DISCUSSION
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The growth of children is also an extremely sensitive index in the general evaluation of the health and nutritional status of children. Growth standards are likely to manifest considerable regional variations in a country like India because of a variety of factors like socio-economic and nutritional status, dietary, educational, cultural and ethnic factors (ICMR, 1983). In most developing countries with generally poor environmental conditions, average infant growth in weight and height is satisfactory until about 3 months of age, then it begins to fall off. Growth faltering at this stage may occur as the child outgrows its mother's capacity to produce breast milk and to provide adequate supplementation. The global concern towards assessing the nutritional status of children gradually grows during the past few decades.

The present investigation has been carried out for the assessment of nutritional status of preschool children (1+ to 5+ year age group) suffering from protein energy malnutrition (PEM) at CINI hospital in 24 Paraganas, West Bengal and NRS Medical college hospital in Kolkata, India. The normal preschool children of the same age group are from two nursery schools in Kolkata and our locality.

Results of survey indicate that the body weight, height, chest circumference and arm circumference of the boys suffering from protein energy malnutrition are severely affected. The values are lower for boys with PEM compared to those of normal boys of the same age group. The body weight, height, chest circumference and arm circumference of observed normal boys are slightly lower than WHO 50th percentile (1983)
but higher than ICMR 50\textsuperscript{th} percentile (Tables 1-12). The body weight of boys with PEM is 44-71\% of observed normal boys, 54-76\% of ICMR 50\textsuperscript{th} percentile and 39-58\% of WHO 50\textsuperscript{th} percentile. The body weight of observed normal boys is 83-96\% of WHO 50\textsuperscript{th} percentile

From the Tables 6-8, it is found that the body height of observed normal boys is higher than the ICMR 50\textsuperscript{th} percentile and 82-96\% of WHO 50\textsuperscript{th} percentile. The body height of PEM boys is 76-85\% of observed normal boys, 79-88\% of ICMR 50\textsuperscript{th} percentile and 70-80\% of WHO 50\textsuperscript{th} percentile. It is clearly evident that the body weight is more affected than the body height as the former is more likely to be influenced by nutritional factors (Banikdutta, 1983).

Tables 13-24 show that the girls suffering from PEM have much less values for their body weight, height, chest circumference, arm circumference compared to the observed normal girls. The body weight of observed normal girls is 80-92\% of WHO 50\textsuperscript{th} percentile (1983), but higher than ICMR reference value (1984). The body weight of girls with PEM is 41-74\% of observed normal girls, 53-77\% of ICMR 50\textsuperscript{th} percentile and 37-59\% of WHO 50\textsuperscript{th} percentile.

From the Tables 18-20, it is very much evident that the body height of observed normal girls is higher than the ICMR 50\textsuperscript{th} percentile and less than WHO 50\textsuperscript{th} percentile but the body height of girls with PEM is 77-84\% of observed normal girls, 80-85\% of ICMR 50\textsuperscript{th} percentile and 71-77\% of WHO 50\textsuperscript{th} percentile. The present observation reveals that the body weight is once again more affected than the body height as the former is more likely to be influenced by nutritional factors.
Compared to normal girls, normal boys are of higher weight and height. Banikdutta et al (1979) reported higher body weight, height, chest circumference in boys than in girls. In the present study weight for age (W/A) of observed normal boys and girls are 80-96% of WHO 50\textsuperscript{th} percentile and NCHS median but the same of observed boys and girls with PEM are 37-59% of WHO 50\textsuperscript{th} percentile. Shakur et al (2000) showed children with W/A <60% of NCHS median (6-60 months) to be severely malnourished and 90% of NCHS median to be normal. Nanda and Mishra (1996) reported an increasing trend in the mean weight and height of the healthy and malnourished infants with advancing age. The present study manifests that the children with PEM have significantly lower mean weight and height.

The comparison of chest circumference of observed normal boys with Indian standard (50\textsuperscript{th} percentile of ICMR, 1984) demonstrates that the chest circumference of observed normal boys is slightly higher. However, if the chest circumference of boys with PEM group is compared with observed normal boys and ICMR (1984), it shows that the chest circumference of boys with PEM is 89-92\% of the observed normal boys and 85-90\% of ICMR 50\textsuperscript{th} percentile (1984).

The comparison of chest circumference of observed normal girls with Indian standard ICMR (1984) shows that the chest circumference of observed normal girls is slightly higher. If the chest circumference of girls with PEM is compared with observed normal girls and ICMR (1984), it exhibits that the chest circumference of girls with PEM is 83-90\% of observed normal girls and 87-92\% of ICMR (1984). Compared to girls, boys have higher weight, height and chest circumference. Banikdutta et al (1979)
reported higher body weight, height and chest circumference in boys than in girls. Bhasin (1998) reported children from Haryana to have higher values for chest circumference than the ICMR values. Nanda and Mishra (1996) reported significantly higher mean chest circumference in healthy children as compared with the malnourished.

Measurement of mid arm circumference (MAC) was shown to be a simple, sensitive and cost effective method for community assessment of early childhood protein energy malnutrition between 12-60 months (Velzeboer et al, 1983). MAC is age independent and has high correlation with weight for age (Sharma and Bora, 1998; Bhatia, 1999). It is worth mentioning that MAC is an index of PEM even at the age of 6-12 months and has been utilised by various countries (Yost and Pust, 1988; Ball and Pust, 1993; Sharma and Bora, 1998; Bhatia, 1999). In the present study, the mid arm circumference of observed normal boys is slightly lower than that observed by Jelliffe (1966) but according to Shakir and Morley (1979), all observed boys are normal. The arm circumference of boys with PEM is 64-80% of observed normal boys and 54-70% of reference value cited by Jelliffe (1966). According to Shakir and Morley (1979), all the boys referred as PEM in the present study are malnourished.

The arm circumference of observed normal girls is slightly lower than Jelliffe (1966) standard. According to Shakir and Morley (1979), all the normal girls have comparable values. The arm circumference of girls with PEM is 64-76% of observed normal girls and 54-65% of Jelliffe standard but according to Shakir and Morley (1979), all the girls are malnourished. Sharma and Bora (1998) also reported lower arm circumference in PEM, which is similar to the present study and confirms its diagnostic importance.
From the Tables 1-24 it is quite evident that the body weight of both boys and girls with PEM are severely affected than height, chest circumference and arm circumference.

Based on the findings of clinical features it has also been observed that the preschool children with PEM are suffering from the deficiency mainly of energy, protein, vitamin A. Analysis of dietary intake (Tables 33-36) also show deficiency of energy, protein, vitamin A, iron and calcium. Present findings are comparable with other observation on preschool children in India (Gopalon et al, 1971; Ramdasmurthy and Mohanram, 1984; ICMR, 1998).

In the present study the mean birth weight of the normal children recorded is 3.1 kg and the mean birth weight of children with PEM is below 2.5 kg. Nutritional status of a mother is also directly related to the birth weight of a newborn and is dependent on nutritional adequacy during pregnancy, which in turn depends on the socio-economic class of the family.

The parents of the normal children are well educated and head of the families are engaged in lucrative service and relatively good business. The socio-economic status of the normal children surveyed is high. Income of most of the families is Rs 4283/- per capita per month. Therefore, it is evident that the normal children are belonging to middle income group (Tata Service Limited, Department of Economics and statistics, 1997). On the other hand, the socio-economic status of the children with PEM surveyed is very low. Income of most of the families is Rs 300-400/ per capita per month. Therefore, it is evident that such children are belonging to low economic group (Tata Service Limited, Department of Economics and
heads of the families are engaged in small business or as daily labour; again only 30% of them are literate.

It is well known that hair as an integumentary appendage is constantly under influence of hormone, protein and minerals supply and transport of other nutritive substances through the hair root. Each individual hair follicle with adequate nutrient supply is regulated by the mitotic activity of the follicular cells and their subsequent cessation (Parker and Haswell, 1967). Therefore, it is not unusual to find dispigmentation, thinness, and brittleness of the hair in children with PEM.

Microscopic examination of hair shaft diameter, colour and pigmentation in children with PEM shows reduction of these parameters compared to those of normal children. This observation is similar to Shimoshima et al (1988) who showed that the hair shaft diameter of rat in protein energy deficiency has tendency to decrease than that of the control group. It has also been observed by Alvares and Nicholls (1980) that there is a reduction in hair shaft diameter in mild to moderate protein energy malnutrition in monkey. The colour of the hair in children with PEM is mostly brownish. The hair is brittle and easily pluckable. In this context it is worth mentioning that Bradfield (1972) also found brittle and easily pluckable hair in case of children with PEM. So, our observations substantiate the earlier report (Jelliffe, 1966; Alleyne et al, 1978).

Tables 25-28 show that the hair diameter and hair weight decrease in children with PEM compared to normal ones. In normal group of children, the hair diameter and hair weight increase with age with no appreciable difference between boys and girls.
The study of hair under optical microscope has been done to measure shaft diameter by ocular micrometer scale and to observe shape and colour of hair root and shaft. Optical microscopic photos of hair root of normal children show round shape with smooth edges (Plate III) with pigmentation, and the same of children with PEM exhibit severe atrophy with decreased pigmentation and broom-like structure (Plate IV). Under scanning electron microscope (Plates V-X), the surface of the normal hair shaft presents the characteristic appearance due to the overlapping of the cuticle cells whose outer margin is free. Sometime the cuticle of normal hair confers the familiar structure. Examination of normal hair under SEM reveals prominent overlapping of cuticle cell with their tips oriented in the direction of growth of the hair shaft. Caputo and Ceccarelli (1969) found the familiar prominent scale structure in hair of normal children. Brown et al (1970) observed less prominent scale structure in diseased hair. In the present study, the hair of children with PEM shows less prominent scale structure and frequently areas are seen in which the scale structure is obscured resulting difficulty in establishing the direction of growth. Moreover, cavities and irregular scale patterns are clearly seen in scanning electron micrograph of hair of children with PEM. Normal hair root shows oval shape but the hair root of children with PEM is distorted oval shape or irregular in shape with cavities and canaliculi. Scanning electron microscopy employed to demonstrate the obvious difference between the cuticle of the hair from child with PEM and normal hair distinctly illustrates the basic assumption that structure and function are interrelated at least in hair (Fernando and Grimalt, 1999).

It is evident from the Tables 29-32 that the diameter of hair shaft of normal children is above 60 μm and that of children with PEM is below
It is evident from the Tables 29-32 that the diameter of hair shaft of normal children is above 60 µm and that of children with PEM is below 50 µm. Moreover, the tensile breaking load (TBL) of hair of children with PEM is much lower than that of the normal children. However, the reduction of ultimate tensile strength (UTS) is insignificant in the present study. Latham and Velez (1966) found a decrease in hair tensile strength in case of severely malnourished children suffering from PEM. Shimoshima et al (1988) showed significantly lower tensile strength of coarse hair in the experimental rats with protein energy deficiency than that of the control. On the other hand, Alvares and Nicholls (1980) reported the hair tensile strength did not change in case of mild to moderate PEM in monkeys. They proposed that a proportional decrease in both tensile breaking load and hair shaft diameter is responsible for keeping almost the same tensile strength values. The present study on UTS also supports the explanation proposed by Alvares and Nicholls (1980).

The results on the tensile properties of hair are comparable with the findings of Endo et al (1953) and Gupta (1983). Endo et al found that TBL values in male to be little higher than in female, but Gupta noted no sex difference in his study. In the present observation it has been found that the diameter is insignificantly higher in male than in female. The present findings on TBL of both male and female reveal that the significance of UTS in evaluation of PEM may not be of much importance compared to hair shaft diameter and TBL. So, it may be considered that more and more studies are needed to generalise this feature.
deprivation. It appears that the hair, though an external appendage, is much affected in severe protein energy malnutrition.

This observation is of great importance in nutrition research on protein energy malnutrition. From the anthropometrics studies it appears that the children who are suffering from severe PEM, their weight for age are more affected both in male and female compared to their height for Age. The present study indicates that the normal children belonging to privileged community in Kolkata are of comparable weight and height with ICMR (Indian) and WHO standard. It appears that the nutritional factors play a greater role than the genetic factor that influence growth rate of children. The weight is more affected than the height as the former is more likely to be influenced by nutritional factors and latter by genetic factors (Banikdutta et al, 1979). The hair of children with PEM is more affected as revealed by optical microscopic examination (hair diameter, root and colour), hair weight, SEM and TBL. In clinical evaluation of PEM hair has gained importance for a long time. Emphasis has also been given on the microscopic examination of hair. Changes in hair growth, hair diameter, pigmentation, lustre, looseness, colour, sparseness have been accounted in evaluation of intensity of PEM. But so far we have reviewed the literature we have not found many ultra structural studies on hair of children with PEM at preschool age group. Therefore, an attempt has been made to study the ultra structural topography and characterize the physical properties of hair (TBL, UTS, hair weight) accurately. The study reveals an outstanding change in the scanning electron micrograph of severely malnourished children and quantifies the physical properties (except UTS) which have changed significantly. Therefore, it may be concluded though this
sophisticated study may not be of practical importance in field studies but it emphasises the importance of protein and energy in the maintenance of not only body weight or growth pattern but also the cuticular pattern of the integument tissues. Whenever the growth of the body is affected even if it is for a short duration it affects the hair properties and structure very adversely. Therefore, it is concluded that hair is very much sensitive and susceptible to nutritional deficiency of protein and energy.