Chapter 2

Review of Literature
Anthropometry has been widely and successfully applied to the assessment of health and nutritional risk, especially in children (WHO, 1995). Low height for age signifies a slowing of skeletal growth and is the principal indicator of long-term nutritional experience or growth impairment caused by malnutrition in the past. Low weight for height indicates tissue wasting and fat mass compared with the expected amount for a normal child of the same height or length. This may be due to failure to gain weight or from actual weight loss. One of the main characteristics of wasting is that it can develop very rapidly but under favourable conditions can be quickly reversed (Ying, Fengying, Wenjun, Keyou, Daxun and Onis, 1994). A child with low weight for age but normal height for age will usually have acute malnutrition of relatively short duration (Seoane and Latham, 1971).

The measurement of head circumference has recently won popularity mainly because of the increased concern about the possible relationship between PEM and retarded intellectual development. But there is no clear evidence that head size and intelligence are related at least in normal persons. The stronger correlation coefficients of head and chest circumference measurements with height for age rather than with weight for age indicate that both head and chest growth are more likely to be affected by chronic long-term malnutrition than by acute malnutrition (Seoane and Latham, 1971).

Socio-economic differences influence the dietary pattern of pre-school children, school age children, adolescents and adults (Gopalan, 1968; Thimmayamma, Rau and Rao, 1982). Though 80-90 per cent of family income is spent on food by low socio-economic groups in India,
adequate nutrients are rarely met (Gopalan, Balasubramanian, Ramasastri and Rao, 1971; Thimmayya et al., 1982). The cause of growth retardation is mainly due to poverty and lack of education (Onis et al., 1993; Ying et al., 1994) which is seen in children of low income group (Yip, Scanlon and Trowbridge, 1993). Gorstein, Sullivan, Yip, Onis, Trowbridge, Fajans and Clugston (1994) stated that the prevalence of underweight was positively correlated with that of stunting and wasting. The high prevalence of stunting was associated with environmental factors, socio-economic development, micronutrient deficiencies, inadequate protein intake and intensity of parasite infection (Gorstein et al., 1994; Ying et al., 1994).

One of the features of PEM is wasting of body muscles which is a part of the phenomenon in which protein and calorie reserves are depleted. Upper arm muscle circumference is reduced in severe malnutrition (Seoane and Latham, 1971). Jelliffe and colleagues (1989) suggested that malnutrition result in wasting of the pectoral muscles. Children having shorter height at the age of five years were found shorter in the later part of life while the children with normal height and weight at the age of five were found to have normal growth (Satyanarayana, Naidu and Rao, 1980). Moock and Leslie (1986) observed that stunting was associated with poor school achievement or intelligent levels in school children. Growth retardation in early childhood is associated with significant functional impairment in adult life. Children affected by marked growth retardation become adults with limited biological and intellectual abilities that diminish their working capacity. In women, stunting is a matter of great concern in terms of increased obstetric risks (Onis et al., 1993).

Countrywide surveys on growth of school children of poor socio-economic group in India show that their heights and weights fall below the third percentile value of normal well-fed Indian children or
Western children. Children of higher socio-economic group were taller and heavier than those counterparts in the poor socio-economic group. Children of elite families were seen as tall and heavy as those of American children. Variations in the growth pattern are due to variations in quality and quantity of adequate nutrition as well as suboptimal environment. As a consequence of the unfavourable circumstances, the children remains stunted in growth until he reaches adulthood (Gopalan, 1968; Gopalan et al., 1971; Vijayaraghavan, Singh and Swaminathan, 1971; ICMR, 1972; Rao and Sastry, 1977; Banik, 1982). Rao, Balakrishna, Veena and Thimmayamma (1991) observed that Indian children were lower in height/weight than children of NCHS, Harvard and England data. Asian children consistently shorter when compared with White and Hispanic children (Yip et al., 1993).

Alterations in the mass of diaphragm muscle tissue should exert a major influence on diaphragmatic strength and endurance (Lieberman, Faulkner, Craig and Maxwell, 1977). Steele and Heard (1973) showed a positive correlation between body weight and diaphragm volume and thickness. Thurlbeck (1973) observed a close relationship between diaphragm weight and body weight. He also noticed a poor relationship between size of the diaphragm and body length. Davidson (1968) postulated that the linearity of the relation between diaphragm and body weights indicate that the work of breathing is proportional to the mass of tissue to be oxygenated.

Chronic debilitation results in reduction of body cell and muscle mass (Willard, Gilsdorf and Price, 1980). Multiple changes in muscle function are induced by starvation, including alteration in fibre size, distribution and myofibril content (Hegarty and Kim, 1980).

Malnutrition induces respiratory muscle weakness and therefore may play an important role in the genesis of respiratory muscle dysfunction.
(Hunter, Carey and Larsh, 1981; Driver, McAvery and Smith, 1982). In patients with emphysema, there was a good correlation between the degree of air flow obstruction and somatic depletion (Openbrier, Irwin, Rogers, Gottlieb, Dauber, Thiel and Pennock, 1983). Arora and Rochester (1982a) demonstrate that poor nutritional status is associated with severe respiratory muscle weakness. The consequence of respiratory muscles' weakness includes reduced VC, increased RV and reduced MVV. They also found that in malnourished patients diaphragm muscle mass was 43% lower than normal (1982b).

Diaphragmatic muscle mass and thickness were significantly less in the calorie-restricted animals than controls. There were small decrease in the percentage of fast glycolytic and fast oxidative fibres and a small increase in the percentage of slow oxidative fibres (Kelsen, Ference and Kapoor, 1985). In animals subjected to prolonged nutritional deprivation, loss of diaphragmatic mass resulted in reduced diaphragmatic strength and this was about 41% than normals (Lewis, Sieck, Fournier and Belman, 1986).

Protein-deficient rats were smaller and had smaller lungs than normal rats and the lungs of food restricted rats may be less compliant than lungs from control rats (Mye:s, Dubick, Gerreits, Rucker, Jackson, Reiser, Williams and Last, 1983). Studies in undernourished rats showed the properties of lung viz. recuced non-connective tissue protein, RNA, collagen and elastin, enlargement of airspaces, decreased alveolar surface area and alveolar number (Ofulue, Kida and Thurlbeck, 1988). Sahebjami and Domino (1992) and Kalenga, Tschanz and Burri (1995a) reported that dry weight of the lung and lung volumes were reduced in starved rats. Kalenga et al. (1995b) also found that the volume and surface density of the lung parenchyma of malnourished rats did not differ from controls consistently.
Lewis et al. (1986) and Sieck, Lewis and Blanco (1989) reported that wasting of skeletal muscle was associated with reduction in muscle fibre size. Another observation suggested that respiratory muscle strength was mildly influenced by nutritional status (Lands, Desmond, Demizio, Pavilainis and Coates, 1990). Murciano, Rigaud, Pingleton, Armengaud, Melchior and Aubier (1994) presented data, which clearly demonstrates that the diaphragm was markedly affected by malnutrition and that the function of respiratory muscle can be restored after nutritional supplementation. The VC and FEV₁ were significantly increased in malnourished cases after nutritional supplementation. Restriction of protein and calorie intake affects the respiratory control mechanisms and respiratory muscle performance resulting in the deterioration of pulmonary parenchyma. The decrease in body weight is associated with a decrease in lung weight and abnormal elastic properties of the lung (Patel and Rupwate, 1994).

Malnutrition induces a reduction in muscle mass, which is associated with a decrease in contractility (Dureuil and Matuszczak, 1998). But Hards, Reid, Pardy and Pare (1990) and Sauleda, Gea, Orozco-Levi, Corominas, Minguella, Aguar, Broquetas and Augusti (1998) revealed that there were no significant relationship between the structure of diaphragm, external intercostals and nutritional status or any index of lung function.

Primhak and Coates (1988) observed a significant reduction in PEFR in wasted children but PEFR of stunted children was higher than average. The FEV₁ was lower in malnourished patients than normals (Lands et al., 1990). Faridi, Gupta and Prakash (1995) observed that FVC and FEV₁ were significantly reduced in malnourished children. PEFR and FEV₁/FVC% were spared from ill-effects of PEM, although the values were always lower in malnourished children. Studies on the structure of latissimus dorsi muscle and respiratory functions by Orozco-Levi, Gea, Sauleda, Corominas, Minguella, Aran and Broquetas (1995) showed an
inverse relationship between the FEV₁/FVC% and the diameter of type I and type II fibres.


Ong, Mehta, Ogston and Mukhopadhyay (1998) were of opinion that nutritional differences influence quantitative aspects of lung development in childhood. Joshi, Sharma, Sharma, Sitaraman and Pathak (1996) found that as a consequence of the growth retardation in children, their PEFR values were also lower in comparison with the normal children. Stein, Kumaran, Fall, Shaheen, Osmond and Barker (1997) stated that adult lung function is "programmed" in foetal life. Gupta (1997) indicated that multitude of factors like environmental pollution, nutritional status, etc., do contribute towards pulmonary morbidity. Swaminathan, Vijayan, Venkatesan and Kuppurao (1997) pointed out that nutritional and socio-cultural factors may play an important role in determining VO₂ max of children rather than ethnic differences alone.

The linear relationship between pulmonary functions and physical characters in children was well-established (Engstrom, Karlberg and Kraepelien, 1956; Onadeko, Iluyon, Sofowora and Adamu, 1979; Carson, Hoey and Taylor, 1989; Rahman, Ullah and Begum, 1990). Most static lung volumes and flow rates are greatly influenced by lung size which is largely determined by body structure (Knudson, Slatin, Lebowitz and
Burrows, 1976; Schoenberg, Beck and Bouhuys, 1978). Lung functions were significantly associated with growth rate of height in pre-adolescent children (Smeets, Brunekreef, Dijkstra and Houthuijs, 1990). BMI has a positive effect on lung function in girls, whatever their weight may be (Fung, Lau, Chow, Lee and Wong, 1990).

It was observed that FVC, FEV1 and FMF25-75% correlated significantly with age, height, weight and BSA (Ali, Vahalia and Ali, 1990). Olanrewaju (1991) suggested a good correlation of age, height, weight, chest circumference and BSA with FVC, FEV1 and PEFR. Shamssain (1991) observed a high positive correlation between FVC, FEV1, FMF and PEF with age and height in both sexes. There was a significant negative correlation between FEV1/FVC% and both age and height. Studies on lung functions in Malay children showed that age and PEFR was correlated with height of the subjects but FVC and FEV1 were correlated with height only (Ismail, Azmi and Zurkumain, 1993).

Roizin, Szeinberg, Tabachnik, Molho, Benzaray, Augarten, Har-Even, Barzilay and Yahav (1993) showed the relationship between different pulmonary functions and physical characteristics. A cross-sectional study on lung functions in Singaporean children showed a linear relationship between FEV1 and FVC with height in both sexes. Regression equations for FEV1/FVC showed that this ratio was independent of height in both sexes (Connett, Quak, Wong, Teo and Lee, 1994).

Jaja and Fagbenro (1995) stated that in both sexes, PEFR was correlated positively and significantly with age, height, weight and BSA. In another study, standing height was correlated with PEFR and FEV1 (Mabrouk and Ibrahim, 1995). It was found that FVC was highly correlated with body length and age. The airflow parameters FEF50, FEF75, FEF85 and FEF25-75% were also highly correlated with body length (Jones, Castile, Davis, Kisling, Filbrun, Flucke, Goldstein, Emsley, Ambrosius and
Tepper, 2000). BMI, along with height and age appeared to be an important predictor, which was significantly associated with VC, FEV₁, FVC, FEV₁/FVC and PEF in both sexes and with FEV₁/VC and FEF₂₅₋₇₅ in females (Pistelli, Bottai, Viegi, Di-Pede, Carrozzi, Baldacci, Pedreschi and Giuntini, 2000).

The linear relationship between respiratory functions and anthropometric measurements in Indian subjects were studied extensively (Bhattacharya and Banerjee, 1966; Ommen, 1987). Rajkappor, Mahajan and Mahajan (1997) and Mahajan, Mahajan and Mishra (1997) reported that lung function has better linear correlation with age and height as compared to weight which was earlier reported by Chowgule, Shetye and Parmar (1995). But Chetty, Ghai and Guleria (1975) observed that height was highly correlated with weight and age and its influence on vital capacity was partly reflected through weight and age.

The significant positive correlation between PEFR and age, height, weight, BSA and BMI was pointed out by several authors (Singh and Peri, 1978; Malik, Jindal, Sharda and Banga, 1981 & 1982; Pande, Mohan, Khilnani and Khilnani, 1997). A linear relationship between PEFR and physical characteristics in adult population was reported by Natarajan and Radha (1978) and Walter and Richard (1991). Mahajan, Maini, Mahajan, Srivastava and Chander (1978) reported linear relationship between FVC, FEV₁%, PEFR, MVV, expiratory flow rates between 25-50%, 25-75% and 50-75% of FVC and height, arm span and upper segment than age. Pande and Pande (1984) and Pande and Deshpande (1984) observed that there was gradual, progressive, parallel and significant increase in arm span, FVC, FEV₁ and PEFR per year increase in age in children from 5 to 12 years of age. It was also observed that height, weight and FEV₁ increased significantly with increase in age in both boys and girls during the school age. Malik and Jincal (1985) noticed a linear relationship of lung function with age, height and BSA. Both for VC and FEV₁, the age and
height coefficient have a positive linear relationship. The coefficient of FEV$_1$/VC ratio is negative for age and positive for height. The flow rate FEF$_{25-75\%}$ has positive linear relationship with age and height as with VC and FEV$_1$. Aundhakar, Kasliwal, Yajurvedi, Rawat, Ganeriwal and Sangam (1985) pointed out that significant positive correlation exists between VC, MVV, PEFR and anthropometric parameters, viz. height, weight and BSA.

Srivastava, Kapoor, Misra, Srivastava, Thakur and Shukla (1995) found a linear relation of FVC, FEV$_1$, FEV$_1$/FVC%, PEFR and FEF$_{25-75\%}$ with age, height, weight and BSA. PEFR, IC, VC, FVC, FEV$_1$, FEF$_{25-75\%}$, FEF$_{75-85\%}$, FEF$_{200-1200}$ ml, MVV were positively and significantly correlated with physical characteristics such as weight, standing height, BSA, arm span, chest circumference and age except FEV$_1$% and FET (Chatterjee and Das, 1995).

Bhargava, Misra and Gupta (1973) proved that mean FEV$_1$ values were not related to age or sex. Gregg and Nunn (1973) and Amin and Pande (1978) showed a negative correlation of PEFR with age and a positive correlation with height and weight. The FEF$_{25-75\%}$ had a negative correlation with age in adults but positive correlation with height. It was seen that height had a better correlation than weight or age for FVC, FEV$_1$, FEV$_2$, FEV$_3$ but a poorer correlation with MBC, PEF, MVV and FEV$_1$/FVC% or FEV$_3$/FVC% (Kamat, Sarma, Raju, Venkataraman, Balakrishna, Bhavasar, Kulkarni and Malhotra, 1977).

Singh and Peri (1979) were of opinion that PEFR significantly correlated positively with height but BSA and weight do not show consistent relation with PEFR in adults. There was no age-related decline in FVC in either sex but FEV$_1$ showed an age-related decline in men. FVC, FRC and TLC and height expressed strong positive correlation in both sexes (Vijayan, Kuppurao, Venkatesan, Sankaran and Prabhakar, 1990).
Ray, Rajaratnam and Richard (1993) observed a significant linear correlation between height and PEF but a curvilinear relation between age and PEF in both sexes. Morris, Koski and Breese (1975) pointed out that FEF_{75-85} had a negative correlation with age and a positive correlation with height, but FEF_{25-75} showed better correlation coefficients for physical characteristics. Age had a significant negative correlation while both height and weight had positive linear correlation with spirometric indices (Giri, Sharma and Jindal, 1996). Choudhury, Alam and Begum, (1997) showed a significant positive correlation of VC, FVC and FEV_1 with height and weight and negative correlation with age among males from Bangladesh. Nadeem, Raza and Malik (1999) reported that FEV_1, FVC, PEF and FEF_{50} were positively correlated with height, though FEF_{50} had a negative correlation with age.

Leiner, Abramowitz, Small, Stenby and Lewis (1963) showed a positive correlation between PEFR and FEV_1 in men and women. Elebute and Femi-Pearse (1971) and Walter and Richard (1991) observed a similar relationship in PEFR with VC, FEV_1 and ERV. Lavietes, Clifford, Silverstein, Stier and Reichman (1979) observed a significant correlation between FEV_{0.5}, FEV_{0.75}, FEV_1 and MVV. Shamssain (1991) found out high correlation among FVC, FEV_1, FMF and PEF.