Review of Literature
A majority of the population in the developing countries suffer from malnutrition and under-nutrition. Around one-third of the world’s malnourished young children are found in India, who are denied a fair start in life. Half or more of the children under four years of age are malnourished (underweight and stunted), despite decades of planning, constitutional, policy, resources and programme support. These figures exemplify the challenge before India of promoting early childhood development and preventing malnutrition, as early as possible, with its adverse effect on limiting the healthy growth and development of the young child (A Report of the National Workshop on Early Childhood Development, 1996).

2.1 Prevalence of malnutrition

Young children are particularly at risk of malnutrition and its consequences are generally more serious in children than in adults. Childhood nutrition is reported to be significantly correlated with nutritional status at adulthood (Vazir, 1990). Childhood is crucial stage for optimum growth and development of a child. There is a substantial body of research available to indicate that malnutrition is an important factor in the environment of the child which can lead to physical growth retardation, reduced stamina, low work output, poor cognitive development and socialization (Kakker et al., 1987; Vazir, 1988 and Solomons et al., 1993).
Nutritional status refers to the health of an individual as affected by the intake and utilization of nutrients. An individual may be considered nutritionally malnourished including either deficiency or excess of one or more nutrients. Nutritional status of the child depends on many variables such as socio-economic, socio-cultural environment and maternal environment. Ecology of malnutrition is so complex that in areas where food is plentiful, malnutrition may be evident (Rabiee and Geissler, 1990).

Rapid population growth and limited food production are universally recognized as the two major global problems confronting human life. Poverty is the main cause of widespread malnutrition amongst people (Devadas and Easwaran, 1967; Devadas et al., 1980; Black Moreno, 1982 and Abbi et al., 1988). Food consumption pattern though is one of the most important determinant of the nutritional status, the nutritional status of children results from the interplay of environmental and family factors also (Lantham, 1990).

Malnutrition is considered as primary if it is primarily due to dietary deficiency and secondary if it is due to some disease. In considerable proportion of cases, both the factors may be operative (Gupte, 1989).

In general, malnutrition in children is reported to be due to inadequate food intake or consumption of particularly nutrient deficit food and which is often influenced by infections. Malnutrition and common infections combine to pose enormous hazard to the health of the majority of the population that lives in poverty. These health hazards particularly threaten children under 5 years of
age and also associated with increased mortality. The children who survive are retarded in their physical, psychological or behavioural development and may have other abnormalities that may contribute to a reduced ability to function optimally as adults (Nabarro, 1988 and Lantham, 1990).

Under-nutrition is the outcome of a synergistic summation effect of two components, i.e. inadequacy of diet with respect to one or more essential nutrients and the superimposition of the stress of infection which may interfere with the intake, absorption or assimilation of nutrients. The common manifestations of malnutrition are protein-energy malnutrition, nutritional anaemia, night blindness and iodine deficiency disorders. Protein-energy malnutrition is the most widespread form of malnutrition among children (Gopalan, 1992).

Rao (1984) reported that prevalence of protein-energy malnutrition (PEM), hypovitaminosis A, anaemia and vitamin B complex deficiency signs were high among rural preschool children and vitamin deficiency signs were found to increase with age. As per National Nutrition Monitoring Bureau (NNMB) surveys (1975-79) in ten states including Uttar Pradesh have reported high incidences of PEM, hypovitaminosis A, anaemia and iodine deficiency disorders among population. Mild and moderate forms of malnutrition are known to be prevalent among nearly 80 per cent of preschool children in India (Vazir, 1988).

The repeat surveys carried out by NNMB (1988-89) in 10 states have shown decline in the prevalence of severe forms of malnutrition and an increase
in the proportion of children in normal category. Still a sizeable population suffer from varying degrees of malnutrition as evident from Table 2.1.

Table 2.1: Prevalence of malnutrition

<table>
<thead>
<tr>
<th>Weight for age as % of NCHS value</th>
<th>Nutritional status of the child</th>
<th>1976-79 (%)</th>
<th>1988-89 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than 90</td>
<td>Normal</td>
<td>5.9</td>
<td>9.0</td>
</tr>
<tr>
<td>75-90</td>
<td>Mild malnutrition</td>
<td>31.6</td>
<td>37.5</td>
</tr>
<tr>
<td>60-75</td>
<td>Moderate malnutrition</td>
<td>47.5</td>
<td>43.8</td>
</tr>
<tr>
<td>Less than 60</td>
<td>Severe malnutrition</td>
<td>15.0</td>
<td>8.7</td>
</tr>
</tbody>
</table>

* National Council for Health Statistics (NCHS)

The repeat surveys of NNMB do not indicate any significant improvement in the dietaries, but improved nutritional status is evident which is attributed to more prompt control of super added infections, which generally serve to aggregate the severity of clinical under-nutrition, than to dietary improvement (Gopalan, 1992). Survey carried out by Government of India (1992) stated that 81.4 per cent children suffered from mild and moderate degrees of PEM while 8.7 per cent children suffered from extreme degrees of PEM. The deficiencies of vitamin A and B complex were found among children, adolescents and adults to a varying degree of extent. The riboflavin deficiency among children has been found to be associated with increased incidences of upper respiratory tract infections (Lakshmi, 1992).

Children are among the worst affected by malnutrition according to various authors in the developing and under developing countries (Swaminathan, 1985). According to Reddy (1996) that PEM is still the most common nutritional disorder
among children in developing countries. A number of nutritional deficiencies are prevailing among the children of various age groups, although the under five age group is considered at greatest risk (Reddy, 1996). The primary school age children which also includes the seven to nine years age group is not an exception from malnutrition.

Chen (1977) examined 2340 children 6 to 9.9 years old in two schools using Malay and one each using Chinese, Tamil and English as the teaching medium. Proportion of children with a defect was 27 per cent in body weight for age 25 per cent in height for age and 9 per cent in body weight for height. Indians had the highest proportion of children deficient in body weight for age, (41%) and weight for height, (16%). Malays had the highest proportion of children deficient in height for age (38%). Chinese had the least percentage of deficient children in body weight for age, (14%) and height for age (13%) and about the same in body weight for height as in Malays. According to Vijayaraghavan (1996) globally it is estimated that every year about 7,00,000 children are likely to develop corneal lesions due to vitamin A deficiency. The problem is considered to be of public health significance in 36 countries in South East Asia, the Western Pacific and Africa. Vir and Nigam (2001) studied the nutritional status of children aged 3 to 59 months in Uttar Pradesh. The results indicated that more than half of the children were found underweight. The percentage of severely malnourished children was 22.4%. The highest incidence
of malnutrition was observed in the eastern belt which is a waterlogged region followed by Vindhyachal.

Malnutrition is also associated with mortality, disability and morbidity of young children (A Report of the National Workshop on Early Childhood Development, 1996). Common childhood infections like diarrhea, measles and pneumonia occur in association with malnutrition and contribute to about 70 per cent of mortality (NIN, 1998). In developing countries like India, more than 60 per cent of preschool age children and more than 50 per cent of school age children, mostly mild and moderate grades, malnutrition is mainly responsible for child death (Bhaskaram, 1999). It is estimated that approximately 6000 to 7000 of 0-5 years children die every day in India due to malnutrition (Devi and Geervani, 2000).

Gerberding (2006) made an statement regarding statistics on nutritional contributors to child death and illness and listed some well documented contributors.

(i) Each year, under nutrition contributes to the deaths of about 5-6 million children younger than 5 years in the developing world, according to UNICEF. Another 146 million children younger than 5 years are underweight and at increased risk of death, illness, disability and underachievement (UNICEF, 2006).

(ii) UNICEF reports that in the least developed countries, 42 per cent of children are stunted and 36 per cent are underweight.
(iii) A vitamin A deficient child faces a 23 per cent greater risk of dying from ailments such as respiratory illness diarrhea and malaria.

(iv) Lack of sufficient folic acid intake among women of child bearing age contributes to an estimated 200,000 babies born with crippling birth defects throughout the world.

(v) Iron deficiency, one of the top 10 causes of global diseases burden contributes to about 60,000 deaths among women in pregnancy and child birth, and roles 40 per cent to 60 per cent of developing world’s children of their intellectual development (UNICEF/MI).

Effective and inexpensive interventions such as food fortification, supplementation and dietary improvements have eliminated most micronutrient malnutrition in developed countries and could result in similar public health improvement in developing countries.

Shiva Kumar (2007) analysed the National Family Health Survey-3 for 2005-06 and reported that 46 per cent of children below the age of three are underweight down from 47 per cent in 1998-99. It is disappointing that despite the acceleration in economic growth and the country’s economic buoyancy, there has been only a one percentage point reduction in the proportion of underweight children at the end of seven years. National Family Health Survey-3 offers insight into some of the factors that account for the abysmal progress in reducing the child nutrition.
(i) Improvement in expanding the reach and coverage of public health services over the past seven years have been very limited.

(ii) Access to critical components of treatment of childhood diseases has deteriorated over the past seven years.

(iii) Critical public health messages are simply not reaching families with children.

(iv) Levels of child malnutrition are closely linked to the care women receive during pregnancy and thereafter.

(v) There is a close link of health and nutritional status of children with the health of mothers.

They further reported that the economic growth rate and efforts at reducing income poverty are also not associated with reduction in child malnutrition in any predictable manner.

2.2 Factors affecting nutritional status of children

Nutrition in childhood is the basis of survival and good health in adulthood because health of an adult determined by the nutritional status during childhood. According to Devi (2000), malnutrition is a complex product of economic, socio-cultural, biological and psychological factors. Factors causing malnutrition in developing countries can be grouped into four groups namely economical, socio-cultural, ignorance and recurrent infections. There is a strong relationship
between nutrient composition of the diet, body function and physiological size of
the individual child.

2.2.1 Socio-economic factors

Feeding practices and growth pattern can not be viewed in isolation from
the socio-economic environment and socio-cultural milieu in which the
communities and family live. This is the physical biological and cultural
environment at the family level and the social, economic and political
environment at the community level which are important. These factors produce
their effects together with other crucial factors like education, sanitation and
health services offered and utilized by community. In developing countries socio-
economic differences in growth are marked and the relationship with the
prevalence of nutritional problems is evident (Waterlow et al., 1977; Bogin and

Grewal et al. (1973) reported that children (6-36 months old) with better
nutritional status come from families with higher income. Owen et al., (1974)
observed that in United States malnourished children in the age group 1 to 6
years came from the poorer groups. Gupta et al. (1976) reported that income
directly relates to purchasing power of nutrients. Similarly, Brown and Tiemen
(1986) also found in their study that dietary intakes of 1 to 5 year old children
from low income households were lower than the dietary intakes of their
counterparts from higher income households.
Ellozy (1978) analysed 3 studies related to socio-economic influence on the weight-height relationship in children from developing countries and showed that the rate of decay was related to the socio-economic levels, with the better off children maturing faster. Protein energy malnutrition was found to be seriously prevalent among the preschool children belonging to poor socio-economic status than those belonging to the higher socio-economic status (Choudhary and Rao, 1983). The relationship between income and malnutrition become significant when per capita family income index was used (Cedraz and Carvalho, 1990). Stunting was inversely proportional to income. According to Reddy et al. (1993) socio-economic status and expenditure pattern of the family are the important determinants of child's nutritional status.

Xerophthalmia is primarily confined to children from the lowest social classes. Families in lower social classes in general have poor acces to vitamin A rich foods and tends to have poor understanding of the role that proper nutrition play in the well being of the children (Brink et al., 1979 and Mele et al., 1991).

Another study conducted by Thimmayamma et al. (1982) showed a decrease in cereal intake and increased milk intake was observed in school age children in upper middle income group. Upper middle income group and high income group children were having higher proportion of energy and protein adequacies than the middle and lower income group children. Valverde et al. (1977); Garon et al. (1978) and Mazur and Sanders (1988) have also reported that the socio-economic status is correlated with child health and nutrition.
Ganguly et al. (1987) documented a positive relationship between nutritional status of child and the household socio-economic status characteristics.

The deficiency diseases are aggravated by infective morbidity prevailing among the low income population group in rural and urban areas due to poor environmental hygiene and paucity of proper health care (Rao, 1999). The study conducted by Anuradha et al. (2000) revealed that water contamination played a significant role in causing diarrhea. The study also showed a significant relationship of hand wash contamination to diarrhea morbidity.

2.2.1.1 Income and occupation

Poverty is the main cause of widespread malnutrition among the children (Devadas and Easwaran, 1967; Devadas et al., 1980). Bairagi (1980) reported that the increased prevalence of under nutrition with increased poverty and over nutrition with better economic status.

Monterio et al. (1992) reported that the existing food availability within the family, family environment and the nature of child care were found to have determinental effect on the diet and health status of the children, contributing to the nutritional status in childhood. These factors were mainly influenced by the family income level.

According to a survey conducted by Grewal et al. (1973), land ownership which is also closely associated with income was found to have a positive effect on the nutritional status of children.
Agrawal et al. (1976) observed a direct relation of income and anthropometry and reported that average heights and weights of children belonging to higher income community were greater than those of their counterparts in low income community.

Dutta (1982) surveyed the heights and weights of two groups of children from birth to 14 years of age by semi longitudinal method. One group consisted of children with good nutrition belonging to families with monthly income of Rs. 1000 and living in better residential quarters in Delhi. The other group consisted of children with poor nutrition coming from families with monthly income below Rs. 200 and living in poor residential areas. The mean (50th percentiles) height and weight of children of both sexes belonging to former group compared well with 50th percentiles of American children. But heights and weights of children of both sexes belonging to later group corresponded with 25th percentile and 10th percentile values of American children respectively.

Income also affects the availability of medical care which has a positive effect on the nutritional status and growth of the child. Higher frequency of common infection was noted in low income group by the Gupte et al. (1976). A little later Dhingra (1977) reported higher incidence of infections, infestations and vitamin deficiencies in the children of low income group. In South India, Devadas et al. (1980) found that dietary intake which reflects the nutritional status was also influenced by monthly per capita income.
On the whole, socio-economic status was found to be related to the nutritional status of children (Banik et al., 1982). Similar were the findings of the studies conducted by Singhaniya et al. (1987); Walia et al. (1988) and Bhuiya et al. (1989).

Jacoby and King (1999) stated that economists have long had a keen interest in the relationship between income and nutrition. One strand of research has focus on how income influences food consumption and consequently, nutritional status. A second strand of research has reversed the direction of causation examining how nutritional status affects income and ultimately, economic growth via labour productivity. This study considers a different route through which nutritional status affects income. Rather than invetiage whether malnutrition among adults diminishes physical efoort, it considers whether malnutrition among young children impedes their acquisition of academic skill.

2.2.1.2 Family size and birth order

Family size has been found to be positively correlated with the prevalence of malnutrition, morbidity and infection among children belonging to the poor socio-economic status (Kumar, 1976). They studied rural families around Hyderabad city and found that restriction of the families to 3 (no.) or less children and increase in inter-pregnancy period to 3 years or more had a beneficial effect on health and nutritional status of the young children.
In rural and urban communities around Bombay, Mudkedkar and Shah (1975) observed higher percentages of preschool children weighing less than 70 per cent of the standard. Protein inadequacy in the diet and clinical symptoms of anaemia were also highly prevalent. Devadas et al. (1991) observed lower incidence of various infections and deficiency diseases among the children with birth order less than 3 (no.) against the children with birth order above 3 (no.).

Czajka et al. (1978) reported high prevalence of anaemia among the youngest sibling in the family. Similar was the conclusion drawn by Easwaran et al. (1975) and Sadasivam et al. (1980) that youngest child was more at the risk of malnutrition.

Family size has been reported to affect the health and nutritional status of members of the family as it is an important factor which influences the per capita availability of food. Mudkedkar and Shah (1975) found in a study conducted in and around Bombay that the incidence of under weight in young children increased with increase in family size. Protein calorie malnutrition among children was found to be very closely associated with size and income of the family according to a study by Srivastava et al. (1979).

Davie et al. (1972) found that children in large families were shorter and lighter even when results were controlled for socio economic levels. After few years, Tenture et al. (1980) also reported similar findings. In another study, Gupta et al. (1976) found a significant direct relationship of family size with
nutritional deficiencies and morbidity. The very next year he noted that although there is significant relationship between the above parameters, the ‘unitary and joint’ pattern of family had no influence on morbidity pattern of children. Birth order is also known to affect the nutritional status of children. This was confirmed by Gupta et al. (1977). Khan et al. (1981) also reported that family size exerted significant influence on mobility and malnutrition. This was further supported by the studies conducted by Kabirallah et al. (1995) and Vajpayee et al. (1987).

Better nutritional status among children of joint families, was noticed by Grewal et al. (1973) in rural Madhya Pradesh.

2.2.1.3 Sex of child

Sex differences in growth and nutritional status have been reported by a few workers.

Grewal et al. (1973) also found that in rural Madhya Pradesh, among the 6 to 36 months old children, boys were better nourished than girls. Srivastava et al. (1979) observed higher percentage of protein calorie malnutrition among 2-3 year old female children of Lucknow. Behera et al. (1982) conducted a cross sectional study in tribal Orissa on 4010 preschool children of low socio-economic status and reported higher measurements in boys than girls upto 72 months. Powell et al. (1985) studied the nutritional status of children under 48 months in Jamaica and reported that children with poor nutritional status were girls.
**Malina et al. (1985)** reported that in rural agricultural community in Mexico growth of boys in terms of weight, sitting height, arm circumference and triceps skin fold was observed to be better than girls. The anthropometric measurements in boys also were different in different socio-economic groups.

Assessment of nutritional status of the community is one of the first steps in the formulation of any public health strategy to combat malnutrition. The principal aim of such an assessment is to determine the type, magnitude and distribution of malnutrition in different geographic areas, to identify the at-risk groups and to determine the contributing factors (*Jelliffe, 1996*).

### 2.2.1.4 Education of parents

Education of parents is known to affect the nutritional status of the child. **Dhingra et al. (1977)** conducted a study and found higher incidences of nutritional deficiencies and morbidity among the children of the family with low educational level. Though the mother’s education had pronounced effect on the nutritional status of children, the education attainment of the father was also found to influence the prevalence of PEM (*Srivastava et al., 1979*). **Devadas et al. (1980)** concluded that parental education level was correlated with immunization and health status of the young children. Higher the education level, better was the nutritional status of the children. **Singhania et al. (1987)** also supported that the parent’s education is more important than occupation and income in contributing to the nutritional status of the child.
The daily intake of vegetables, milk, fat and oils, and sugar and jaggery by the preschool children paralleled to the mother’s education, while fruits, green leafy vegetables and flesh food consumption was low even among the children of highly educated mothers (Devadas et al., 1980). Energy inadequacy was observed among the preschool children of illiterate or less educated mother in rural households in 10 states according to National Nutrition Monitoring Bureau (Brahman et al., 1988).

Devadas et al. (1991) have also reported the greater percentage of healthy children in highly literate group to medium and illiterate group. They also found higher incidence of diarrhea, viral diseases, followed by diarrhea and various nutrition deficiency diseases like anaemia, under-nutrition, angular stomatitis and conjunctival xerosis among both preschool and school going children 6 to 10 years old of illiterate mothers as compared to those of the mothers with high literacy level.

Anoop et al. (2004) reported that the interactions between current maternal depression and low birth weight and between postpartum depression and low maternal intelligence were statistically significant. The level of maternal intelligence was associated with nutritional status. The severity of malnutrition was also significantly associated with major depression during the postpartum period and maternal intelligence.
A study conducted by Nutritional Foundation of India (2007) suggested that in semi-urban Punjab, a relatively wealthy part of India, children are not malnourished because their family is too poor to provide adequate amount of food for its members. This study has documented that malnourished children receive lower calories than normal children despite adequate household calories for all household members. The high prevalence of under nutrition in infants and toddlers, at least in Punjab, is not due to lack of food but rather due to poor feeding practices. Hence, decreasing under nutrition in young Indian children is within our grasp, through intensive health education to mothers regarding infants and toddler feeding practices.

2.3 Nutritional status assessment methods

The FAO/WHO Joint Expert Committee on Nutrition (1950) published a report on the nutritional status assessment of the population. The application of anthropometric, clinical and dietary methods to assess the nutritional status was described in this report. According to Gibson (1990), dietary, laboratory, anthropometric and clinical methods are used either alone or in combination to assess the nutritional status of the population. These methods involve collection of data on socio-cultural variables, food beliefs and food habits, health and vital statistics, immunization of children, nutritional adequacy and dietary intake, anthropometric measurements, clinical examination for assessing nutritional deficiencies and biochemical assessment. These methods are also being used by ICMR, NNMB and WHO in nutrition surveys.
2.3.1 Anthropometric measurements

Nutritional anthropometry is the most useful and practical method for the nutritional status assessment of the children. According to Jelliffe (1966) nutritional anthropometry is defined as measurement of the variations of the physical dimensions and the gross composition of the human body at different age levels and degrees of nutrition. Gibson (1990) stated that anthropometric measurements are most commonly used in nutritional status assessment, specially in the case of chronic imbalance between protein and energy intakes. Besides being genetically determined, the physical growth of the body is mainly influenced by diet and nutrition. Therefore, anthropometric measurements serve as useful criteria for nutritional status assessment (Swaminathan, 1990).

Vijayaraghavan et al. (1974) stated that body weight and height, two most common measurements to evaluate growth and nutritional status, give information only about total body mass and linear growth. They do not give measure of two body composite (body fat and muscle mass). Arm circumference gives information about the status of muscle development and the extent of fat deposit. The use of skinfold thickness and arm circumference along with weight and height enhance the value of anthropometric data. In less industrialized countries where the amount of subcutaneous fat is very little, mid upper arm
circumference (MUAC) is directly proportional to change in muscle mass (Harries et al., 1984).

According to Chen et al. (1980); Trowbridge and Sommer (1981) and Alam et al. (1989), arm circumference is sensitive to changes in nutritional status and is superior to other anthropometric indicator to predict subsequent mortality. According to Alam et al. (1989) addition of arm circumference improved the predictive power of weight, height and age based indicators while the predictive power of arm circumference did not improve after addition of weight based indicators. The predictive power of arm circumference did not improve after addition of weight based indicators. The risk of death in children with arm circumference ≤120 mm was two times higher than in those children, measuring arm circumference< 140 mm.

Chen et al. (1980) found weight/age and arm circumference/age strongest to discriminating power of anthropometric indices increased by addition of maternal age, maternal height or housing size.

Rao et al. (1978) were of the view that height with weight/height index might be used in place of absolute weight to evaluate protein calorie nutritional status of the children, when age was not accurately known. Height and weight for height and weight/height$^2$ were considered to possess the best discriminatory power in children by different grades of body weight deficit and PEM in rural and urban area of Hyderabad (Rao et al., 1979; Choudhary and Rao, 1984).
The most widely used anthropometric measurements of growth are those of stature (height or length) and body weight. These measurements can be made quickly and easily with care and training. Anthropometry provides measures of body size and shape, and also indicates the dimension of some body compartments. The general consensus of those working in this field, is that nutritional anthropology has a significant role in the direct assessment of nutritional status in communities especially in young children among whom the problem of malnutrition is most severe and extensive (Jelliffe, 1966). Anthropometry is relatively efficient to detect individuals at high risk of mortality associated with malnutrition (Bamji et al., 1996).

Gurney et al. (1986) stated that arm circumference and triceps fat folds are two practical measurements for assessing nutritional status. Under the circumstances in which the recording of even weight and height is not feasible but a rapid information survey is required, arm circumference as a single anthropometric measure can provide satisfactory information on nutritional status of the subjects between the age of one and 18 years. Briand et al. (1988) stated that mid upper arm circumference is the most sensitive and specific anthropometric measure to assess the risk of dieing.

According to Swaminathan (1993) measurement of the circumference of the mid-upper arm may prove to be a useful and practical means of assessing protein-calorie deficiency of early childhood. Gurney et al. (1996) stated that arm circumference and triceps fat folds are two practical measurements for assessing
nutritional status. Under the circumstances in which the recording of even weight and height is not feasible but a rapid information survey is required, arm circumferences as a single anthropometric measure can provide satisfactory information on nutritional status of the subject between the ages of one and 18 years.

Both mid upper arm circumference (MUAC) by itself and in relation to age are used to assess wasting, a condition resulting from acute malnutrition and amenable to nutrition intervention (McDowell and Savage King, 1982). Some investigators claim that MUAC differentiates normal children from those with protein-energy malnutrition in the same way as weight for age (Shakir and Morley, 1974) and weight for length (McDowell and Savage King, 1982).

Anthropometric measurements like height, body weight, head circumference, chest circumference are the simplest method and are reliable means for assessing growth status (Behera et al., 1982). Rao and Vijayaraghvan (1998) reported that body weight is the most widely used and the simplest reproducible anthropometric measurement for the evaluation of nutritional status of young children. Serial measurements of weight in growth monitoring, are more sensitive indicators of changes in nutritional status than any other single measurement at a point of time.

Measurement of body weight for young children and height for older children and adults in nutritional assessment is well recognized. Height is
affected in undernourished children (Swaminathan, 1993). Height is a reflection of past nutritional status whereas other measurement refers more to current or transitory nutritional status (Seoane and Latham, 1971).

Chest circumference and head circumference alone can not be helpful in assessing the nutrition of an individual or group. Ratio of these two circumferences is used to screen undernourished children (Beal, 1980). Head size relates mainly to the size of brain which increases quite rapidly during infancy. The chest in a normally nourished child grows faster than head during the second and third year of life. As a result, the chest circumference over takes head circumference by about one year age. In poor children suffering from protein-energy malnutrition (PEM), due to poor growth of chest, the head circumference may remain to be higher than chest even at the age of 2.5 years to 3 years (Rao and Vijayaraghvan, 1998).

2.3.2 Dietary intake and nutrient adequacy

Diet survey, an essential part of any study of nutritional status of individuals or group gives information about nutrient intake, sources of nutrients, food habits, attitudes and frequency of food consumption. Studies have been conducted in different countries and it has been found that diets consumed by school children eminently affect their nutritional states. Nutrient deficiencies in the diets have been found to contribute to widespread incidence of protein
energy malnutrition, anaemia, vitamin A deficiency diseases, goiter and several other deficiency disorders. Diet survey also provides information about the extent of dietary or nutrient deficiencies and type of food and quantity, required to combat them. Fehily (1983) has recommended ‘diet diary’ or ‘food diary’ as a useful method in diet surveys. It includes the recording by the subjects of all the foods and drinks consumed in household measures for a specified period.

A number of diet survey methods are available. Depending on the purpose, level at which information is needed (individual, family, community or country) and the availability of time and resources survey method is chosen. Bamji et al. (1996) has listed food balance sheet method, inventory method, weighment of food, expenditure pattern method, diet history, oral questionnaire, duplicate sample method, dietary score method and recording method.

Dietary surveys assist in getting information on nutrient intake levels, sources of nutrients, food habits and attributes of an individual or groups. Hence, it forms an essential and important part of any complete study of nutritional status assessment (Swaminathan, 1990).

The dietary habits of individual/families/communities vary according to socio-economic factors, regional customs and traditions. Precise information on food consumption patterns of people through application of appropriate methodology is often needed for assessing the nutritional status of people for elucidating the relationship of nutrient intakes (Thimmayamma and Rao, 1996).
2.3.3 Clinical examination

Jelliffe (1966) examined those changes believed to be related to inadequate nutrition, that can be seen or felt in superficial epithelial tissue especially the skin, eyes, hair and buccal mucosa, or in organs near the surface of the body.

Pike and Brown (1975) were of the view that clinical examination reflects the long term nutritional status. Clinical lesions do not appear, unless the deficiency or disease is well advanced. They may also be influenced by other non-nutritional factors like intestinal parasites or infections, influencing absorption and metabolism of nutrients irrespective of the dietary intake.

Chase et al. (1981) stated that trichotillometry can be used as an indicator of protein-calorie malnutrition. This is based on determination of force required to pluck the individual hairs of the patient. Plucking force was found to be significantly and positively correlated with weight, arm muscle circumference and triceps skin fold.

According to Swaminathan (1990), clinical examination constitutes an essential part of all nutritional surveys to assess health level of the individuals or population group as influenced by their dietary intake. Clinical assessment consists of a routine medical history and physical examination to detect physical signs and symptoms (Gibson, 1990). Clinical examination is the most
essential part of all nutrition surveys to assess levels of health of individual and population groups as influenced by the diet they consume (Swaminathan, 1993).

2.4 Classification of nutritional status

Several classification schemes, utilizing at least one anthropometric index with its associated reference limits or cut off points are used to identify individuals 'at risk' to malnutrition, and in some cases identify the type and severity of malnutrition (Gibson, 1990).

2.4.1 Gomez classification

Various methods have been suggested to classify children into various nutritional grades using the body weights. The most widely used classification is the Gomez classification based on weight for age (Table 2.2).

Table 2.1 : Gomez classification (1955)

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Expected weight for age (%)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>&gt;90</td>
<td>Normal</td>
</tr>
<tr>
<td>2.</td>
<td>75-90</td>
<td>Mild malnutrition</td>
</tr>
<tr>
<td>3.</td>
<td>60-75</td>
<td>Moderate malnutrition</td>
</tr>
<tr>
<td>4.</td>
<td>&lt;60</td>
<td>Severe malnutrition</td>
</tr>
</tbody>
</table>
2.4.2 Indian academy of pediatrics classification

The classification recommended by the Indian Academy of Pediatrics (Table 2.3) is also based on weight for age. This classification is currently used by the Integrated Child Development Scheme (ICDS) for selection beneficiaries and growth monitoring (Rao and Vijayaraghovan, 1998).

Table 2.3: Academy of pediatrics classification

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Expected weight for age (%)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>&gt;00</td>
<td>Normal</td>
</tr>
<tr>
<td>2.</td>
<td>70-00</td>
<td>Grade I</td>
</tr>
<tr>
<td>3.</td>
<td>60-70</td>
<td>Grade II</td>
</tr>
<tr>
<td>4.</td>
<td>50-60</td>
<td>Grade III</td>
</tr>
<tr>
<td>5.</td>
<td>&lt;50</td>
<td>Grade IV</td>
</tr>
</tbody>
</table>

2.4.3 Waterlow classification

Waterlow (1972) has recommended use of only weight for height and height for age (Table 2.4). In this classification children with low weight for height are considered as 'wasted' and those with height deficit are considered as 'stunted'.
Table 2.4 Waterlow classification

<table>
<thead>
<tr>
<th>Height for age</th>
<th>Weight for height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of stunting</td>
<td>Degree of wasting (%)</td>
</tr>
<tr>
<td>(%)</td>
<td>Grade</td>
</tr>
<tr>
<td></td>
<td>Grade 0</td>
</tr>
<tr>
<td>&gt;95</td>
<td>(Grade 0)</td>
</tr>
<tr>
<td>95-90</td>
<td>(Grade I)</td>
</tr>
<tr>
<td>85-90</td>
<td>(Grade II)</td>
</tr>
<tr>
<td>&lt;85</td>
<td>(Grade III)</td>
</tr>
</tbody>
</table>

Country wide surveys indicate that more than a half of the Indian preschool children (1-5 years) suffer from sub-clinical undernutrition as indicated by low weight for age [<75% of National Centre for Health Statistics (NCHS) median weight for age]. About 65% of them are stunted (low weight for age), which indicates that undernutrition is of long duration (NIN, 1998).

Both mid upper arm circumference by itself and in relation to age are used to assess wasting (McDowell and Savage King, 1982).

The finding of the study done by Popkins (1985) suggests that the Gomez index may be best for identification of young children at risk of malnutrition and related morbidities within population.
QUACK-stick, a simple, inexpensive and reliable method was developed by Arnhold (1969) to identify acute malnutrition among children. According to Shakir the QUACK-stick assessment of PEM is probably as satisfactory as that of weight for age, and has many practical advantages under field conditions. According to Prasad et al. (1982) QUACK-stick identifies the result of poor nutrition better than long term chronic undernutrition.

The classification of prolonged and severe energy deficiency is very important to identify the incidence of protein energy malnutrition and dimensions for treatment. Categorization of the disease as acute, chronic or acute with chronic base is done by anthropometry to assess current nutritional level and degree of growth retardation among children (Tarun and Viteri, 1988).

2.5 Impact of socio-economic status on cognitive development

Most of the mental and physical development of human beings occurs in the first few years of life. These years are the child's one and only change to develop normally in brain and body and to grow to the highest genetic potential. If the various stages of development are not complete at the appropriate time, then lasting damage may be done to the complex process of growth. There is no second chance.

A data from low per capita income countries showed the effect of poverty on child development. In the U.S., among poor African-American and Hispanic babies anaemia is as high as 20 to 24 per cent. Countries in low per capita
income with iron deficiency anaemia (IDA) causes poor performance on mental and motor tests among children. These data suggested that IDA is a major public health problem among poor minority children that require prompt attention (Pollitt, 1994).

Choudhary and Rao (1984) stated that lower intellectual performance may be due to the higher prevalence of various forms of malnutrition, poor growth and poor socio-economic status, environment of the children and anthropometric measurements.

Trowbridge (1972) in his study suggested that in Australian sample, low socio-economic status, as measured by the mother’s educational level, family income and measure of composite chronic socio-economic disadvantage, was associated with the development of the child. Interestingly children born to mothers who were financially poor or with little education were likely to manifest developmental delays as children born to parents who had been chronically disadvantaged over a long period of time.

Grantham-McGregor (1999) studied the effect health and nutrition on cognitive development in children. They reported that almost 25 million low birth weight (LBW) infants (<2,500 g) are born each year, 95 per cent of them in developing countries. In developing countries, LBW infants are more likely to be born at term than those in developed countries and more likely to be small due to intranataline growth retardation secondary to maternal under nutrition and
infection. They also reported that infants born at term but small for gestational age (SGA) have a greater incidence of perinatal complications than normal birth weight infants (NEW) babies which may detrimentally affect their subsequent development. They also come from poorer homes than NEW children and are less likely to be breastfed. The babies from the poorest homes and those who have the poorest development are most likely to drop out. SGA infants were found to suffer from more infections and high mortality rates in the first year of life than NEW babies.

Most studies evaluating SGA children before 12 months have failed to find differences in developmental levels between SGA and new infants. However, a recent Brazilian study showed that SGA babies scored significantly lower on the Bayley mental and mortar subscale at 6 month and that the differences increased by 12 month. In American children who were arrested at 4, 5 and 7 years of age, IQ, language development and reading readiness were worse in NBW children when gestational age was controlled for, even without differences at 8 months of age. Similarly, SGA children who had not been different from NEW children before 12 months had significantly poorer developmental levels in their second year and had lower scores on a cognitive battery verbal factors score than the NEW group at 3 years of age. All studies in which IQ was measured showed this SGA children had lower scores or higher rate of mental retardation or learning deficits than adolescents who were NEW, although the differences were sometimes small and not significant (Grantham-McGregore, 1999).
The study conducted by Croizet (2004) showed that students from low socio-economic status backgrounds perform worse on standardized tests than other students. The term development embraces the concept of the unfolding of normal language, cognitive, motor and social skills — all of which are relevant to the child’s educational and social progress in contemporary society.

Karande and Kulkarni (2005) stated that education is one of the most important aspects of human resource development. Poor school performance normally results in the child having a low self esteem, but also causes significant stress to the parents. They gave many reasons for children to under perform at school such as medical problems, below average intelligence, specific learning disability, emotional problem, poor socio-cultural home environment, poor socio-economic status and even environmental causes.

2.6 Impact of nutritional status on cognitive development

A longitudinal study conducted by Stoch and Symthe (1955) showed that persistent malnutrition produces a child who has a lower intelligence quotient (IQ) and who exhibits behavioural problems. Champakam et al. (1968) studied 19 children aged 8 to 11 years who had been successfully treated for Kwashiorkor during preschool age, in order to observe the effects of early malnutrition on growth and mental functions. These children were matched with appropriate control for age, sex, religion/ caste, socio-economic status, family size, birth order and education levels of parents and subjects. Comparison between the
performance of experimental (Kwashiorkor treated) and control children indicated a significant difference which was more pronounced in the younger age group but intended to diminish in the older age group.

Yetkin and Mcharen (1970) reported the results of their first intervention study aimed at improving the behaviour of 17 severely malnourished hospitalized children in Lebanon. The nurses played with the experimental children using colourful toys and generally strived to enrich with the environment in the hospital. The developmental quotients (DQs) of these children showed greater improvement compared to DQs of 13 control children who were only intervened with medical and nutritional care but did not receive the added psycho-social stimulation.

Chavez and Martinez (1979) in Mexico demonstrated the beneficial impact of food supplementation on children's mental development as well as some specific behaviours such as activity and verbal interactions with parents. These workers hypothesized that the activity of the children could be instrumental in stimulating parental attention.

A study by Agarwal et al. (1989) on 1336 children (6 to 8 years) in relation to their nutritional status showed that, nutrition was the only factor weakly associated with the poor performance of the children in various tasks. The effect of nutrition was more pronounced in conversation tasks indicating poor verbal reasoning and comprehension in malnourished children.
In a longitudinal study conducted by Vazir et al. (1992) at NIN, Hyderabad stated that childhood nutritional status (Height and weight for age) at age 5 years was not related to intellectual level at adulthood. Results of linear multiple regression analysis indicated that educational status of the subjects could explain 23 per cent variation in their intelligence quotients. This was followed by per capita income and occupational status. Adult height had significant but weak correlation with the performance scale of the Wechsler's adult intelligence test. However, childhood nutritional status was significantly correlated with adult nutritional status.

Elyse (1999) showed an increased likelihood if mild or moderate associated with anaemia, independent of birth weight, maternal education, sex, race-ethnicity, the mother's age or the child's age at entry into the programmes for women, infants and children. These findings support the preposition that efforts to prevent mild and moderate mental retardation is to provide children with adequate nutrition during early childhood.

According to Fernstrom (2000) dietary intake affects brain function. Another study by Fernstrom (2000 a) indicated that nutrient supplements modify brain function. He showed that Zn supplementation in infants and pregnant women had demonstrated benefits in terms of the physical health, growth rate and cognitive development of the infants and babies born to the mothers taking supplements.
A cross sectional survey by Ketema et al. (2001) in Ghinchi, farming community, central Ethiopia assessed the level of association between children's nutritional status, families socio-economic gradient, and degree of maternal attention and cognitive development. Findings implicated a need for comprehensive approach, which incorporates, programs in nutrition, environmental sanitation, family planning, and strategies to reduce maternal work load, to ensure adequate physical and mental development of children.

A cross sectional study conducted by Aina and Morakinyo (2001) on ninety six healthy children aged 7.5, 10, 12, 18, 24 and 30 months (sixteen subjects in each age group). The anthropometric indices of weight, height and mid upper arm circumference (MUAC) were measured on each subjects, who was in turn subsequently assessed with the Barely Scales of Infant Development (BSID) a performance developmental inventory. All the subjects scored above the nomral developmental index of 50 when assessed with the BSID. The findings suggested that, malnutrition (as indicated by the anthropometric indices), on its own alone may not necessarily cause poor psychomotor development but perhaps, in synergy with some other environmental factors linked with retarded development.

A longitudinal study (Liu et al., 2003) on 1559 children aged 3 years, followed up, upto age 11 years revealed that, malnourished children had poorer cognition at both ages i.e. 3 and 11 years. Deficits were stable across time, applied to all sex and ethnic groups that means, malnutrition at age 3 years is
associated with poor cognition at age 11 years independent of psychosocial adversity. Further, promoting early childhood nutrition could enhance long-term cognitive development and school performance especially in children with multiple nutritional deficits.

Associations between taller stature and higher cognitive performance have been found to be robust across ethnic groups and geography, and have been interpreted as better nutritional status during periods of brain development leading to more advanced cognitive development (Manary and Solomons, 2004).

Michael et al. (2006) noted that the information processing fine motor skills and visual problem solving are improved by iodine repletion in moderately iodine deficient school children. As iodine is required for the production of thyroid hormones which are necessary for normal brain development and cognition.