; severe degree being documented as 10.2 per cent in 1988-1990 (FAO, WHO, UNU report, 1994). In other African, European and Latin American countries the prevalence of CED was lower than that compared to India. The highest percent prevalence of severe degree of CED recorded was only 3.6 (Hungary), Grade II CED was 3.9 (Chinn, Ghana) and Grade II was 13.3 (Ghana).

Waterlow, Ferro-Luzzi and James (1987) defined the use of definition of CED as a steady state which can be maintained but at a level at which certain functions of health are impaired, using as indicators the body mass index and the ratio of energy turnover to basal metabolic rate in adults, and the deficit in weight for height in children.

The steady state will change when either energy supply is reduced or demands for energy output increase and this change is not counter balanced on the other side of
the equation. In response to this change, there is a fall in body weight but not in essential energy output. Monitoring of individuals has shown that body weight does change as soon as energy imbalance occurs (Ferro-Luzzi, 1990).

The capacity of man to adapt to chronically marginal energy intakes is of great interest to physiologists and Nutritionists. When energy intakes are chronically low, three distinct adaptation mechanisms can come into play: *a physiologic adaptation which consists of weight loss and a modification of body composition, both of which entail a lowering of basal metabolic rate a behavioral adaptation consisting of reduction in spontaneous physical activity; a metabolic adaptation involving an increase in the metabolic efficiency of different organs and tissues* (Léquier, 1992).

Adaptation under condition of limited energy intakes was described as a set of processes enabling the organism to respond to variation in food intakes without any negative long-term consequences.

Metabolic adaptations were observed among villagers subjected to seasonal variations in food intake. This adaptation allows energy to be saved by reducing diet induced thermogenesis and energy expenditure during sleep. This is a useful process and does not entail any negative consequence for the individual but it is limited in scope. The other metabolic and behavioral adaptations associated with chronic energy deficiency are no doubt useful for the survival of the individual but have negative functional consequences and certainly not desirable. *Serrinshaw used the term “accommodation” to describe these adaptations which are undesirably.*

While CED continues to be a problem in India, annual data provided by NNMB (1994) show that 3.6 percent of the rural population had a BMI exceeding 25 indicating the prevalence of obesity. Considering the populations covered by NNMB surveys that comprise of predominantly low-income groups, these figures must be considered
significant. There has been a rapid increase in the proportion of middle-income group in recent years. The incidence of obesity in these sections may be expected to be much higher than the values reported for the low-income group by the NNHII.

CED has been proved to be a disorder strongly associated with economic deprivation. There is evidence both in the western and Indian contexts that obesity is positively correlated with income. However, several research works done in India (Gupta et al., 1983; Dua and Seth 1988) focus on the fact that obesity among women is not uncommon even in the low and middle income groups. The recent National Family Health Survey reveals that 5.9 percent of rural women suffer from obesity. The only community based study carried out in northern India revealed the prevalence of obesity to be as high as 33 percent in adults of more than 30 years of age (NFHS-2, 2000).

All countries of the world are currently in different stages of demographic and developmental transition has been particularly marked in countries of the so-called-the third world, especially in recent times chronic degenerative diseases are now emerging as major causes of morbidity and mortality. These are oblivious factors incident to development, which affect diets, lifestyles and environment, and which contribute to this escalation; these are the ones that needs to be addressed (Gopalan, 1994).

While discussing issues related to standard of reference Jelliffe (1966) pointed out that an improvement in nutrition and other environmental influences such as disease control would definitely lead to secular changes. At the same time, there may well be developing an undesirable relation between larger, early maturing, possibly overfed population and subsequent disease pattern in adulthood that includes among other things an increasing incidence of atherosclerosis and obesity.

The nutritional component in the development of obesity is of utmost interest. Do obese people eat more or less than those of normal weight? Dietary intake data
support the opinion that they eat less, but urinary excretion data reveal that they underestimate their protein intake. Does this underestimation of intake have significance for developing adiposity? Can we explain the epidemiology of obesity among the rural women? (Isaksson, 1985). There is a threshold at which risk dramatically increase. Obesity is highly reversible, and if it is corrected in time, some of its risks are too corrected. Mortality rates are no higher for the formerly obese than for the never obese. Prevention is desirable, but where it has failed, treatment is needed (Whitney et al., 1987).

It is widely accepted that obesity is detrimental to health (Bray, 1985; Kisslah et al., 1989). Prospective studies have confirmed the significant association between obesity and mortality related to cardio-vascular diseases (Terry et al., 1992).

Developing countries as compared to the rich countries must rely much more heavily on prevention rather than on therapeutic management of these diseases; their national health systems can just not afford the massive cost of the therapeutic care of these diseases on large scale. Research in prevention would mostly consist in the identification of factors in diets and lifestyle, which would favour the control of these degenerative diseases (Gopalan, 1994).

During the process of economic development communities often evolve from rural societies where physical activity is needed for agricultural production into urbanized, industrialized communities where the demand for physical labour and activity declines. There is little if any information on secular trends in patterns of physical activity in developing countries. The exception is China, where the change in the diet and the prevalence of obesity has been shown to be associated with marked changes in physical activity patterns. Data from China also show that urban residents in all income groups demonstrated a trend towards increased levels of sedentary activities
in 1991 as compared to 1989. In contrast rural Chinese show a significant increase from low and moderate to high activity patterns. Corresponding data on activity pattern of urban or rural residents of developing countries are not currently available and need to be collected (Shetty, 1997).

Data on energy intake and energy expenditure, which focus on diets and lifestyles, are of great value in explaining the nutritional states prevalent in groups or communities.

The International Conference on Nutrition (ICN) reaffirmed that practical, accurate and cost-effective methods to identify nutritionally at risk populations are essential to the design and implementation of effective policies and programmes to promote nutritional well being and to monitor the impact of such programmes. After examining a wide range of possible monitoring tools, FAO selected the Body Mass Index (BMI) as a potentially valuable monitoring approach (Shetty and James, 1994).

Imnink et al., (1992) examined the relationship between BMI, body composition and concluded that quetelet index should not be recommended as a universally valid indicator to classify CED in adult groups similar to rural Guatemalan’s suffering a degree of CED. James et al., (1988) and several other researchers reported that BMI represents both fat and lean body mass and both are negatively affected in CED. Norgan (1990) has argued that in developing countries the BMI represents a more valid indicator of fat mass than fat proportion and its relation to body energy stores may vary depending on body size, height and fat free mass.

The FAO/WHO/UNU reported the use of BMI in the assessment of nutritional status of the community. The scope of BMI was described as: BMI is a simple but objective anthropometric indicator of the nutritional status of the adult population and seems to be closely related to their food consumption levels. It is relatively inexpensive
easy to collect and to analyze. Collection of data on weight and height from which BMI is derived can readily be incorporated into regional and national surveys that are presently being conducted. It could be used for the purpose of nutritional surveillance or for the purpose of monitoring since this allows for inter-regional or inter-country comparisons as well as longitudinal comparisons within the same region or country.

The BMI is sensitive to socio-economic status and to seasonal fluctuations in food consumption relative to the level of physical activity. The BMI is reasonably sensitive index of function and physical performance and may be useful if development projects depend on the physical activity of the community. The deleterious consequences of a low BMI status in an adult are only now being recognized; there is considerable need to evaluate immune function proneness to illness, morbidity and mortality in low BMI adults. There is also scope for evaluation of intervention strategies in community using the BMI as a parameter of choice to identify individuals at risk. Further, epidemiological research on anthropometric data and individual food consumption measurements are still necessary, especially in different socio-economic contexts. The percentage of false positives and false negatives need to be assessed. However, there is a reason to believe that the BMI is a simple, responsive and useful index of nutritional status of the adult in a community and may indeed be the method of choice to assess the numbers of people who are undernourished world wide.

PURPOSE OF THE STUDY

Women are a potential resource and particularly in the context of developing nations optimizing the potentials of this resource is crucial. In this context an analysis of the situation of women with regard to nutrition is of prime importance and this exercise may be repeated any number of times if resources permit. Use of simple, objective indicators of nutritional status has great significance when the assessments are
to be made on a large population groups. BMI has been proposed as a suitable indicator, which suits the purposes of national surveys. Research so far conducted pertains to developing nations, which have comparable backgrounds to that of India. This extrapolation of the data of other nations not only that of BMI but also regarding body composition, physical activity patterns have been shown to lead to wrong interpretations. Ethnic differences in body composition have been pointed out; different levels of energy intakes and energy expenditures were also focused. There is a need to examine these in the Indian context.

BMI also allows for the simultaneous monitoring of the emerging problem of obesity in developing countries since it is a continuous index from grades of CED to grades of severe obesity. The cut off suggested is arbitrary, but based on available data from developed countries. It is crucial to realize that apparently normal individuals may exist in developed and developing countries with BMI’s below the suggested lower limit of 18.5.

It is thus, felt that it will be useful to study the select physical, nutritional, physiological and metabolic and biochemical parameters in two extreme conditions of malnutrition among rural women viz., CED and obesity in comparison with the supposed normal group. This enables to focus on the overlaps if any in relation to each nutritional status parameter when BMI is used to distinguish between the extreme states of malnutrition. Thus, validation of BMI among rural women for a wide range of nutritional status parameters is attempted in this study, while examining the nutrition situation of women existing within a close range of socio-economic and cultural contexts.
Aims and objectives of the research project –

- The aim of the study is to focus on the nutritional profile of rural women belonging to three nutritional states viz., CED, obese and normal.

To achieve the aim the following objectives were set –

- To examine the difference between the three different states of nutrition viz., CED, obese and normal with regard to each parameter of nutritional status.

- To draw a picture of relationship between the chosen physical, physiological, metabolic and behavioral parameters, irrespective of the nutritional state.

- To examine the relationship between BMI and all chosen indicators of nutritional status within each group and when the groups combined.

The study intends to focus on the relative value of BMI and other select parameters in the establishment of the nutritional states such as CED, obesity and the normal. The examination of nutritional status profiles of rural women will be of great value to nutritionists and health workers to have an insight into the malnutrition problems of this group.
Review of Literature
2. REVIEW OF LITERATURE

Assessment of nutritional status of community is intended to facilitate planning relevant interventions that would ameliorate the nutritional problems prevailing in a community. These assessments not only are guides to manage the nutritional problems but also act as pointers to the future consequences through facilitating early detection of malnutrition. An attempt is made in the present study to examine the physical, physiological and metabolic consequences with references to two extreme conditions of malnutrition the CED and obesity. In line with the objectives of the present study the available and extent review is presented in the following sections -

Section i  – Chronic energy deficiency and obesity – assessment and prevalence.


Section iii  – Food and nutrient intakes of women.

Section iv  – Energy expenditure and nutritional status.

Section v  – Biochemical and clinical assessment of nutritional status.

2.1. Chronic energy deficiency and obesity – definition and assessment:

Since the early 19th century the extreme malnutritional states viz; CED and obesity have attracted the attention of several researchers. Attempts have been made since 1950’s to define these states and interpret the nutritional status of the individual.

2.1.1 Chronic energy deficiency:

Keys et al., (1950) through their classic Minnesota study noted that CED is characterized by falls in body weight and fatness, falls in resting metabolic rate and habitual physical activity and in physical working capacity.
CED is defined as a "Steady State" where an individual is in an energy balance, i.e., the energy intake equals the energy expenditure, despite the low body weight and low body energy stores. Thus, by never growing to a normal size or having experienced one or more stages of energy deficiency, the individual has arrived at a reduced body weight with possibly limited physical activities, which have allowed the energy demands of a lower BMR and reduced amounts of activity to balance the lower intake (FAO, 1994).

The steady state will change when both energy supply is reduced or demands for energy output increase and this change is not counter balanced on the other side of the equation. In response to this change, there is a fall in body weight but not essential energy output. Monitoring of individual has shown that body weight does change as soon as energy balance occurs (Ferro-Luzzi, 1990).

Assessment of CED using BMI:

The need for a method of diagnosing chronic energy deficiency in adults was a major issue, which emerged at the first meeting of the International Dietary Energy Consultancy Group (IDECG) held in Guatemala in 1987. Further efforts to examine this problem were recommended and a report representing the first attempt at the international level to devise an operational definition of chronic energy deficiency (CED) in adults was made (James et al., 1988).

CED has been defined by Waterlow, Ferro-Luzzi and James (1987) as a steady state which can be maintained at a level at which certain functions and/or health are impaired, using as indicators, the body mass index (BMI = Weight/Height$^2$) and the ratio of energy turnover to basal metabolic rate in adults, and the deficit in weight-for-height in children.
The report of working party of the IDEFG defined chronic energy deficiency (CED) using BMI for adults. It proposed 18.5 as the cut-off point for CED identification (James et al., 1988). Women were classified as chronically energy deficient using BMI. Chronic energy deficiency grades I, II and III correspond to body mass index (BMI) 17.0-18.4, 16.0-16.9 and < 16.0 respectively. Women with BMI 18.5-24.9 were classified as normal (James et al., 1988; WHO 1993).

2.1.2. Obesity:

Obesity may be defined as a condition in which excessive accumulation of fat in the adipose tissue has taken place. It arises when the intake of food is in excess of physiological needs.

Obesity is a severe physical handicap; it is unlike other handicaps in two important ways. First, mortality risk is not linearly related to excess weight. Instead, there is a threshold at which risk dramatically increases. Second, obesity is highly reversible, and if it is corrected in time, some of its risks are too corrected. Mortality rates are no higher for the formerly obese than for the never obese (Whitney et al., 1987).

Overweight and obesity are commonly defined by the measurement of BMI. However, this is an imperfect measure, since both fat and fat-free mass (bone, muscles and body water) is estimated. An important limitation of the BMI as a measure of obesity is that it tends to ignore the distinction between fat and fat-free mass. Cut-off levels of the BMI for over weight and obesity are based on the 5th and 9th centiles of body weight and the mortality profile derived from the Caucasian population (WHO, 1995, 1998).

Obesity is something different from overweight, because an overweight individual may have normal body fat, and may not be obese (Gupta, 1989). It's
significance requires constant emphasis because it is associated with (a) increased mortality, and (b) predisposes to the development of many diseases like cardiovascular, cerebrovascular, respiratory insufficiency, hypertension, and diabetes (Lakhanpal, 1978; Lew, 1979).

Asthana et al., (1998) stated that in India the problem of obesity has been scantily explored even among the affluent groups and the criteria for defining obesity in the Indian context are not well spelled out.

Assessment of Obesity:

So far, the parameters that have commonly been used in various studies are Body Mass Index (BMI), Skin Fold Thickness (SFT), and body weight in excess of expected weight, singly or in various combinations (Asthana et al., 1998). The practical and clinical assessment of obesity is based on the Body Mass Index (BMI) weight (kg)/height (m²).

Garrow (1981) proposed to call the BMI range from 20.0 to 24.0 Kg/m² as normal, from 25 - 29.9 as overweight and above 30 as obese, these cut-off points were generally accepted by WHO in 1995 (WHO1990,1995).

Later, James et al., (1988) proposed the BMI cut-off values for different grades of obesity. According to him obesity grades I, II and III correspond to BMI 25.0 - 29.9, 30.0 - 39.9 and 40 respectively.

BMI is popularly being used as an indicator of choice to diagnose obesity in adults and Garrow's classification of obesity proposed in 1981 has been replaced following its universal use by the international criteria developed and endorsed by the World Health Organization (WHO). Recent WHO recommendations in 2000 include the suggestion that a BMI of between 18.5 - 24.9 in adults be considered appropriate weight for height. A BMI between 25 - 29.9 is indicative of overweight and possibly a
pre-obese state while obesity is diagnosed at a BMI > 30.0. Further, it has been classified as 30.0 - 34.9 moderate, 35 - 39.9 severe and > 40.0 very severe obesity.

Norgan (1994) stated that ethnic groups differ in frame size as well as in relative leg length (relative sitting height) and that this has an impact on the BMI.

Ko et al., (2001) addresses an important issue; the validity of the currently used cut-off points for overweight and obesity based on the BMI for various ethnic groups. There are a number of recent studies showing that the relationship between BMI and percent body fat is not only age and sex dependent, but also differs among ethnic groups. According to Luke et al., (1997) there are also differences among different groups from African origin.

Recent studies (Deurenberg, 2001) show that in some Asian population’s morbidity and mortality of obesity related diseases are high even at a low level of BMI. This affirms the WHO definition of obesity, namely that not only BF % should be increased, but in addition health and well being should be affected.

2.1.3. Body mass index as an indicator of nutritional status:

FAO started exploring the possibility of using the Body Mass Index (BMI) of adults as an indicator of the food situation and nutritional well being of a community. Further, several efforts were put forth by both FAO and WHO jointly to appraise the value of BMI in the assessment of nutritional status.

The BMI is a simple but objective anthropometric indicator of the nutritional status of the adult population and seems to be closely related to their food consumption levels. It is relatively inexpensive, easy to collect and to analyze. Collection of data on weight and height, from which BMI is easily derived, can readily be incorporated into regional and national surveys that are presently being conducted.
Weight-for-height indices are in common use for community epidemiological measurements. In adults a weight/height index provides measure of body weight corrected for height. As a measure of body composition, intact body fat, a Wt/Ht index has to have both a high correlation with amount of body fat, as well as low correlation with body height or else in short and tall people body composition would be systematically over or underestimated.

Several Wt/Ht indices have been proposed in the literature. Examples are the Quetelet (1869) or body mass index (Wt/Ht², Kg/m²). The Broca’s index (Wt/Ht – 100) the Ponderal index (Wt 0.33/Ht, Kg 0.33/m). The Rother’s index (wt/ht; g x 100/m³) and the Benn index (Wt/Ht²) in which the exponent P is population specific (Deurenberg, 1992).

Shetty (2002) reported that the standard or average weight is frequently derived from large population samples. However, differences between standards can be large across populations and hence relative weight, despite being a readily interpretable and an easily usable measure, is of limited use for international comparisons.

The power type index for international use should be that it is maximally correlated with weight and is unbiased by height, that is poorly or not at all correlated with structure in all populations. Body Mass Index (BMI) shows consistent high correlations with weight and is consistently independent of height, Wt/Ht² or Ponderal Index, on the other hand, shows substantially lower correlations with weight but also shows negative correlations with height.

The Belgian astronomer Adolphe Quetelet in 1869 observed that the body weight of adults of different heights is more or less constant to the square of the height. In 1972 Ancel keys and Colleagues christened this relationship between body weight of adults and square of the height as the BMI and replaced the term Quetelet Index (Garrow, 1988).
The choice of BMI as the likely objective index for the assessment of nutritional status of adults was based on the observation that BMI was consistently highly correlated with body weight (a proxy for the available energy stored within the body) and was relatively independent of the height of the individual (Shetty, 2002).

The correlation of the BMI with body fat is relatively high (ranging from 0.6 to 0.8 depending on age) and correlation with the body fat is generally low (Khosla and Lowe, 1967; Keys et al., 1972; Womersley and Durnin, 1977; Garrow and Webster, 1985; Lee et al., 1981; Deurenberg et al., 1991).

IDECG, which met in Guatemala in 1987, recommended BMI as the suitable indicator of nutritional status (James et al., 1988). BMI was subsequently accepted by FAO (2000) as a simple, responsive and useful indicator of nutritional status of adults to serve as an important and valuable tool for monitoring nutritional status of populations (Shetty et al., 1994).

Thus, BMI has now become a very valuable nutritional assessment and monitoring tool that is useful to assess the continuum of nutritional status ranging from undernutrition, normal and overnutrition; that is, the spectrum from nutritional deficiency to excess prevailing in the community.

2.1.4. Prevalence of obesity and CED among women:

The prevalence of obesity is increasing both in developed and developing countries. Industrialized, developed countries are showing increasing trends in prevalence of obesity over the last two or more decades while developing countries are showing a rise in overweight and obesity among their population along with economic development and urbanization. Two critical factors that have influenced this explosion in the prevalence of obesity are changes in dietary intake and levels of physical activity. Obesity is the result of energy intake being chronically in excess of energy expenditure, resulting in a positive energy balance and weight gain (Shetty, 1997).
Shetty and James, (1994) showed that the prevalence of obesity is much lower in African and Asian countries. Obesity is increasing in several countries of the developing world particularly among those in an economic transition, and in some of them high rates of obesity is already evident in children as well as in adults. The prevalence of obesity is higher in women as compared to men.

According to NNMB (1994) survey CED is prevalent in 37 - 47 percent of the women with the severe degree being documented in 10 percent. Obesity was also beginning to emerge (7to12 percent) as a nutritional problem.

A study of adults from new Delhi, India found that the percentage of women with a BMI > 25kg/m² was between 28% and 50% of the middle class but only 4% among the slum poor (Gopalan, 1998)

National Family Health Survey -2 (1999) of India shows that more than one third (36 percent) of women have a BMI below 18.5, indicating a high prevalence of chronic energy deficiency. In each income group one quarter of women has a BMI of 25 or more and 6 - 7 percent has a BMI of 30 or more, indicating the prevalence of obesity even among rural women. Nutritional problems are serious for rural women, illiterate women, working women who are not self-employed and women who live in households with a low standard of living.

The prevalence of adult undernutrition is likely to be a better indicator of and reflect more truly the nutritional status of the community than estimates of childhood undernutrition alone.

A study on nutritional status in 5,817 non-pregnant women in 15 to 49 years of age conducted in Purworejo district, Indonesia showed that the total prevalence of chronic energy deficiency among the women was 17 percent and the total prevalence of obesity was 11 percent. Further, chronic energy deficiency grades III, II, I was found
among 1.2, 3.0 and 12.8 percent respectively. 71.7 were normal and in grade I and II obesity there were 10.0 and 1.4 percent of the women respectively. The prevalence of chronic energy deficiency in Indonesia was lower than that in East Java (41%) and also lower than that in other developing countries, such as, India (61%) and Ethiopia (57%). Chronic energy deficiency was more prevalent among women who worked in agriculture or at home than non-agricultural workers. Chronic energy deficiency grade III was less common among women who lived in hilly and high land areas. Obesity was most common among older women and chronic energy deficiency was most common among the youngest and the oldest (Nurdiati et al., 1998).

Use of BMI in conjunction with indices of energy turnover e.g. physical activity level was recently proposed by Ferro-Luzzi et al., (1992) for classifying adult CED. Three deprived populations in Africa and Asia were chosen to assess the classification system. The prevalence of CED was consistently related within each country to indices of socio economic status. Yet in Zimbabwe 18% of women and 6% of men had grade-I obesity compared with 11% and 14% respectively, with CED. Less than 1% of Indian and Ethiopian adults were obese, but 61% of women and 70% of men in India and 57% and 50% respectively in Ethiopia were classified as CED. The researchers proposed that adult BMI alone is sufficient to provide important new insights into the problems of food availability and its control in less developed countries.

The prevalence of underweight among African rural women, as assessed by measurement of BMI and MUAC, was far less than the one obtained by BMI measurement alone (9.0% Vs 18.7%). Underweight in adults is a common answer to energy deprivation, where adipose and lean tissues are then used for fuel. The prevalence of thinness, estimated by a low BMI associated with a low MUAC, did not change with age. Prevalence of underweight women was in fact due to a slight but
equilibrated decrease of body compartment which, if far from an ideal situation at least should not limit their current activity nor endanger their health situation (Gartner et al., 2001).

Nurdiati et al., (1998) stated that obesity affects many women in western countries. Thirty five percent of adult women in the United States are obese. It is more common among women of lower socio-economic status in western countries, whereas in developing countries the opposite is true.

Geok Lin khor (1999) reported on the prevalence of over weight among Malaysian adults from rural communities. The mean BMI for men and women of all age groups are 22.5 kg/m² and 22.8 kg/m², respectively. The mean BMI for both genders increased with age between 18.0 and 49.9 years, after which the value declined. The prevalence of pre-obese (BMI ≥ 25.0 - 29.9 kg/m²) was 19.8% for men and 28.0% for women. The prevalence of obese men and women (≥ 30.0 kg/m²) was 4.2% and 11.1% respectively. The highest prevalence of pre-obese and obese men was found in the age groups of 30.0 – 49.9 years while that for women was in the 40.0 – 49.9 years age group. The prevalence of pre-obesity and obesity is high in women than in men for every age group. A similar result was indicated by WHR where by a higher proportion of women (22.5%) than men (5%) for all ages was found to show central obesity. The prevalence of over weight adults was higher when compared with previous studies on subjects from similar rural communities. This study indicated that over weight is on the increase in rural communities, especially among female subjects.

The prevalence of obesity among Palestinian West Bank village women, pooled for all age groups was about twice that of men. Since this population is relatively young, the total prevalence of obesity was slightly increased when directly standardized to the world population (WHO, 1996). For women, the total prevalence of Obesity was 42.1 percent when standardized to the world population of 30-64 years (Stene et al., 2001).
Yamuchi et al. (2001) reported that urban women, but not men, were significantly heavier than their rural counterparts \(p<0.08\), while urban men were significantly taller than their rural counterparts \(p<0.05\).

The socio-economic differences in height and body mass index of adults in urban areas of Karachi, Pakistan reveal that the height status improved with income level among adults and children of both sexes. Among females, rates of underweight were not significantly different at any age. Rate of overweight increased significantly \(p=0.048\) with income level among 41 to 60 years old women (38%, 53% and 60%) at low, middle and high income levels, respectively. Among 19 to 40 years old females the prevalence of both under weight and over weight was highest at the lowest income level. However at the household level the burden of urban malnutrition is seen most often among low-income families Hakeem (2001).

The review focuses on the fact that while CED is a nutritional problem of the past and present, obesity is emerging as a problem of the future. While there are ethnic, regional, and socio-economic and gender differences in the prevalence of obesity, it is evident that obesity is on the increase.

2.2 Body composition:

The body is structurally made up of organs, tissues, and cells. These in turn are made up of different chemical elements held together in varying combinations. The predominating chemical elements in the body are Oxygen 65 %, Carbon 18 %, Hydrogen 10 % and Nitrogen 3 % together they represent about 96 % of body weight and account for the principal constituents of the body namely water, proteins, fats and a small amount of carbohydrate as glycogen. The remaining 4 % of body weight is made up of mineral elements of which calcium and phosphorus account for three fourths. Many of the important constituents such as vitamins, hormones, and enzymes are
present in such small amounts that they have insignificant effect on total body weight (Joshi, 1992). Nevertheless enough is known to state that the data in table 1 are representative of normal women.

Table 1: Percent body composition of women

<table>
<thead>
<tr>
<th>Body Composition</th>
<th>Kg</th>
<th>% Percent*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein</td>
<td>11</td>
<td>8.5</td>
</tr>
<tr>
<td>Fat</td>
<td>9</td>
<td>22.3</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Water</td>
<td>40</td>
<td>61.6</td>
</tr>
<tr>
<td>Minerals</td>
<td>4</td>
<td>6.1</td>
</tr>
</tbody>
</table>

* Ref. Joshi, 1992

Most of the material listed in table 1 is part of the essential structure of the body, but a portion represents reserves of stores of the 9 kg of fat not more than about 1 kg is essential; the remainder represents a store which can be drawn upon in times of need. Most of the protein is an essential component of the cells, but some is a reserve, probably about 2 kg can be lost without serious results. By contrast, the body can be depleted at most of 200g of carbohydrate. During starvation the store of carbohydrate is continually replenished by synthesis from the larger reserves of protein and fat. The body can lose about 10 percent of its total water and at least one third of the mineral content of the skeleton without serious consequences.

Indices of body composition are used in clinical setting to identify the persons with chronic under or over nutrition, and to monitor long-term changes in body composition during the nutritional support.

2.2.1. Use of anthropometry in the assessment of body composition:

Both direct and indirect methods have been used to evaluate the composition of the human body. For conducting field studies select anthropometric measurements are recommended for use, which is an indirect method of assessment of nutritional status. Anthropometric methods used to assess body composition are based on a model in
which the body consists of two chemically distinct compartments. The fat and fat free mass. Anthropometric techniques can indirectly assess these two body compartments and variations in their amount and proportion can be used as indices of nutritional status. Anthropometric measurements of body composition are relatively quickly obtained, non invasive and require the minimum of equipment compared to the laboratory techniques.

(i) Height and weight (ii) Skinfold thickness (iii) Mid upper arm, waist and hip circumferences are some of the anthropometric measurements popularly used as indicators to body composition.

*Height and weight measurements:*

Height and weight usually were the minimal anthropometric measures to assess a person’s nutritional status. If children do not get sufficient food, they fail to grow properly. Similarly adults without enough to eat lose weight and those who over eat gain weight. Measurements of weights of adults and of large groups children of various ages have been used as an index of nutritional status, and have proved very valuable when correctly interpreted (Davidson and Passmore, 1970).

*Measurement of Skinfold Thickness (SFT) for assessing Body Fat:*

Skinfold thickness measurements are said to provide an estimate of the size of the subcutaneous fat depot, which in turn provides an estimate of the total body fat (Durnin and Rahaman, 1967). Such estimates are based on two assumptions: a) the thickness of the subcutaneous adipose tissue reflects a constant proportion of the total body fat, and b) the skinfold sites selected for measurement, either singly or in combination, represent the average thickness of the entire subcutaneous adipose tissue (Lukaski, 1987). Neither of these assumptions is true. In fact, the relationship between subcutaneous and internal fat is non-linear and varies with body weight and age. Very lean subjects have a smaller
proportion of body fat deposited subcutaneously than obese subjects (Allen et al., 1956). Moreover, variations in the distribution of subcutaneous fat occur with sex, race and age (Robson et al., 1971; Durnin and Womersley, 1974). The most popularly used skinfolds to assess body fat are:

a. Triceps: skinfold measured at the mid point of the back of the upper left arm (fig. 1) (Weiner and Lourie, 1969).

b. Biceps: skinfold measured as the thickness of a vertical fold on the front of the upper left arm directly above the center of the cubital fossa, at the same level as the triceps skinfold (Weiner and Lourie, 1969).

c. Subscapular: skinfold measured just below and laterally to the angle of the left shoulder blade, with the shoulder and left arm relaxed. Placing the subjects arm behind the back may assist in the identification of the site. Skinfold is grasped at the marked site with the fingers on top, thumb below and forefinger on the site at the lower tip of the scapula. The skinfold should angle 45° from horizontal, in the same direction as the inner border of the scapula (i.e., the ideally upward and laterally downward) (fig. 2) (Jeté, 1981; Lohman et al., 1988).

d. Suprailiac: skinfold measured in the midaxillary line immediately superior to the iliac crest. The skinfold is picked up obliquely just posterior to the midaxillary line and parallel to the cleavage lines of the skin (Lohman et al., 1988) (fig. 2).

As early as 1921, Matiegka formulated an equation for calculating body fat from measurements of surface area and 6 SFTs.
Durnin and Womersley (1974) using 4 SFTs recommended the following classification as the criteria for diagnosing nutritional status - (a) sum of SFT > 40 mm (normal), (b) sum of SFT 40 to 59.9 mm (above normal), (c) sum of SFT 60 to 79.9 mm (over weight), and (d) sum of SFT ≥ 80 mm (obese).

Fig 1: Location of the mid of the point of the upper arm

Fig 2: Location of the subscapular and suprailiac sides
The researchers also described a procedure for assessing total body fat with relative ease. Linear regression equations were calculated for the estimation of body density and hence body fat, using single skinfolds and all possible sums of two or more skinfolds. Separate equations for different age groups were given. A table was derived where percentage body fat can be read off corresponding to differing values of the total of the four skinfolds.

Kuriyan et al., (1998) estimated the body composition of South Indian men and women using hydrodensitometry, bioelectrical impedance and skinfold thickness. Comparison of the hydrodensitometry used as the standard for reference and the skinfolds methods proposed by Durnin and Womersley (1974) showed that there were no significant differences between the methods for estimation of percent fat and fat free mass. The researchers showed that skinfold method could be used as an accurate and expedient method to determine body composition.

Assessment of lean body mass (LBM) from SFT:

Using the skinfold thickness method proposed by Durnin and Womersley (1974) after assessing the percent body fat, fat in kg is calculated for the specific body weight of individuals. To assess the LBM the fat in kg calculated is subtracted from the weight of the individual. Kuriyan (1998) showed that the SFT method predicts FFM accurately when compared with the reference method, the hydrodensitometry.

(a) Mid upper arm circumference:

The arm contains subcutaneous fat and muscle. A decrease in mid-upper arm circumference may therefore reflect either a reduction in muscle mass, a reduction in subcutaneous tissue, or both. The fat free mass is a mixture of water, protein and minerals with muscle serving as the major protein store.

(b) Waist hip circumferences and ratios:
Prentice et al., (2001) stated that the BMI continues to serve well for many purposes, but that the time is now right to initiate a gradual evolution beyond BMI towards standards based on actual measurements of body fat mass. The current situation is that recommendations based on waist circumference sit somewhat uneasily alongside BMI in international guidelines and clinical assessments, but are generally accepted as providing a valuable additional insight into the problem. International Obesity Task Force (IOTF) cut-off for class III obesity (associated with very severe co-morbidity) and waist circumference is well over the IOTF action level of 94 cm.

Han et al., (1995) proposed a waist circumference of 102 cm or more for men and 88 cm or more for women as indicative of abdominal obesity. Willette et al., (1999) defined a waist hip ratio indicative of obesity as > 0.95 in males and > 0.80 in females.

Though several direct measures are available to assess body composition different anthropometric measurements continue to be simple and valuable indicators. The review reveals the efforts made by several researchers to standardise the same by comparing with direct methods. This further focuses on the need to validate the proposed measures and equations to different population groups across the globe.

2.2.2 Anthropometric status of women:

Data on anthropometric measurements of adult Indian women is available through studies done by the NNMB (1980). The mean heights and weights of women aged between 25 and 44 years living in rural areas of 10 states are shown in table 2 for the 10 states. The rural Indian woman was 150.6 cm tall and weighed 42.4 kg. Regional variations were seen, but not very striking. The weights ranged from a low 39.9 kg in West Bengal to a weight 44.4 kg in Madhya Pradesh. In other eight states values were in a close range of 41.9 to 43.6 kg for weight. Mean height was lowest in West Bengal
148.5 cm and highest in Gujarat – 152.9 cm. In the other states mean heights like mean weights, were very close to each other varying from 149.3 to 151.5 cm.

Table 2: Mean height, weight and BMI of rural adult women in India (Ages 25-44 yrs)

<table>
<thead>
<tr>
<th>State</th>
<th>N</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerala</td>
<td>1290</td>
<td>149.3</td>
<td>42.3</td>
<td>18.98</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>1385</td>
<td>150.7</td>
<td>43.5</td>
<td>18.90</td>
</tr>
<tr>
<td>Karnataka</td>
<td>1976</td>
<td>151.5</td>
<td>42.6</td>
<td>18.56</td>
</tr>
<tr>
<td>Andhra Pradesh</td>
<td>1645</td>
<td>150.8</td>
<td>42.7</td>
<td>18.80</td>
</tr>
<tr>
<td>Maharashtra</td>
<td>1560</td>
<td>150.1</td>
<td>41.5</td>
<td>18.44</td>
</tr>
<tr>
<td>Gujarat</td>
<td>1791</td>
<td>152.9</td>
<td>43.6</td>
<td>18.68</td>
</tr>
<tr>
<td>Madhya Pradesh</td>
<td>873</td>
<td>150.7</td>
<td>44.4</td>
<td>19.55</td>
</tr>
<tr>
<td>Orissa</td>
<td>474</td>
<td>148.6</td>
<td>42.0</td>
<td>19.02</td>
</tr>
<tr>
<td>West Bengal</td>
<td>1344</td>
<td>148.5</td>
<td>39.9</td>
<td>18.10</td>
</tr>
<tr>
<td>Uttar Pradesh</td>
<td>1288</td>
<td>150.0</td>
<td>41.9</td>
<td>18.62</td>
</tr>
</tbody>
</table>

Urban women belonging to the low-income group and women working in industrial establishments were heavier (44.8 kg) but not taller (150.7 cm) than were their counterparts (table 3).

For Indians utilizing the NNMB data, deficits in weights and heights compared to standards have been calculated. In several states the deficit in women has been found to be less than in men by 5 to 10 percent. In no state was the deficit in women larger than that observed in men (Visweswara Rao, 1980).
Table 3: Mean height, weight and BMI of rural and urban Indian women

<table>
<thead>
<tr>
<th>Details</th>
<th>N</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>13626</td>
<td>150.6</td>
<td>42.4</td>
<td>18.69</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High income</td>
<td>129</td>
<td>154.9</td>
<td>52.2</td>
<td>21.75</td>
</tr>
<tr>
<td>Middle income</td>
<td>592</td>
<td>151.8</td>
<td>49.2</td>
<td>21.35</td>
</tr>
<tr>
<td>Low income</td>
<td>538</td>
<td>150.4</td>
<td>44.8</td>
<td>19.81</td>
</tr>
<tr>
<td>Industrial workers</td>
<td>661</td>
<td>150.7</td>
<td>44.8</td>
<td>19.73</td>
</tr>
<tr>
<td>Slum dwellers</td>
<td>649</td>
<td>150.0</td>
<td>42.2</td>
<td>18.76</td>
</tr>
<tr>
<td><strong>ICMR (1991)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rural</td>
<td></td>
<td>150.7</td>
<td>42.0</td>
<td>18.49</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td>154.1</td>
<td>44.3</td>
<td>19.16</td>
</tr>
</tbody>
</table>

Sivety (1984) while comparing the food intake of a group of 14 chronically undernourished unskilled labourers with that of a group of 14 healthy male controls of similar age living in Bangalore, India, made observations on anthropometric measures of height, weight, triceps, subscapular, suprailliac and infra-mammary fat fold. BMI, body surface area (BSA), percentage body fat and lean body mass were calculated. The controls were taller, heavier, had larger BSA, skinfold and BMI’s than the labourers.

Seven hundred adults consisting of 401 males and 299 females in urban Hyderabad and 918 male and 1088 female rural adults surveyed by Visweswara Rao et al., (1986) revealed that the mean values of weight and height of subjects belonging to upper middle-income group were higher than those of lower income groups (P<0.05). Similarly arm circumference and fat fold at triceps were also significantly different between the two groups. Rural adults were shorter and lighter than those of upper middle and lower socio economic groups. The indices weight/height and weight/height³ were correlated with stature and correlation coefficients were significant (P<0.05).
In Indians, Shetty et al., (1990) recorded physical characteristics and distribution of BMI in Bangalore citizens aged 20 - 65 yrs. The mean age of women was 38 yrs and the mean Ht and Wt recorded were 152 cm and 41.3 kg respectively, with a mean BMI of 17.8. The percentage distribution of women in different ranges of BMI <15, 15-17.49, 17.5-19.99, 20-22.49 and >25 were 8.9, 36.4, 41.1, 10.9, 1.9 and 0.8 respectively.

Female subjects including manual workers educated working women such as teachers and researchers as well as house wives showed that manual worker had shorter heights and lower weights. The number of manual workers in the range of heights of 140-155 cm was 54 compared to 22 and 26 working women and housewives respectively. The number of manual workers with weight below 55 kg was 100 compared with 38 and 11 members of working women and housewives respectively (ACC/SCN Reports, 1990).

NNMB repeat survey (1991) aggregate data on heights, weights and body mass index over the period shows a definite improvement. Weight increments were more visible in adults and adolescents.

The mean values of attained height are estimated as around 150-151 cm for women in Asia. The prevalence of under weight (<45 kg) women is very much higher in proportion compared with North and Western countries up to about 60 % in South Asia, around 45 % is South East Asia. The deficit in weight and height can be useful to look at direct indicators like BMI (ACC/SCN Reports, 1992).

The health and nutritional status of women working at nuclear power corporation (Mumbai) was assessed by Amita and Nita (1993). The mean height of the subjects was recorded as 152 ± 1.3 cm while the mean weight was 53.2 ± 9.96 kg. Nearly 16 % of women studied were underweight (BMI < 18.8).
Anthropometric data available through NNMB survey were analysed to study BMI profiles of adults and relate them to various parameters such as nutritional status of preschool children, socioeconomic status and low birth weight and mortality. The results show that nearly one half (49 %) of adult Indian rural population is suffering from some grade of chronic energy deficiency. Mean BMI values were lower in landless agricultural, occupational groups and low per capita income group households compared with cultivators, artisans and higher income groups (Nadamuni Naidu and Prathad Rao, 1994).

Mehatha and Dodd (1994) conducted a study on the health status of working women and house wives in Bombay. The researchers used BMI to assess health status. The data revealed that obesity was more prevalent in house wives (39 %) compared to working women (20 %).

Norgan (1995) studied the changes in patterns of growth and nutritional anthropometry in two rural modernizing Papua New Guinea Communities. The results revealed that adult heights were 2-3 kg greater in 1984 than in 1969 and weights were greater by 2-3 kgs with peak differences in the 30-39 yrs old. The percentage of coastal women with BMIs of less than 18.5 kg/m² fell from 32 % to 15 % (p < 0.01). Mid upper arm circumferences and triceps skinfolds were significantly higher in all groups. National and regional data suggest that the communities were better off in 1984 than 1969, but social and economic changes were associated with variable benefits in growth and nutritional status.

Yamauchi et al., (2001) attempted a study on New Guinea highland population of adult male and female subjects (n=56) including twenty-seven rural villagers and twenty-nine urban migrants. The lack of significant difference in body weight for men and in stature and BMI for women was attributed to the small sample size. Furthermore, the finding that urban subjects who were born and raised until pubescence or
adolescence in their home villages had a significantly larger body size, especially in height. A long adolescent growth spurt was observed to be contributing to the difference between the height of urban and rural groups (H Leywood and Norgan, 1982; Norgan, 1995).

Nurdiati et al., (1998) conducted population based cross-sectional study of nutritional status in 5817 non-pregnant women 15-49 years of age in villages of Purvuorejo of Indonesia. The mean BMI was 21.2 ± 3.1. The mean BMI of the Indonesian women was higher than the average BMI of women of reproductive age in Ethiopia (18.5 ± 1.8) and India (18.0 ± 2.1) and slightly lower than that of for Zimbabwean (22.0 ± 3.3) and Thai (21.4 ± 2.5) women (Ferro-Luzzi et al., 1992; Sanchaisuriya et al., 1993).

The dietary intake and nutritional status of women and pre-school children and their mothers in the Republic of the Maldives, a small island nation in the Indian Ocean was examined by Andrea (2001). This study shown that the average anthropometric values for the women were 48.6 ± 9.4 kg for weight, 149.4 ± 5.5 cm for height and 21.8 ± 4.0 kg/m² for the BMI. In total, 22.0 percent of the women had a BMI below, 18.5; of these, 11.3 percent were classified as mildly underweight (BMI = 18.5 - 17 Kg/m²), 6.2 percent as moderately underweight (BMI = 17.0 to 16.0 Kg/m²) and 4.5 percent as severely underweight (BMI < 16 Kg/m²). The majority of women 58.4 percent were found to be within the normal range (BMI = 18.5 to 25 Kg/m²). Furthermore, 16.5 percent of the women were possibly overweight (BMI=25-30 Kg/m²) and 3.1 percent were overweight (BMI > 30 Kg/m²). The BMI did not show any relationship to age.

The studies reviewed in this section clearly focuses on the fact that low statures and low weights and low BMIs occur more frequently in high percentage of women in the poor section of the population. However, the anthropometry over the years is showing a secular change. This phenomenon though appears to be universal the trends are specific to certain demographic characteristics, select socio-economic situations and ethnic characteristics of different population groups in different countries.
2.2.3 Association between select anthropometry and BMI – Empirical evidence:

Micozzi et al., (1986) conducted a study on correlation of body mass indices with weight, stature and body composition in men and women for NHANES-I data of US population. Stature was significantly correlated with weight in men but not correlated with fatness. Stature was correlated somewhat with arm muscle area in men not in women. Weight was highly correlated with fatness and frame size in men and women. In general, BMIs were more highly correlated with weight in women than they were in men. In women, all BMIs and weight were highly correlated and were more highly correlated with arm circumference than with either triceps or subscapular skinfold thickness or arm fat area. BMIs are more highly correlated with the subscapular skinfold measurements than with triceps skinfold measurements. The BMIs were highly correlated with measures of central fat (subscapular skinfold thickness), which has been suggested to be important for the risk of chronic diseases, than with peripheral fat (triceps skinfold thickness). The researchers stated that the arm circumference may be more highly correlated with measures of excess weight such as BMIs because they are more reliable, although not more biologically meaningful, than are triceps skinfold measurements and as BMIs were highly correlated with other estimates of body fatness they will continue to be useful in population studies of body size and body composition.

Asthana et al., (1998) while screening of obesity in affluent females assessed BMI and SFTs with those of non-obese in Varanasi city. Body measurements in terms of mean and SD for weight, height and skinfold thickness at four sites of obese and non-obese subjects obtained revealed that obese women were shorter in height, heavier in weight and had higher value of skinfold thickness as compared to non-obese women. The sensitivity, specificity and predictive value of sum of SFT at four sites were calculated at different cut-off points, and it was observed that value ≥ 90 mm is the best
cut-off point instead of 80 mm, for detecting obesity in the Indian context. The prevalence of obesity (all grades combined) by body mass index (BMI) was observed to be 30.24 percent.

Yamauchi et al., (2000) conducted a study on rural and urban dwelling Papua New Guinea Highlanders. Rural subjects had significantly lower skinfolds (p<0.05) in males and (p<0.005) in females than their urban counterparts. The difference was particularly evident in women. The sum of skinfolds in urban women was twice that in rural women. Rural women had significantly lower body fat (P<0.005) than their urban counterparts, but this was not significant in men.

The profile of dietary nutrients, anthropometry, and lipids in urban slum dwellers of Northern India was reported by Misra et al., (2001). Anthropometric, body composition and metabolic data were compared for men and women. BMI was statistically comparable in both the sexes however, WHR was higher in males (p<0.02) while triceps skinfold (p<0.03) was significantly higher in females (p<0.001). In females particularly although their mean BMI was at a lower range (20.5 ± 4.2), their % BF was high (26.7 ± 8.6 %). Since there were very few subjects with BMI> 25, the lower limit of a BMI of 22 was taken to categorize the groups. Eighteen percent of males and 27 percent females had BMI ≥ 22. Despite generally low values of BMI, high prevalence of abdominal obesity was noted a waist hip ratio of > 0.95 in 22 % of males and >0.8 for 16 % of females was evident.

Norgan (1993) conducted a study on men and women farmers from 100 km northwest of Bangalore men and women from Hyderabad in Andhra Pradesh. The relationship between MUAC and BMI was tested using a stepwise multiple regression analysis. Results revealed a significantly linear relationship between MUAC and BMI. The BMI units tended to be within or below the normal range. The women were shorter and lighter than the men.
The use of BMI for assessing undernutrition in adults is now being applied world wide (Shetty and James, 1994). The BMI value can also be affected by the relative lengths of the trunk and legs. Although in women regression line of MUAC against BMI can be derived, the variability is such that MUAC values cannot be used to correctly classify the intermediate categories of BMI. MUAC values of 22.0 cm in women are useful cut-off points for simple screening of nutritional state. In combination with BMI it may provide a more refined classification of CED.

Nurdiati et al., (1998) investigated the nutritional status of non-pregnant women of 15-49 years of age belonging the Purwerjo district of Indonesia. The MUAC cut-off commonly used for indicating risk was 22.5 cm. The mean MUAC for the study sample was 25.8 ± 2.9 cm, which was higher than this cut-off point although still only in the 25th percentile of NHANES standards. The mean triceps skinfold thickness was 15.0 ± 6.3 mm, which was in the 25th percentile of the NHANES standards.

The rural agricultural African women have shown the BMI of 17.0-18.49 categories, compared with the body composition of "normal but vulnerable" women with those having a MUAC < 23.0 cm. The mean of the triceps skinfold thickness value was similar in the two groups, as in the multiple sites approach, where body fat did not differ between MUAC groups as reflected by the sum of four skin fold thicknesses. There was therefore no difference in peripheral body fat within this 17.0-18.49 BMI range, whatever the category of MUAC value. On the other hand, the arm muscle area was significantly lower in low MUAC when compared to normal MUAC women. The lower MUAC was then explained by a specific loss of arm-fat free mass (Gartner et al., 2001).

The waist-hip circumference (WHC) ratio and its relation to age and overweight in British men, showed that the mean body weight was 75.6 ± 11.6 and BMI was 24.7 ±
3.4 kg/m² and WHC ratio was 0.89 ± 0.06; it increased with age and overweight separately and in combination. These indices suggest that in men abdominal obesity and whole body obesity are usually separate conditions and that abdominal obesity was less common than obesity (Jones et al., 1986).

Weight cycling and cardiovascular risk factors in obese women of 25 to 45 years old was studied by Jeffery et al., (1992). The mean weight was 83.42 ± 6.4 kg. The mean BMI of women was 31.03 ± 2.09 kg/m². The WHR was 0.89 ± 0.06. The body fat percent was 49.16 ± 3.44. The LBM was 38.34 ± 6.60. The biochemical profiles of lipids viz., cholesterol and triglycerides; the mean values recorded were 5.06±0.93 mmol/l and 1.36±0.83 mmol/l. When compared with those of women in the lean category and normal groups of the third world all the values were rather very high.

Tienboon et al., (1992) focused on early life factors affecting of body mass index and waist hip ratio. Anthropometric measurements taken in adolescence and their parents showed that there were sex differences at the 1 % level for all measurements except hip circumference and BMI. The correlation between BMI and WHR was 0.5 in the parents.

The major metabolic cardiovascular risk factors aggregate independently with both body mass index and waist hip ratio and improve with weight loss. The circumference of the waist relates closely to body mass index and is also the dominant measurement. The waist hip ratio reflects the proportion of body fat located intra-abdominally, as opposed to cutaneously and waist circumference is the indicator of changes in intra-abdominal fat due to weight loss (Vander Kooy et al., 1993).

Joan et al., (1995) examined anthropometry among women and showed that the association between the waist to hip ratio and mortality from all causes from 1986 through 1992 was weaker than that between the body mass index and mortality. The waist to hip ratio was a strong predictor of death due to coronary heart disease in this cohort.
Lean et al., (1995) examined the waist circumference used to identify people at health risk both from being overweight and from having a central fat distribution in North Glasgow adults. The results showed that body mass index and hip circumference were similar for men and women in the age range 25 to 74 years. However, men were heavier and taller and had a larger waist circumference and WHR than women. In both sexes WHR correlated positively with BMI.

Deurenberg (1999) studied the manifestation of cardiovascular risk factors at low levels of body mass index and waist to hip ratio in Singaporean Chinese. The odds ratios for high serum total cholesterol; low HDL cholesterol, high total cholesterol/HDL cholesterol ratio, high serum triglyceride level, high blood pressure and high fasting blood glucose were higher in upper BMI and WHR quintiles. The effects were more pronounced in males compared with females. The odds ratios for having at least one of the mentioned risk factors in the different BMI quintiles for females were 1.3, 1.89, 1.6, 2.1 and 2.7 while in males they were 2.7, 4.1, 6.2 and 7.3. For the WHR quintiles the odds ratios were 0.9 (ns), 1.3 (ns), 1.9 and 2.1 for females, while for males they were 2.1, 4.7, 6.7 and 12.6. As the elevated risks were already apparent at low levels of BMI and low levels of WHR, it can be queried whether the cut-off points for obesity based on BMI and for abdominal fat distribution based on WHR as suggested by the WHO are applicable to the Singaporean Chinese population. There are indications in the literature that Asian populations have higher body fat percentages at lower BMI. This may explain the high odds ratios for CVD risk factors at low BMI and WHR and the high morbidity and mortality from CVD in Singapore, despite relatively low population mean BMI and obesity rates.

Stene et al., (1999) showed that the mean WHR among women was 0.88. The association between WHR and BMI obtained an r² of 0.07 for women. A high waist hip
ratio is expected to reflect an abdominal body fat distribution and although the linear association between BMI and WHR is highly significant it is far from complete. The value of WHR observed by Stone et al., were higher than that of all, mostly European populations in the WHO MONICA project. The pooled data from WHO MONICA project indicated an r² (proportion of variation in one variable explained by the other variable) 0.30 for women. This is only slightly higher than that observed for the study by Stone et al.

2.2.4 Association between body fat, anthropometry and BMI:

Durnin and Rahaman (1967) studied the assessment of the amount of fat in the body from measurements of skinfold thickness. The mean SSFT values of women were 40.9 ± 16.2 ranging from 23.1 – 99.6 mm, the body density (BD) g/ml was 1.044 ± 0.0142 and % fat was 24.2 ± 6.5 ranging from 14.0 – 46.1. Measurements of SSFT and body density (BD) in young adults, subdivided for body build assessed subjectively by appearance shows that the thin women had mean SSFT value of 31.2 ± 6.3 mm and BD 1.0547 ± 0.0073. Intermediate body build women had mean SSFT of 39.9 ± 10.9 mm and BD 1.0442 ± 0.0082 and plump and obese had SSFT of 66.0 ± 22.7 mm and body density 1.019 ± 0.0122 respectively.

Adaptive changes in BMR and lean body mass in chronic under nutrition were reported by Shetty (1984). The normal controls were slightly taller had significantly larger body weights and body surface areas and had higher BMIs. They had larger skinfolds at all four sites measured, with an estimated total body fat of 14.3 percent compared with only 6.1 percent in the labourers.

Norgan (1990) described through his study that BMI is an indicator of size as well as fatness, its relation to fatness and interpretation as a measure of energy stores may vary in different groups. Very low BMI reflects low fat and fat free mass, a state for greater concern than low fat mass alone, and possibly more typical of chronic energy deficiency.
Georges (1993) showed that general socio-economic status is related to body fat distribution in men and women of Hispanic Health and Nutrition Examination Survey of United States. For both sexes in all Hispanic ethnic groups except Puerto Rican men, as socio-economic status declined, subcutaneous fat became more centrally distributed. This relationship was statistically significant for all subsamples except Cuban American women. No consistent relationships were found between body fat distribution, drinking and depression. The data support the hypothesis that body fat distribution may be linked to the social stress of low socio-economic status, independent of the behavioural factors tested. Recent studies have also found a relationship between low social class and central body fat distribution (Mueller and Wear 1991; Bjorntorp, 1988; Larsson, Seidell, Svardso, Wellin, Tibblin, Wilhelmsen and Bjorntorp, 1989).

Immink et al., (1992) attempted a study on body mass index, body composition and CED classification of rural adult populations in Guatemala. The study involved four samples of rural men and women in Guatemala, who had mean BMI of approximately 21 kg/m². Mean body fat % and FFM (kg) of men were 11.6 (±4.7) and 47.7 (±4.9) and for women 21.6(±5.3) and 35.8 (±3.5) respectively. The Durnin and Womersley equations based on various combinations of skinfold measurements consistently over estimated body fat content with low precision and validity the BMI was more related to BFM and FFM than to fat proportion, but explained little of the variation in both body components, particularly at low BMI levels. A small number of men and women had BMI values below 18.5 kg/m², and only one woman fell below 16 kg/m². The power coefficients of height in the weight/height ratio, which provided the strongest correlations of with BFM and FFM, were: BFM 1.0 and 1.5 for women and men respectively and FFM 0.5 for both women and men. Thus, the researchers expressed that Quetlet index should not be recommended as a universally valid indicator to classify CED in adult groups.
Wang et al., (1994) studied the correlations between body mass index, percent body fat as measured by Dual Photon Absorptionmetry (DPA) in 445 white, and 242 Asian adults aged 18-94 years. Although Asians had lower BMI, they were fatter than whites of both sexes. The correlations between fat percent and BMI varied by BMI and sex and race. Comparisons in anthropometry showed that the Asians had more subcutaneous fat than white and had different fat distribution from whites. Asian had more upper-body subcutaneous fat than whites. The magnitude of differences between the two races was greater in females than in males. The linear relationships between BMI and fat percent were significant for all groups' studied. All six measured circumferences in white males were significantly larger than in Asian males. In females, arm and waist circumferences were not different between whites and Asians, but other circumferences were larger in whites. Females had larger skinfold fat areas than did males in both races. BMI had higher co-efficient for females than for males in both races.

The effect of age on bone mass, body composition and fuel metabolism in caucasian women showed that the total fat mass remained stable in women, irrespective of menopause, but a redistribution of fat occurred with advancing age ($r=0.43$, $p < 0.001$), resulting in a higher upper to lower body fat ratio ($p < 0.05$) in older than in younger women (Horber et al., 1997).

Untoro et al., (1998) showed that a BMI between 18.5-22.5 had an average body weight of 45.6 kg consisting of 25 percent of the fat mass. Whereas, subjects with a BMI > 22.5 had an average body weight of 52.5 consisting of 30.6 percent of fat mass. The higher fat mass partially explains why subjects with a BMI higher than had reduced work outputs.

Robert (1998) assessed the validity of BMI in predicting percent body fat, among postmenopausal women. There was a strong association between % fat and BMI
in postmenopausal women. The researcher expressed the current NH1 BMI based classifications for obesity may be misleading based on currently proposed % fat standards. BMI > 25 kg/m² rather than BMI > 30 kg/m² may be superior for diagnosing obesity in postmenopausal women.

Ruderman et al., (1998) described individuals with normal weight but who were "metabolically obese" with insulin resistance, hyper insulinaemia and dyslipidaemia, but have weight within normal limits. The common denominator for the metabolic abnormalities of subjects has increased with percentage of BF and abdominal fat.

In a study carried out on migrant Indian male volunteers in the USA, a mean BMI of 24.5 ± 2.5 kg/m² in BF was associated with 33 ± 7.0 percent BF (Benerje et al., 1999). Further, the majority of the fat was localized in the subcutaneous tissues. According to a few studies it is the subcutaneous fat in the abdominal region that has the major impact on the metabolic variables (Abate et al., 1995; Misra et al., 1997).

Study on Chinese, Malays and Asian Indians by Yap et al., (2000) used multiple methods for body fat measurements including skinfold thickness. The BMI was a poor predictor of BF with the mean prediction error ranging from 2.7 to 5.6 percent. The relationship between BMI and BF was different among the three ethnic groups, with Asian Indians having the highest percentage BF for the same BMI, age and sex.

According to Prentice and Jebb (2001) ageing is accompanied with a progressive increase in the ratio between fat and lean body mass. This occurs even in individuals who manage to maintain a constant BMI as they become older. Thus, the relationship between BMI and body fat is age-dependent. These discrepancies are accentuated after middle age and during the menopause in women.

Karl et al. (2001) evaluated the value of anthropometric equations to assess body composition changes in young women aged 17-33 years. Women lost 1.2 ± 2.6 kg
fat (x ± SD) and gained 2.5 ± 1.5 kg FFM. Fat loss (r=0.47), but not FFM gain (r=0.01), correlated with initial fatness. Thus for any women who lost fat body weight did not change or increased, Fat loss was associated with a reduction in abdominal circumference but this alone was not a consistent marker of a fat loss. One circumference equation and one skinfold/thickness equation yielded the smallest residual SDs (2.0 % and 1.9 % body fat respectively) compared with the other equations in predicting body fat. The sensitivity and specificity of the best equations in predicting changes in percentage body fat were not better than 55 percent and 66 percent respectively. These data suggest that for women anthropometry can provide better estimates of fatness than body mass index but it is still relatively insensitive to short-term alterations in body composition. Not surprisingly, the circumference equation that includes the most labile sites of female fat deposition (i.e., waist and hips instead of upper arm or thigh) proved to be the most reliable.

Gartner et al., (2001) studied 'normal but vulnerable' adults, as defined by body mass index. BMI in combination with mid-upper arm circumference was closer to normal than to malnourished ones of non-pregnant women residing in rural area of Republic Congo. The prevalence of thinness decreased from 18.7 percent as defined by BMI alone to 9.0 percent. The ratio comparison with the BMI > 18.5 kg/m² category showed that in normal but vulnerable subjects lower BMI was accompanied by lower body fat and lean compartments, in absolute values, but the equilibrium of body water compartments was not altered. In BMI < 18.5 women, low MUAC was associated with altered lean tissues, at peripheral and whole body level, whereas fat tissue did not differ.

Dudeja et al., (2001) attempted a study to establish appropriate cut-off levels of BMI for defining overweight, considering percentage BF in healthy Asian Indians in Northern India as the standard. A total of 123 healthy volunteers (86 males, aged 18-27
years and 37 females aged 20-69 years) participated in the study. BMI for females were 23.3 (SD 5.8) kg/m² and percent body fat was 35.4. Receiver Operating Characteristics (ROC) curve analysis showed a low sensitivity and negative predictive value of conventional cut-off value of the BMI (25 kg/m²) in identifying subjects with overweight as compared to the cut-off value based on percentage BF (male > 25, female > 30). Furthermore, a novel obesity variable, BF, BMI was tested and this should prove useful for inter ethnic comparison of body composition. The prevalence of over weight in females according to percentage BF estimation was more than twice that estimated by BMI. Benarjee et al., (1999) also observed a higher percentage BF in Asian Indians at a comparatively low BMI.

It is evident from the select research studies reviewed that several investigations studied the association between BMI and other anthropometric indices such as MUAC, skinfold thicknesses. The primary objective of these works is to evaluate the validity of using BMI as a tool to discriminate the different nutritional states such as CED which is characterized by loss of both fat and muscle and obesity which is characterized by increased percent body fat. The results reveal that while BMI may be used successfully to discriminate extreme malnutritional states, for some population groups it becomes necessary to further investigate its validity due to varying body composition data obtained specific to these groups.

2.3. Food and nutrient intakes of women – Empirical evidence:

Bengoa in 1940 stated that human malnutrition is always an ecological problem in that it is the end results of multiple overlapping and interacting factors in the context of physical, biological, and cultural environments. Thus, the amount of various foods and nutrients available to persons of different age levels will depend upon such environmental conditions as climate, soil, irrigation, transport, storage and economic
level of the population as well as on such cultural influences as local cooking practices and food classifications especially in relation to the distribution or restriction of foods for the vulnerable groups. It is obviously important to have as much detailed knowledge as possible of the foods actually eaten in the family and the community, both for assessing nutritional status and for discovering the dietary ecological factors that may be available for correction. Diet surveys are an essential part of any food consumption assessment surveys (Jelliffe, 1966).

Devadas (1974) described the human element that determines the food habits which affects food intake and nutritional status. The human factor was seen as a complex variable consisting of many dimensions inclusive of the psychological dimension. Each of these dimensions was further elaborated as follows -

Physiological: taste, colour, feel, size, and texture in food preparation.

Economic: income, assets.

Social: family considerations, family size and intra-family distribution of food.

Cultural: customs, religious perceptions and prohibitions, prestige value and beliefs.

Psychological: emotions, sentiments and attitudes.

These are said to interact in a synergistic manner. Of the several factors listed, income, family size, family considerations and intra-family distribution of food were stated to affect food consumption. The cultural and psychological factors were said to influence the accessibility to foods.

In India the National Nutrition Monitoring Bureau was established in 1972, to assess dietary and nutrition situation in the country on a continuous basis. It commenced its activities with units in 9 states and five years later one more state was included. The NNMB is the only organization in India which has been generating data on food and nutrition intake and nutritional status on a continuous basis using standard
techniques on representative samples in rural, urban and tribal areas. Andhra Pradesh is one of the states among the 10 states covered by NNMB.

The average food consumption was assessed from 1976 to 1995. It was observed that the average consumption of cereals and millets was consistently higher than the RDA, while that of pulses and legumes, milk and milk products and fats and oils were about two-thirds of the RDA. The intake of green leafy vegetables was grossly inadequate, while that of other vegetables was half that of the requirement.

With regard to nutrients, the consumption of protein, energy and iron was satisfactory. However, the intake of riboflavin and Vit A was about 50% of the RDA. A similar trend was observed among the rural communities with regard to food and nutrient intakes assessed during 1975-79 and 1988-90.

It was also observed that the intake of energy showed a marginal increase in agricultural labourers, while it decreased among cultivators and others. However, the energy intakes in other labourers did not show any change. The mean intake of calories (k.cal) were 2043 and 2171 for agricultural labourers, 2123 and 2118 for other labourers, 2514 and 2356 for cultivators and 2244 and 2168 for others respectively during the survey periods 1975-79 and 1988-90.

Food and nutrient intake by socio-economic variables among rural communities during 1994 revealed that in all income groups the intake CU/day of cereals and millets is comparable to RDA, while that of other foods was low. The consumption of the income elastic foods such as milk and milk products and fats and oils was much less among the weaker sections like scheduled castes and scheduled tribes. In contrast the intake of GLV showed a reverse trend, however intake was lower for all income groups. The intake of various nutrients except iron was less than the RDA. The deficit was more among the weaker sections.
As related to occupation the intake of foods (Cal/day) such as cereals and millets of land less agricultural labourers and cultivators were above the RDA. There appeared to be a decrease in cereal intake with better occupational status. The consumption of income-elastic foods like milk and milk products, fats, oils, sugar and jaggery was higher in the households with occupations like services, business etc.

The intakes of energy, protein, total fat and riboflavin were lower among the labourers and artisans, while, compared to households with occupation like services and business groups. However, no perceptible occupational differences were observed.

NNMB reported the intake of nutrients per capita/day for women as 1701 k.cal for calories, 48.7 g for protein, 339.0 mg for calcium, 22.4 mg for iron, 1600 µg for Vit A, 1.456 mg of thiamine, 7.76 mg for riboflavin, 14.0 mg for niacin, 21.0 mg for Vit C and 64.0 mg for folic acid (Narasinga Rao, 1989). NNMB rural survey (1975-80) revealed that the intake of iron by the adult women doing sedentary work was 20.6 mg/day while the RDA was 30 mg. The intake of Vit A µg/day for the same group was observed to be 200 µg/day while the RDA is 600. Sex discrimination as a factor responsible for poor health and nutrition of our women becomes less important when compared to the overwhelming role of poverty which equally affects vast section of men, women and children in the rural countryside (Gopalan, 1989).

Protein intake based on NNMB (1980) survey data showed that mean protein intake was 48.7 g/day in females of Andhra Pradesh. The protein intake was below 75% of RDA in all states. Several investigators (Phansalkar et al., 1959, Apte and Venkatachalap, 1962 and Narasinga Rao, 1989) have stated that in India the diet of a large majority of the population consists predominantly of cereal and lacks protein rich and protective foods.
According to Walter et al., (1971) calorie intakes of low-income urban women in India ranged from 1200 to 1600 kcal/day.

Thimmayamma et al., (1982) examined the food consumption pattern and nutritional adequacies of population groups in and around Hyderabad as judged by age, sex and socioeconomic status. 574 subjects from 176 families in urban areas and 783 subjects from 171 families in rural areas were selected and their dietary intake was assessed by oral questionnaire for previous 24 hours. A decreasing trend in the intake of energy and proteins with a decrease in socioeconomic status was observed in all age groups. Adults in the upper middle and middle-income group had better energy and protein adequacies than those of low income and rural groups. There were no differences in adequacies between upper middle income and middle-income groups. Among adult females the adequacy was 69, 59, 47 and 63 percent of RDA in the four socio-economic groups respectively.

According to Thimmayamma (1982), Visweswara Rao (1987), Gopalan (1985), dietary intake differences in intake of calories and proteins by socio-economic grades were significant among school age children, adolescents and adults. Intake of iron was found to be inadequate in all the socio-economic groups. Per capita availability of majority of foods, calories, vitamins and minerals in India have been more or less steady over the years and were below the suggested requirement.

Misra et al., (2001) assessed the nutrient profile and its association with anthropometry, percent body fat and blood lipids in urban slum dwellers in northern India. The diets averaged 59-60 percent of energy from carbohydrate, 12 percent energy from protein and 24-27 percent energy from total fat. Overall, the carbohydrate, protein and cholesterol intake of both males and females was within the prescribed limits. Total consumption of fat was near 30 percent in the females, although intake of saturated fat
percentage energy was within normal limits in both males and females. As compared to females, males consumed significantly more total energy (p<0.001), total carbohydrates (p<0.001), total proteins (p<0.001), percentage of energy from protein (p<0.05), total fat (p<0.05) and saturated fat (p<0.05). Carbohydrate intake of this population deserve further comments since good correlation of total carbohydrate intake as percentage energy and triacylglycerol was observed in the study and that significant prevalence of hypertriglyceridaemia in the subjects is obvious.

Keyou (1997) attempted a study on young Chinese rural and urban adults of 20 to 45 years of age. The analysis of individual province data resulted in no significant correlation of energy consumption with means or distribution of BMI in most groups. It has been found that in rural populations, the undernourished declined, while achieved satisfactory rate for energy consumption increased. Overconsumption of energy is generally believed to be an important contributor to obesity in adults. Some studies, however, revealed that 300 - 400 Kcal less energy was consumed by obese people than by healthy weight people.

Andrea’s (2001) study on Maldives women showed that 22 percent had a BMI below 18.5. The diets of women and children were sufficient in protein (14 %) and carbohydrates (67 %) but deficient in fat, which contributed only 19 percent to the total energy intake. The low intake of β-carotene was underlined by low plasma concentration. The estimated iron intake was low, although blood hemoglobin was normal.

According to Elizabeth et al., (2001) among American women aged 20 - 45yrs the energy density influenced energy intake across all fat contents in both lean and obese women (P < 0.0001). Women consumed less energy in the low (7531 KJ) than in the high (9414 KJ) energy density condition. Despite this 20 percent lower energy
intake, there were only small differences in hunger (7 %) and fullness (5 %); women consumed a similar volume, but not weight of food daily across conditions. Differences in intake by weight, but not volume, occurred because some versions of manipulated foods, weight and volume were not directly proportional.

Thus, the research reviewed clearly depicts that in the rural areas the food and nutrient intakes of women from low socio-economic status groups is low in a majority of contexts. These low intakes have been shown to influence the anthropometric, physiological and biochemical status at varying intensities and levels with respect to different population groups.

2.4 Energy expenditure and nutritional status:

The body needs energy for maintaining body temperature, metabolic activity supporting growth and for physical work. The energy allowances recommended are designed to provide enough energy to promote satisfactory growth in infants and children and to maintain constant body weight and good health in adults. Among the factors which influence energy needs are age, body size, activity and in a limited way, climate and altered physiological status such as pregnancy and lactation (ICMR, 1992).

Energy requirements are best determined by measurements of energy expenditure. Total energy expenditure in convention is considered to be made up of three physiological components: a) BMR b) Thermogenesis and c) Physical activity (Jequier, 1984). The recommended energy allowances take into consideration the BMR and the physical activity pattern of individuals and the RDA for energy represents the mean requirement of individuals averaged over a period of a year. The energy intake level chosen as the cut-off point must not be just sufficient for mere survival but should be adequate for a minimal output of economically useful work by an individual consistent with his occupational status. During famine and drought situations, when scarcity of food and work exist, an individual's intakes of energy may be grossly
inadequate. In the initial period of such an event, the affected individual will progressively cut-down his activity to reach a maintenance level of requirement (That is 1.4 times his BMR) and if semi-starvation follows, the individual may become progressively wasted and less mobile. This is obviously not the situation during normal times. Hence, cut-off point to assess energy inadequacies should represent the actual requirement of individuals of the two sexes in a population averaged over the entire range of activity and body weights, that is, the weighted average. Such a level of intake permits at least a minimal quantum of socially desirable and economically useful activity. The committee therefore suggests the weighted average of energy requirement of population as the cut-off point for energy for determining the extent of energy inadequacy of the population. The weighted average of daily energy requirement for the entire population on the basis of present RDA is specified as 2200 k-calories in the Indian context.

2.4.1 Basal Metabolic Rate:

The metabolic contribution to energy expenditure normally amounts to at least two-thirds of the energy spent in a day.

BMR is defined as the rate of energy expenditure generally measured in the post-absorptive state at complete physical rest, lying down in the non-neutral state, 12-14 hours after the last meal, half-an-hour mandatory rest shortly after being waken up and without the presence of any disease or fever (Taylor et al, 1963; ICMR, 1992).

BMR has a stronger correlation with body weight than with any other nutritional anthropometric index used as a single independent variable. It is important to point out that the relationships are not perfect and the high correlations obtained with height are largely the result of the contributions of large numbers in the database.

Further evidence support these observations and implied that this phenomenon of a lower BMR in tropical populations was not unique to Indians but was found in other Asiatic groups as well. Soares and Shetty (1988) therefore reexamined the issue in
current population groups in India to see if the conclusions can still be held and in adult Indian males (18 to 29+ years) the entire group of men had mean BMRs 9.3% lower than those predicted by Schofield's equation for non-Indians. The percentage deviation of Indian data from this particular BMR predictive equation of Schofield varied among the subgroups from the same ethnic sample. The better nourished from upper socio-economic groups (in both urban and rural areas) had BMRs only 5.5 - 5.7% less than the Schofield's European and American values. The age matched individuals from poor socio-economic groups who were likely to be undernourished deviated by 12.7%. BMR and the Schofield predicted BMRs over deviations from the predictive equation showed 5kg body weight ranges, a curvilinear pattern decreasing to a minimum from <45 to >65kg.

Piers and Shetty (1993) measured the BMR of Indian women aged 18-30 years and residents of Bangalore during the mid-follicular phase of the menstrual cycle. The data were used to obtain a predictive equation for BMR from body weight. The BMR measurements were comparable to BMRs of 52 Indian women reported more than 50 years ago. There were no differences between the two groups. BMR of two groups was 4.7±0.6 mj/d and 4.4±0.4 mj/d respectively.

The relationship between body weight and BMR is not necessarily one of simple linearity as commented upon earlier by Francois (1981). The correlation between body weight and BMR are good, the differences may be accounted for by differences in the body composition affecting not only the ratio of fat to fat-free mass but also differences in the contribution of muscle and visceral tissues within the FFM (Shetty, 1993).

It is now generally accepted that weight provides the best predictor for BMR (Schofield et al., 1985; Soares and Shetty, 1988). Since the two are linearly related on regression analysis. Indians within age ranges 18-30 years suggested that height and
BMI contribute roughly in equal measures to variations in BMR (Soares & Shetty, 1988). The addition of other variables makes hardly any difference to the strong correlations that body weight has with BMR. However in the 30-60 years, age explained variance in BMR by 5.3% (Soares, Francois and Shetty, 1993) which is in contrast to Schofield's observation that age made little difference to the final prediction equation relating BMR to body weight for males >18 years old. Single equations could be successfully fitted using a single independent anthropometric variable of weight or weight square and that the addition of several variables such as age or height added nothing more to the prediction other than a small increase in noise.

Study reported by Dakshayani et al., (1962) on BMR and body composition of normal Indian women showed that the BMR / hour were 48.1 kcal. The BMR of women is lower than that of men when expressed in terms of surface area, but tend to be slightly higher when expressed in terms of LBM or cell solids.

Benedict and group in 1919 and Keys et al., 1950 during the second World War, has demonstrated that following a period of energy restriction, individuals attain energy balance at a new, but lower level. This new plane of balance in energy is attained partly by a reduction in energy output and partly as a consequence of changes in body composition. The observed decrease in BMR in these semi-starved subjects was explained on the basis of both a decrease resulting from loss of metabolically active tissues associated with the reduction in body weight as well as a decrease per se in the metabolic rate or activity of the remaining active tissue mass. It is this latter response that is being projected as an indication of the increased “metabolic efficiency”.

Nirmala (1968) conducted study in post-adolescent women aged 17-19 years residing in several hostels in India. The BMR of the subjects were on an average $34.3\pm0.84$ kcal/hr/m$^2$ of body surface which was similar to other reports in India. A
calculation of the daily caloric expenditure from the BMR and from activities by factorial method showed an average output of 1967 kcal, which was not being met by the intake.

Influence of energy supplementation and its cessation thereafter on the BMR of chronically undernourished individuals studied by Soutes and Shetty (1992) showed that the rise in BMR exceeded that accounted for by the increases in FFM during the 12 weeks of supplementation and was attributed to increases in the amount and activity of the visceral tissue as well as to an added cost of lipogenesis. BMR at this stage were significantly lower than at the 12th week of supplementation, when expressed per kg FFM or when adjusted for FFM using an analysis of covariance. These results suggest an increase in the metabolic efficiency during this negative energy balance period. The study demonstrated that, in the chronically undernourished, the changes in BMR are reversible and hence, physiologically important to the process of adaptation to low-energy intakes.

Demonstration of existence of metabolic efficiency is erroneous on the basis of changes in the index BMR/kg FFM since these changes may reflect alterations in body composition of the individual (Shetty, 1993).

Crovetti et al., (1997) attempted to study the influence of thermic effect of food on satiety of normal healthy women from University of Milan and showed that the mean BMR of the 10 women selected as 5713±335 kJ/24h (1365±80 kcal/24h). The mean energy expenditure of the volunteers before lunch (11.0 – 11.30hrs; pre-meal) was 5911±279 kJ/24h (1413±67 kcal/24h). The individual CV's for the triplicate measurements were less than 5 percent. There was a significant difference between the BMR and the pre-meal energy expenditure.
Deviations between the observed Indian data and predicted BMRs, using Schofield's equations, were seen as the BMIs change from BMI 14 to 25. The lowest deviations, (-6.5%) is seen in the BMI range of 18-20 which could be considered as normal for Indians (Soares & Shetty 1988).

The association seen between BMR and BMI, in both well-nourished adults and those with low BMIs in developing countries has also been reported in well-nourished populations and those with increasing degrees of obesity in the West (Garrow et al., 1988).

Vasey et al., (1992) who followed up a group of men and women over a period of 30 or more years, showed that the BMI increased from 21.3 for men and 20.7 for women at age 18 to 27.5 and 26.1 at age 50. Such changes in weight and BMI will alter the energy requirements since increase in body weight will increase BMR.

BMI is thus not as useful predictor of BMR as body weight and so is not the most useful index for predicting the BMR of individuals or population groups when applying the factorial method to estimate human energy requirement. The value is same for short, medium height and tall individuals. BMR and consequently total energy expenditure can be predicted from the derived optimum body weight and thus BMI may be a useful addition in arriving at desirable levels of energy requirements of individual or populations (Shetty and James, 1994).

BMRs may be expressed either in absolute forms or as per unit body surface area (BSA), the latter procedure being a generally accepted practice till recently. BMRs were low in individuals who were chronically undernourished or energy deficient. Beattie and coworkers as early as 1947 reported undernourished German prisoners who had lost more than 25 percent of their body weight had BMRs per unit BSA, 16 percent below normal values. As per Venkatachalam and group in 1954, male adults who were
malnourished and semi-starved showed a 20 percent reduction in their BMRs per unit BSA. According to the Flieederbaum and coworkers in 1979, victims of severe malnutrition in the Warsaw ghettos also had markedly lower BMRs varying between 10 percent to 30 or 40 percent depending on the severity of the malnutrition. Similar findings were reported in other groups or chronically malnourished individuals during the Second World War. Srikanthia, Gopalan and others in 1962 also showed that the BMR expressed per unit active tissue was considerably lower in adult undernourished males. As per reports of Srikanthia et al., 1985, a comparable large series of measurements also showed the same trend; BMR per unit body weight increasing as the weight for height expressed as a percent of the standard diminished below 70 percent.

Lower limits of acceptable BMIs depend not only on the fat mass and FFM of an individual but also on the level of physical activity, which would enhance their energy turnover. The likelihood of thin, tall, physically active adults having a lower than a optimum range of BMI and presumably having normal or adequate energy intake has been recognized since even the NCHS data on adults suggests the presence of a reasonable number of underweight (BMI<18.5) but not necessarily under-nourished individuals in a community (Abraham, Johnson & Najjar, 1979).

Individual habituated to low energy intakes over prolonged periods exhibit change in BMR that suggests an increase in the metabolic efficiency. Shetty (1984) demonstrated a lower BMR per kg FFM in chronically undernourished individuals when compared with well-nourished subjects. Soares and Shetty (1991) showed that the CED subject from lower socio-economic strata with < 18.5 have a significantly lower BMR adjusted for FFM which may be indicative of an apparent increase in metabolic economy of the tissues of CED individuals.
BMR, body weight, height and fat-free mass by under water weighing in healthy, physically active urban (Bangalore, South India) dwellers of low socio-economic status was assessed by Perro Luzzi (1997). Subjects were selected on the basis of BMI and classified as three groups: severely undernourished (BMI<17.0) marginally undernourished (BMI 17.0 - 18.5) and wellnourished (BMI>18.5). The BMR of the wellnourished groups expressed in absolute terms (5.18 mj/d) was significantly higher than that of the severely undernourished group (4.64 mj/d). Normalizing BMR for either body weight or FFM by analysis of covariance abolished all differences. The mean BMR of the low BMI study group was substantially higher (11-14%) than that reported previously for undernourished Indian adults.

Prentice et al., (1986) reported on energy expenditure in over-weight and obese adults in affluent societies in analysis of 319 doubly labeled water measurements. The comparison between energy intake and expenditure revealed no difference between 24 EE and reported energy intake. This finding suggests, underreporting since physical activity outside the chamber during normal circumstances is likely to be higher than inside the chamber. The degree of underreporting was not possible to estimate as the researchers did not know how much more active these over-weight patients were outside the chamber.

Overweight and BMRs in men and women was examined by Goldberg et al., (1988) using the data from 80 healthy subjects measured on a total of 246 occasions. In a sub-group of 40 normal lean subjects the mean ratio of overweight metabolic rate (MR): BMR was 0.95. The mean ratio of lowest sleeping metabolic rate of BMR was 0.88. Ratios of overweight MR: BMR was not significantly affected by different levels of exercise on the preceding day. The ratio was significantly higher for subjects who were obese, late pregnant.
Schoeller (2001) stated that the obese individuals were deficient in energy expenditure and it was clear that obese individuals generally have a higher energy requirement than do those who weigh less. Energy expenditure in the etiology of obesity can no longer just depend on a finding that indicates of low energy expenditure but must also explain how expenditure increases above that of lean control subjects during or after the development of obesity.

Most of the difference between lean and obese subjects could be explained by increased heat loss across the abdominal wall in the less insulated lean individuals rather than by thermogenesis per se. Numerous investigators used the doubly labeled water method to measure energy expenditure in lean and obese humans. The results of the respiratory chamber studies showed that obese subjects have greater average energy expenditure than do lean and normal weight subjects.

2.4.2. Physical activity:

Energy is expended in performing various types of activities broadly classified as (a) essential or occupational activities (b) discretionary or non-occupational activities e.g., household tasks, socially desirable activities and activities aimed at physical fitness and promotion of health.

Physical activity is the major determinant of variation in the rate of energy expenditure among individuals of the same age, sex and body size and composition. Muscular efforts of every type qualify as external activities. Activity is the most variable factor affecting the total energy requirement. It is the external work of the body, but clearly, external work must involve a speeding up of the internal work and therefore, an increase in the metabolic rate, metabolism especially involved in production of work and extraneous motion incidental to the performance of work. Pike and Brown in 1970 stated that it is the extraneous motion that often determines the difference in energy expenditure between the two individuals performing the same task.
The energy cost of activities varies not only with the nature of the activity but also with speed and efficiency with which they are carried out. Walking fast requires more energy than cycling at 10 – 15 m/h. Also, a person with more efficient muscular co-ordination is likely to require less energy than one whose co-ordination is poor. Obviously it costs more energy for a heavy individual to carry out these activities when compared with the lean individual. King et al., in 1987 conducted studies on women groups and stated that occupation does affect the activity pattern. However, homemakers with children and working women expended more energy than unemployed women without children.

It was recognized that considerable variation may occur in the amount of physical work involved in any one occupation due to differences in the degree of mechanization. Bouchard et al., (1983) classified the activities into 9 groups and gave codes and energy costs (kcal / min for 60 kg person). Thus, under each code day-to-day activities were included.

2.4.2.1 Measurement of physical activity:

The method described by Passmore, Warnock and Durnin (1955) to assess the habitual physical activity was used by Jean and Chan in 1970. In this method each subject recorded his or her activity in a booklet with a page for each 24 hours divided into squares of 15 minutes. Different code letters were used to denote different activities. The appropriate code letters being placed in a square to indicate the activity during a particular 5 min. Squares could be divided when an activity took less than 5 minutes to perform. The energy expenditure was calculated by taking the values assigned for the energy cost of each activity.
The procedures followed were:

i. Timed observation of the activities performed by an individual, and
ii. Measurement of energy cost that cover the range of activities in every day life conditions.

Record of minute by minute observation through a so-called time and motion study is one method of assessing physical activity. The other feasible way is the determination of energy expenditure on the basis of heart rate measurements, which has been sufficiently accurate (Andrews, 1972). In this method simultaneous measurements of oxygen consumption and heart rate are taken with the subject at rest and at several levels of activity in order to establish the individual regression of energy expenditure on heart rate.

Of the total energy derived from the food, nearly 50% is used for basal function and the other 50% for physical activity. The energy expended in physical activity may vary from 1 to 3 times the activity. The level of O₂ consumption depends upon the intensity of energy expenditure. During rest and normal level of physical activity, only 30% of maximal O₂ consumption may reach the maximal capacity. Such capacity may vary from individual to individual. The work capacity can be expressed as the maximum work capacity (VO₂ max) or sub maximal work capacity that is 70-80% of VO₂ max. Maximal or sub maximal work capacity depends upon lung volume, maximal tolerable heart rate, rate of recovery of heart rate and the circulating blood haemoglobin level (Narasinga Rao, 1996).

Habitual energy expenditure is also measured by the method of direct indirect calorimetry. Direct calorimetry is technically a difficult and costly procedure. Energy output is also obtained with accuracy by indirect method (Rama Rao, 1990). Questionnaires, dairies and also interviews are used to measure the energy expended in physical activity (Montoye, 1971).
Several methods of energy expenditure in free-living human populations covering periods extending from one day to several days are in vogue. Self-recording of various types of activities by the subjects for 1440 min a day in a record booklet is one of the popular methods used in the developed countries. Considering the difficulties in obtaining compliance in recording minute-to-minute activity over the 1440 min during the day, Bouchard et al in 1983 suggested condensation of 1440 min into 96 blocks, each 15 minutes period.

Satyanarayana et al., (1988) proposed a method based on the combination of procedures used earlier as mentioned above to suit Indian rural conditions. Each subject was assigned for observation for 3 day period in a week. The subject was informed about the procedure of observation to be followed by a trained investigator recruited from the subject’s area. Care was taken to clear all doubts raised and assurance was given that the information collected would be kept confidential. Twenty four hours data period, spread over three shorter periods of direct observation on three consecutive days was recorded. The hours or minutes spent by the person under each of nine categories of energy cost were recorded. After completion of transcription of 24 hours of activities these 1440 minutes were separated into nine activity zones and total time spent under each activity code / category zone during 24 hours was obtained and correction factor for body weight should be taken into consideration.

This method makes it possible to assess total energy output in terms of kcal / day approximately, as well as enables us to classify individuals into known life styles like sedentary, moderate and heavy work categories with greater confidence. This method is an alternative to diary method, which could be completed only by highly motivated literate groups. Nutritionists, social scientists, anthropologists, sports scientists can now estimate the physical activity pattern of groups of individuals taking advantage of published values for energy cost of different groups of activities (Satyanarayana et al., 1988).
The problem in measuring energy expenditure (EE) particularly total daily energy expenditure (TEE) in free-living situations was reviewed by WHO / FAO / UNU (1985) and Durnin (1990). According to Yamauchi et al., (2001) there are only few studies that have compared the pattern of physical activities between urban and rural dwellers who shared the same genetic traits and cultural background.

2.4.2.2 Physical activity observed among different groups of Women-Empirical evidence:

WHO (1973) conducted a study on women’s activity pattern. The light activity in women required 36 kcal / kg / day and moderate activity required 40 kcal/kg/day. Lawrence et al., (1985) conducted a study on the energy costs of common daily activities in 92 individuals. Activities ranged from sitting quietly to standing, pounding grain (5 to 20 kg), which required the energy expenditure of between 1-5 kcal per minute and involved a variety of body movements.

Beliberg et al., (1980) estimated energy expenditure of female farmers in Burkina Faso (Uppervolta) in different seasons. In the dry season the women were found to have a total daily expenditure classified as moderate active, according to the FAO/WHO grading system, while in the rainy season their energy expenditure was classified as exceptionally active. The results indicated that women have much heavier work in traditional societies than that is supposed.

Durnin et al., (1990) conducted a collaborative study in Glasgow, Hyderabad (South India) on seasonality and marginal nutrition. The study was carried out on a group of 102 economically poor adult women living in a larger village near Hyderabad. Women not only looked after their households but also did agricultural work in the fields. A control group of 30 ‘middle-income’ women were also studied: they did only limited work in the household and no work in the fields. Serial measurements (six in all,
three in the harvest season and three in the lean season) were made of body weight, body fat and various anthropometric variables. There was a small loss in body weight and body fat (about 0.5 kg) and reductions in energy intake, BMR and exercise capacity in the working women. No changes occurred in the control group middle-income women.

According to Popkin (1994) the data on physical activity pattern of rural Chinese women show a significant increase from low and moderate activity patterns to high activity patterns.

Satyanarayana et al., (1987) attempted quantitative assessment of physical activity and energy expenditure pattern, among rural women. Results showed that mean body weight of women under study in Edulabad village was 39.0 ± 5.17 kg. During summer season of 1986 in the months of April, May and June, working women had spent 13.3 h of the day in the first of two categories of activities. They spent about 3.2h in the activities related to field operations of agriculture under categories 5, 6 and 7. They had spent 3.7h and 3.9h in group 3 activities and group 4 activities. The average energy output would place them in the category of moderate workers even in summer months. Rural working women were undertaking substantial agricultural activities even in the summer season. A total energy output of less than 2000 kcal/day would appear to be deceptively low before correction for body weights recorded in the village. In the same village middle income group women weighed 9 kg more and the average was found to be about 47.9 kg. An energy output of 48.5 kcal/kg/day during summer months by working women is certainly a higher estimate than one would tend to imagine. More than three hours duration of light and moderate field activities is a new observation for summer months. Two crops of rice raised in this village had provided opportunity for these women to be active and earn income from agricultural activities in summer.
Grant men et al., (1985) performed a second data analysis in which they adjusted the energy intake data for the participants reported physical activity. This eliminated the negative correlation in men but not in women (r = -0.16), suggesting that although some of the decrease in energy expenditure was related to physical activity, there must also be reductions in the other components of energy expenditure.

Studies on women in India have helped in the understanding of the time use patterns and the double work burden of women from different urban and rural backgrounds (Baliwala, 1985; Jeffery et al., 1989; Shatruga et al., 1993). However, the energy equivalents of the different activities were not measured in these populations.

Yamauchi et al., (2001) reported that there were no significant differences in total Energy expenditure and PAL. In contrast, significant differences were found in these indices in women (TEE, P<0.05, PAL, P<0.01). According to the work levels of WHO/FAO/UNU (1985), PAL were moderate to heavy for rural women moderate for urban men and women, and heavy for rural women. High levels of physical activity in the morning especially in women were also reported. This reflected the intensified agricultural activities done by women in the rural New Guinean highlanders. These results suggested that urban men and women were less active than their rural counterparts, although not significantly so for men.

According to Stubbs et al., (1993) increasing fat energy of a diet has been shown to increase food intake and at the same time interacting quite strongly with level of physical activity.

Sujatha et al., (2000) attempted to measure the energy cost of activities of women from the poor socio-economic group residing in urban slums located in the busiest part of the Hyderabad. When the RMR factors were calculated, the results of the energy equivalents for the standard activities such as sitting and standing in this present study appear to be lower when compared with the values reported by WHO/FAO/UNU (1985).
Yamauchi et al., (2000) conducted a study on Papua New Guinea Highlanders. The energy expenditure tended to be higher in rural men and women than in their urban counterparts. In resting conditions (i.e. lying EE, sitting EE, standing EE and RMR) rural women had significantly higher EE values than urban counterparts.

Shetty and James (1994) observed that in African women as in others physical activity for active life was better when BMI was 18.5 kg/m² (i.e. the normal group), while a BMI below 17.0 kg/m² (i.e. clearly underweight) increased the frequency of illness. However, the case was not so clear for women lying in the range between these two BMI cut-off points.

According to Gilbert (1989) in adolescents and adults of widely varying weight and body fat content, the energy requirement of the obese was due in part to their larger body weight and in part to their greater burden of body fat; together these accounted for 8 percent of the variance. That obese individuals need more to eat than the non-obese in order to stay in energy balance, whether confined in a whole body calorimeter or permitted to engage in light physical activity was experimentally proved.

It is commonly thought that the shifts in dietary structure and decrease in physical activity that occur with urbanization are at least partly responsible for the increase in obesity in many rapidly developing countries (Popkin, 1994).

The examination and assessment of physical activity as part of nutritional status assessment becomes imperative to explain adjustment, adaptation and functional failures in situations of either low or high energy intakes over long short duration.

2.5 Biochemical and clinical survey in the assessment of nutritional status:

Biochemical studies together with the data of physical examinations provide a means for estimating the proportion of the population in various broad zones of nutrition. When considered together with the physical examinations and dietary data, the biochemical studies, including saturation tests enable a more definitive appraisal of the nutritional status of individuals and populations (ICNND, 1957).
Clinical examination is the most essential part of all nutrition surveys, since ultimate objective is to assess levels of health of individuals and population groups as influenced by the diet they consume. The numerous signs and symptoms of dietary deficiencies have been classified by several individual scientists or expert committees.

For nutritional assessment of individuals and population groups, a number of schedules are now in use in different parts of the world. More commonly used consists of medical history, nutritional rating of subjects by general appearance, anthropometric measurements and a number of clinical signs and symptoms relating to various dietary deficiencies. The signs and symptoms commonly observed in malnourished subjects have been classified by the FAO/WHO Committee under three heads: Group-I signs related to malnutrition and known to be of value in nutrition cut-off points.

2.5.1 Haemoglobin

Haemoglobin is an important tool for diagnosing anaemia. Haemoglobin present in the red cells contain iron, which is needed to carry oxygen to all parts of the body. For the formation and normal growth of red cells, iron and vitamins like folic acid and B12 are essential.

Anaemia is defined as reduction in the haemoglobin level in circulation. WHO (1972) after having analyzed data of haemoglobin values in large number of different population groups has suggested cut-off points for diagnosis of anaemia (table 4).

Table 4: Cut-off points for Haemoglobin values for diagnosing anaemia

<table>
<thead>
<tr>
<th>Group</th>
<th>Haemoglobin (g/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult men</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Adult women</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>&gt; 11</td>
</tr>
<tr>
<td>Lactating women</td>
<td>&gt; 12</td>
</tr>
<tr>
<td>Children 6 years</td>
<td>&gt; 11</td>
</tr>
<tr>
<td>Older children</td>
<td>&gt; 12</td>
</tr>
</tbody>
</table>
Anaemia was further classified by Centers for Disease Control and Prevention (1998) and differentiated as mild, moderate and severe forms (table 5).

Table 5: Classification of haemoglobin values for diagnosing anaemia

<table>
<thead>
<tr>
<th>Haemoglobin (g/dl)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;12.0</td>
<td>Normal</td>
</tr>
<tr>
<td>10.0 - 11.9</td>
<td>Mild</td>
</tr>
<tr>
<td>7.0 - 9.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>&lt;7.0</td>
<td>Severe</td>
</tr>
</tbody>
</table>

Gopalan et al., (1989) stated that prevalence of anaemia among the urban population seems to be of a much lower magnitude than among the rural communities. The percent prevalence of anaemia among Hyderabad and Delhi rural women was 68.8 and 48.8 for the age groups 25 - 44 years and 44 years. For women of the same age groups in Calcutta the percent prevalence was 96.9 and 90.1 respectively.

Madhurima (1992) studied haemoglobin level, anthropometry and parasitic infection in 55 tea garden women workers of 25-35 years in Assam. Almost all the women were suffering from mild to severe form of anaemia. The mean haemoglobin level was about 10 mg/dl and out of the total sample 10.01 percent were between 8 - 9.9 g/dl, 65.45 percent between 6.0-7.9 g/dl and the rest 20.28 percent had haemoglobin level less than 6.0 g/dl.

Subhadra Kanani (1992), in Baroda, applied rapid ethnographic assessment (EA) as a methodological approach to understand women's perceptions about their morbidity especially anaemia Hb data of 482 women revealed that 80% women were anaemic (Hb<1 l g/dl).
Amita and Nina (1993) conducted a study on the health and nutritional status of women working at nuclear power station (Mumbai). Mild anaemia as indicated by Hb level of (10-11.9 gm/dl) and severe anaemia of Hb <8 g/ dl was encountered only in 7.4% and 0.6% of the subjects respectively. Other common health problems were related to skin (20%) or hair (26%) general debility, back pain and frequent headaches were also observed.

NFHS-2 (2000) study on anaemia among rural Indian women shows that 53.9 percent of women were suffering from different degrees of anaemia. The percent distribution for mild, moderate and severe degree of anaemia was 36.1, 15.8 and 20 percent. When the data was classified according to BMI, among women with a BMI <18.5, 37.0 percent were in the mild, 17.1 percent in the moderate and 2.7 percent in severe anaemic condition. Among women with BMI of >18.5, 34 percent were in mild, 13.7 in moderate and 1.5 percent were in severe anaemic conditions.

Untoro et al., (1998) studied the relationship between body mass index and haemoglobin concentration and work productivity in 230 Indonesian female industrial workers engaged in cigarette rolling. The median of the BMI of the women included in the study was 19.4 and ranged from 15.1 - 25.0 among the subjects. 41 percent of the selected subjects had BMI less than 18.5 and 12.2 percent had a BMI below 17.0, six percent of the MUAC and 82.2 percent of arm muscle bone area were below the 50th percentile of the MUAC reference values. Seven anaemic women had a BMI below 17.0, their average production was 533 cigarettes per hour whereas 55 non-anaemic women with a BMI between 18.5 - 22.5 produced 661 cigarettes per hour. The relationship between BMI and work productivity also remained significant (P < 0.05) after correction for marital status, or for work experience using analysis of co-variance.
Anemia has been found to be having several functional consequences. It has been shown to alter physical activity patterns in adults and children. Among adults physical work capacity and endurance capacity were shown to be significantly lowered. Further, the anemic state predisposes the individuals to several infections because of reduced resistance to disease.

2.5.2. Cholesterol:

Cholesterol is the basic steroid molecule associated with fats but is chemically different from them. Cholesterol is not only obtained from diet, but is also synthesized in various tissues. It is present both in free form and as cholesterol esters. All tissues containing nucleated cells synthesize cholesterol. The microsomal and cytosol fraction of the cell is responsible for cholesterol synthesis.

Acetyl co - A is the source of all carbon atoms of cholesterol.

Both dietary and biliary cholesterol contribute to the cholesterol in the duodenum. Biliary cholesterol is mostly non-esterified, and present in the form of micelles. It is more effectively absorbed than dietary cholesterol. Dietary cholesterol is present in both free and esterified forms. Pancreatic cholesterol-esterase activated by bile salts splits the dietary cholesterol esters to free cholesterol and fatty acids. The free cholesterol that is released is absorbed only via micellar solubilization which is a rate-limiting step in cholesterol absorption. Cholesterol absorption is facilitated by triglycerides in the diet. In the mucosal cell, free cholesterol is re-esterified by the action of acylcoenzyme A - cholesterol - acyl transferase (ACAT). The absorbed cholesterol is incorporated into chylomicrons.

Kurup (1989) indicated that there was increased hepatic cholesterogenesis as was evident from the increased activity of HMG CoA reductase and increased
incorporation of labeled acetate into hepatic free cholesterol. Decreased esterification of cholesterol in the liver as indicated by the decreased incorporation of labeled into ester cholesterol, increased hepatic degradation of cholesterol to bile acids. Sucrose produces the higher serum cholesterol when compared to glucose or cornstarch.

2.5.3 Triglycerides:

These are the esters of fatty acids with trihydroxy alcohol (glycerol) and form a storage form of energy. One gram of triglyceride gives approximately 9 kcal or 36 k joules of energy in the body after absorption. The melting point of triglycerides determines their digestion and absorption. Melting point depends on the constituent fatty acids, their chain length, number of double bonds and cis or trans configuration of double bonds. Some free fatty acids especially saturated and trans fatty acids of chain length greater than 18 carbons that are released from the 1 and 3 position of triglycerides during digestion are not absorbed. However, the same fatty acids are absorbed efficiently in the form of 2-monoacylglycerol. Therefore, knowledge of the structure of triglyceride with respect to fatty acid distribution besides the fatty acid composition is essential to understand the nutritional and metabolic significance of dietary fats.

Triglycerides are synthesized from glycerol 3-phosphate and two molecules of fatty acyl-CoA. The phosphatidate formed is hydrolysed to generate 1,2 diacyl-glycerol (DAG) which is converted to triacylglycerol by the activity of 1,2 diacyl-glycerol acyltransferase in the presence of acyl-coA. Most of the enzymes are present in the endoplasmic reticulum.
Triglycerides digestion and absorption:

Digestion is initiated in the mouth where in chewing disrupts the cell wall of the food material and disperses the fat into small droplets. Small amounts of short and medium chain triglycerides are digested by lingual lipase in mouth and gastric lipase in stomach.

About 95% of the fat digestion takes place in the duodenum. In the duodenum fat emulsification occurs by the detergent action of bile salts (Lecithin and 2-monoglycerides). When the concentration of bile salts in the intestine reaches its critical micellar concentration, lipids and bile salts interact spontaneously to form negatively charged spheres known as micelles. Pancreatic lipase enzyme released from the pancreas into the duodenum preferentially cleaves off the fatty acid in position 1 and 3 of triglycerides and forms 2-monoglycerides. The process of lipolysis by pancreatic lipase is an extremely fast reaction compared to micellar solubilization. The function of the micelles is to solubilize the products of lipid digestion and facilitate their transport across the diffusion barrier called unstirred water layer, to the intestinal brush border membrane. The diffusion of the long-chain fatty acids and 2-monoglycerides are taken up by the smooth endoplasmic reticulum and re-esterified to triglycerides. These are then packaged into chylomicrons and transported to blood. Unlike the long chain triglycerides, the short and medium-chain triglycerides are completely hydrolyzed to glycerol and free fatty acids. The latter are bound to albumin and directly transported to the liver. Since the medium-chain triglycerides are easily digested and absorbed they are used in fat malabsorption syndromes.
A study by Devadas et al., (1980) on Tamil vegetarians, non-vegetarians and Gujarati women in the age group of 40-60 years, reported that their serum cholesterol levels were 192, 225 and 226 mg percent respectively.

Singh et al., (1980) reported cholesterol levels of normal group of healthy adults to be ranging from 140-300 mg/dl. Females had 186±25.20 mg/dl and men had 205.3±28.79. It shows higher levels in male subjects as compared to the females majority of the subjects were in the range of 181-120 mg/dl.

In an epidemiological survey carried out in Punjab (Kaverners and Saracen, 1988) the serum cholesterol levels of 3057 persons belonging to the middle or lower socio-economic groups were estimated. The value varied according to age. It was 133.46 mg/dl for adolescents, 160.82 mg/dl for adults. Among the above persons, the mean values were around 20 mg/dl higher than those of non-obese persons in each of the age groups.

According to Martin et al., (1986) in humans the total plasma cholesterol is about 200 mg/dl raising with age, although there were variations between individuals. An increase by 100 mg in dietary cholesterol causes an increase of 5 mg cholesterol / 100 ml serum.

Krishnaswami (1989) examined 630 patients in the southern states in India, of them 417 proved to have coronary artery disease and 216 were normal. The mean cholesterol (gm/dl) was 216.49 in the coronary artery disease and 183.16 in those with normal coronaries. Triglycerides again were 171.56 in CAD and 146.89 in the normal coronaries. Data from five zones reported were comparable and there was no difference in the regional distribution of cholesterol and triglycerides values. Low cholesterol and triglyceride levels were observed inspite of having very severe coronary artery disease,
Saturated fat and kilo calories did not have any statistically significant relation on the cholesterol levels whereas the carbohydrate intake, proteins, fats and poly unsaturated fats and cholesterol in the diet appeared to have a significant relationship with the present total cholesterol levels. The same could be said of the relationship between dietary intake and triglyceride levels.

Thune (1998) reported that physical activity improves the metabolic risk profiles in men and women of Northern Norway. Measurements of BMI and levels of serum triglycerides, total cholesterol and HDL – C were studied in relation to 4 levels of physical activity. There was a dose-response relationship between serum lipid level and BMI, and levels of physical activity in both sexes after adjustments for potential confounders. The combined sustained hard and very hard exercising group of women compared with sedentary women had lower total cholesterol concentrations (220 mg/dl Vs 228 mg/dl), triglyceride levels (91 mg/dl Vs 104 mg/dl), BMI (23.1 Kg/m² Vs 23.6 Kg/m²). An increase in leisure time activity over the 7 years improved metabolic profiles, whereas a decrease worsened them in both sexes. Sustained high levels and change from sedentary to higher levels of physical activity relative to sedentary men and women improved the metabolic risk profiles in both sexes.

Misra et al., (2001) conducted a study in urban slum colony of Northern India. The mean ± SD values of the metabolic parameters of the adult subjects were projected. A complete anthropometric and biochemical profile could only be obtained in 197 subjects (45 males, 152 females). Although statistically not significant, mean values of TC were higher in males and mean values of triacyl glycerol were higher in females. Significant prevalence of dyslipidemia was evident in both males and females. 52 percent of males and 20 percent females had a level of TC 200 mg %. A remarkable aspect was high levels of LDL – C (> 100 mg %) in 65 percent of males and 44 percent
of females. A low level of HDL – C (< 40 mg %) was also an important observation, recorded in 47 percent of males and 43 percent of the females. High triacylglycerol levels were observed in 14 percent of male and 13 percent of female subjects.

Steine et al., (2001) attempted a study on obesity and associated factors in Palestinian West Bank village population aged 30 – 65 years. The results showed that there was a relatively strong association between WHR and serum triglycerides, which persisted even after adjustment for age and BMI. There were indications of a weak positive association between WHR and serum total cholesterol, but this diminished upon adjustment for BMI. The pattern of creed and age adjusted associations of waist circumference with blood pressure and blood lipids were generally very similar to that of BMI with blood pressure. However, in models with both BMI and waist circumference, the association between circumference and blood pressure tended to diminish. The opposite pattern was seen for blood lipids, although the associations were generally relatively weak. The results of regression analysis of association of BMI with blood pressure and blood lipids related that BMI was significantly associated with blood pressure. The association between BMI and blood pressure was weaker after adjustment for waist circumference, particularly among women. There was a borderline significant association between BMI and serum triglycerides. BMI was negatively associated with HDL – Cholesterol, but the association was weak and only borderline significant. There was no significant association between BMI and serum total cholesterol, except a weak unadjusted association among women, which disappeared upon adjustment for age and WHR.

In Maldives women, the mean plasma concentration of cholesterol was normal (average 148 mg/100 ml) which was attributed to the very low fat intake. It is well known that, in adults, α – tocopherol plasma levels were closely correlated with cholesterol and total lipid concentrations (Andrea, 2001).
Several factors appear to modulate the serum lipid profiles both in undernutrition and overnutrition states. Further, anthropometric indices were shown to correlate with these lipid profiles, though not in all contexts. However, while desirable lipid profiles are essential, many a times they are mentioned only in the context of overnutrition. Therefore, a focus on these lipid profiles among poorer sections of the population is needed to examine the consequences and to interpret them in proper perspective.

2.5.4. Prevalence of clinical nutritional deficiencies among women:

Lakshmi and Gayatri (1997) studied the nutritional profile of about 1000 workers in age group of 30 – 50 years. They were performing heavy and moderate work and were randomly selected. Among these subjects occurrences of B-complex vitamin deficiency namely chelosis (10.2 %) and angular stomatitis (8.7 %) and vit C deficiency namely bleeding gums (7 %) were observed.

Sunanda and Prerna kumari (1995) studied the nutritional status of women in sericulture farming (n=30, age 20 to 46 years). Angular stomatitis was the major deficiency sign, followed by bleeding gums and glazed tongue. Occular manifestation of vitamin A deficiency observed in women was xerosis of conjuctiva. Anaemia was one of the most commonly observed deficiency disease among women. Dry and rough skin observed among women was partly attributed to inadequate intake of vit A rich foods and partly due to exposure of skin to climatic conditions.

Chaliha et al., (1993) studied the nutritional status of the women in knitting industries of Tirupur. Clinical examinations recorded the prevalence of several deficiency diseases like anaemia, angular stomatitis, red glazed tongue and bleeding gums.
Mehta (1994) studied health status of middle class working women of Bombay. The percent prevalence of hair problems was 33.3 %, dental caries was observed 38.9 % and mild anaemia in 60.0 % of the subjects.

Ranjana et al., (1996) conducted a study on health and nutritional status of working women from Jodhpur showed that the vitamin A, B-complex or vitamin C deficiency was not noted among the women. Thyroid enlargement was seen only in 2 % of individuals and less than 2 % of the working women had hypertension.

NNMB (1984) reported the percent prevalence of vitamin A and B-complex deficiencies in the adult females belonging to different social group (table 7).

<table>
<thead>
<tr>
<th>Social group</th>
<th>Vitamin A deficiency</th>
<th>Vitamin B-complex deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural females</td>
<td>2.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Urban HIG females</td>
<td>-</td>
<td>0.4</td>
</tr>
<tr>
<td>MIG</td>
<td>0.2</td>
<td>1.6</td>
</tr>
<tr>
<td>LIG</td>
<td>1.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Industrial laborers</td>
<td>0.5</td>
<td>2.6</td>
</tr>
<tr>
<td>Slum females</td>
<td>1.3</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Clinical nutritional deficiencies indicate a severe form of malnutrition, where a chronic specific nutrient deficiency has projected itself as a disease condition when adjustments and adaptation have failed and a pathological condition has set in. This assessment becomes crucial to the examination of both over and under nutritional states. Where chronic imbalances in the proximate principles co-exists with multivitamin or mineral deficiency states predisposing the individual to severe health consequences.